Volvo Maintenance FAQ for 7xx/9xx/90 Cars

Editor: S. Ringlee

This list was developed for the owners of Volvo 7xx/9xx series cars who are interested in maintenance tips that are not generally available in commercial manuals. It was compiled from Brickboard and specific websites with useful information. Items which appeared to be of lasting value to 7xx/9xx/90 series owners were excerpted and copied to this file. Sincere thanks to all those who took the time to answer others' questions and contribute to this public discussion. Because these remarks represent contributors' personal opinions, users need to exercise caution about any advice given; indeed, some of the comments are contradictory. This list is current as of the revision date below and was compiled by Steve Ringlee, who is NOT a consulting mechanic but only recording secretary. While this public domain list may be shared either whole or in part without attribution, it may not be sold or rented. This site is not affiliated with nor sponsored by AB Volvo, Volvo Car Corporation, Volvo Cars of North America, Inc. or Ford Motor Company."Volvo" is a registered trademark of AB Volvo and Volvo Cars of North America, with worldwide rights, and is used by way of reference to products of AB Volvo only.

Buying a Used Volvo 700/900? See Buying Used and Vehicle Preventive Maintenance for tips, trouble spots, and items to look for.

Note: If you are having **specific driveability problems** (no start, poor idle, etc.) with your Volvo, start your search with the Engine Tune and Performance; Symptoms section where many common symptoms are described and diagnosed. Other driveability problems are described in Electrical: Ignition System, Electrical: Engine Sensors, Etc, Engine: Fuel Injection and other areas.

If you need help or consulting advice, several Internet sources exist. Visit the Brickboard Rear-Wheel Drive Forum and post a message. You can reach this at http://www.brickboard.com/RWD/. If you are in the UK, the UK Volvo Owners Club at http://www.volvoclub.org.uk/ has a high quality series of forums arranged by Volvo model. A US distributor of Volvo parts, RPR in Berkeley, maintains a technical advice forum at their website: http://www.rprusa.com. Another good source of basic help is the Swedishbricks mailing list, found at http://www.swedishbricks.net/contents.html . This is a closed list and requires that you join in order to participate. You will receive good, unbiased advice very quickly at any of these forums. If you have a 200-series car, there is an excellent FAQ by Bob Scheer, now maintained at http://www.swedishbricks.net/contents.html

Here is a short testimony from someone who benefited from Brickboard: *"I would just like to thank the wonderful people on the Brickboard who helped me fix my car. I was about to sell the car because I couldn't fix it and couldn't afford to take it in to a shop. But the wonderful people who helped saved me by finding the problem and helping me fix it for $5. Thanks again! Charles."* This is typical.

Your contributions, along with corrections and suggestions, are always welcome. Please send a message to stephenringlee@hotmail.com (the subject line MUST contain the word "Volvo") and attach a word processing file if you are submitting a written contribution. Scanned pictures or illustrations are also welcome in any format. To print out an individual file, do it directly from your browser or download the file, save it, then open it in a word processer that can read and print html files.

240 Owners. Many of the engine and transmission systems on your cars are identical to those on 740/940 cars of the same vintages. These notes selectively apply to you as well.

European/Canadian/International Users: The US uses the old English (not Imperial!) system of measurements. One inch= 2.54 centimeters; one foot= 12 inches; one pound= 0.455 kilograms; one quart=.946 liters; one US gallon=3.784 liters; one foot-pound=1.356 Newton-meters; 1 psi (pound per square inch)=0.069 Bar=6.89kPa=0.068 Atm. For more conversion tables see Online Conversion or Google's Calculator.

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See the section entitled High-Mileage Vehicle Preventive Maintenance for detailed info.
See the notes entitled Purchasing Used Diesel for detailed info on diesels.

General Tips on Buying a Used Car:

Maintenance History. [Inquiry] If you know the VIN for a car is there anyway to get a history of the service and mileage of last service? [Response: Beau Springer] Yes, but the "work" has to have been done [recorded] at a Volvo Dealership/Service Center since the system used to record and track the service is on a "closed" Volvo network. In addition to this, the person doing the work history research must be willing to "de-code" the service codes for you. I tried utilizing this service last Friday at my local Volvo Dealership, so your mileage may vary depending on the level of cooperation that you receive.

Body Damage. [Inquiry] How do I tell if a car has had an accident? [Response: Rob Bareiss] Look at the paint. The factory paint is usually very smooth. The car is uniform in color. The gloss of the paint is the same from panel to panel. The fit of doors and hoods is correct, straight, and evenly spaced side-to-side. When a car gets hit, usually the affected panel is replaced, not repaired. The area around it gets primed and repainted at the same time. Sometimes there are non-accident related reasons to repaint a car- parking lot scratches, scrapes, key scratches, "garbage can" scrapes down the side, paint chips in nose and wheelwells. Generally you can tell if the panels have been replaced. Are all the factory decals and insulation on the inside? under the hood? in the doorjambs? When a quarter panel is replaced, there WILL be obvious welds at the rear door opening and in the hatch or trunk frame. Look at the seams on both sides of the hatch. Look at the inside of both rear doors up the back edge. Both should look the same. It all should be smooth and should match the outside paint. There is NEVER overspray on ANYTHING from the factory. You should not see any paint spray on the door hardware, or on the rubber window seals, or the chrome, or in the corner of the headlights. IF YOU FIND such items, ask for an explanation. Ask about the car's history, if known. Ask your mechanic if he agrees with whatever you find. If it's untouched and original, great. If it's repainted original bodywork, fine. If it's had a full nose and 2 doors, red flags should go up. Have it inspected much more closely.

Odometer Fraud. Not having that much time, I did an internet search and found Carfax (1-800-FIND-VIN). They search through DMV and auction records in the US and Canada and while they don't give a complete ownership history of the car or any details on previous owners, they can tell you if the car was ever totaled, salvaged, stolen, or in my case, that the car actually had 183k instead of 63k.

Odometer Change. I'd check the maintenance book to see whether the speedometer/odometer has been changed. I believe that quite a few of these had problems, and were replaced. The manual should say what the mileage was on the unit that was removed, if there was a replacement. Add this to the mileage showing on the odometer in the car for total mileage. Maintenance and repair records often state the mileage at which the car came into the shop, and can substitute for the maintenance manual, if it's not available.

Flood Damage. [Tip from Bob] Recent floods in North Carolina and Houston resulted in thousands of flood-damaged, totaled cars. Weak title laws and frequent title fraud result in many of these cars entering the used car market. The flooded cars (last week Houston became one of a 28-county disaster area) will no doubt have some Volvos in the mix, and some may wind up for sale far away from Houston. If the price is too good to pass up, there is one check that works: using a mirror look on the top of the fuel tank for flood-left debris.
[Editor] You can check in other nooks withing the car for flood debris: inside door panels, up under the instrument panel, etc. Flood damaged cars usually suffer from major problems, including electrical, engine, accessory, and transmission. While the title is supposed to state whether the car has been flood damaged, many titles are fraudulent. In the US or Canada, check the VIN through Carfax as a first step. Caveat emptor.

Maintenance Requirements. For tips on necessary maintenance, removing tobacco smells, etc. for a used car see the FAQ section in Preventive Maintenance.

Model Tips:

Buying a Used 740: Check the following before buying: (1) cooling system pressure test to check for cylinder head or block cracks, or other cooling system leaks; (2) look inside valve cover for varnishing/condition of rockers/cam etc (should give a fair indication of oil change interval); (3) a compression test; (4) starting the car when cold and noting color of any exhaust smoke; (5) examine the air filter; (6) Rear axle pinion seal for leaks; (7) A check of the rear axle fluid for suspended metal particulate; (8) color of brake fluid, dark meaning high moisture content and no recent change, and likely repairs; (9) Listen for knocks, squeaks, groans from the front end. All the bushings there could be up for replacement. (10) Check the bottom of the front of the engine for leaks; flame trap may be plugged resulting in blowby past the seals; (11) engine wiring harness for loss of insulation, cracking, etc. (12) rust in the tailgate or center and side storage bins in the trunk and the floors (13) Overdrive engagement in transmission if manual.
[Don Foster:] Inspect the aluminum pipe in the A/C line under the metal clamp -- they corrode through, then you have an expensive repair (if you want A/C). Also inspect the operation of the air conditioning system. See the High Mileage section for more details, as well as individual FAQ functional sections.

Buying a Used GLE with B234F. [Tip: Jason Kneier] the block is the same as the B230 you are familiar with. Only the head head/manifolds are different. It's good that the car appears to have been cared for, as these engines are slightly less robust than the 8V versions.
The two concerns I have heard regarding this engine are :
1) The head is an INTERFERENCE design. Change the timing belt and oil pump bolt religiously, and make a point to pop that cover off every now and then just to inspect it, because if it breaks you will bend valves. [Chris Herbst] ANY timing or balance belt on a multi-valve Volvo should be changed if at all in doubt.
2) Keep an eye on the hydraulic lifters, as they are inherently weaker than physical valve lifters. One other thing - a lot of the 16V engines got the ZF-22 4spd lockup tranny. This tranny is problematic, but is easily replaced with an AW70L or 71L. With proper care, this will be a great car! [Tip: Abe Crombie] The oil pump bolt is a weak point. It would be a good idea to replace it if it not noted as having been replaced at the same time as cam belt. The bolt is not a high strength bolt and can be obtained at a parts store. Loctite is a good idea when it is installed. The tensioner for balance shaft belt can lose its plastic teeth and this throws off the cam belt. Jason's correct mention of the valves hit pistons (interference) is a good reason to not let either of the things I mentioned happen. The transmission (in the '89 740 GLE) is not the ZF gearbox with the bad history but is a different gear ratioed version of the AW71L called the AW72L. Its gear ratios are revised to better suit the 16 valve engines lower torque production at lower revs as compared to the 8 valve versions.
[Comment: Al Asamov] As this is an interference engine(if a timing belt should break, valves can be damaged at least), you will have to be scrupulous about getting the timing belt(s) changed at intervals. If you love to drive, this car will please you. If you resent paying for scheduled maintenance, something
else might suit you better.

[Tip from Paul Bente] If you buy one, change timing belt and the intermediate shaft pulley bolt religiously every 50K, use synthetic oil (Amsoil or Mobil 1), use combustion chamber and fuel injector cleaner frequently. [Tip: Sheldon Fast] I would replace all belts and inspect very closely the timing belt covers, and in fact if original I would replace them with the newer versions (the plastic covers over the timing belt disintegrate and a piece can fall into the belt cogs, jamming it.) I would also replace the idlers if at all less than perfect and replace the seals. The belts could deteriorate if there was excessive oil leakage getting on to the belts. The cases of destruction have usually been caused by exceeding the service interval, or I have heard of poor oiling service causing cambearings to seize leading to belt breakage. This is one of the many reasons I use synthetic oil.

Buying a Used 760 with V-6. [Inquiry] What is your opinion of the reliability of a used six-cylinder 760? [Response: Abe Crombie] The odd fire mechanical fuel injected version used from 1976 through 1986 is the one with the tendencies for premature cam failure.
The 1982-1986 760 GLE uses this engine.
The 1987-1990 v6 is the later revised version with LH electronic fuel injection and superb reliability and smooth running.
The 87-90 760 GLE models often have a low resale value due to the reputation of the earlier motor and can be found as a real value. Maintenance Notes: These motors are easier to access and repair than any of the late model GM or Ford V6's. The exhaust gaskets are easy as is cap and rotor access. The intake is sealed to head with O-rings and these don't go bad. The intake is dry so there's no water to leak. The water pump sits front and center, really easy. The front timing cover gaskets can slip out and fail allowing an oil leak, time consuming but not brain surgery to fix. The bolts for cover being snugged up would likely prevent this. The valves need 30K adjustment via adjustment screws with jam nuts; easy as a Beetle except for setting the a/c compressor off the RH valve cover. The heads have oil troughs through which the cams dip and get oiled before the oil supply reaches the rocker arms and drips off to oil cam lobes (No more short cam life as in earlier pre-87 motors). The timing chains seem to have a lifespan of over 250K miles. The LH 2.2 fuel system is as reliable as any 85-88 240 (actually think the AMM's do better than 240 version). Less spunky than the 4 cyl turbos but tons more quiet on high speed cruise (no 4 cyl buzzies on this engine). There are very few interchangeable parts between the pre-87 and 87-90 motors so don't let anybody scare you with stories they've heard about somebody who had a V6 Volvo and how bad it was. The 87-90 motor is a whole 'nother story. I give it two ratchets up.

[Tips from Herb Goltz] Things to look out for--

1. Change your oil every 3K mi-- use the specified 15W40 (actually a high detergent diesel oil-- keeps the oil galleys clean)
2. Change your coolant every two years (the aluminum used in the block is somewhat prone to corrosion)
3. Have the valves adjusted once a year (they are solid, not hydraulic like most modern motors). No need for shims like the B230-- the B280 has adjusters that look just like the old VW aircooleds
4. The B280F is prone to oil leaks at higher mileage (possibly also on low-mileage cars that sat for protracted periods of time). Mine leaks a bit from the timing chain covers (which

have 25 bolts and two gaskets) and the rear main, and seeps slightly from behind the crank pulley. Higher-mileage engines will see front crank seal leaks.

5. This motor fouls throttle bodies just like the B230s do. If you get a surging idle, clean your throttle body first. That fixes 90% of weird idle problems. A gunky idle air valve seems to account for the other 10%.
6. This motor also uses a plastic capped aluminum rad. The plastic gets brittle and will crack when it gets older. Watch for it and replace it early
7. Make sure your water pump belts aren't too tight-- if they are the B280F will eat water pumps
8. The B280F has lots of coolant hoses-- replace them if they look suspect
9. The B28/280 has two timing chains that do wear and can break or more likely slip a tooth or 2. The engine is an 'interference' engine and valves will bend if the chain slips or breaks. There are wear indicators that can be checked with the valve covers off. While the lifetime is around 200k+ miles, you need to watch chain wear.

Besides these things, drive it and enjoy it! There are a lot of underinformed types out there that will want to tell you that any Volvo V6 is trouble. That simply isn't true. Their prejudice will get you a great value!

[Inquiry:] I'm about to buy a 1990 760 sedan, 85K and all service records. Opinions?
[Response: Eric D.] The biggest concern on the 760s are the abundance of luxury equipment, which gets pretty expensive if things start to break. Take some time and go over all of the power amenities and luxury features in the car, especially the power assists (seats, windows, sunroof, mirrors, antenna, etc.) and find out if it's all working properly. Make sure the sunroof itself tilts and slides properly, and doesn't leak. Also, make sure the automatic climate control system and A/C are working well--air conditioning units in these cars can have a reputation for spotty reliability and leaking hoses. At 85k miles, the Nivomat auto-levelling rear shocks should still be in good shape and should last well over 100k miles, but be aware that they are very expensive to replace, and cannot be substituted with standard shocks on this model.

[Response: Zippy] Go for a 740 turbo, as new as you can get. Those are 25 year plus life span cars and have HALF the problems of the 760s. Failing to find a 740 Turbo, settle for a 940 Turbo. Skip any Volvo that has "60" in the name, unless you like paying lots of money to repair things like vacuum motors in the AC, costly power seat parts (older is definitely not better with power seats) and other "refinements" over the 7/940s.

Buying a Used 780. See http://www.geocities.com/MotorCity/Garage/6570/tips.html for great information on buying a used 780.

Buying a Used 940. Volvo improved the brakes in 1992, by reducing front rotor diameter from 11.3 inches to 11 inches and increasing thickness considerably. New calipers to accomodate the wider rotors. The change was intended to reduce warpage of rotors. The 1990-on engines are all very good and stronger than the 85-88 motors and stronger than the 88-89 motors. In 93 or 94 oil jets were added to cool the underside of the pistons. I believe all 92 and later 740/940s were automatics, but the changeover may have been 93.

[Editor's Notes:] Check some of the 940 anomalies before buying. These include puckering door panels around the lock buttons which are very expensive ($800 parts) to replace (especially model year 1995), the functioning of the transmission shift lock switch and release button, and functioning of all body electrical components including power seats, power sunroof, power mirrors, mirror heaters, rear defrost. Check as well the performance of the air conditioning system: repairs are expensive and these cars have suffered from leaking condensers.

See the notes on rust in front frame members at 940 Rust Alert

940SE. [Rob Bareiss] In North American markets, Volvo imported a 1991 "940SE" which has differences from the normal 940. The 940SE wagon has the same solid rear axle as the 740's, but it has the Nivomat self-leveling rear shocks rather than the conventional shock/spring arrangement of the 740 or 940 wagon. This can be converted, as noted in the FAQ and then you won't have to buy $400 shock absorbers. The sedan has the multi-link rear suspension and has no good choices for shock replacement other than buying new expensive Nivomats. Another difference is in the front bodywork. The car has the lights, hood, cowl, grill, turn signals, and bumpers of a 89+ 760 or a 92-94 960. That means that it has corner lamps that are different from a base 740, either early or late, and the lamp assemblies will be different also depending on whether you've got foglights. However, many parts from the regular 740/940 models do fit the SE. Virtually everything mechanical is the same.

Buying a Used 960/90.
[Major Caution:] See the 960/90 section about sticking valves, cracked exhaust manifolds, driveline noises, leaking rear main seals, failing engine wiring harnesses, and other major problems. Reports from Brickboard buyers are not encouraging about the reliability and cost to repair these cars.

College Cars: Thinking about buying a 960/S-V90 for your high school or college kid as a first car? **DON'T**. These cars suffer from complex, expensive systems. They require regular maintenance. If certain maintenance is not done on time or correctly, the engine will self-destruct. These are not cars for people who don't pay attention to rigorous maintenance schedules.

[Inquiry:] What is the best 960 model year to buy? [Response: Lars Lundblad]   Regarding Volvo 960, the best year model to buy secondhand is 1996. Problems with 960:

> 1991-2 Camshaft belt too thin, giving vibrations and in some cases total breakdown See 960 Timing Belt Change
> [Editor's Note: see Porous 960 B6304 Blocks for major block porosity problems, reportedly occurring randomly in 92-95 960 cars.]
> 1994 Camshaft belt (wider) to get away from problems. Helped much.

1995 New construction on the camshaft belt now much wider, no problems reported since then.
1995 New look on the outside, nicer and newer. A lot of things are specific to local markets. See your local dealer to get a "printout" on what was standard equipment in what year/model in your market.
1996 (in Europe) Totally new electric system (Motronic 1.8 ignition system; no reports of failure), new engine control system, SRS (airbag) in front seats, new front wheel suspension, new rear axle design with a composite spring laying down instead of the usual ones

1996 960 is the best year/model to buy secondhand, at least in my opinion. The Volvo 6 cylinder engine 3,0 liters (2,5 1995->) is extremely well built it runs and runs. It is the same engine that is in S/V70 (850) only with one fewer cylinders. Before I bought my 960 1996, I looked around and in the southern part of Sweden I met a cabdriver whose 960 1993 had run for 700,000 kilometers with no repairs, just the standard "service". [Response 2: Ross Gunn] I have a '95 960 (Canadian market), and it has most of what is mentioned here as new in '96 (2 front air bags, multi-link rear suspension with composite (flat) rear spring. I'm not sure what changes in the electrical system and engine control system Lars refers to, but mine has the Motronic 1.8 ignition system. I also don't know what front suspension changes he refers to. As far as I am aware, there are no significant changes after '95, so '95 or newer should be a good choice. The S90 is the same as the 960 and will be discontinued after this model year.

[Tips from Rob Bareiss] Make sure the timing belt has been changed and is documented. ANY timing or balance belt on a multi-valve Volvo should be changed if at all in doubt. Check the VIN# out with a Volvo Service department, to see if the car has any "open service campaigns". That would mean it was not brought in for a dealer recall item. There could be a minor thing, but it's a good indicator of whether the previous owner cared about the car, or not. Look under the car, particularly for exhaust leaks at the rear flange or flex-joint of the catalytic converter (next to transmission). If you see or hear leaks, this is an EXPENSIVE fix on a 960. Volvo gets over $1100 USD for a new cat; non-Volvo replacements are over $500. Also look for oil drips at the front end of the transmission- a rear main oil seal is an EXPENSIVE repair. Drive the car- it should have no shake at all in the wheel when braking. Front rotors can warp, and they're over $100 each to replace. Make sure the Auto Climate Control does everything right. Run the A/C fan on full, and accelerate hard. The vents must not stop working. If they do, you've got expensive work ahead. And finally, look to see that when you arrive, the back of the car is not sagging. These cars have very expensive Nivomat self-leveling shocks in the back- they're $250-$450 USD each! The car shouldn't sag more than 1 inch overnight.

[Editor's Notes:] Check some of the 960 anomalies before buying. These include puckering door panels around the lock buttons which are very expensive ($800 parts) to replace (especially model year 1995), and functioning of all body electrical components including power seats, power sunroof, power mirrors, mirror heaters, rear defrost. Check as well the performance of the air conditioning system: repairs are expensive and these cars have suffered from leaking condensers. [Tip from Rafael Riverol] If you have a 960, I please take off the plastic cover atop the engine and examine the female connectors at each of the six coils. I suspect you will likely find crumbling insulation, brittle barrels and poor connections. I can tell you these can fail you anytime. You will also likely find crumbling wire sleeves that will allow wire chaffing againt the engine head. Expect to replace both the timing belt and the belt tensioner and idler pulley. Failure to do so can destroy the engine.

Buying a Used Turbo. [Inquiry:] What are the engine and model specs on the turbo series? [Tip from Abe Crombie] I don't know what your $$ limit is but the 93-95 940 T will have the engine with piston oil cooling and the improved tolerances on lower end.
The 92 and later have the bigger brakes up front and larger piston size for rear calipers.
The trans on turbo models is the same except the balls used as check valves could deteriorate and cause harsh shifts on 85-87 models.
The 88 and later have the larger diameter mains with a full circle thrust bearing for crank.
The 90 and later have the smaller, fast spool up time turbo but this hurts the absolute limit for boost as the exhaust housing is more restrictive.
92 and later have bigger radiator and intercooler with all electric cooling fans. The sips structures in 92 and later likely adds some body rigidity.
87 and up have hydraulic engine mounts that are more costly and have a finite life span.
91-93 turbos have the auto locking diff, it was part of cold weather package (heated seats=locking diff) on 94-95. The auto locking diff is not the best for Hi-Perf track/gymkhana style activities.

[Editor] Pay attention to the maintenance given the turbo, including oil changes, turbo hoses, vacuum hoses, coolant hoses (including the oil cooler coolant hoses), etc. Hoses embrittle in the higher underhood temperatures created by the turbo.

Buying a Used Diesel. Anyone contemplating buying a used 7xx/9xx with a D24 or D24T diesel engine should see more detailed notes at Purchasing Used Diesel.

Buying a Used LPG Conversion. [Inquiry] Does anyone out there run a 740 that's had a gas conversion? One has come up for sale in my area and as I drive around 30k each year I am considering buying it as a second car solely for commuting up and down the motorway (and hoping to save a few pennies in the process). [Responses: George Holmer/ Ivor Guyett/] MPG goes down by 20 % so expect worse fuel economy than on petrol. Does performance suffer? No Does it need more servicing? Yes, it will need the head rebuilt about every 100,000 miles. Valve seats wear out and occasional misfires kill the AMM. Insurance may depend on whether kit is DIY installed or fitted by approved installer.

Replacing Your 740/940 With an 850/70. [Inquiry] My pristine 745 was totaled. I'm considering replacing it with an 850. Anything to watch for?

[Response] My 850 was an absolute lemon. But rather than bore you with details, here are the the most common 850/70 problems:

- Rear Main Seals; costs about $1000 to repair (10-12 hrs labor): these are unreliable on all five cylinder engine cars. Clean the flame trap!
- AC evaporator unit; costs about $1000 to repair
- Auto transmission PNP switches failing
- Auto transmission clutch failure and fluid overheating in earlier 850s: consider using synthetic and flushing regularly
- Tie rod ends and ball joints fail at 50-70k miles
- Heater fans
- ABS control module failures(certain years); also affects traction control systems. These units can be rebuilt with repaired electronics.
- Check engine and Service Soon lights seem to always come on and require a special reset device
- Most use quite a bit of oil between changes
- Also known for defective seat heaters, sunroof shades falling out of the tracks, peeling door panels, peeling moldings on roof, losing the rubber molding above the windshield, squeeks and rattles, noisy suspensions.
- Make sure the timing belt has been replaced recently; if this snaps it ruins the engine. It is very expensive to have the belt replaced.

The 850's are more labor intensive than the 2/7/9 series and are more maintenance intensive, in most cases.

Moral: Keep your RWD Volvo going as long as you can.

See the section Buying a Used 7XX/9XX for related information.

How to Keep Your Car Rolling for a Long Time to Come. [Editor] Simple preventive maintenance will keep your car on the road virtually forever. If Irv Gordon can secure two million miles from his Volvo, then so can you. Follow the instructions in this FAQ section, along with additional tips in Engine: Lubrication and Buying Used.

Fuel Economy Improvements. How can I improve my 740/940 fuel economy?

Driving Styles. Rule One is slow down: these non-aerodynamic cars burn far more fuel at 75 mph than at 65. Avoid the jackrabbit starts as well.

Mechanical Improvements. [Bob Wilson] For more MPG, try the standard stuff first: fresh spark plugs, air filter and properly inflated tires. Stock thermostat (92C non-turbo, 87C turbo). Get a wheel alignment. Synthetic lubricants can help. I use Mobil-1 5W30 in the engines, RedLine everywhere else. Their 75W90 synthetic gear lube works fine for the 940's ALD rear axle. I've changed engines over to Mobil-1 at mileages ranging from 40,000 to 260,000, and immediately gone to extended oil change intervals depending on usage patterns. [Editor] Try Mobil 1 synthetic ATF in the transmission and power steering systems. Small improvements can also come from low-rolling-resistance tires, which are hard to find but do make a small difference. Keep them inflated to 34 pounds or so for better mileage. The recommended inflation pressures are usually determined more for comfort than economy.

Turbo vs. Non-Turbo. If you have a turbo, you likely have the non-lockup torque converter in your automatic transmission and a lower gear ratio in your rear differential, both installed for performance and not economy. A US spec turbo has a 3.73:1 ratio without a locking torque converter. The last of the non-turbos came with 4.10:1 and locking torque converters. Is it worth changing over? Almost certainly not: your mileage improvement will be at most five to seven percent or so (up to 2 mpg). The cost will be the replacement transmission and differential and the labor to install them. Far better to focus on the simple improvements to fuel economy noted above.

"Service Engine" Light Reset in Various Models. See the discussion in Electrical-Instruments for information about re-setting the "service engine" lamp, which is an engine oil change timer.

Preventive Maintenance Supplies. Here is a short list of special supplies useful for keeping your car on the road forever.

Spray Lube. Forget WD-40 and cheap lubes. Use a quality spray lube on locks, hinges, pivots, sunroof mechanisms, cables and the like. Good lubes include:

- Valvoline Synpower Spray Lube. Another quality lube, sold in auto parts stores.
- Superlube Spray and Grease. PTFE-based, this is great for sliding parts. The grease comes in a small tube. Buy it from Superlube, at marine supply stores, or at Lowe's/Home Depot.
- Silicone Spray. Use a can of generic silicone spray for your power antenna lube: it does not attract dirt and does a good job lubricating the sliding surfaces. Use it as well to lubricate your door seals. But DON'T spray it near your intake system because silicone poisons oxygen sensors.

Penetrating Oils. Forget about WD-40 and Liquid Wrench. The only stuff to buy is PBBlaster, available at IPD, Walmart and other mass marketers. Kroil is another good brand. [Peter Milne] In the UK, try E.A.C.'s PlusGas Formula A, available from tool and engineers' supply shops.

Electronics Supplies. Try Caig Labs "DeOxIt", used by electronics techs to solve computer problems. Miracle stuff for connector cleaning and deoxidation. Spray both sides of the contacts then treat the connection (with the sole exception of the oxygen sensor connector) with silicone dielectric grease. Buy it at Radio Shack. Use OxGard conductive grease on chassis grounds.

Rubber and Vinyl Maintenance. Armorall and the like are suspect. Look for a marine-grade UV block for fabrics and vinyl. 303 is superb, available at marine stores.

Maintenance: Air Filter Replacement. [Various] To change your air filter, locate the air filter box under the hood, behind either the left or right headlamp. CAREFULLY unclip the metal spring clips holding the top to the box. These have a tendency to break their mounts. Because the plastic can fracture, don't do this in very cold weather. Look carefully for all the clips, some of which are in strange places. Unscrew the air mass meter clamp from the boxtop. Lift the top off. If you have a turbo, you will find various parts of wiring harness and fender in the way and you may need to move the entire assembly to access the top. The filter fits in the box, with a gasket snug in a recess. Replace this. If your boxtop has silencing foam glued in it, remove the foam since this deteriorates and clogs your expensive air mass meter. Replace the box top snugly and CAREFULLY secure each spring clip. If you have any broken clips, you can repair them by following the instructions in the FAQ file. Under no circumstances should you let a quick lube mechanic "inspect" your air filter, as they will most certainly break most of your box clips off in the process.

Preventive Maintenance After Purchase: When I buy a used 700-900 series car, these are the items to inspect or replace in order to improve reliability and longevity. See the recommended maintenance schedule in your owners' manual to know when routine items need to be replaced. The Volvo dealer 150-point check, which costs about $85, is well worth the expense since you will receive an evaluation of Technical Service Bulletin and recall compliance. The list below is exhaustive and includes almost all items that wear or fail on the car.

- Change oil and filter, using a Mann or Volvo OEM filter.
- Change air filter.
- Flush coolant.
- Flush the auto transmission fluid.; Change the rear end/differential lube .
- Chassis lubrication: radio antenna, hood release mechanism, door locks and hinges, hood hinges, sunroof and other lube points according to the Volvo service charts. Use a good spray lube (Mobil 1 Spray, Superlube, etc.)

- Brake fluid - thoroughly flush
- Fuel filter - replace
- Throttle body - clean
- Flame trap - clean the breather system to prevent oil leaks
- Plugs/wires/cap/rotor - replace or check as required. Use Bougicord OEM wires.
- Accessory Drive Belts - all three, replace if needed
- Timing belt - replace with Volvo unit. When you do the timing belt replacement, it's relatively cheap to replace the cam, intermediate and crankshaft oil seals and the tensioner.

If this is a B6304 six-cylinder or B234 16-valve, changing the timing belt is CRITICAL (and see: oil pump bolt for the 16-valve)

- Radiator/hoses/thermostat/water valve - replace radiator if it is older than eight years. Change all hoses: radiator upper/lower, heater hoses, reservoir hoses, turbo oil cooler coolant hoses (if a turbo), and the heater control valve. Since this valve is made from the same plastic as the radiator, it'll eventually fail, usually catastrophically . The maximum reliable lifetime of plastic radiators and heater valves is about eight years. I've added the plastic overflow tank to my list of replace/repair on 740's with >100K miles, and especially on the Turbo cars. The overflow tanks are cheap enough to include in the general cooling system maintenance program. [Editor's Tip:] See the Loss of Coolant discussion for information on components that age and break. Consider installing a Loss of Coolant sensor.
- Vacuum hoses can split at the ends and cause unexplained driveability troubles. Older cars likely need new hoses. The small hose to the turbo wastegate is especially vulnerable and if it fails, will overboost the turbo.
- Check the water pump for leaks and replace if needed.
- Inspect front and rear engine oil seals for leaks
- Replace the O-rings on the distributor and the oil fill cap o-ring gasket, and inspect the valvecover gasket for leaks.
- Set valve clearance although the B23X engines tend not to lose their valve tappet clearance.
- Oil filter mount O-rings: check for leaks. Only $7 and can be done yourself
- Check the rubber hose that connects the tank prepump with metal fuel line; these tend to deteriorate with age.
- Vacuum hoses: mark ends with duct tape and replace if they are hardened or cracked.
- Hydraulic engine mounts...if the pan is less than 1/4" to the crossmember you're on borrowed time...if it touches...replace both of them.
- Air box thermostat: check to see it operates. Remove or replace as needed.
- Transmission output shaft bushing - check/replace as required if over 130K [This is not a problem area, just a wear issue. There is a bushing on the output shaft of aw70 and aw71 trannys that wears over time. It costs about $200 to replace at transmission shops.
- Turbos: Turbocharger oil return pipe to block O-ring...only $4 or so but labor again... replace the paper turbo to pipe gasket. Check ALL, and I do mean ALL, of the

vacuum or pressure hoses in the engine compartment, especially the little one that controls the turbocharger pressure to the wastegate...blow this one and the engine will grenade from overboost. Check condition of rubber in harmonic balancer.

- Oxidized Engine Wiring Connectors. See the narrative to find out how to clean and protect your engine wiring harness connectors.
- Battery cables: clean, deoxidize, and protect with battery terminal cleaner
- Rotting engine harness wiring (83-87 cars): Get busy with a roll of electricians tape or plan on rewiring a lot of stuff...many wires under the hood have had their insulation broken down over the last 10 years...not so bad if they're ground connections, but eventually even those wires/connectors will corrode to the point of not connecting. Evil things will befall thee. [Note: see prior notes above on Baked Wiring Harness problems, and connector cleaning.]
- Clean and preserve chassis and engine grounds.
- Fuel Injection relay: resolder
- Check to see if the splash shield under the engine is whole, or even still there!! That shield helps to keep the engine clean and air flow correct....it's relatively cheap from RPR or other suppliers.
- Brakes: check pad and rotor thickness and lubricate the caliper guide pins.
- Suspension bushings: check or replace the front conical strut bushings and the condition of all other front bushings. Rear bushings last a long, long time.
- Useful manuals from Volvo include the Wiring Diagram Book for your car, an indispensable book when tracing any electrical faults.

Flame Trap Preventive Maintenance. [From RPR:] On four-cylinder non-turbo engines, the flame trap (a replacement for the old PCV valve in the "positive crankcase ventilation" system) prevents engine backfires from igniting in the crankcase. However, airborne contaminants and oil residue will eventually clog this device and cause excessive crankcase pressure. Symptoms of this problem may include finding your oil dipstick lifted up from its entry tube and worse, leaking engine seals. The flame trap is "buried" under the intake manifold [between 2 and 3 cylinder intake manifold inlets.] Do not let this discourage you. Replace the flame trap every year for trouble-free engine performance. Also replace the hoses connected to it if they appear bloated or "spongy" from engine oil damage. Do not use clamps to hold flame trap hoses in place; if they are popping off, you may have excess crankcase pressure. Also check that the vacuum fitting on the induction (intake) manifold is open and providing vacuum for the PCV system. The fitting is connected by a small hose to the flame trap housing. See the extensive Flame Trap discussion in the Seals, Belts and Vent file. Note that using synthetic oil seems to eliminate flame trap clogging.

Lubricant Preventive Maintenance. See the fluid filter under "Steering" and the notes on fluid change/filters in "Transmission" for tips.

Alternator Preventive Maintenance. It would be wise to inspect the voltage regulator/brush

unit (VR/BU) for wear while the alternator is removed from the engine bay. The small slot screws which retain the VR/BU can be quite difficult to remove, especially if your car is driven in the "rust belt". The VR/BU sells for around $70.00 and can be obtained at any Bosch supplier. I apologize for not being able to give you a part number, but the VR/BUs are selected to match particular alternators and, if my memory serves, later model 240s were fitted with one of three Bosch models (depending on trim & accessories). One tip I can provide is to avoid cheaper, third world units as these can fail prematurely! When re-assembling the VR/BU with the alternator body, place a small dab of anti-seize compound on the retaining screws. This will make it easier to remove the VR/BU in the future. The rubber bushings used in mounting the alternator, power steering pump, and a/c compressor tend to require replacement after about 7 years.
[Tip: Editor] Remove your alternator and take it to an automotive electric shop, where they can rebuild it for around US$70 including new bearings, brushes, voltage regulator and a complete electrical test.

High-Mileage 1990 740/760 Problems. [Inquiry: Any "special" problems I should look for in a 760 of this vintage?] [Reply:] I bought my 89 740 (non-turbo) at approx. the same mileage. Some items since then have been the radiator (replaced with an all-metal unit as opposed to the factory plastic tank version), the heater water control valve, the FI ECM, motor mounts and now at 175k miles the steering rack needs to be replaced. None of the above parts alone are insanely expensive, except the FI unit, so if you do your own work, it's not too bad. A recurring problem on my car is that the power window switches keep flaking out and I'm too cheap to get a new set and too tired of opening them up and cleaning them. [Editor's Note: see the section on engine wiring harness problems with 83-87 7xx cars.]

Regina Fuel Pumps. [Tip] If your car does have a Regina system and you have over 150k miles then replace the fuel pump (f you haven't already) I've taken a couple apart to see why they failed; the commutator & brushes show excessive wear. Both wore the brass out and one had the brushes wear so thin it popped out & the wire broke.

V-6 B280F Preventive Maintenance. See the "Buying Used" section for more information on V-6 maintenance.

960/90 Preventive Maintenance. See the 960/90 Section for specific tips on preventive maintenance to these six-cylinder cars. Pay particular attention to timing belt , sticking valves and wiring harness, and make certain you change your engine coolant.
[Tip from Rafael Riverol] If you have a 960, I please take off the plastic cover atop the engine and examine the female connectors at each of the six coils. I suspect you will likely find crumbling insulation, brittle barrels and poor connections. I can tell you these can fail you anytime. You will also likely find crumbling wire sleeves that will allow wire chaffing againt the engine head. [Tom Irwin] To inspect the FI wiring harness, open up the "Volvo 24 valve" black spark plug cover and check the wire pairs going to each coil pack. The REAL hazard, the one that will stop you cold with 1-1-3 or 1-1-4 errors is fixable only by taking out the manifold and cutting and splicing. Your choice: to repair on failure or pre-emptive strike.

How to Clean Interior Trim. [Tip from Darell] To clean the Interior including the vinyl seats, headliner door panels, carpet and the rear cargo deck of my 89 Wagon, I bought some Murphy's Oil Soap. Mixed it with some warm water appox. 30-70% water solution. Used a brush and a dish sponge. Worked great. Almost good as new. It removed some stubborn stains I couldn't even get with Simple green.

How to Remove Tobacco Smell From Newly-Purchased Brick? I had the same problem and used a product sold by Sam's Club called "Odor Ban". Sprayed it on the seats and carpets before I used a regular upholstery cleaner. worked very well for me. [Numerous] Also try "Febreze" spray. [Tip from Skip] My local Volvo mechanic also sells late model used Volvos. He uses a commercial ion generating deodorizer on the smokers. He uses a new filter on each application. Put the unit in the closed car and run it for several hours. Not cheap (he charges about $100 per job) but it works wonders. [Tip from Bret] A trick I learned from a chemical tank cleaning place I used to work...Vanilla...Any time they had a hard time getting the smell out of a chemical tanker they would soak a roll of paper towels in vanilla extract and hang it inside the tank overnight. For a car I'd stuff a big coffee can or such with paper towels and soak it down... then leave it uncovered overnight. (Variations on this include a tin of coffee grounds or sliced apples, left until they rot. Or volcanic rock odor eliminator, found in the cleaning supplies section at Home Depot (if you are in the U.S.) for US$6 that is very effective.)

Maintenance Records. [Tip: Steve Ringlee] Zee's recent post on "Computerized Maintenance" was very insightful. I've tried to keep two sets of maintenance records for each car: one on my computer and one in the engine compartment. The computer records in an Excel file show date, mileage, who did the work, and a detailed description of not only the major work done but things to watch for in the future. This is backed up by a file of all receipts (remember the lifetime warranty on shocks? you'll need the receipt!) and warranties, etc. This goes beyond the stamps in the Volvo maintenance book: things are described in more detail and include work never done at the Volvo dealer, who is seldom visited. The other set is in the engine compartment. My father's mechanic taught me this: use permanent marker and white duct tape on selected flat, cool surfaces to record routine things like:

> the complete record of all fluid and filter changes: oil, trans, diff, brake, coolant, brake fluid, power steering
> tire rotations, wheel alignments
> changes of plugs, plug wires, cap & rotor
> seals and belts
> air, fuel filters
> replacement of relays, sensors, battery, etc.

When you are maintaining five cars for self, wife, kids, in-laws, etc. it is impossible to remember what is going on. Every time I bring one of them in for service, the mechanics at either the dealer or Sears, etc. are unbelievably grateful that someone has made life easier for them by posting the obvious in the engine compartment. It also makes diagnosis a whole lot easier and keeps me from doing things twice because I forgot that I had done the work last year. I just open the hood and instantly know when something is due for work. Even better than duct tape (which tends to shrink over time) is a Brother or Casio label maker and white label tape.

[Tip from Zee] I am trying Automotive Wolf software, which seems very good for input about services, parts, PM schedules, reminders, etc. Very easy interface. Program opens up to an "Alarm Notice" and a "What's Due" window. Very handy. The diagnostics and technical info areas are rather superficial, though.

High Mileage Badges. To obtain high mileage badges for your Volvo (each 100k up to 500k, then in larger increments) contact Volvo through their appropriate country website. In the US, you can call 1-800-550-5658 for a registration form or visit: Volvocars.US To mount them on your grill, see Brian Murphy's techniques in the FAQ file.

Towing Your RWD Volvo. [Inquiry] My car is disabled and needs to be towed. Is there an approved technique? [Responses: George Downs/Robert Ludwick/Randie Starkie/John Sargent] Towing the car with the rear wheels on the ground can cause lubrication problems in the transmission. There is no internal oil circulation because the only oil pump is run by the input shaft. Therefore no lube. Comments:

- When I had to call my auto club for a tow, they had it on their computers that any volvo was an automatic flatbed call. They won't even send out a regular hook.
- The last time I required a tow the company used a truck that lowered a platform with indentations for the REAR wheels. They slid it under the car/wheels and then lifted the rear off the ground. The steering locked in a straight forward position (don't know what they would do if it hadn't). This prevented any worry over the transmission being damaged and from what I've read automatics can suffer damage as the distance of the tow increases.
- Most tow operators have a dolly; when they tow a RWD, they will put the rear tires on the dolly while hoisting the front tires. If I was hauling the car with a tow dolly (which I have done), all I would do is mark and disconnect the drive sahft at the rear axle.

Car Storage Tips. [Inquiry:] I will be leaving the country in another month and have to put my Volvo in storage. What type of preparation should I do to the car before I leave and what should I do on my return? I plan on disconnecting the battery and I may even have a friend start the car once a week...the storage will be outside with a car cover and will be sitting for the majority of a Phoenix summer.

Shorter-Term Storage Hints: [Response 1: Paul Seminara] Shouldn't be a huge ordeal to store a car in Phoenix through the summer. Just keep it in the shade!! (car cover 'll work) Make sure the tires are out of the sun, too. I don't think it's too good to just start the car once a week, unless you do a full warm up cycle with some good driving. I think you'd be better off just dumping some fuel stabilizer in, filling the tank all the way, changing all the fluids, squirting some oil in the cylinders, turning it over, put new plugs in and remove the battery (you may do the battery monitor thing, but I'd be wary if I couldn't eyeball it once in awhile) and let her sit. [Response 2: John Erickson] All the things Paul mentioned are good things to do, but you can get away with little or nothing. If you can get someone to drive the car once a month, you don't need to do anything else. If no one is going to touch it for six months, then you should put it on blocks (tires get flat spots that won't run out - especially in the heat), top off the gas tank and disconnect the battery. The battery will be dead when you get back, but it will recover after a jump start. [Response: Peter Penguin] Mice can enter the car through the vents at the bottom of the trunk/boot side compartments. Place metal mesh hardware cloth in these rubber vents to keep mice out.

Long-Term Storage Hints. [Inquiry:] I am going to put my brick ('91 940gle) on the block (storage) for approx 12 - 18 months in the garage. Anything else I need to do other than the suggestions from the board. The existing timing belt has 47000 miles on it and the manual recommends timing belt replacment at 50000, should I go ahead replace the belt now and then put it in storage, or can I replace the belt after I put the brick back on the road 18 months from now. if I leave the existing belt in the car, will the existing belt break when I attempt to re-start the engine 18 months later (the 940gle is an interference engine - major repair if the timing belt breaks). Any particular areas require extra attention before I put the car in storage? [Response: JohnB] Store the car and replace the belt after a few hours of running after you take the car out of storage. Reason is that the belt is supposed to be replaced at x miles (50k in your case, my 90 B230FT is supposedly 45k in the chilton book but I still figure 50K) or if the car has been stored for 'any length of time,' whatever that means. Apparently the idler pulley puts a dent or fix in the belt, a reverse dent or set, and the belt reliability suffers. As you already know, the engine (non-DOHC 4 cyl) is non-interference, even if the belt snaps when you start the car or after a few hours, no damage to the engine will result.

You might consider using amsoil marine synthetic lubricant for storage...the marine oil has a hefty anti-corrosion package that is ideal for long term storage. One should probably change the engine oil before storage, as well as the engine coolant.

I like to 'fog' the cylinder walls with marine storage lube, i.e., pop the plugs, squirt lube in the holes, put the plugs back in, disconnect and ground the ignition coil secondary, pull the fuel relay, and spin the engine a few seconds while blowing lube in the throttle body.

You can either drain the fuel tank and drop a dessicant bag (onna string...you will need to remove it!) into the fuel filler neck...it should be pretty well sealed unless the cap is defective, or you can use a quart of gas stabilizer mixed in with a full tank of gas. 18 months is a long time for gasoline, however, and you'll probably find yourself dumping the gas so it's better to have less gas than more to dump. If you have a non-steel gas tank, I'd run the tank as low as practicable, add the fuel stabilizer, run the engine a few minutes to distribute the stabilizer, and then pull the fuel relay at the storage site when you fog the engine.

Plug every orifice on the car you can....squirrels or whatever will find them if you don't. Find a couple bags of dessicant and put them in the car...clean the car real good before you close it up! If you have someone to air out the car every 3-6 months (no start!) and reactivate or replace the dessicant bags, so much the better.

Best case is if you can find a giant plastic bag to put the entire car in, suck the air out of the bag (wet/dry vac works good, and then bleed dry nitrogen into the bag. There are storage bags available, obviously you have to drive the car into the bag, look in the back pages of Autoweek or Motor Trend or whatever. Or check out http://www.carbag.com

The Army learned a good lesson from the Israelis on bagging entire tanks/armored battalions... The tanks start up every six/12 months with nothing more than new battery packs (not a small deal....a modern tank takes 4-6 BIG batteries, like the size of those on semi trailer rigs.)

Take the battery out and sell it....you'll need a new one in 18 months almost no matter what you do with it.

Fuel Quality Concerns and Engine Deposits: [Tips from Chris Herbst] Be careful when storing cars. Make sure you use a quality gas storage stabilizer in the fuel tank before placing the car in storage. We have found that rotten, stale reformulated (ethanol) gasoline glued the valves into the valve guides on a 740T we had in the shop. This was the fifth time this shop has had the problem with stale gas reacting in such a way that it turns into glue. Apparently the common denominator is plastic or lined fuel tanks. You can literally reach into the tank and scrape this molasses-like sludge from the sides of the tank. The same, I believe, as with this particular 740. The results are the same--total intake valve seizure leading to timing belt stripping. There are no deposits on the cylinder walls or the pistons themselves, which pretty much rules out byproducts of combustion causing the problem. While carburetor cleaner removes the gluelike stuff from the valves, it also re-deposits the sludge when it evaporates. Therefore it's necessary to wash the head out with carb cleaner, not just spray the stuff off.

High-Performance Tires and Flat-Spotting. [Mercedes] Storing vehicles for long periods can cause flat-spotting of high-performance tires. These tires typically are made with a nylon overlay that enables them to achieve their designated speed rating and enhanced handling capabilities. Problem is, the nylon material also has memory-retention tendencies. With this in mind, the following steps should be taken to avoid flat-spotting when vehicles equipped with high-performance tires are not used for extended periods: Vehicles should be stored with 44 psi of pressure in the tires. When a vehicle will be driven, the air pressure should be reduced to the recommended running pressure. The pressure should be increased once again to 44 psi before placing the vehicle back into storage for periods longer than 30 days.

Useful Mealtime Tips. [Inquiry: After driving my Volvo, I am hungry. What to do?] You can heat canned food (small cans) on the engine block of many 4 cylinder Volvo engines by removing the paper label and placing it on the engine just under the intake manifold. The car's cooling system regulates the block temperature, and this should keep the can at around 130 degrees fahrenheit for whenever you'd like to stop for lunch. In WWII, soldiers actually cooked roasts and potatoes, etc. on those flat jeep engines on trips between posts (I got this idea from one of these old vets) and I believe there's actually a book out called "Manifold Cookery" or something like that. Just keep your motor clean and don't try to stuff cans tight into the wiring. B230's are great for this...turbos too, but forget the frogmotors and 16v's (no room).P. S. This works year round!

Abbreviations

Note: Symptoms may involve several potential failures, so diagnosis should start with a general perusal of this entire section. Most of these notes apply to Bosch LH 2.2 and LH2.4-equipped cars. Regina-equipped cars have some differences in components and component failure patterns. Where known, these are noted in the relevent section. Symptoms for B6304 engines used in the Volvo 960/90 series cars with Bosch Motronic are covered in a separate 960 file. Diesel symptoms are covered in the diesel file. Some notes relate to carburetted cars: they are identified as such.

Caution on Diagnostics and Shop Errors

General Symptoms and B2XX Series Engines:

Idle Problems:

Start or Stall Problems:

Mixture, Misfire or Idle Control Problems:

Car Won't Start: Neutral A/T Safety Switch at Fault

Car Won't Start; Plugged Catalytic Converter

Turbo-Specific Symptoms:

Turbo has Poor Acceleration; Diagnostics

Turbo Suffers Severe Misfire: Leaking Intake System

Engine Cuts Out; Rich Running: Turbo Electrical Harness Degradation

760T Misfires; FI Resistor Pack Defective

Hot Start Problems: Faulty Hall Sensor

Hot Start Problem: Power Stage Overheats

Diesel Engine Symptoms (see Diesel section)

960/90-Specific Symptoms (see 960 section):

960 No-Start: Sticking Valves

960 Stalls: Wiring Harness

960: Transmission Lights Flash, Cylinders Quit: Bad Ground

960 Sudden Idle Surge: ECT Sensor Failure

[Editor: 960/90 series cars suffer from numerous wiring and electrical troubles, all explained in the 960 section.]

Emission Control Problems (High HC, CO, NOx):

Emission Control Problems: High HC, CO or NOx

Abbreviations:

AMM Air Mass Meter
ECT Engine Coolant Temperature sensor
ECU Engine Control Unit computer (either fuel injection or ignition)
FI Fuel Injection
FPR Fuel Pressure Regulator
IAC Idle Air Control solenoid valve
TB Throttle Body
TPS Throttle Position Sensor
VSS Vehicle Speed Sensor

Caution on Diagnostics and Shop Errors. I solved my 95 960's mystery of code 2-3-2, uneven rpm's at idle, and an apparently faulty MAF. The local Volvo dealer wanted to put in two O2 sensors, a new MAF, and other unnecessary service at a cost of $1275. I tested the car's single O2 (not two sensors), and it was fine. I replaced the MAF with a used one for $150, and when the 2-3-2 persisted, I found a plugged vacuum hole in the throttle body! I cleaned it out and now it runs fine.

Word to the wise: shop service writers will take you any way they can unless you are well informed. Always do some research before you entrust your car to the shop. The dealer wanted $1275 mostly for parts that my car does not have (2nd O2), was not broken (existing O2), could be found used very easily (MAF), and were very easy and simple to fix (throttle body vacuum). Caveat Emptor.

Idle Problems:

Poor Idle, Idle Surge and Hunt: Cleaning Your Throttle Body. .

Symptoms and Why You Should Regularly Clean Your Throttle Body. The throttle body regularly fouls on the throttle blade and bore. The contaminants are oil droplets from the crankcase ventilation system. Every engine generates some blowby (gases blowing past the rings) - especially turbos. When the crankcase ventilation system routes these gases into the throttle housing, they carry oil residue with them. When this oily residue strikes the hot throttle blade, it condenses out due to reduced pressure and temperature inside the bore and "cokes" it with nasty, varnishlike deposits that restrict airflow around the throttle blade. Although the ECU tries to compensate for this restriction by tweaking the idle air control valve (IAC), it often can't compensate enough-hence, the driveability symptoms. Cleaning the throttle body often fixes the following driveability problems:

Throttle Body: Before and After

- stalling on deceleration
- rolling idle
- rough idle (hot or cold)
- off-idle or tip-in hesitation
- stalling just once, when the driver shifts into gear first thing in the morning
- sticking throttle in subfreezing weather (which may cause a no-start)

Note that contaminated throttle bodies do not set OBD trouble codes relating to these symptoms, so you need to consider a cleaning first if these symptoms begin. Make this a regular procedure every year.

Tools and Supplies Needed. You will need a new throttle body paper gasket (cheap, from the dealer); an old toothbrush or bottle brush; and a reputable spray cleaning chemical marked "fuel injection cleaner". Using regular spray carburetor cleaner, for example, can erode protective coatings on the throttle shaft or destroy a plastic TPS housing. Tools: flat blade screwdriver to remove the air intake hose clamps, a combination wrench to remove the three nuts secure the TB, and pliers to loosen the pinch spring clips on vacuum hoses.

Special Note on Use of Solvent Cleaners. [Larry Carley, Brake and Front End Magazine, Dec 02] Using conventional aerosol carburetor cleaning solvents on fuel injection throttle plates, for example, can be an extremely expensive mistake.

Although strong solvents instantly dissolve gum, varnish and carbon from throttle plates and bores, they also dissolve throttle shaft seals, throttle position sensors or (when applicable) the Teflon from the air inlet horn! Nevertheless, specially formulated throttle body solvents do as good of a job without causing potential driveability complaints. Most are also good for cleaning delicate import carburetors for the same reason. Unlike "killer" carb cleaners, throttle body solvents don’t cause comebacks by eating away at delicate switches, potentiometers and neoprene diaphragms found on import carburetors. Most throttle-body aerosols also spray in the inverted position for cleaning hard-to-reach components.

Cleaning Procedure. [llustration copyright RPR, used by permission]

- Disconnect the wiring harness from the throttle switch by compressing the wire bail on the connector body, then pulling the connector straight away.
- Disconnect the three rubber vacuum lines. Two have spring hose clips which must be compressed to loosen and pull off.
- Disconnect the throttle actuator rod by using a small flat-bladed screwdriver to gently pry away the little locking tab on the end of the lower ball-and-socket. Use a flashlight to see it better. (The plastic ends which have the socket & ball attachment on the link rod can break when they are removed from an old or very cold engine, so be very gentle and don't work on a frigid piece of cold plastic. Get replacements from the dealer. One is a right-hand thread, the other left-hand.)
- Unscrew the three nuts holding the TB on to the intake manifold. You may need a magnet here if you drop one.
- Remove the throttle body from the intake manifold. The gasket on my car lifted right off with no fuss, but if you have to scrape be sure to use a plastic or wood scraper so as not to damage the aluminum facing. You can reuse the gasket if it is in good shape. Better to replace it if old.
- Clean the entire throat and the throttle plate paying particular attention to the edges and pivot points to make sure it can close completely. Use an old tooth brush and spray fuel injection (not carburetor) cleaner. Don't spray the cleaner on the black plastic TPS. Remove the base idle black adjusting knob if so equipped and blow out that passageway and blow out another bypassing passageway that you will see in the throat. [Norm Cook] If you don't have compressed air, take this base idle boss off and

pour solvent in to soak. The internal passage is quite small and engine oil easily plugs it. Clean out the tiny vacuum holes in the fittings that lead to the vacuum tubes which may be completely plugged.. If you don't have an air compressor to blow out the passages, use the spray tube on the FI cleaner can for that. Of course you will want to clean the outside of the throttle body so it will look nice. Assemble in reverse of disassembly. The holding nuts go on tight enough to prevent air leaks at the gasket, but don't overdo the torque in the aluminum manifold. I like to lube the ball-and-socket ends to free them up next time I clean the TB.

Notes on TPS Adjustments.

- Do not remove the TPS when cleaning the throttle body. If the TPS or idle speed need adjustment, see the information in Throttle Body and Throttle Position Switch Adjustment. But if you can't help yourself -- take a small screwdriver or other object that will make a fine scratch and scribe a line across the edge of the throttle sensor switch's flange and it's mounting bracket, right where the Allen screws hold it tight. Doing so will get you in the ballpark when it's time for reassembly. After re-assembly, be sure to check for the "click" when the throttle butterfly comes off its stop: you should hear a distinct click RIGHT as the throttle is just opened, noting the switch is signalling the ECU the engine wants off idle NOW. If this switch is even slightly slow, so will your off idle response. If no click at all, you may find your engine running at higher rpms at idle since the ECU does not pick up the "idle" signal.

- The mechanical throttle butterfly blade stop is a setscrew on the forward side of the TB aimed up. It has a nut (8 mm, I think) on the underside. It's right near the big coil spring that turns the throttle to idle. When you turn the throttle and allow it to return to idle position, you can see a small arm bear against this setscrew.
  The throttle switch is on the backside of the TB, opposite the setscrew, and is locked by two small screws. It has an electrical cable plugged into it.
  With the TB off the car, I first loosened the switch so it didn't inadvertently act as a stop (very bad for the switch!). I backed the setscrew out until the throttle butterfly plate was completely, jammed shut. Then I turned the setscrew in until it just touched the arm, and another 1/4 turn. This takes the mechanical force off the butterfly, so when the throttle slams shut, it doesn't wear the butterfly or damage the switch. Don't forget to tighten the locknut, and then recheck the adjustment -- tightening the locknut can change the screw position slightly.

Then, with the throttle at idle position (the spring forces it there), you carefully turn the switch until it goes "click". Tighten the two screws. Be sure, as you rotate the throttle (TB still in your hands) you can clearly hear the switch "click" and that it does it while the arm is maybe 0.030" off the setscrew.

Notes on Idle Speed Adjustments [Gregg Stade]:

[*Adjustment of Pre-89 TB, TPS and Base Idle*:] The p/n's for the gaskets you will need are 1271488 and 463766. There is an o-ring on the black knob (pre-'89 only) that you will have to remove to thoroughly clean the housing p/n 947114. Do not remove the throttle cable, but with a small screwdriver unclip the small plastic linkage lock from the throttle body and swing it up , then disconnect the throttle switch . After the housing has been cleaned the throttle stop is adjusted. Loosen the 8mm lock nut and back out the screw, turn the screw back in just till it contacts the lever. Rotate the screw another 90 degrees and lock it down. Install the throttle switch and rotate it till it clicks with the throttle plate closed. Lock it down, the switch should make a click as soon as the throttle plate is moved . Test it several times in your hand at varying opening speeds make any fine adjustments now. BTW don't loose the o-ring on the switch if you remove it; it is not available as a spare part. With the housing back on the car, adjust the linkage rod so that the throttle plate doesn't move when it is hooked back up. After everything is hooked back up there are two more things to do. First, adjust the cable with the threaded piece at the throttle bobbin. You just want a little slack. Second, base idle has to be reset. (Pre-1989 only:) For this, you will need a tach/dwell meter. You need to read engine rpm. Warm the engine to operating temp. Here s the tricky part. There is a blue connector behind the battery with nothing plugged into it . There should be a blue/white wire in the connector. Ground this wire it shuts off the idle speed motor so that base idle can be adjusted with the black knob on the throttle housing. Base idle for this car should be 700 rpm. When the ground lead is disconnected the idle should go up to 750rpm's +/- 20 rpm's.

[*More on Setting Base Idle Rate*:] Just adjusting the base idle by the set screw is not a good idea. First, you must check to make sure the throttle housing is clean from oil deposits, as above. Upon re-assembly, the base idle set screw must be backed off, then turned in till it just touches the housing. You want to turn the screw 1/2 turn then lock it down with the 8mm nut. Remount the throttle position switch and rotate it just so it clicks then lock it down. In 1989, Volvo did away with the black idle speed screw, everything is controlled by the fuel ECM .If the throttle plate doesn't return completely and energize the TP switch, the fuel ECM doesn't know the throttle has returned to idle.

Poor Idle; TB Cleaned; Now Idle is Too High. [Inquiry:] Well my problem is certainly gone. It now idles at 1600 rpm, but that's a steady 1600. Did I do something wrong, or was the crud in the throttle body masking another problem? [Response: Evan] Nope, the crud WAS the problem. Crud makes the car idle lousy and slow. Lazy mechanics simply dial up the idle to mask the problem, rather than fixing it. You just need to dial the idle back to spec. On the end of the butterfly shaft, the end where the spring is, there's a stamped metal plate. It has a 'leg' bent down that rests against the idle stop screw. The screw is held in place with a lock nut. loosen the nut and adjust the screw. [See Throttle Body and Throttle Position Switch Adjustment for more detail on 89+ cars and Adjustment of Pre-89 TB, TPS and Base Idle: for pre-89] Be careful, the screw head has a tendency to strip out. In retrospect, you should have taken a minute to make sure the screw was free while the TB was on the bench.
Another thought: Before you do any of the above, make sure that the 'leg' on the stamped metal plate actually touches the stop screw at idle. Some REALLY lazy mechanics just adjust the throttle cable length at the big obvious pulley, rather than adjust the stop screw

Notes on TB Disassembly:

[*Tips on reassembly of TB shaft spring*:] I carefully took the spring off the side of the throttle body, noticing that it was under tension... one full turn, but alas... I forgot to note if it was under tension one full turn CLOCKWISE or COUNTER CLOCKWISE. [Response:] The throttle body spring, attached to the throttle body lug that goes into the throttle body and points out from the throttle body to the radiator goes CLOCKWISE! The spring has a little bent-out stop that catches under the idle adjustment screw. You put the spring on so that catches... twist the dang thing one turn clockwise, put your nut on, attach the throttle control rod and it's done.

Poor idle, Smoke, Oil Leaks: Clogged Flame Trap [Symptoms:] Smoke out the tailpipe, gradual oil loss, fouled plugs, valve cover gasket or main oil seal leakage. [Tip: Bob Savasta, Motor Magazine, Jul y 2001] These are classic symptoms of a bad PCV or flame trap system, which is clogged with sludge or carbon.

Fuel Intake Carbon Removal.

Problems With Valve and Injector Deposits. [Motor Magazine, Dec 2002] As a vehicle approaches higher mileage, you can generally expect intake valve deposits (IVDs) and injector deposits. Their onset can vary widely, depending on driving conditions. Engine operating temperature, intake manifold gas speed (rpm) and hot soak cycles are some of the critical operating parameters affecting these deposits. To lubricate an intake valve, tiny amounts of oil have to run down the valve stem. Over time, this oil is deposited and heated on the intake side of the valve, forming a carbon cone. This has multiple effects on the intake event. The carbon changes the aerodynamics of the intake event - causing higher gas speed and a change in the direction of intake and swirl - which affects the combustion process. The IVDs also act like a sponge, creating a delay in fuel control. This delay not only creates a temporary enleanment on acceleration but also causes a temporary enrichment on deceleration. When the throttle is closed, the intake manifold vacuum goes high, pulling the fuel out of the carbon sponge. This affects fuel control. When the engine is shut off, a small amount of liquid fuel is left on the tips of the injectors; this fuel evaporates and leaves behind solids that were originally dissolved in the fuel). Eventually, these deposits cause an injector to act like a squirt gun rather than an atomizer. Aggressive drivers and drivers with long highway drive cycles may not have deposit issues until very high mileages. Stop & go drivers, especially delivery drivers with many hot-soak cycles, are more likely to experience deposit problems sooner.

See the FAQ Section on Fuels and Lubricants for more information.

Carbon Removal in Injectors, Intake Manifold, Valves and Cylinders:

Gasolines with Detergents. In the United States, the new Top Tier gasolines are certified to have adequate detergent levels to remove intake system deposits as determined by the Top Tier group of GM, BMW, Honda, and Toyota. See their website at http://www.toptiergas.com/

Gasoline Additives. BG44K is the heavy duty stuff - and recommended in Volvo and

BMW TSB for removing carbon deposits, particularly from intake valves and fuel injectors. Use no more often than 2/yr, and only 1/yr if your system is in reasonable condition. Pour the can in the gas tank only with the tank full. Use it when you will be able to drive out a tank of gas in a day or two. Plan on changing the oil and filter soon after use as it can contaminate the oil with unwanted chemicals. Distributor at website: http://www.bgprod.com . Other effective products include Chevron's Techron, STP's Complete gas treatment, and GM "Top Engine Cleaner". Using these cleaners in conjunction with an "Italian Tuneup" (driving at high rpms while the engine is fully warmed up) is frequently very effective. [Caution from Zippy] Volvo specifically recommends AGAINST using any fuel or oil additives. I know they used to suggest it was okay, but then decided that catalytic converter damage is done when additives are used. Since about 1993 gasoline improvements have made additives unnecessary.

Cleaning Machines. Snap-On decoking machine (reported very effective by Robert Price) It does clean injectors but it removes carbon better! Also, try Motorvac (a variation on the Sun machine.) Other techniques include walnut shell blasting/flushing (many sources of good success) in a shop with the equipment, most often a BMW specialist.

Injector Cleaning. See the FAQ section in Engine: Fuel Injection for tips on injector cleaning.

Combustion Chamber Deposit Removal. See the FAQ section in Engine: Mechanical for a water-based technique that works, although using it with turbos may be a bad idea.

Engine Dies After Starting, Won't Idle; Needs Intake Cleaning. My '85 with 230F had a similar problem. It would die after starting and put into gear when cold and Idle was not stable. Here's what I did to fix it:

> Replaced all vacuum hoses and checked for vacuum leaks.
> Removed and cleaned air control valve.
> Removed and cleaned throttle body in fuel carb cleaner, replaced all gaskets.

At this point it was running better but not perfect.

> Adjusted throttle body linkage and throttle position sensor per the book. It

has to be done in sequence.
Ran a can of BG44K through the tank to clean up intake valve and fuel system deposits.

Car now runs very strong.

Poor Idle: Injectors Need Cleaning. See Injector Cleaning for more information on how to solve chronic idle problems due to dirty injectors.

Poor Cold Idle: B230F/T ECU E-Prom Needs Update. [Inquiry] My wife's 95 945T (90k miles) starts fine on a cold (below 40F) start, but idles like crap for 20 to 30 seconds. If I hold my foot on the gas and keep it at 1500 rpm for 8 to 10 seconds, its fine. Car idles nicely when warm, and runs like a dream. When I pull the plugs, they look great. I've replaced ECT and other parts and cleaned the TB. [Response: Abe Crombie] Go to a dealer and have them look at Volvo Service Bulletin 28-102 "modified e-prom for cold start with low rvp fuel". This says the symptoms are: car starts and then immediately dies and requires re-start. Runs rough for the first 45 seconds and may hesitate on acceleration. Recent EPA regulations have necessitated changes in the formulations of gasolines (i.e. "oxygenated fuels"). The result of these reformulations has been a decrease in the relative vapor pressures (volatilities) of these fuels, which seems to be particularly problematic for cold starts/ idling. The updated eprom chip to be installed in the ECU is the fix to make it have correct fuel mixture computations for cold start. You must have the number from your ECU in order to cross-reference the correct eprom update kit P/N. The change procedure described in 28-102 requires careful attention to static discharge.

Idle Speed Control Problems.

High or Unstable Idle. [Symptom] My 945T (94 - 99k) has been having high/low idle problems - it wanted to idle around 400 or 1500+ - there was no middle ground. [Solution] Replace the throttle position switch, which detects idle when the switch is closed and, if faulty, will cause idle problems.

Idle Speed Control on Late 7xx/9xx. In Volvo 700/900 cars with LH2.4 fuel injection, the idle speed is controlled by a bypass system. When your foot is off the gas, the throttle plate is fully closed and a separate idle air control valve admits the required amount of air to get the engine to idle at 750 rpm. This separate valve is controlled by the computer. No adjustments are possible.

Start or Stall Problems:

No Start; Frequent Stall or Hesitation: Basic Diagnostics. [Inquiry:] I have an 88 740 non turbo 150k miles. Intermittently the engine will stall typically at lower speeds or idle. It will not restart unless I turn off the ignition and back on again as if this resets something (the computer?). Also there is a stumble or miss when starting out from a stop. This is fairly consistent. Another symptom is that intermittently at cruising speed of say 60mph the engine appears to cut out for only a half second, this will continue several times a minute until I shut off the engine and restart. Plugs and wires good, throttle body clean, fuel pressure OK, O2 sensor OK, have checked all connectors that are easy to get at. It appears that the computer sometimes gets out of whack for some reason and wants to be reset. Any suggestions?

Basic Diagnostic and Preventive Maintenance Checklist [from Paul Grimshaw/David Hunter]
You've either got a fuel or spark problem. Here is a basic diagnostic checklist:

1. Watch the tach carefully when a stall occurs. If it drops to 0 even before the engine winds down then that would indicate loss of ignition pulses to the coil negative terminal. Primary suspects would be the power stage or the crank position sensor. If tach tracks the engine speed as it winds down then that would indicate a fuel injection problem. Suspect radio supression relay or loss of fuel pressure due to relay or pump.
2. Confirm condition of distributor cap, rotor, spark plug wires and spark plugs. If *all* of these have not been replaced in the past two years with OEM or better (ie. higher quality ~ more expensive), do so now. (Yeah, I know that you have not yet determined that the problem is spark related, but there's no sense troubleshooting a problem unless the basic bits of maintenance are completed and certified correct).
3. Remove each spark plug, ground the threaded base against the engine block and, with the spark plug wire connected to *only that plug*, have a friend crank the engine. You should see a spark. If not, there is a problem with spark delivery. Repeat with each plug/wire. Note: In most cases, its not the spark but the fuel. That said, any failure to complete basic maintenance on your engine will only lead to a poor running engine and multiple, intermittent faults.
4. If your have not replaced the fuel filter in the past 3 years, do so now. The fuel filter/fuel pump is located under the passenger footwell (driver's side). Replacing the filter is not a particularly difficult job for the experienced shade

tree mechanic with a complete set of hand tools. If you're unsure of your experience level or tool crib, have the job done professionally. Ensure that the sub-assembly is completely cleaned and dried before disassembly as FI systems do not react well to ingested dirt. It will require Volvo PN 1389562-8. While you're replacing filters, don't forget the air filter -- you engine will always run better with a new one of these! Again, a bit of basic maintenance that should never be skipped.

5. If you lack a fuel pressure gauge capable of reading fuel pressure to at least 400 kpa and lacking the proper fittings, true troubleshooting will be difficult. Your car's LH system is supposed to operate at a constant 300 kpa.
6. Lacking the proper diagnostic equipment, your only solution will be to replace each component until the problem is solved. I won't list all of the possible problem components as most situations are traced back to either the main fuel pump or the pressure regulator. Use a long piece of hose to listen for the main fuel pump as the car is being cranked. If you cannot hear the fuel pump turn, check the voltage using a VOM.
7. If all is well, skip to the fuel pressure regulator. Replace the unit with Volvo PN 1389564-4, but may also be replaced by Bendix PN 4088942-0001.
8. If the car now runs, but frequently requires long periods of cranking to start, then suspect the check valve in the fuel pump. The check valve is a threaded in-line valve that maintains line pressure between 200-300 kpa after the engine is shut off.
9. If the car still does not start, check the fuel pump relay. If in doubt, replace it with Volvo PN 3523608-3.
10. If the car will not re-start while warm, check the radio suppression relay and the rpm sensor (LH2.4) or Hall sensor (LH 2.2).
11. If the car stalls while hot, check the ignition power stage amplifier which is cooled through body contact.
12. *Regina-Equipped Cars:* Check as well the coil pack and MAP sensor.
13. Conclusion. The beauty in the approach listed is that you first complete the basic maintenance required; car's just won't run well without regular maintenance! Second, you're using a rudimentary tool (the hose) to check for fuel pump operation. That's important since the fuel pump is a very expensive piece of gear that you would not really wish to replace unless it is dead. Third, there's some merit in repair by replacement, especially if you lack the proper fuel system diagnostic equipment. The pressure regulator is about $40 buck and, with age, will eventually die anyway. So replacing it just saves you being stranded at some point in time. Finally, the pump relay is the next most likely culprit. [Editor's Note: See the notes below about rpm or Hall sensor and radio suppression relays; these can also be frequent culprits.]
14. Hope this helps. Remember the merits of maintenance before trying to solve any recurring problem.

Basic Ignition and Fuel Injection Component Diagnostics. My '87 740 GLE routinely dies. My mechanic tells me there is no injector pulse with the hall effects switch or the fuel injection control unit being the most likely causes. Is there any way to test these components?
[Tips from Bob Dietz] When the car dies run a test light from the negative side of the coil to ground. If the light flashes brightly when you bump the starter then all the ignition components are ok, and the fuel pump should run for a few seconds. If the light barely flashes and the fuel pump doesn't run, then suspect the ignition amplifier (between the air filter housing and the inner fender wall.) If the light flashes and the fuel pump doesn't run, suspect the fuel injection relay (the white relay behind the ashtray--remove the lighter, lighter cover plate, two screws and the ashtray to access). Pull the cover off and reinstall, turn the key to run position and operate the contacts by finger. If the fuel pump runs then the relay is suspect--resolder or replace--your choice. If by turning the key to start and holding the fuel pump point set closed the car runs, release finger pressure on the fuel pump contacts. If the contacts stay closed for a few seconds after you release the contacts then the relay is bad and the fuel injection control unit is ok. If the motor shuts off as soon as the fuel runs out after you take finger pressure off the relay contacts then replace the relay and the fuel control unit--the protection diode on the relay has failed and wounded the computer.

Other Component Tips:
[Tips: Mark Klein] Sounds like you've been fairly thorough already. There is a radio noise suppression relay on the coolant reservoir which can go bad and cause a variety of similar symptoms including not running at all. Be sure the fuel pump relay is in good shape. It is the white one in the 2nd row back on the far left. Check the date code printed on the side. If it is the original, it wouldn't hurt to replace it anyway. The Hall sensor sender wiring (pre-89 cars) coming out of the bottom of the distributor can short out against the distributor housing if the plastic connector breaks. This is quite common but I doubt if this is giving your symptoms. The rpm sensor on later LH 2.4 cars can also fail. The FI control unit itself can go bad. One of the more common circuits which fails is the one that grounds the fuel pump relay and, in turn, turns the fuel pump on.
I doubt if an air mass meter would give the symptoms you're getting but you might try removing and reconnecting the electrical connector a few times. See also the tips in the FAQ sections below.

Wiring Shorts. [Tip from Chris L] Stalling combined with fuse 11 failures (fuse 11 supplies the fuel pump and the oxygen sensor, at least in Regina cars) can result from wiring shorts at the fuel sender unit at the tank or in the oxygen sensor heater wiring near the exhaust, which can fray and short against the pipes, causing the fuse to blow.

Carburetted Engines. See the note regarding relays below. Don't immediately conclude you need a rebuilt carburetor.

No or Slow Hot Start: Problem Diagnosis and Repair. See the attached file for a quick-reference guide to no- or slow-hot-start problems and diagnoses.

No or Poor Cold Start: Problem Diagnosis and Repair. [Editor] Assuming you have reviewed the checklist above and eliminated ignition or fuel injection components as sources of a poor cold start condition, look for vacuum leaks. Holes in the air intake hose, vacuum tubes, a failing vacuum check valve in the brake booster, a broken booster diaphragm, or a leaking intake manifold gasket can all cause your engine to fail to start or to perform very poorly once started, with fluctuating or high idle and poor tickover.

Regina System No Start or Re-Start on Cold Mornings. [Tip from Bruce Young] If your car has Regina fuel injection and you have difficulties with re-starting after the car has been sitting for half an hour or so, see the Volvo TSB 23-135 from January, 1990 regarding Cold Start Problems. Here's a summary:

"Below 23°F (—5°C) cold start difficulties...rich fuel mixture during cold start crank and warm-up"

Before chasing this down, you can tell if this TSP has been applied or not by checking the wires at the cold start injector plug. First, peel back the rubber boot. If the 2 connected wires are Gray-Black and Blue-Green, the TSP has NOT been applied. If the wires are Gray-Black and any other color (with Blue-Green cut off and taped back -- or removed --) the TSB HAS BEEN applied. NOTE: This TSB rewiring will cause a permanent 3-2-1 OBD code, but no CE Light.

Background: The CSI has voltage is applied from the Radio Suppression Relay, like the regular injectors do. And is controlled on the ground side by the ECU, based on temperature. The TSB changes the CSI's voltage source to an auxilliary terminal on the starter solenoid. So the CSI now gets activated only during cold cranking, rather than as soon as the key is turned on for that 1-2 second pump buzz — and all during warm-up, till warmed above the "cold start" temp criteria.

Intermittent No Start or No Warm Restart: Radio Suppression, FI Relay, RPM

Sensor. [Inquiry:] Sometimes the ’88 749GL just won't start. It seems like it's not getting gas when this happens, but after sitting for awhile (a few hours, overnight, or occasionally just a few minutes) it starts right up like nothing is wrong [Editor:] If your car fails to start until after it has cooled down, the three items to check are the rpm sensor, radio suppression relay and fuel injection relay solder joints. [Response] Try the *fuel injection relay*. Find the relay in your center console relay bank and tap it to see if this restores fuel flow (starting immediately). [Response] I have a 90 740gl that had the same problem. When you're cranking the engine and it won't start, is the tachometer needle moving a little? If not, as mine didn't, I believe you want to check into the *RPM sensor*. Check the RPM sensor located on the back of your engine, connected to the bell housing. The wire runs up the back of the engine compartment towards the drivers side. Look for the part number on the wire and check if the part number ends with 399. This rpm sensor has a heat related problem: common for it to cause a no- start but able to start a little while later. Since I replaced mine for about 30 $ I haven’t had the problem. [Editor: post-88 cars have this sensor; pre-88 cars have a Hall sensor inside the distributor.] The third common cause of no-hot-restart conditions is failure of the *radio suppression relay*. This relay is usually mounted beneath the coolant expansion tank and may be next to the identical coolant fan relay. You can often test it by swapping leads with the coolant fan relay, but only if the latter is working. This may not be the case in cooler regions where it is not frequently used.

Tach Needle Movement. [Chris Herbst] In all of the Bosch systems, the tach jumps when you crank the car. In the Regina systems the tach does not usually move until the car is running. I have noticed this in all the Rex ignition ('Regina') cars. Unless the car is running, the tach is normally lifeless.

If you Have a Regina System: [Chris Herbst] If you have problems with a Regina system that has an intermittent no-start:

1. Crank sensor
2. Interference relay
3. Fuel pump relay
4. Coil pack (THIS IS A BIG ONE)
5. MAP sensor. Not very expensive.
6. Regina Only: Wiring to cold start injector

Far Less Frequent But Still a Related Symptom: Ignition Amplifier. If the car will start and then die, or refuse to start again until it's cooled off, or just not start period. or just randomly die or misfire under load, then suspect a failing ignition amplifier. This is located on the driver's side fender (wing) behind the headlight.

If You Have a Turbo: Boost Overpressure Switch Failure (if so equipped). See the FAQ file.

Intermittent No Start: Fuse Contact Failure. [Tip from Roman Shestakov] I had a situation when my 1990 740 GLE just would not start. Engine turns, lights come on the dash, but does not start at all. No pre-charge noise from the fuel pump could be heard before turning the engine. After pulling out the relay tray to inspect the fuel injection relay, I found instead that fuse #1 that supplies power to ECU and fuel pump was making bad contact with connector in fuse box. Plastic around that fuse was melted and looked brown. You immediately could tell that there was an excessive heat around that fuse. Repairing it was easy. After pulling the fuse/relay assembly box out of console, remove all fuses. Take a flat screw driver and pop the fuse box upper cover out by prying on its sides (there are already slots available for that kind of tool), exposing fuse contacts. Examine the fuse contacts. Mine were all oxidized and looked very brown (heat caused copper to oxidize and made contact surface even less conductive over time) causing current to heat up the contacts. Take a small piece of sand paper (spread contacts apart with screw driver if necessary) and clean contacts inside surface from deposits until it turns copper-red like other contacts next to it. In my case, I had to scrape them with a knife as well. Then straighten contacts carefully so that they are parallel to each other and "lean" against each other as tight as possible, similar to undamaged fuses. Your fuel injection fuse is rated at 25A and must go in tight, or you will be facing the same problem again. Then pop the top cover back on and reinstall all fuses. Re-install everything back into console except the fuse cover box. Test drive the car for 5-10 minutes, and while you are driving, put a finger on fuse #1 and the plastic upper plate around it. It must be cool to touch.

Intermittent No Start: Water Leaking Onto Distributor.

Leaking Washer Fluid Line. [Tip] My 940 suffered from intermittent no starts until I discovered that the windshield washer fluid anti-check valve on the firewall was leaking and squirting water onto the distributor cap. A new valve, cap and rotor solved the problem.

Rain Leaking Past Failing Firewall-Hood Gasket. [Tip: Georege Pigg] My 93 940 went through a period of time where it would randomly fail to start. On one occasion the engine even quit as I was making a right turn. Looking back over all of the "no starts" I discovered that all of the events occurred during rainy weather. Further investigation revealed that the weather stripping seal between the rear of the hood (engine lid) and the firewall had failed. This allowed rain water to reach the distributor and the connector for the rpm sensor. After placing tape over the gap between hood and the firewall there have been no more failures to start even during rainy weather.

Intermittent No Start: Battery Ground Connector Failure.[Inquiry] My 1988 740 GLE has been having an intermittent no start problem; all other causes have been ruled out. [Tip:Dan] I would follow the battery ground cable to the block , it is just in front of and just below the oil filter. Pull on the cable hard while wiggling it. I had the same symptoms as you have and in my case that was the problem. When I just touched my cable at the block, where it went into the connector it came right off in my hand. I bought a new one of the correct length and re-routed it, instead of running back through the frame, where by the way, the plastic insulation was worn completely off to bear wire. That is what caused my start sometimes and sometimes not. [Editor] Check your engine ground straps for oxidation and corrosion.

No Start; Tear in Air Duct Intake Hose. [Inquiry: David Smith, courtesy UK Volvo Club] For the last six months it has been getting harder to start. Up to now there has been no problem - has 170,000 miles. Fuses are OK and I replaced the distributor cap, rotor, installed a new wire set and replaced the spark plugs. I also noticed that one of the wires leading to the coil was also in very bad shape at the coil end. I snipped off some of the wire and replaced the female connector. I’ve been to two dealers who put it on the computer ‘scope’ - no problem shows up. One dealer cleaned the throttle body (dirty) and the other installed a new crank case sensor. A third dealer said it may be a poor ground (all seem OK) or a computer module. I said that nothing showed up on the computer analysis at two different dealers - and he said that it probably wasn’t the module in that case. Very recently it just wouldn’t start. It turned over OK and I unsuccessfully tried to jump start it from two different vehicles, a light truck and a V8 Chevy (using a good jumper set). There was spark from the plugs when turning over. We also sprayed di-ethyl ether in to the engine via the fuel injection system and engine fired OK when turned over. Tried again - turning over OK - but not starting. However, just three hours later it started up with no problem on its own and has run OK for 3 days. From what I can gather I suspect that it may be an ECU problem - but nothing has shown up on the computer scope at two dealers. [Later reply from David:] A local mechanic found a small tear in the large diameter air hose (has the bellows) that runs from the air mass sensor (and air filter end) up to the throttle body. He did a quick repair using a sealant. Since then everything has been fine - no more starting problems. It's very easy to inspect this air hose - just undo the clamps at either end - make sure they are tight when you put the hose back on! I spoke to another Volvo dealer recently - regarded as the best in Toronto - and they said that this air hose vibrates - hence the need for the bellows section. In addition the material used to make the hose does start to perish over time and this may lead to some brittleness and tears appearing. When that happens - it can lead to all sorts of problems they claimed. The replacement hose costs just $50 Canadian.

Frequent Stall or Hesitation: Carburetted Engines. [Tip from James] My 1986 740 with B230K (carburetted) suffered from a constant stalling problem, needed to be revved all the time. Following the dealer's advice, I installed a rebuilt carburettor which did not solve the problem. I found that a relay had burnt out that controls the idle solenoid/cut off valve/intank pump/ IAC. The relay is green and about 2 inches long by about 1 inch deep and one could quite clearly see the burnt-out solder joints when it was opened. I fitted a new one for £32.00 including the diagnosis and this solved the problem.

No Start, Poor Fuel Economy: Timing Problems [Tip from Tom Francis] Poor fuel economy and then a perplexing no start situation was the result of a broken indexing pin (roll pin) in the end of the cam shaft used to keep the cam pulley and the cam shaft in alignment. The broken pin allowed the cam to rotate out of alignment 30-40 deg until the no start condition. Remains of the hardened steel pin in the cam can be drilled out using solid carbide drills bits in successively larger sizes, but not large enough to ream out the hole. High speed steel or carbide tipped drill bits may break off in the hole. The roll pin is most likely a standard M5-80mm size (5mm dia hole, 80mm long), available from a dealer for $0.90 or well supplied hardware store. [Editor] This applies as well to the crank timing gear, which has a similar indexing pin, and is a very good argument for using the correct torque procedures when reinstalling the cam or crank bolts.

Stalls in Heavy Rain: Water Leak in Hood. [Tip] I finally figured out my stalling problems after a heavy downpour (ie, Tropical Storm GASTON and FRANCES) My 940 once again stalled on me about 5 miles away from my house... This is the second time in a row and it was after a heavy downpour, with water leaking onto the distributor cap. After examining the hood weatherstripping, I found that the water was pouring down through the windshield washer nozzle hole in the hood. Sealing this with silicone caulk solved the problem.

Mixture, Misfire or Idle Control Problems

Runs Rich; Black Smoke; Poor Acceleration: ECT, TPS, FI. [Inquiry:] I have a 1985 740t with 244,000 miles and a m47 manual transmission. It has the 230ft engine that is all original including the non-liquid turbo without an overhaul. The car runs rough throughout the rpm range and put out black smoke while doing so. Lots of black smoke. Other times (less and less) it runs like a top, no problem. I replaced the fuel pressure regulator but it did not help. I am getting about 43psi at idle. When it is running in the bad mode the fuel pressure is still 43psi. When I drive the car I have to accelerate either very easy or in wide open throttle to get the car to go. It is at its worst just as boost comes on. Any Ideas? [Response 1:] Here's one idea, but it really applies to the non-turbo engine -- so I could be a million miles off base on yours....... The fuel mixture is influenced by the block temperature sensor (Engine Coolant Temperature ECT see Diagnosing ECT Failures). A cold engine requires more fuel, and a warm engine needs less fuel. A cold sensor is a high electrical resistance. An intermittent open condition of the sensor, the connections, or the wiring harness will "trick" the FI ecu into thinking it's about -60 degrees. It will pump in tons of fuel. On many of the engines -- and again, I'm not positive about yours -- there are two sensors. The sensor for the dash gauge is in the head, about under the intake runner for cylinder #2. The sensor for the FI system is in the head, about under the intake runner for cylinder #3. Tough to get to.
I helped fix a situation (on a '90 740, non-turbo, Rex-Regina system -- yours is Bosch) where the connector had pushed out of the plastic housing but made intermittent contact with the spade connector in the sensor. Some days, it ran great. Other days it flooded so bad it wouldn't always start. Fixing that stupid problem made a world of difference!
[Response 2:] Also..... be sure the throttle switch (Throttle Position Sensor TPS) is working and adjusted, and the AMM is operational.
[Response 3:] Very similar situation in my '86 745T drove me nearly crazy for about 2 months. It was a leaking fuel injector

Symptoms of ECT Failure:
[Tips from Isaac Babcock, who disconnected his ECT to find out]

- Difficult cold starting. Approximate crank time 4-5 seconds.
- Extremely difficult hot starting. Cranking 20 seconds may or may not yield a running vehicle.
- Once started, car idles like absolute crap for 5 minutes while the engine burns

out all the excess fuel that the computer is blindly dumping in. May die repeatedly during this time. Small amount of black smoke flows from tailpipe.

- During 5 minute crap idle time, car will not tolerate any accelerator input. Depressing accelerator kills the car immediately.
- After the 5 minute extreme fuel enrichment exercise, the car lets out its last puffs of black smoke and you can drive off.
- Idle once engine has 'stabilized' is a fairly steady extremely high idle. It will be quite noticeably higher than normal (over 2,000 revs). I thought my computer had fried the IAC motor circuit with it stuck full open. Turning the idle bypass screw all the way closed can only bring the idle down to 1250rpm.
- Smell of unburned fuel floats around car at all times. Gas mileage is atrocious under all conditions. I achieved 16-17mpg on my last tank.
- Power is fairly crappy, though not much worse than usual.

760T Floods and Stalls: ECT?. [Inquiry:] I have a 1986 volvo 760 turbo with 207,000 miles on it. I recently purchased and at the time it was running on three cylinders and had sat for about six months. I replaced the flux amplifier and it ran on all cylinders. The man who sold it to me also told me that he had an intermittent problem... It would stall out occasionally. He was true to his word...If it is cold (running about 15 min.) and you give it too much gas it starts to flood out. If you floor it while it is flooding out it starts to catch on the other cylinders and eventually will go. If you stop the car while it is flooding out it will either stall or run on 1 or 2 cylinders. One time I disconnected the map sensor while it was flooding out and it started to idle normally. While driving behind the Volvo it spits black smoke when it is flooding and sometimes even when it isn't acting up a little bit of black smoke will come out of the exhaust. The problem clears up if you drive about 30 miles on the highway at constant speed. After that you can stop it idles pretty good.... misfires a tiny bit.... and you can take off like a bat out of hell...also about a week ago I tried to start the car and it would only run on 1 cylinder, then not at all. I pulled the plugs and they were all fouled I put in new plugs and it fired right up. I tested to make sure every cylinder was firing and they were...is it my computer??

[Response: Don Foster] I'd consider looking at the temperature sensor or connections to it. There are two sensors -- one for the temp gauge, one for the FI ecu. The gauge sensor is a one-wire device, the FI temp sensor is a two-wire device. The FI temp sensor is mounted in the head, under the intake manifold, approximately under runner #3. It's not impossible to get to -- just almost. (The gauge sensor is under runner #2 -- ignore it.)

The sensor is an NTC thermistor -- that's "negative temperature coefficient", or as the temperature drops, the resistance rises. If the sensor fails or if you have a bad, broken, or corroded connection at the sensor (or anywhere in the harness going to it) the FI ecu measures high or infinite resistance. The ecu thinks it's about -100 degrees, and sends tons more fuel to the engine.   See [Symptoms](). And if it's an intermittent problem, your engine can be running fine and then go into gas overload 5 seconds later. And vice-versa.   I helped fix a problem in a '90 non-turbo with terrible intermittent flooding. We found one connector in the sensor plug had "loosened" so when the plug was pushed onto the sensor, the connector got pushed back up the plastic housing and sorta dangled freely -- one second it touched, the next it didn't. It took hours to zero in on this tiny failing. See more at Diagnosing ECT Failures

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Cold Start, Dies; Dirty or Faulty IAC. [Symptoms:] Cold Start: Car starts immediately with no throttle application, idles smoothly for about one second, then hesitates and dies. Ditto for my 1990 245DL. Starts up cold for one second, then dies. Sometimes, all cranking I wish to do will not restart it. If I sit and wait about 5 minutes, it will start and run like a kitten, with no problems. I have replaced all spark plugs, s.p cables, rotor, cap. If it is a computer problem, can I fix it? [Suggestions:] Check the IAC (idle air control- This provides for more air, or faster idle on start up. The fact that it starts readily when cold indicates the cold start injector is working properly. See hints below.

Idle Air Control (IAC) Valve

[Symptom:] *Poor idle*. [Diagnosis:] Clean the dirty Idle Air Control Valve (IAC). I should have remembered. The car did not start at ALL. So, I took out, removed the two hoses and cleaned it by spraying it with engine grease remover. It had a lot of dirt in it. The Idle Air Control Valve is located under the intake manifold; below the second cylinder. It is about 3 inches long and about 1.5 inches in diameter (I do not have one next to me so these dimensions are from my memory.) It has two rubber hoses connected to it through a "T" connection. It also has a snap-on electrical plug. This is most likely your problem. Here is how I clean it:

- Remove all hoses and electrical connector, then remove the IAC
- Open the rotating valve to expose the innards. Spray some carburettor or fuel injector cleaner into the opening and shake it around. Make sure you plug the other end with your palm to trap the liquid inside the IAC.
- Open and close the flapper valve with a small screw driver to loosen any dirt, etc. contained inside. Don't scratch the valve

- Turn the IAC upside down to empty out the dirt and fluid.
- Repeat step 3 through 5 about 8 times.
- Test the IAC on the car without permanently installing it. You might have to repositioned some hosing to accomplish this task.

If you still have problems, then either your IAC is dead and must be replaced or the problem is somewhere else. [Editor's Note: See the IAC rebuilding procedure noted below.] [Ian Giles] By the way, when installing the IAC the arrow points in the direction of airflow through the valve, so it points towards the intake manifold.

Poor/Surging Idle: Idle Speed Control Motor. [Tip from Anonymous Source]
I have a 1987 model 780 with about 115K miles. Just wanted to share my experiences:
About 10% of the time my Idle would start to surge between 200 and 1200 rpm while sitting at a light with the foot on the brake. This up and down action would load up the engine with fuel and it would start emitting black smoke. It seemed to be somewhat related to engine temperature. Occasionally it would get bad enough to kill the engine, but at highway speeds it seemed to run fine. I first looked at the idle speed motor, but it appeared to be functioning properly when the voltage was applied to the terminals per the normal checks. I then performed the disassembly and cleaning of the idle speed motor as described in this web site. Even though the inside of the motor was reasonable clean, I went ahead and polished the commutator. I detected that the bearings that the rotor turns on were a bit gummy so I cleaned it well and lubricated it with a bit of graphite. Ever since this little operation it has been idling like a champ. I suspect that small bits of commutator crud and wear on the brushes may have been creating dead spots and poor response to idle demands form the processor.

Intermittent Stalling: Faulty IAC or Hall Sensor. [Symptom:] Intermittent stalling/no start condition on an 86 740 (b230F) manual trans: occasionally dying (engine suddenly has absolutely no power, but the dash lights do not come on) while driving on the expressway and around town. After pulling over to the side, the car invariably will restart and seem to run fine. No rough idle or other problems were noted.

[Fixes Attempted:] Several months back (per list advice), I replaced the fuel relay, which up until the last week seems to have cured the problem. Over the last couple of days, the car has started acting up again in the same manner. Now, the car also, when it does restart, sputters and runs extremely poor for awhile, then goes back to normal. Also, in the driveway, I was able to get the car to reliably stall when he put on the brakes. I replaced the idle speed motor, which seems to have affected the brake-induced stalling (plus the car idles much better), but not the intermittent stalling. He

also noticed a bare temp-sending wire, which he cleaned and re-taped (but we don't suspect that has to do with this failure.) Per past list advice, I've suggested

- examining all vacuum lines
- rechecking fuel-pump relay and socket for cold-solder joint/overheating socket
- in-tank pump and screen
- the power stage connectors for corrosion
- radio suppression relay
- general condition of wiring harness (the car lives in the very heavily salted road conditions of northern Ohio)

[Diagnostics and Suggested Fixes:] Below you'll find several procedures [Composite from Steve McChesney and others]. Hope they will help.

Fix 1: Clean the Idle Air Control ("IAC") Valve. See above for procedure.

Fix 2: Rebuild Idle Air Control Valve: Save $150 by fixing IAC instead of replacing it. (***Note: the IAC on newer LH 2.4 cannot be dissassembled but it can be cleaned*.**) Also note that Regina and Bosch IACs are NOT interchangeable if you are considering a replacement.

Symptoms:

- No fast idle at start up.
- Grounding CIS (test point) does not have any effect on idle. (grounding the test point should disable air control valve (IAC)
- OR: The idle ('87 745ti) shoots up to about 2500 RPM. No amount of cooling off, throttle blipping, or general search for vacuum leaks would bring it down. I checked all the hoses, fuel pressure, mass air sensor, and coolant temp sensor. Everything was fine. And the car ran fine too, just a high idle.

This is a common problem on cars that use this Bosch system, including Volvos and BMWs. It's especially bad on turbo cars, and cars that use crankcase air for idle makeup because of the oil that comes along with the air.

Solution: clean the slip ring inside the IAC The IAC is a metal can beneath the intake manifold, with two 1" hoses that feed extra intake air around the throttle body to control idle RPM, and reacts to loads like A/C or heavy electrical (alternator) loads. The "valve" has three pins, the center is a constant 12V supply, and the outside pins are pulsed by the ECM to ground, to either open or close a circular shutter -- looks something like a revolving door. (Except mind would only open, and close halfway.)

Electrical Diagnostics:

- Start the engine.
- Disconnect quick connector at air control valve.
- Test for battery voltage on the middle pin (it is pin number 2 "GREEN wire" if you slide the rubber off), you should detect 12V or so (with engine running).
- Turn off the engine.
- Test for ohms on IAC between middle pin and any side ones, you should have between 6 and 20 ohms in each case depending on the model. If you do have this resistance, then it means that the motor of the IAC is good. If not, don't give up yet.
- Disconnect the hoses from the manifold and the intake hose, disconnect the 3-pin electrical connector, loosen the top nut on the band clamp around the valve body, then remove the valve. Off the car, look down the bore of the valve, and then by supplying the center pin with 12V and shorting either of the outside pins to ground, the "door" should fully open or fully close.

Disassembling and Cleaning the Valve

- Clean the slip ring (the one wherein the brushes are touching) inside the IAC by taking the IAC apart. [Editor's note: this is not possible on newer IACs with no housing clips.)
- Before you take it apart, mark the housing (a pen mark or screwdriver will do) so you can assemble it in the same position. IT IS IMPORTANT!
- With a small screwdriver pry up the clips or crimps which are holding the housing (there are four of them). Once they are up, pry on the housing a bit and the whole thing should come out. At this point, you will encounter a bit of resistance because of the strong magnet inside, but there is nothing to worry about, just keep going until everything comes out. Be careful not to lose the o-ring or the small cone piece -- which will probably fall off the armature shaft and be laying at the bottom of the barrel with the permanent magnets and the wiper contacts. You MUST NOT try to push it in once you started separating the housing (or you will destroy the brushes inside the valve). Once you open it, you

will understand why.

- You will then see oil and crud all over the armature and the commutator. Clean it up with brake cleaner and carefully flush away all crud especially from gaps in commutator.
- Clean the contact points with very fine emery cloth or a Scotchbrite pad and polish them. Be careful; don't bend anything. Again, make sure you don't lose the little cone piece. You'll need to get it out of the barrel for re-assembly - it will come out easily but you have to use something non-metallic because of the strong magnets around the housing.
- When everything is spotless and oil free, put the cone on the end of the armature shaft, so that it tapers away from the armature. The cone is important, because it acts as a ramp when you replace the armature, gradually spreading the wipers so they land on the commutator without bending them out of contact. Also, a little silicone grease on the o-ring seal can't hurt. Once you take it out, slide it over the shaft and keep it in the upward position (so it won't fall off) while assembling it.
- To re-assemble, put the tee upside-down on the workbench, with the cone in place, and gradually feed the barrel down. It's a bit of a trick to keep it straight, because the permanent magnets have a habit of sucking the armature from side-to-side. It doesn't take much force. Once the armature is seated properly, re-align the marks on the barrel and tee by simply twisting the tee relative to the barrel. If you forget this step, the valve may likely not open or close fully.   After doing so, then you are done. Push back the clips (if you have clips, and don't use a hammer)
- Re-test the valve as above with test leads before the final crimping. Mine worked fine now, fully open, fully closed. I then squeezed the crimp tabs back into place with large channelock-type pliers, and double-checked the alignment marks. Replace the valve, making sure the flow arrow on the tee points in the proper direction. The arrow should point TO the intake, FROM the main throttle inlet hose. Tighten the hose clamps, and viola! "New" IAC valve. The entire procedure, including the pulling of the valve out and installing it back takes about 30--45 minutes. Test the side pins for ohms and re-install the IAC. You should now have a fast idle. Oh, make sure your PRM at idle is about 800 rpm. PS: I drilled and put in a small screw to prevent housing from rotating.

[Another Tale of IAC Repair:] The following Idle Air Control Valve repair might be of interest to fellow tightwads who experience a HIGH idle problem. I removed the bad

IAC. The valve was not frozen, but moved quite easily back and forth. That's when I decided to open it up and look inside. Opening involved prying open several tabs around the unit's waist. Out came the solenoid innards which looks like the armature of a small motor with enamel wire winding around three arms. The cap removed from the valve contains a magnetic lining along the wall and three brush contacts near the top. The top of the armature where the brushes should contact was VERY greasy. I cleaned that and the contact brushes inside the IAC cap. A multimeter confirmed that there was continuity among all three arms of the armature: ohms1to2=21, ohms2to3=21, ohms1to3=42. So apart from the grease, I could see no problems. Therefore, I put the armature back in the IAC cap. This required some trial and error because the armature keeps wanting to stick to the magnetic sides of the cap. Once back together, I bent the holding tabs back in place (keeping pressure between the two parts).

The first time I started the car after installing the cleaned IAC, the idle was still high. However, I removed the IAC again, wiggled the valve back and forth a few times, and reinstalled the IAC. I checked the resistances at the electrical connection pins and this checked out. Maybe the contact brushes hadn't quite seated themselves yet. The second start resulted in a nice idle control. In PARK, the car idled 600-700 RPM when warm as opposed to about 1600 RPM when the IAC didn't work. I've been driving with this cleaned IAC for several days now. The idle system is working fine. And I hope it stays that way! Was all this trouble worth it? Well for a tightwad, I'd have to say yes (since the IAC was successfully repaired).

> *[Fix 2: Check Hall Sensor] Below is the procedure to check Hall Sensor (inside distributor) for B230F/FT ignition systems: EZ-117K, EZ-118K on pre-89 cars.*
>
> > Disconnect WHITE/RED AND BLUE leads from ignition coil (to prevent arcing damage).
> > Undo the distributor connector
> > When the ignition is ON the Voltage between positive terminal (red lead - Nr. 3) and ground should be approx. 11V. Voltage between (blue lead - Nr.2; middle one) and ground should be 5V. Resistance between (black lead - Nr. 1) and ground should be "0" Ohms-
> > Undo connector from the control unit (above the brake pedal) and remove the sealing washers (plastic inserts on the side of the connector).
> > Replace connector without cover or sealing washers.
> > Disconnect white/red and blue leads from ignition coil.
> > Measure voltage between terminal 24 at rear of connector (blue lead) and ground. NOTE: Connector must be attached to control unit.
> > Switch on ignition. Turn crankshaft by hand. Voltage should indicate

OVER 1.8V each time a vane passes Hall generator. Instrument should read approx. "0" (0 - 0.7V) each time an opening passes Hall generator. Correct voltage: Less then 0.7V or more than 1.8V.

Slight Hesitation on Acceleration; Several Diagnostic Checks. [Symptom:] Slight hesitation on acceleration.

> [Diagnosis 1:] Check the health of the knock sensor. It is an inexpensive part that "listens" to the engine, senses knock and automatically retards the timing. They get full of crud etc. and give false information. Incorrectly retarded timing will give you a noticeable hesitation.
>
> [Diagnosis 2:] A "slightly" faulty AMM, i.e. during low air mass conditions, can output a too low "air mass" signal to the ECU causing a too narrow (lean) basic injector ON pulse width. Carefully check the AMM's wiring harness plug. Slight misalignment of the female contacts can cause ECU input problems.
>
> [Diagnosis 3:] Clean throttle body.
>
> [Diagnosis 4:] Is your temperature gauge correct? Is the engine heating up properly? I had the exact same problem and it was finally "cured" several weeks ago after the dealer replaced the thermostat that controls the temperature gauge. Now the engine is a lot more smoother and the car has regained some of it's power!
>
> [Diagnosis 5:] The fuel pressure regulator is worth a careful inspection. The fuel pressure must rise instantly in response to the vacuum signal fall that accompanies a throttle opening. A hardened diaphragm might be causing the fuel pressure that has been lessened by the fuel pressure regulator to not increase as rapidly as it must and you won't get the appropriate fuel quantity in spite of lengthened injector duration. Try an acceleration test with the vacuum hose pulled off fuel pressure regulator. Easiest way to check the FPR is to pull the vacuum hose off of it while the engine is idling. If the idle picks up, your FPR is good.

Hesitation; Poor Driveability: Bad Air Mass Meter Symptoms.
"Limp-Home" Mode:
[Would someone give me give me a description of what a bad AMM feels like?] My

single experience with a bad AMM was that the engine would barely run at all and was not driveable. I think it reverts to "limp home mode" if you pull the connector off. But I still think you should clean the throttle body. Since the purpose of an AMM is to regulate air flow to the throttle body, it usually sits right on top of the air cleaner or close by and there is some sort of connector on it. Remove the connector and see how your engine runs. It should run like crap, i.e. no power, idle fluctuates wildly, or engine stalls. If this is similar to the problems you're experiencing now, chances are that the AMM is bad. Another thing to check is that there aren't any air leaks between your AMM and the throttle body. [More Symptoms] When I depress the gas, the car hesitates severely, backfires a few times and if I keep pressing the gas, will stall. If I back off the gas I can usually accelerate very slowly and once I get up to speed it is ok. When this is happening the idle goes up to 1300 instead of the normal 750. I get codes 1-2-1 (Faulty signal to/from Air Mass Meter), 3-2-2 (Air Mass Meter wire burn-off signal absent or faulty) and 2-3-1 (Fuel trim (lambda control) too lean or too rich at part load). Pulling fuse 1 for fifteen minutes to reset the ECU would solve the problem temporarily. The solution was to replace the AMM.

Air Mass Meter

Connector Problems:
More than one inexperienced technician has failed to cure an intermittent driveability problem by replacing the mass airflow sensor. Even if your pinpoint tests suggest a failing sensor, always inspect the sensor's harness connector for loose terminals first. Be sure all the terminals are locked securely inside the connector before you condemn the mass airflow sensor. Some routinely remove a harness connector and then reinstall it to see if "reseating" the connector solves the car's problem. But reseating the connector on this Bosch airflow sensor may complicate diagnosis by pushing the loose terminal outward. So, your quick-fix trick actually makes the car run worse than before! Also, try cleaning and de-oxidizing the connector before reinstalling it.

Disintegrating Air Box Foam:
[Tip from Chris de Courcy-Bower] Check the air mass detector. This can be defeated or even damaged by bits of disintegrating foam rubber that break away from the upper casing of the air filter box. As the foam rubber seems to serve no purpose, it is my recommendation that owners remove every trace of it before it causes a failure.

Backfire, Poor Acceleration: Failing Radio Suppression Relay.[Tom Rolyak] I've had two radio suppression relay failures. Both times Both times I noticed abnormal backfiring when decelerating. Much more pronounced than when a throttle switch sometimes sticks. Also the idle speed would drop down to about 500 rpm's and then return to normal. It also seemed a little balky on acceleration. I swapped the relay and the problem was solved. I pulled the old relay apart and using a microscope could see cracks in the solder.

Hot/Cold Air Box Thermostat and AMM Failure. Unless you live in a very cold climate I don't recommend replacing the cold/hot intake air valve and plumbing. The valve has a tendency to fail in the hot air position thus supplying your intake system with pre heated air and having a tendency to fry your air mass meter. In addition, it can cause mid-range knocking if it fails. Check out the Turbobricks net page (http://www.turbobricks.org/). There are instructions there on doing an "air box mod" that recommends and explains how to do away with the hot/cold air valve and plumbing and redirect the incoming air to the air box. You can, though, just change just the thermostat itself. While Volvo will only sell you the complete air duct w/ thermostat, you can buy an aftermarket thermostat for any 740/940 from fcpgroton and install it yourself.

Operation of a functioning thermostat: The air flap is closed at +5C (41F), +10C (50F) half open, +15C (59F) only cold air.
[Editor's Note: See Air Box Thermostat Change for more information about changing the thermostat in 7xx/9xx cars.

Misfire and Broken Distributor Wires. [Symptoms: Misfire is very pronounced under heavy throttle -- think of a mechanical bull -- which leads me to suspect something in boost control. But the tach also shows about 150 RPM variation at idle, which hints that the misfire exists under no load conditions.] I had this happen to my 85 as well. It turned out to be the connector for the distributor wires under the dist. cap. had broken, and the wire insulation had disintegrated. The wires were grounding out on the distributor housing. For a while it would run fine, then it would miss like you say. I went around the barn on this and spent significant time on things that made minimal difference. I don't know if I broke the connector off or not, but the wires had fallen to the insulation eaters that befall Volvos of that era. I ended up putting in a new distributor because it was convenient and the car had completely died. I did find out that a new hall effect pickup can be installed by drilling out the rivets on the old one and screwing on a new one. To check, put your hand under the bottom of the distributor and see if there is significant wiggle in the connector there. The cap should hold it tight, but on mine, once I was told where to look, it was obvious what the problem was.

Failing Distributor Shaft. [Andrew Smith] After noticing misfire and stumbling in my 110k 760, I discovered my distributor had mechanically failed: the shaft was worn and allowed the rotor to wobble and miss contacts. A new distributor solved the problem.

Misfire Under Load: Ignition Power Stage. [Dick Riess] 1987 B230F has had a miss or hesitation under load for ages and I have replaced or traded just about every possible item. This has been one of the most tough to diagnose problems I have encountered. Purchased a new power stage and plugged it in (aftermarket) and this seems to have cured the problem. [Tip from Matt] In my 740, this was accompanied by idle problems, misfiring, and a fluctuating tachometer needle. Solved with a new power stage unit.

Stumble, Stall, Poor MPG: Bad Engine Ground Connection. [Tip from David Hungerford] What appeared as fuel supply symptoms were not relieved by replacing the filter, FPR, or both pumps (or by checking lines with vacuum pump/gauge). The problem turned out to be a (very) loose FI ground connection. When reaching around blindly to loosen the distributor mounting bolts (checking Hall's sensor connections), my eyes happened to be looking at the intake when my arm brushed the ground strap running from the intake to the firewall--the wires moved at the fuel rail mounting bolt, which also serves as the main round connection for the injectors. It was loose enough that the wires bounced around with engine vibrations. I just tightened it and all stumbling/stalling/AND poor mpg went away. The main lesson here is to NOT skip over the first instruction in all troubleshooting guides: First, check all connections for tightness and evidence of corrosion. See also the section on maintaining engine and chassis grounds.

Symptoms Related to Engine Sensors or ECU:

Engine Failure/No Start/Severe Stumbling: Bad ECU See the FAQ file for much more information.

Common symptoms of a failing LH injection computer:

- Engine will not run at idle
- Air-fuel mixture is too rich (this can damage catalytic converters)
- No fuel pump operation, but the fuel pump operates when its relay is jumpered between pins 30 and 87/2
- The engine will not rev higher than 3000 RPM
- Engine will not start, spark plugs are dry and the ignition system produces spark.

Intermittent stalling in 89 760T. The owner of the shop hinted that "late 80s and early 90s 760s have had problems with their computer chips" Has anyone heard of this?] [Response 1:] Yes, very much so...LH 2.4 modules from 1989-1991, maybe 1992 too, have been very troublesome. However, as far as I know, 1989 Turbos still used LH2.2 modules, so I'm not sure that this applies to your car. Also, often when the modules fail, they fail rather radically, such as the car running very rich, or a no-start or cases like that. [Response 2:] I experienced almost identical symptoms for several years. They went away when the ECU on my 760 Turbo had to be replaced because the AC enrichment circuit went south.

Marginal Operation. When mine died it got stuck in diagnostic mode 3, pulsing the injectors every second, which was enough fuel to start the car but not much more. Other cases I've heard of has the adaptive rich code getting set permanently. [Yet Another Opinion:] As a general rule, ECU's don't go half bad, and don't work intermittently: they work fine or they don't work at all. It is wires and connectors that have "off days". [JKordzi]The 561 ECUs have had very high failure rates. Used 951 ECUs (the replacement model) are pretty reasonable now and may be had on EBay or in wreckers' yards for US$50 or so. [Editor] In my case, my 556 ECU vintage 1990 failed in such a way that the car would idle, but any application of throttle to raise rpms above about 1,000 would suddenly cause total injector failure: they would just stop pulsing until the rpms dropped. Changing the ECU solved it.

Hesitation, Poor Idle: ECU Failure with Codes 2-3-1; 2-3-2. [Tip from Al Nettleton] Symptoms:

1. Error codes 2-3-2 & 2-3-1 (Mixture too lean or rich)
2. O2 sensor replaced with no success
3. If the error codes were read & cleared, they come back almost immediately
4. If the ECU is unplugged (or the battery disconnected), the codes clear but come back after about 150 miles. For the first 50, or so, of these, idle is rough, next 50 - hesitation from a standing stop, the last 50 - runs well. BUT . . .
5. Running lean.

Successful repair required replacing the air mass meter (AMM), intake bellows between AMM and throttle body, and ECU. Parts swapping confirmed the need for all three. One important finding - the air bellows can leak at the end connections, even though there are no cracks or holes in the bellows and the clamps are tight. Apparently they get to be so inflexible that a good seal is not possible. We should now be ready for another 100K.

Loss of Power; Rough Running; Knocking: Bad Engine Knock Sensor. A failed knock sensor may be felt as a general weakness throughout the powerband and a different tone to the motor. When no knock sensor signal is detected the EZK ignition system defaults to full spark retard. This can also result in the motor running a little on the rich side, as a kind of side-effect (More ignition advance usually = leaner burn, more NOx emissions; less advance usually = richer burn, more HC and CO emissions.) See Engine Sensors for more information.

Symptoms. Higher idle, no power; running rough at RPM higher than idle. It jerks every few seconds and there is no pattern to it. It idles and starts fine. [Rafael Riverol] Other symptoms include hesitation, poor throttle response, lack of acceleration, especially when cold. [Marc] The car starts fine and will run for 2 miles and then lose power. It never stalls just won't move. If I shut it off and immediately restart it, it will run fine again for another 2 miles and so on and so on. When it runs fine, with a timing light hooked up on acceleration the timing will retard 1 or 2 degrees before it advances. If I check it when the problem is occuring it will retard 6 or 8 degrees before it tries to advance. Solution: new knock sensor.

Diagnosis. Check the knock sensor, it senses knock (no kidding) and retards the timing. When this gets faulty, it will make the engine have very poor power, lousy and jerky acceleration, but will start and idle fine. It's a small black plastic covered unit bolted to the block (ten mil. bolt) under the intake man. with a plug attached to it. One minute to remove. It "listens" to the engine. Mine had a cracked plastic cover and was covered in oil. I put a used one in (new they're ~$40) and it's like I suddenly had a new car.

Mid-Range Engine Knock. Anecdotal evidence notes that if you experience mid-range engine knock when the engine is warm, inspect the airbox thermostat for proper operation. If it sticks in the "warm" position, it allows preheated air into the intake system. This will also, over time, ruin your air mass meter.

Retarded Timing or Knock Sensor Code: Wiring Interference. [Tip from Charles Dinges] If you have unexplained timing retardation (poor acceleration) or an unexplained knock sensor error code, try re-routing the knock sensor feed wiring away from the alternator. Anecdotal reports of electromagnetic interference seem to implicate the alternator in this problem.

Rough Running; Cylinder Diagnosis [Inquiry: 1992 740/ B230F] The car is hard to start and when it does, it idles badly (everything shakes like it's running on 3 cylinders). Once the engine warms up, it runs smoothly and the problem disappears. [Response: Chris Mullet] When it's running rough try to identify a particular cylinder that might be the problem by pulling spark plug wires one at a time until you find one that has little negative effect when removed. If you find a bad cylinder, make certain the intake manifold is properly torqued. While it's running rough, squirt something like light oil around the intake gasket in the area of the bad cylinder. If it smooths the idle temporarily, you found the problem. If not, try swapping injectors between two cylinders and see if the problem follows it. If not, try swapping injector wires. (You could do this on the older models, as injector timing wasn't particularly critical, so I assume you can do it on the newer ones.)

Hunting Idle; Faulty TPS or ECT. [Symptom:] In the last 2-3 weeks the engine idle speed can vary wildly or act normally. Specifically, sometimes upon first start the RPM's will hold at close to 2000. Then upon warming (3-5 min) the idle speed will swing instantaneously from near die out to about 1600 RPM's. This wild swing occurs only when in park or neutral and never shuts completely down. The RPM's will stabilize when in gear (auto trans) and holds at about 1000 RPM's and will hold at about 1600 RPM's when taken out of gear. The symptom is intermittent. When the engine is acting normal the idle in park is about 1000 RPM and in gear about 750 RPM. I cleaned the throttle body (for the third time since owning the car) about a week before the first time the unusual symptoms occurred. I have disconnected the AMM wiring during an episode and the engine speed changed but I still am not sure if I know what to look for there.

[Diagnosis:] What you describe could be the FI computer trying to limit the rpms at idle so it doesn't over rev. The control loop is rather crude and is there only to save the engine from self destroying. Something is telling the computer to rev up and it does and then cuts off things at 2000 rpm. The most obvious guess would be that the throttle position sensor (TPS) is mis-adjusted or broken. Make sure that it "clicks" just before the throttle plate closes. Also, you may want to check that the FI-unit actually sees this "click" by looking at pin 2 of the FI unit. It should be 0 Volts at idle and battery voltage when the gas pedal is depressed a bit. You say you cleaned the throttle body BEFORE the symptoms started appearing, so perhaps there's a chance you accidentally didn't adjust the TPS position properly?

The other thing to check is the engine coolant temp sensor (ECT). Look at pin 13 of the FI unit. When the engine is warm you should see 350mV. See Diagnosing ECT Failures for more information. In addition, since you've disconnected the mass airflow sensor (MAF), the computer may have gone into limp-home mode permanently which will cloud the diagnostics, so you should really check and reset any error codes stored in the system before you do anything else. However, unless the Check Engine light has come on the MAF disconnect didn't trigger any code setting.

High Idle at Startup: TPS Failure. Symptom: the idle surges immediately to 2000-2500 rpm after a cold start, then gradually declines to 950-1000 rpm as the engine warms up. The idle rate seems dependent on temperature: lower temperatures cause a higher idle. Diagnosis: TPS failure The TPS internal microswitch does not sense the idle condition, even though a "click" might be heard at the switch. As a result, the ECU does not control idle through the IAC valve and idle is too high. See Throttle Position Switch for information on diagnosis, adjustment or replacement.

Idle Surge, High Idle, Poor Idle: Vacuum Leak [Inquiry:] Idle surges at times between 1200-1600 RPM when car not under load. Idle Control Motor? Other? [Response: WBain] You have a vacuum leak. Check all lines especially at the throttle body. Also if it's a turbo, look for a bad intake manifold gasket.
Intake Manifold Gasket Leak. Mine has had a very rough idle. I checked the FAQ and cleaned the throttle body and checked for leaks in the hoses. I was finally able to isolate a leak in the intake manifold gasket. The propane test didn't find the leak. The only way I was able to isolate the leak was with the mechanic's stethoscope with the probe removed and only using the tubing to get very close to the gasket and follow the contour of the manifold. Replaced the gasket (approx. 2 hours) and the car runs fine.
[Tip from Gary Goms] Vacuum leaks can be easily diagnosed by several methods. I believe the safest and easiest method is to use a modified mechanical stethoscope to listen for vacuum leaks throughout the system. To modify the stethoscope for locating vacuum leaks, replace the probe with a length of plastic hose or fuel line. Alternate methods include listening for a change in engine speed while spraying propane or aerosol carb cleaner around manifold and vacuum connections. The various brands of "smoke" machines are also very handy diagnostic aids to use when attempting to locate vacuum leaks at the manifold-to-cylinder head gasket, throttle body shaft, throttle body-to-manifold gasket and vacuum hoses.

Slight Backfiring While Coasting; TPS Mis-adjusted. [Inquiry:] The car is a 945T and, after fully warmed up 30-45 minutes on the highway), makes a "pupp pupp pupp" sound when on the highway and backing off the accelerator. The sound seems to be emanating inside a "tin can" and is not loud at all. If I had to guess, I would say that unburned fuel/air mixture is getting into the exhaust system. [Response: Abe Crombie] The injectors should go off on coast. This is controlled by the fuel control unit being able to see closed throttle via the throttle switch. If that isn't adjusted properly or has a faulty internal switch then the injectors may not be off on coast and you may very well be hearing a weak backfire in exhaust. See Throttle Position Switch.

[Dave Stevens] My 740 had a hunting and lurching symptom when coasting at low throttle. The remedy: Check that the throttle cable has not stretched - if it has, the throttle microswitch will be opening the fuel solenoid too late and the engine will be starved at low revs, but will recover fine when accelerating or running on an open throttle. All that is required is to adjust the microswitch setting by the two screws that fix it in place. With the throttle closed and the engine switched off, reposition the switch slightly so that it clicks as soon as the throttle cable moves. Make sure you don't move it so much that it doesn't click off again when the throttle is released, or the engine may overrun when the ignition is switched off.

Symptoms Related to Electrical Malfunctions:

Sudden Cut-Out While Driving; Electrical Causes.[Symptom:] On occasion, it will just completely cut out on me going down the road. No sputtering, just "dead". Usually it starts back up on its own recognizance as I coast for 50 yards or so. Sometimes it does not, but if I pull off and let it cool down for 5 minutes, it starts right back up, and does not cut out again for a couple weeks or so.

> [Opinions:]
>
> Since this car has an EFI system, LH-Jetronic I suppose, you could be getting an intermittent electrical fault in that system that'd cause similar symptoms... or I might be totally wrong. First thing, I'd install a tach. If the tach drops to zero as the engine cuts out, then it IS the ignition. But I'd clean all the EFI grounds, the underhood fuse and fuel pump fuses, fuel pump connections, and such before proceeding.
> I would check the electrical connections to the fuel pump. Especially the grounding, maybe it is not so much getting too hot that causes the engine to quit, but an intermittent ground. Once you pull over, the broken wire or whatever

falls back into place. I once broke the ground wire to my alternator and that caused the engine to quit, though it did sputter a little. The wire was broken in the middle and once I pulled over and the car was still, I had good ground, but once moving, it would make intermittent contact

Have you checked the fuel pump relay? Similar symptom to yours and seems to be a fairly common problem among Bricksters. A bad/weak coil in my experience shows up as consistent poor performance under high spark load conditions, such as starting and large throttle openings at low RPMs. I check the coil by removing the coil wire at the distributor and firmly locating (not holding unless with insulated pliers) the the wire's tip about 3/8 inch from a block or frame ground point. The spark should be a "thick" blueish white and easily jump the 3/8" air gap with the engine being cranked by the starter. A weak spark tends to be "thin" pinkish and sensitive to proximity to ground. The normal arcing voltage (engine running) is in the 12-15 KV range for my '82 B21F LH1.

I have had the similar problem on a 84 GL and found that the ignition pick-up coil in the distributor was faulty. When the pick-up got warm the resistance in the wire showed an open circuit and when it cooled off it was normal again. I replaced the pick-up and problem was solved.

I had such a condition on an '83 245 twice once it turned out to be fraying wiring harness right between the rear of the engine and the firewall and once it turned out to be the computer on the inside of the right front fender.

See the FAQ section on Grounds for information about engine and chassis ground maintenance.

Engine Cuts Out at Speed: Ignition Power Stage Failure. [Inquiry:] My 1990 740 GL Wagon (186,000 miles) stalls intermittently with the tachometer immediately dropping to zero. It does it while cruising on the highway or while idling. I'm able to restart it sometimes with the clutch if I'm moving along, otherwise with the key after I get to the side of the road. If it sits for a few minutes that seems to help in restarting. It appears that all other electrical components are not affected when this happens (radio works, blower, flashers, etc.). It now happens almost daily, but started months ago happening 1-2 times a month, then 1-2 times a week, etc. It's getting worse. My mechanic has replaced some likely components: FP relay (behind fuse box), radio relay (on the coolant reservoir) and crank sensor (with the white band - I had replaced this at 90K as well). I also had a cracked distributor cap that was replaced. Plug wires are in good shape. [Another similar case:] My symptoms were, the tach dropping to zero and then the engine would bump start at speed and at a stop the car would shudder and then die unless the motor is revved up at a stop to bump start the car.

[Response: Lincoln] I would check your power stage, it amplifies the signal from the computer to the coil. I had the same thing happen to me two months ago. I think another person had it happen to them too. I think I paid $90 for the part and $100 for them to find the problem. The part is located to the right of the battery on the fender. [Response 2: Fred Guest] In our case it is caused by a bad connection at a plug connecting the power stage mounted on the left inner fender. We unplug the connector, clean the spade terminals with emery cloth and squeeze the female connectors with needlenose pliers if we have them with us, then put it back together and it is fine for a while. [Editor's Note: use electronic connection de-oxidizer instead] I believe the round things on the fender have something to do with the fuel injection. Since your tach goes to zero I expect you have a similar corroded connector problem - but probably in the ignition system rather than in the fuel injection.

Note: faulty engine and chassis grounds can play havoc with the electrical system and cause component failure. See the FAQ section for more information about diagnosing, curing and preventing ground troubles.

Poor Power; Poor Engine Response. [Symptoms] Symptoms: no power under 3K RPM; poor power after 3K RPM; no engine response, very slow response; will not brake-boost past 2 psi; idle fluctuation between 750-1200RPM; rough idle; engine makes loud "bog" noise from intake when throttle is opened and takes several seconds to respond, even in neutral. Does not seem to get terrible gas mileage, but could be better. Does not smoke white, blue or black. Spark plugs are white on the electrode and have black carbon around the face [Duane Hoberg] Based upon an age-old experiences, it appears that your ignition timing is off (late)and is not responding properly contrary to what the base timing light indicates. The plugs with white center indicate a lean fire condition, the black ring indicates a rich, incomplete burn cycle. ie, fuel being burned late in the power stroke or after the exhaust valve is open. Late ignition timing. The ECU via the O2 sensors is leaning the mixture out after they enter the cycle because of the excess oxygen from the interupted incomplete burn after the exhaust valve opens. Causes: Ignition wires not in the proper sequence. Certain engines will run but with little power if two ignition wires are swapped. Has the flywheel been removed and replaced lately? Flywheel off by one bolt or backwards would cause a lot of problems. If the flywheel and everything else is on the money, the ignition portion of the ECU is at fault. Verification via diagnoses step by step with a Volvo Service Manual would be well worth the 20 or so dollars for the manual.

Intermittent Ignition Shutoff: FI Relay or Ignition Switch. [Inquiry:] I have had my Volvo 760GLE for over a year. Currently it has 214K miles. Lately it has been cutting off (the ignition) while driving. It happens only when the car is warm, say 10-15 minutes after driving. It first started while driving on the highways. Without any prior signal it would abruptly shut of f. (indicated by all the dash lights coming on) once or twice it start back up on its own a second or two while still cruising and I would drive as usual. Sometimes I would coast it down to the side of the highway, try starting a few times, wait, try again, and it would start again. By the way it shuts off, it seems very unlikely that it is a fuel system problem (does not sputter or hesitate, just shuts off abruptly) Looks more like an ignition problem: could it be the ignition module, coil or simply a poor ground ? [Response 1:] Try removing the fuel injection relay and replacing. Your symptoms sound very much like a failing FI relay. Many of them fail through solder fatigue on the back of the board inside, and you can try to R&R the unit by resoldering where you see cracks or dull solder. FYI, the FI relay is above the fuse board under the cigarette lighter. Take off the pop-on cigarette lighter cover, remove the two screws holding the storage box and pull the box out. You then have full access to the relays. The rectangular white one in the middle row, driver's side, is the FI relay. (Green relay on some 940SE and 960 cars.) I carry a spare relay around in the back of my 1990 740 in case of failure on a long trip. They seem to last around eight to ten years. [Response 2:] In addition to the fuel relay mentioned the ignition switch can do that to you and it is certainly a candidate to be failed at 214K miles. I would replace it and see, if it's not that then it won't be wasted effort as it will fail soon if it has not already. The switch can somewhat be checked by twisting ignition key a few degrees either way the next time it does its shutdown number on you.

Unexplained Driveability Problems with ECU Error Codes; Oxidized Connectors. The recent steamcleaning problems with a 240 and connector problems with another 240 bring to mind a recent Volvo Tech Service Bulletin from March, 1993 which describes a procedure for cleaning, de-oxidizing and protecting engine electrical connectors to eliminate driveability problems when unexplained error codes appear at the ECU. Apparently, they started using protective grease at the factory in 940 chassis numbers 128400 and 945: 079100; before this, the connectors are unprotected. No 7xx cars have grease applied at the factory. It helps to have a Volvo wiring diagram at hand to locate all of the appropriate connectors, each of which has to be disconnected, cleaned and greased. Be careful in removing connectors, since the plastic connector and the wiring insulation can harden and become brittle over time. You use a cleaning/deoxidizing spray such as "DeOxIt" from Caig Labs or Chemtronics Tuner Renu (available at electronic stores) and a low-temperature silicone dielectric (non-conductive) grease for electrical connectors, available at auto stores. Don't use "OxGuard", which is conductive. You turn off the ignition and disconnect, clean and grease the following connectors leading to the sensors noted:

RPM sensor at back firewall near brake booster
MAF sensor at the AMM

Power stage at fender
Knock sensor beneath intake manifold
ECT sensor near flame trap
Throttle position switch on throttle body
EGR temperature sensor (California cars)
IAC valve beneath throttle body

The deoxidizing spray is applied to both connector halves, then you squeeze the grease in and around the connector (but don't fill the protective boot), then reconnect. After everything is back together, you turn on the ignition and start the engine. They note that this procedure is supposed to be used for driveability problems or if oxidation is noticed, but I can imagine that it would be good practice as a PM technique on higher mileage engines on older 240/7xx cars. If you go to this trouble, then you might also follow the advice on maintaining engine and chassis ground connections, which also corrode and lose connectivity.

CAUTIONS: DON'Tdo this to the oxygen sensor connector which operates at millivolt levels. DO NOT do this to any SRS/Airbag/Seatbelt connectors: these are all gold-plated and do not oxidize. If they get dirty from spilled drinks, etc., just clean them with a no-residue cleaner.

Unexplained Driveability Problems: Rotten Battery Cables. [Editor:] If your car is not idling correctly or shows strange error codes, including ABS warnings, see the 960 and Circuits sections on rotten battery cable connectors. These corrode away and reduce voltage to the car electrical system, causing ECU and control problems, including possible problems with engine sensors.

Unexplained Driveability Problems: Bad Voltage Regulator. [Tip from Zach Gurley] Bad voltage regulator symptoms on a 740:

- pulsating lights (not necessarily rpm-sensitive)
- the car lunges and jerks, especially when in gear and coasting (similar to the feeling of disengaging the clutch too quickly)
- intermittent engine spit and sputter at a specific rpm in any gear including neutral (mine was at 1900 rpms)

It took me a while to figure this one out. Of course I figured the voltage regulator might need to be replaced because of the pulsing lights, but no one thought the problems were related to the violent sputtering I was getting. Apparently, the regulator was having difficulty coping with the additional power produced from a faster moving alternator, which was in turn messing up the ECU. The brushes were in good shape, but the regulator was an aftermarket brand, so it could be an isolated problem.

Car Runs but Won't Re-Start; Bad RPM Sensor. I recently posted a starting problem with a 1991 240, where it would start fine when it was cold and would start fine hot if restarted immediately after cutting off the engine. However, if it were left for 10 minutes or more after cutting it off hot, the starter motor would just turn and turn until it finally started - sometimes it did not and the battery just ran down. As it turns out, it was the RPM sensor, which is also a crankshaft position sensor. The heat soak after turning off the engine made the sensor open circuit most of the time - during starting, apparently, the computer did not pick up enough crankshaft position information to start the car. However, since the car ran fine if it did start, the sensor must have been intermittently putting out a signal, enough to update the computer in order to correctly operate the fuel injection and ignition systems after starting. After replacing the sensor, I have had no further problems with starting. [Chris Herbst] If the car stalls while turning corners,check that the rpm sensor wire isn't split open and grounding on the rear of the engine somewhere when you turn corners or slow down.

Car Stalls When Brakes Applied: Vacuum Leak or FI Relay. [Inquiry:] I am having a problem stalling under hard braking. I have had it checked for vacuum leaks and they appear OK. It only happens when the car is warm and I apply the brakes hard. [Response 1:] I would look in the direction of the power brake booster. Right after you brake, you fill up the booster with air, which has to be evacuated by the engine. If your idle is somewhat shaky, throttle plate is out of adjustment or you have a lazy idle air motor the idle can drop enough to stall it. The check valve in hose from intake manifold to booster has an arrow on it indicating the direction of installation Take it out of the line and suck on it to see it opens and shuts correctly. [Response 2:] Check the solder joints on the fuel pump relay. Cracked joints will sometimes cause a warm relay to drop out when the engine speed drops and the alternator slows and the system voltage drops.

Car Stalls at RPM: FI Relay or Hall Sensor. [Inquiry:] Car is 1986 740T with B230 engine and A/T. Occasionally, while accelerating, RPM at approx. 2500 the engine will start to hesitate, choke, and die. I pull over to the side of the road where it will restart on first attempt. I take off and all is well for days and weeks. I thought that once the engine shuts off, and the car still moving from inertia I could move the shifter into Neutral, and restart the engine. Starter will Not even engage. However, with the car stopped, it will start in Neutral. Why is this ? Fuel pump relay is about a year old. Other than this, car runs and idles fine. [Response 1: FI relay] It sounds like the fuel pump relay is cutting out. Behind the ashtray is the fuse box and relay panel. About the ashtray should be the lighter and a storage bin. Pull the lighter out and remove the square piece of trim , there are two screws , remove them and the whole box should come out. The fuel pump relay should be the relay located directly below the big red round one. It is rectangular and white (green in some 940SE and 960 cars.) The current p/n is 3523608 . The relay should have six terminals on it. [Response 2: Hall sensor] The easiest way I know of checking the distributor is to remove it with the plug for the pickup still attached. Turn the key to the run position, and spin the dist. If the injectors start clicking the pickup is good. If the pickup is bad , good news bad news. The good news is there is a replacement pickup p/n 1346792 (the black plastic plug is also available it doesn't come with the pickup p/n1346793) The bad news , the pickup is riveted to the distributor body, and you run maybe a 50/50 percent chance of breaking the housing. A rebuilt distributor is available from Volvo it comes with a new cap and rotor, but more importantly a new shaft seal in the housing that is not available as a spare part (dist p/n 8111214) Either way get new o-rings for the dist. p/n 969330 & 969331.

Rich-Running Problems:

Rich Running Problems: General Diagnostic Notes. [Tips from Duane Hoberg] For the LH system injectors to function properly, three items are sampled at all times and are used to determine the injector pulse time based upon the fuel pressure at a specific pressure. Those items are critical to a normal running engine.

Causes of Running Rich Problems in LH Systems.

- High fuel pressure. Check fuel pressure. If the fuel pressure is out of spec the engine runs rich or lean until the O2 sensor compensates if the range is not that far out of spec. This shows up as a cold running and start problem that may go away when hot with an adverse effect on gas mileage.
- Check injectors to make sure they are closing. If your crankcase oil is full of gasoline, you probably have an injector that is failing to close.
- Fuel check valve on front of fuel pump. If stuck part way, it restricts the flow which causes a lean condition. Mechanics may have compensated by adjusting the AMM. This "cured" the hot running condition but did nothing for the cold start. As the valve restricts or opens further, the car runs like crap. If suddenly opens full, the car will run rich. Associated symptom is it takes a long time to start first off in the morning. Normal time should be no more than 3 seconds. Anything longer and there is a problem. If you test fuel pressure at the rail and

residual or resting pressure is zero, the check valve has failed.

- Temp sensor for the ECU is bad or out of specification or its ground is faulty. From cold to hot the engine needs different amounts of fuel to run efficiently. The sensor that determines this info needs to be consistent across its range. If at various points it is out of spec, open or full closed the engine computer responds appropriately and adjusts the pulse rate which will lean out or flood the engine. Measurement is remove sensor, cool it in freezer, attach ohmmeter, place in cold water on stove and heat to boiling while watching meter, needle movement must be smooth over entire range. Final test is in engine at full operating temperature with test point at ECU connector. It must be with 10 to 15 ohms of the chart in the various service manuals.
- Faulty AMM. Amount of air is determined by AMM. If the meter is out of specification the ECU will cause the engine to run rich or lean. A slight out of spec can be compensated for by adjusting the mixture control. If adjusting the mixture control does not work AT ALL engine running conditions, then replace the AMM. Obviously, any air entering downstream of the meter leans the mixture. An exhaust system that is not tight or partially plugged changes the amount of air that can move through the engine and changes the running parameters of the engine. Adjusting the AMM can compensate until the specs shift too far and then engine performance and running problems abound. Make sure the charcoal cannister is not faulty and allowing engine vacuum to suck fuel from the tank to the intake manifold through it. A definite rich condition.
- O2 sensor out of spec or damaged. Once the sensor gets to operating temp, it provides a compensating signal to the ECU which is still running the engine based upon air mass and engine temp at a specific fuel pressure. The ECU is constantly "looking" for this signal after a certain engine temp. Once found it uses the signal from the O2 sensor to adjust the pulse rate to control emissions.
- [Turbo models] A loose Compressor Blowoff Valve at the mounting bracket on Garrett turbos will leak on boost and give a VERY rich mixture, as will any holes in intake air hoses, pipes or the intercooler.

The idle control valve only controls idle. It allows measured air to bypass the throttle plate based upon a specific fuel pressure and the tach signal.

[Jeremy] Here is a quick trick to start a flooded car: Disconnect the four injector electrical plugs and crank with the pedal mashed to the floor and burn out the extra fuel and then reconnect.

Car Stalls; Bad Fuel Pressure Regulator Likely Cause. [Variety of "car won't restart or is driving along and stalls abruptly" problems.] There have been a number of these problems recently--the car won't start after I drive it 20 minutes, the car won't start after I turn it off after driving a short distance unless I wait several minutes, the car made me wait 20 minutes at the grocery store then started and ran fine...ones like this, that all sound to me similar to the problem that afflicted me a while back, which was cured by a new fuel pump relay. My problem was sporadic, and the symptoms varied, but boiled down to a well-running car simply, now and then, refusing to start. Given that it now seems clear that the FPR is fairly often culprit in these cases, and given its low cost, I'm wondering if maybe trying to replace the fuel pump relay, after checking for loose wires and that the fuses are content, shouldn't be the first line of attack. What I mean is that intermittent failure in the FPR is not uncommon once you get into years and miles, it's something most of us would not have a hard time replacing, and it seems, from many of the postings, to be not only the usual suspect, but actually the real culprit. Sure, there are lots of other things it *could* be, but it seems that this is what it comes down to more than 2/3 of the time. Starting with the FPR should, on average, save most people a lot of time I think.

Car Stalls During Turn; Bad Fuel Pre-Pump Likely Cause. See Fuel Pre-Pump Problems for more information about pre-pump problems causing odd stalling situations.

Poor Performance; Rich Mixture Smell: Diagnostics [Inquiry: Jarrod Stenberg] My non-turbo, auto transmission car has been running real crappy for a while now; I think it was gradual. Sometimes when I start it it takes forever. This can include some backfiring. When it finally does start it sometimes spits out a cloud of smoke. It often smells like gas as well. Seems to be running rich. The oil smelled like gas. I replaced it since this scares me for good reason. Of course this improved nothing but my peace of mind. When idling it will race a bit and cycle back down to near stall (to and fro to and fro but not REAL bad). Things I have checked and symptoms: Weak spark? Replaced the plugs and I have new wires. Checked the distributor cap and rotor. All are good. I have done the easy checks for vacuum leaks: sprayed wd40 around and listened for the engine to choke on it. I am pretty certain this is not it.
[Diagnostic Notes: Don Foster]
Failing FPR. First, it certainly could be a failing fuel pressure regulator. Pull the small vacuum line and sniff for gas -- possibly the diaphragm has a pinhole and is bypassing fuel directly into the intake manifold. But even if no gas smell, the regulator could have increased the fuel pressure creating an always-rich condition -- this is not uncommon.

Fuel Pressure Regulator

Failing ECT. Second, my favorite is the connections at the temperature sensor -- the two-connector sensor under intake runner #3. (The single connector sensor under runner #2 is for the dashboard temp gauge.) This sensor uses an NTC (negative temperature coefficient) thermistor. When the temp is low, the resistance is high, and when it's hot, the resistance is low. The FI ecu adjusts the injector pulse duration based partly on this reading to compensate for engine temperature. So a failed sensor, a bad or broken connector, corroded connections, or broken wire would create very high resistance and simulate a very cold engine (like minus 50 degrees). The ecu would adjust fuel delivery accordingly.

Bad Air Mass Meter. There's always the old "limp home" trick. If you find the engine runs well (with the AMM unplugged) above about 30-35 mph, then you probably have TOO much fuel pressure. If it were my car in this case, I'd suspect the regulator. But if the engine can't get above 30 mph, more or less, then it's probably the AMM.

Injector Ground Wires and Harness. [Don Willson] Check the ground wires on the injectors. Remove the manifold bolts and solder the ground wires to the crimp lugs. Wire brush the connector and around the manifold bolt and tighten the lugs down securely. A smart mechanic said this is the first thing he "fixes" on any European car that comes in. When these ground wires develop a high resistance an injector starts to misfire sending excess oxygen to the O2 sensor which it thinks is a lean condition and calls for more gas. Let us know if this works.

[Mark Stites] In one situation, the injectors were constantly grounded, causing massive flooding and engine stalling. Before concluding that the ECU is shorted internally, consider that a more likely culprit is the harness. It has been years since I have seen one do it but, in the harness under the intake manifold there is a splice where all of the injector grounds come together. I have seen a harness deteriorate to the point where that splice shorted to ground and kept the injectors on continuously. There are a couple of connectors under the brace that runs from the firewall to the passenger's strut tower, under that brace you need to find the 8 pole connector that has a gray wire in the #7 position. Leaving the connector connected, pop open the back side of it and slide out wire. Turn the key on and if it continues to barrel fuel then your problem lies between the injectors and that wire connector (i.e. it's in the harness somewhere). If you turn the key on and it no longer runs the injectors then it is being grounded somewhere between the connector and the ECU, most likely the ECU.

Poor Perfomance, Bad Acceleration: Faulty FPR. [Inquiry: Aidan] I have a problem which I just can't seem to figure out- what would make my '89 744 GL with just a tad over 105k go from running beautifully smooth to not-so-good nearly overnight? Basically, the car has been running great for a couple of months, ever since I had some (relatively) minor work done on it. Everything has been absolutely wonderful- until yesterday evening. Literally, all of a sudden the car started giving a great deal of resistance when I would accelerate- the RPM's would jump back and forth like crazy, and the car would shudder and jerk when accelerating and idling...

(like, say, at a stop light.) This is all while the car has a full tank of gas. It began to do this pretty much as soon as I started the car, but continued even after it had been running for about an hour. The temperature just dropped a great deal up here in MA, and as it was late at night after getting home, I didn't really have a chance to take a look at it. I didn't use the car again until tonight, so it had been sitting cold for about 9 hours. When I tried it was VERY hard to start, so hard that I feared that for the first time ever I wouldn't actually be able to get it started. When it did start, the engine jumped around a great deal between .75 and 2 RPM's while in Park, and the car continued to shudder a great deal even after the engine had warmed up and was put in both Drive and in Reverse. The car seems most unresponsive to acceleration when the engine is running under 2 RPM's, though trying to accelerate causes the same reaction from the engine at nearly any speed/RPM. After taking a look under the hood, I noticed that when the engine can be seen shaking a great deal more than it should, literally jerking itself back and forth. It often sounds like the engine is just going to cut out, only to rev up again. (it repeats this process indefinitely, warm or cold.) Without saying, the car is very difficult to drive like this, and I fear that one of these times its either just not going to start, or going to cut out while driving- both things I'm not looking forward to. Does anyone have any suggestions about what could cause it do this, or have any ideas about what I should be looking at/for? Any help/ideas/suggestions would be MUCH appreciated!
[Final Diagnosis and Fix: Aidan] After fiddling around and trying a variety of different things, I've come upon what seems to be the solution- a faulty fuel pressure regulator. After replacing it first with a test part and finally a new one for $58.87, I have not experienced any kind of problem in running, idling, or starting. I came upon finding it pretty much by trial and error- the AMM checked out and appeared fine, as did the thermostat in the air filter.

Engine Hesitation: Bad Fuel Pressure Regulator. [Symptoms:] occasional stalling engine at idle; occasional stumble at cruising speed, resulting in 1-2 seconds of deceleration like I'd turned the key off. [Diagnosis:] The bottom line is the fuel pressure regulator was bad, causing too high pressure; replace pressure regulator. This whole problem was compounded by the fact that there isn't a commonly available pressure gauge that fits a Bosch FI system; even my mechanic has a homemade one. I delayed and delayed getting the gauge in place, which would've immediately solved the problem when it first started occurring! Excuses: I was unable to get the fuel rail to unbolt from the hose to the pump either, so I eventually cut the fuel line itself, which was a two-piece construction (rubber outside, poly liner inside). I purchased Sunpro ($35) fuel gauge because it had a hose (with GM/Ford fittings) that I could remove; and I basically purchased one of every part at the local plumbing supply shop. Anyway, putting the gauge in instantly revealed too high pressure. Jumpering the fuel pump was easy too. And nothing could've been easier than replacing the pressure regulator -- two screws and it's out. The hardest part was swallowing the $80.00. Note:

Imparts carries nice 1.5" fuel pressure gauges (you mount them directly in line) #153008 60psi - 1/8" 27NPT connection $21 USSummit carries nice small aluminum connector for those gauges - hose to hose to 1/8" 27NPT thread - part # SUM-G1710 $5.99 they have gauges at the same price as well.

Note: I had a hose assembly made at the local hydraulic shop. the fittings were made by GATES (the hose people) The sizes are 14mm with a 1.2 mm/pitch and a 37(?) degree JIS flare.

[Another Tip from Mike W.] Some of you may recall that I posted a week or so ago regarding my car which had been idling roughly. LH 2.4 OBD was giving me 1-1-3 (fault in fuel injectors) and 2-3-2 (fuel system compensating for rich or lean mixture at idle). After chasing down numerous red herrings (IAC, TPS, AMM, ECU, cold start injector, coolant temp sensor) the problem turned out to be a bad fuel pressure regulator. I've experienced two failure modes for LH-jet FPRs; the first where inadequate fuel pressure is delivered and fuel comes out the vacuum line connection on the front of the unit, and the second (which occurred in this case) where the unit simply pressures up to the point that NO fuel is let out the return line side and excessive pressure is delivered to the injectors (hence the OBD code). Easy to test, just disconnect the return line to the tank from the back of the FPR and connect a couple feet of hose. Aim the hose into a gasoline safe container and turn on the engine. You should get a good strong stream of fuel from the return line at idle, probably something like a half gallon a minute or more. If you get little or no fuel, the FPR is bad, and your main fuel pump will run hot and start screaming for attention pretty soon. Also found out that this same FPR (Bosch 0 280 160 294) is used on both the LH 2.4 in the 240 and in my wife's '94 940T. Now I need to go by the pick and pull to get a "spare" for my "inventory."

Fuel in Oil: Faulty FPR or Injector. [Inquiry:] My brother's 740 with a B230FT has gas in the oil. I lent him my fuel pressure gauge to check for over pressure, guessing that it was a bad fuel pressure regulator. Bad news is that his pressure is right on the money, I think he said about 45 psi. Anyway, the only thing we could think of is a leaky injector that's dribbling when the car's off. The problem with that diagnosis is that if gas was leaking from an injector, the car would take a few extra turns to start in the morning since fuel pressure would be down. He says that it starts right up. I should probably have him leave the pressure gauge on overnight and check the pressure in the morning.   Anyone have any ideas?   [Response: Steve Seekins]
There are only two sources for fuel in the crankcase. First one is the fuel pressure regulator - however, this may not affect the working pressure! With the engine running, disconnect and plug the vacuum line to the intake manifold. If fuel comes out

of the regulator vacuum line, there is a hole in the diaphragm and that is the source of the fuel. Replace the regulator and change the oil and filter. This is a fairly common problem.
The second source of fuel in the crankcase is an over-rich engine. First, if this is your problem, your mileage will be terrible - on the order of 12 to 16 mpg. If so, it can be EITHER leaking injector OR a clogged injector, or possibly a bad oxygen sensor. Leaking injector can be checked by removing the injectors, leaving them connected to the injector rail. Cycle the fuel pump several times with the starter, then wipe the injector tips and observe for droplets forming. Also, have someone crank the engine while you observe the injector spray patterns (CAUTION: RAW FUEL WILL BE SPRAYED. BE SURE TO DISCONNECT THE SPARK AND OBSERVE SAFETY PRECAUTIONS.) Look for spurts, squirts, etc - basically anything other than a nice even cone-shaped spray. Poorly atomized fuel may not burn completely and result in some fuel getting to the crankcase. Also look for a CLOGGED injector. A clogged injector will make one cylinder run very lean, but the computer which looks at the average will try to compensate by richening up ALL injectors and net result is engine running very rich on 3 cylinders and lean on 1 cylinder. Don't forget to check the cold start injector if installed - some engines have them, others do not depending on year and type of injection system.

Other Running Problems:

Car Stalls Repeatedly on Startup: Fuel Pump Check Valve. [Inquiry:] I have a 1985 740 GLE and every morning when I start my car it will stall approx. 3 times before leaving the driveway. After this it works fine, and if I park the car and then come back a while later it starts right up and is fine. It just seems to have a problem when it’s been sitting a while, i.e. overnight and getting to/leaving for work. It has new Bosch platinum plugs as well as new ignition wires. And this problem occurs regardless of the temperature both summer and winter in upstate NY. [Response: Steve Seekins] This sounds like a classic fuel pump check valve problem. The check valve is there to prevent the fuel from draining back to the tank when shut off. In the AM, try ticking the starter just enough to make the fuel pump run for a second or so - but not enough to start the car. Do this 3 times, then start the car. If it starts and runs normally without stalling, replace the check valve located back at the fuel pump. Other things to check - make sure that throttle body is clean, check injector seals, wiring harness, etc. Clean, replace, repair as needed. Consider running a can of BG44K through the fuel system to clean it -particularly if this car has not had regular maintenance of the fuel system.

Car Stalls, Lights Die: Electrical Ground Fault. [Inquiry:] Does anyone know if the bulb out sensor box can cause a dim headlight intermittantly. Sometimes if at a stop light or parked, if I turn on the brights the engine will die. Also sometimes the rt. turn sign and bright indicator on the dash appear to be dim when they shouldn't be lit at all. [Response:] There is a ground bar on each inner front fender. Make sure all of these wire connectors are clean and tight. I forget what else grounds here but a dirty/ loose ground at this grounding point will cause the engine to die and also dim headlights. Check both ground points for the inner fender area for being loose and/or dirty.

Car Over-Revs RPMs While Under Acceleration. [Inquiry] I occasional get an over-rev when accelerating hard. The car is a 940 Turbo with a manual transmission and overdrive. Typical symtoms appear when I accelerate in third or fouth; there is an increase in engine revs without the increase in speed. [Response: JohnB] The condition is called "flare"; you have clutch slip or clutch slip in the overdrive unit. Bring it up to 50mph in 3rd or fourth (somewhere around 3500 rpm, your choice/speed) and use full throttle with your other foot on the brake to maintain speed....engine speed should not increase.

LH-2 Cold Idle Problems -Bad ECT or O2 Sensor and Wiring Harness Notes (BB) The block temperature sensor (ECT engine coolant temperature sensor under the intake manifold) plays a big part in cold running decisions and could pre-maturely allow the O2 sensor signal being used before the engine is warm. Because of this a cold idle problem rarely involves a faulty O2 sensor, but may involve the temp sensor and more specifically the wiring at the temp sensor. My experience is that this usually leads to quite rough running at all times, but fast idle and poor acceleration are known symptoms. With the ignition on and all wiring in place, you should see voltage at the temp sensor terminal connected to the blue (or orange) wire that goes back to the ECU. See Diagnosing ECT Failures for more information. No volts means broken wiring or bad ECU. A bad ECU may actually just be a bad ground at the ECU, so be warned. A cold engine should read 2-4 volts, a fully warmed engine 0-2 volts. If you see the full supply voltage of 4-5 volts (the reading you should get from the ECU when the connector is pulled off the temp sensor) then the temp sensor or its ground wire are faulty.

The temp sensor wiring goes into the wiring harness and along the firewall before joining with the O2 sensor wiring and going through the firewall to the ECU behind the right side kick panel. If you have a general wiring harness deterioration problem then a fair bit of digging and careful tracing may be required to isolate the problem. You can splice in your own repairs, but for extensive problems a total wiring harness replacement may be needed.

Automotive wiring from your local retailer is often not up to the job of being near a hot engine. If possible, make your splices using heat resistant wiring (like oven/stove wiring from an appliance parts/service shop). Also use heat resistant connectors (nickel or copper) rather than auto grade (aluminum), you should be able to get them at the same place. Heat shrink tubing can be used to insulate the connectors and can also be used to insulate short runs of bare wire. Better quality shrink tubing is available from electronics/electrical or appliance supply houses.

BTW Cheap PVC clad wire, electrical tape, shrink tubing, dielectric grease, etc. should not be used at the O2 sensor lest it melt and burn from all the exhaust manifold heat. If in doubt, test a scrap for heat resistance.

So, with wiring harness problems in mind, resolve to keep your engine compartment a little cleaner so that engine oil and road grunge buildup on the wiring doesn't hasten deterioration of the insulation. If your engine is weeping oil onto the head then get the valve cover gasket and/or camshaft seals attended to. You don't have to become a fanatic and start waxing the firewall, just use detergent and an old wash mitt and maybe the occasional spray-can of engine degreaser. When rinsing off, avoid drowning your distributor and ignition control unit. Everything else is pretty much waterproof (actually the ICU is also normally waterproof, but why take chances).

Car Won't Start: Neutral A/T Safety Switch at Fault. [Inquiry:] Starter will not operate when ignition turned to "start". [Response:] I've had a starting problem with my 89 744GL, and discovered that the 'neutral safety switch' was the culprit. It's a device in the base of the (automatic) shifter that will only allow the car to start in neutral or park. Mine had worn to where the contact wasn't always made in neutral or park either, so I bought a new one at the dealer ($48) and it was simple enough to install.

Car Won't Start; Plugged Catalytic Converter. I hate to post another "my car won't start" question, but "my car won't start!" This is an '87 240 B230F, 196k miles, LH-J 2.2, Chrysler Ignition with Bosch Distributor. The car cranks over properly. Fuel pumps both verified running. Injectors generate "clicking" noise indicating operation. Measured resistance of all 4 injectors - all correct. Sparks happen at spark plugs. Verified distributor points at #1 when both #1 cam lobes point up. Spark plugs fire at correct time (as close as I could estimate with timing light.) Tested all I/O to ECU - all points had correct continuity/resistance/voltage per Bentley testing procedure. Tested Air Mass Meter - proper voltage & resistance on all points; no change when unplugged. Tested fuel pump delivery volume - ok. Checked resistance of coil - within spec. Suspected gas; drained tank and fuel lines, and added 3.5 gallons of fresh fuel. Installed new Cap/Rotor/Plugs/Wires. Verified proper operation of throttle switch. Compression good at 190/190/190/180. Two instances of flaky wiring noted, on oil pressure sensor and temperature sensor; verified both not shorting or grounding. All other wires look clean and almost new. Still no go. At this point, the car *almost* runs when you crank it. It sounds like it would if you just cranked it for long enough, but it never does. Occasionally, after standing a while, it will run badly for 10-15 seconds before dying. Spark plugs are wet after cranking. I have run out of things to check - I'm stumped. [Diagnosis:] Have you checked for a plugged exhaust system? [Result:] I pulled the plug from the test port just ahead of the cat, and it started and ran, with a loud hissing coming from the port. I disconnected the catalytic converter at the inlet, and found that the cat had broken up inside. A large piece had bounced forwards and become firmly lodged in the inlet, blocking almost all flow. I removed the piece, and the engine started up promptly and ran very well, albeit loudly.

TURBO-SPECIFIC SYMPTOMS:

Turbo has Poor Acceleration; Diagnostics. [Inquiry:] Symptoms: When I give it gas the turbo boost goes into the yellow, however, acceleration is sluggish. The car fights me all through acceleration. It starts fine and has a new turbo. Diagnostics: See the Engine: Turbo sections on Basic Diagnostics and the sections following for more tips. You likely have a leak in the intake system.

Turbo Suffers Severe Misfire: Leaking Intake System. [Symptoms] Passed someone on a two lane road at full power. A mile of two later the car starts to vibrate from what feels like the transmission, even when coasting. As we begin to accelerate the vibration starts again and it loses power. After I drop it into 2nd gear, it revs and seems to be running better. Go back into drive and drive the car gently, seems to be ok. [Response: Jason R.] You blew or popped off a turbo hose: check those hoses. I had a small tear one time which would not let me get past 40-50mph but would run fine below that. [Editor] A leaking turbo hose will enrichen the mixture, causing misfire in multiple cylinders. Opening the throttle will worsen this significantly.

Engine Cuts Out; Rich Running: Turbo Electrical Harness Degradation. [Tip from

Jeremy] Symptoms in my turbo were cutting out and dieing when driving then restarting with no problems, not starting after sitting 8 hours and being totally flooded. Fuel was weeping out the manifold! The cause of my problems: The power wires from the injector to the turbo injection resistors were shorting together or to ground (note: non-turbo cars do not have these resistors). This would cause the injectors to open and stay open all the time in one or more cylinders. I found this by attempting to test continuity through the wires and in the process of disconnecting the next connector it would cause a loss of continuity in the connector I had just checked. Lesson- disconect all connectors so you don't get the chance for a false good reading due to an unknown short between wires. In another case, the wiring harness for the injectors was rubbing against the bottom of the valve cover and had worn through three of the injector's wiring. Now the solution: Replace the wires from the injectors to the resistor pack in the forward left side of engine compartment and the wires going to the connector that feeds thru the fire wall. The four wires going to the firewall connector are the signal wires that give a ground to the injectors. They all end up at the same pin so if you want to connect them at the injectors and just rum on wire to the plug that will work too. I routed the new wires along the top of the engine away from heat sources. Splice the new wires as close as you can to the existing connectors if you are not planning to replace them.

760T Misfires; FI Resistor Pack Defective. [Symptom:] My 86 Volvo 760 turbo is running very rough.. when I tested the cylinders the #2 cylinder wasn't firing. After many hours of frustration I found a relay which is located next to the battery. This relay is a little box with four cylinders in it The cylinders are about 3 inches long with a radius of about 3/8 of an inch. five wires go into the box One attached to each cylinder and one going down the center. I presume the lone one is the constant power. On this box I saw one wire was dislocated. I re-attached this wire but the cylinder still wasn't firing. I then took of another wire and the #4 cylinder stopped working. I then attached the working electrode (off the box) to the #3 cylinder but it still wouldn't fire. I also though have a periodic problem. Sometimes when I am driving normally my car will start to misfire. If I floor it will eventually catch (3-4)seconds later. If I keep it floored it does go.. but when I release the gas to 1/2 it starts to putter out. Could this be the same problem? What is the name of this part? [Response:] What you are describing is the resistor pack for the fuel injectors. Only the turbo's have them. The Volvo p/n is 3531339 and Volvo lists it for $59.39 dollars US. There is one resistor per injector. We have seen the batteries corrode the connector over a period of time, from the lack of battery maintenance.

Hot Start Problems: Faulty Hall Sensor. [Note from Steve Seekins:] Note that if your car is a turbo, you do not have the crank position sensor, but you do have a hall effect sensor in the distributor that can also be the problem (cars with the crank position sensor do not have the hall sensor in the distributor).

Hot Start Problem: Power Stage Overheats. [Note from Boris] I had a hot start problem on my car. It drove me bananas. I would pop the hood just slightly after each frequent stop, and this reduced the frequency of the problem drastically. Why do you ask? Volvos, especially the turbo models generate enormous amount of heat once parked after a drive. This heat has no place to escape. It just sits under hood for a LONG time and can damage various components. I believed whatever part was malfunctioning must be under hood and not on relay board. Replaced Hall sensor needlessly. Problem was in the Power stage. Took it off, cleaned the contacts very well, and coated with dielectric grease. Next, I coated the heat sink side of it with thermal compound which to my surprise was not there before. This helps keep it cooler. For extra protection I taped a styrofoam cup over it (Yes I too can be frugal…) Problem gone. I was stuck the other day going 11 miles in 3 hours, and the car ran fine. It was so hot under the hood, I could have baked a good lunch under there.

GENERAL EMISSIONS CONTROL PROBLEMS:

Emission Control Problems: High HC, CO or NOx. Below are some generic diagnosis notes (non-Volvo-specific) to help you begin pinpointing why you failed the smog/emissions/MoT etc. tests.
[Excerpted from "Exhaust Emissions Diagnosis: The Precursor to Finding Engine Performance Problems", Larry Carley, ImportCar, June 2000.

GENERAL DIAGNOSIS. Elevated hydrocarbon (HC) emissions usually indicate ignition misfire due to fouled spark plugs or a bad plug. But high HC emissions can also be caused by burned exhaust valves (check compression), lean misfire (check for vacuum leaks, low fuel pressure or dirty injectors), or rich fuel conditions (excessive fuel pressure, leaky injectors or a dead O2 sensor).

High carbon monoxide (CO) emissions are a telltale sign of a rich fuel mixture. On newer vehicles with feedback fuel controls and fuel injection, leaky injectors, excessive fuel pressure and sluggish or contaminated O2 sensors are all possibilities to investigate.

Harder to diagnose are *elevated oxides of nitrogen (NOX) emissions.* NOX levels are affected by engine combustion temperatures. When the temperature inside the combustion chambers exceeds 2500°F, nitrogen combines with oxygen to form oxides of nitrogen, or NOX. Many engines rely on EGR to lower combustion chamber temperatures and reduce NOX formation to an acceptable level. When the engine is running at stoichiometric level (mixture at 14.7:1), NOX production ranges between 1700 and 2500 parts per million (ppm). Since NOX formation is a temperature-related reaction, lean mixtures cause higher NOX production. Mixtures leaner than 14.7:1 (stoichiometry) increase combustion temperatures and cause NOX production to increase. When the mixture reaches 16:1, NOX production drops off. To find the cause of NOX problems, you'll need to determine what's causing the engine to run too hot or too lean, or both. Causes here may include air intake or vacuum leaks; defective EGR valve, EGR vacuum solenoid or motor, or plugged EGR ports in the manifold; a failing or sluggish oxygen sensor; failing or contaminated air mass meter, carbon deposits in cylinders or on plugs; over-advanced ignition timing; fuel pressure too low due to plugged filter or failing pump; a failing catalytic converter; or engine overheating due to cooling system malfunction or overheated intake air due to air intake box thermostat failure.

IDLE EMISSIONS. A vehicle that has *sharply elevated HC or CO emissions at idle* will usually have a noticeable misfire and/or rough idle. The most likely causes here would be:

- Fouled spark plug(s);
- Shorted spark plug wire(s) or defective plug boot(s);
- Vacuum leak;
- EGR valve stuck open;
- Burned exhaust valve;

An extremely rich fuel condition can also cause elevated HC and CO at idle, while an extremely lean condition will only cause HC to rise abnormally. A leaky EGR valve can act like a vacuum leak and cause a lean misfire at idle. HC and CO will be somewhat higher as a cold engine warms up because the fuel system may still be running in open loop. Until the engine reaches a predetermined temperature and/or the oxygen sensor gets hot enough to produce a good signal, the ECU will supply a relatively rich mixture while the system is in open loop. A faulty thermostat that is stuck open or a defective coolant sensor may prevent the system from going into closed loop.

NOX emissions are always lowest during idle and decel because that’s when engine load and combustion temperatures are lowest.

ACCELERATION EMISSIONS. During acceleration, the engine momentarily drops out of closed loop and receives a richer fuel mixture for more power. During this time (depending on the system), the Airflow Sensor and the TPS sensor play critical roles in controlling the fuel mixture. Most fuel-injected engines have either a throttle position

sensor or switch that indicates when the engine is at idle. When this device indicates that the engine is no longer at idle, the on time of the injectors is increased to temporarily richen the fuel mixture. The same thing happens any time the engine comes under load and manifold vacuum drops. The AMM sensor tells the computer the engine is under load, and the computer responds by adding more fuel.
It is normal to see some spikes in CO during acceleration, but unusually *high CO readings* indicates that the fuel mixture is too rich. Possible causes might include:

- Flooded charcoal canister or a leaky purge valve;
- Defective mass airflow (MAF) sensor, or
- Defective throttle position sensor.

If the feedback fuel control system is working properly and there are no apparent sensor or purge valve problems, the catalytic converter may be contaminated or not functioning.
Elevated HC readings during acceleration indicate ignition misfire under load. The causes could be:

- Defective knock sensor;
- Weak ignition coil(s);
- Excessive resistance in spark plug wires;
- Arcing inside the distributor cap;
- Worn, fouled or incorrectly gapped spark plugs;
- Over-advanced ignition timing; or
- Lean air/fuel mixture.

NOX readings will rise sharply during acceleration and will peak a few seconds after the cruising speed is reached. If the EGR system fails to recirculate exhaust back into the intake manifold, combustion temperatures will rise causing an increase in NOX. The higher temperatures may also cause some detonation (spark knock) to occur, which may be audible when the engine is under load. *Causes of elevated NOX emissions during acceleration include*:

- Defective EGR valve;
- Leaky EGR valve plumbing or control solenoid;
- Carbon deposits in EGR manifold passageways;
- Carbon buildup on pistons and in combustion chamber;
- Over-advanced ignition timing;
- Defective knock sensor or too low octane fuel;
- Engine overheating (check thermostat, fan, coolant level);
- Exhaust restrictions or failing catalytic converter
- [Chris Herbst] Check for low fuel pressure due to bad pump, clogged filter, or a

bad (low pressure) regulator on fuel supply system.

CRUISE EMISSIONS. At cruise, the engine is lightly loaded and running at high rpm. Under these conditions, HC and CO should be low if the oxygen sensor and feed back control system are working properly, and the catalytic converter is in good condition.

High CO readings during cruise indicate a rich fuel condition. Causes here may include:

- Defective O2 sensor;
- Exhaust leaks upstream of the O2 sensor (check manifold gaskets and air plumbing
connections);
- Defective AMM sensor;

High HC during cruise would indicate a steady misfire or loss of compression (leaky exhaust valve).

DECEL EMISSIONS. When decelerating, the engine will typically either lean out the fuel mixture or shut the fuel off completely (some fuel-injected engines). The computer typically uses inputs from the Vehicle Speed Sensor, TPS, Airflow sensor, and engine rpm to determine when this occurs. When the throttle closes and manifold vacuum shoots up, the computer cuts back on the fuel. Normally, HC, CO and NOX emissions drop during deceleration because the engine is no longer under load and is receiving little or no fuel.

If *CO emissions remain high during deceleration*, the engine is receiving too much fuel.
Causes may include:

- Leaky fuel injectors; and
- Faulty VSS, TPS, or airflow sensor.

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	or Won't Turn

Abbreviations:

AMM Air Mass Meter
ECT Engine Coolant Temperature sensor
ECU Engine Control Unit computer (either fuel injection or ignition)
FI Fuel Injection
FPR Fuel Pressure Regulator
IAC Idle Air Control solenoid valve
TB Throttle Body
TPS Throttle Position Sensor
VSS Vehicle Speed Sensor

Maintenance, Plugs, Cap, Wires:

Spark Plug Notes. See Removing Spark Plugs, Re-Threading Spark Plug Holes, and Installing Spark Plugs for more information.

Spark Tester. [tip from Don Foster:] To test whether your plugs are receiving a spark impulse, try this. It's dumb simple and works flawlessly. How to build:
Go to your electronic junkbox, or the local electronics workshop, or to Radio Shack. Get:

A neon bulb, NE-2
About 15' of light-gauge stranded wire (insulated, of course)
An alligator clip
A collection of heat shrink tubing

Connect a 3-4' piece of wire to one lead of the neon bulb. Insulate the solder connection with heat shrink. Attach the alligator clip to the other end of the wire. This is your GROUND WIRE. Connect a 10-12' piece of wire to the other lead of the neon bulb. Insulate the connection with shrink tubing. This is your ANTENNA WIRE. I like to put a larger (diameter) piece of shrink tubing over the bottom part of the bulb, including the other shrink tubing for mechanical strength.

How to use:
Find a convenient, out-of-the-way location for the bulb (preferably out of the light). Connect the ground clip to metal chassis. Feed the "antenna wire" through the firewall and over the engine. Take pains tosecure it away from moving stuff, like the fan. Wrap the "antenna" around one plug wire about 15 times, and tie the end of the wire back over itself. DO NOT electrically connect the "antenna" to the plug wire or to anything else. It picks up the electrical pulses by induction (hence the term "antenna").
Anytime there is a spark pulse in the wire, the neon bulb will flash -- dimly, but still flash. This does nothing to the effectiveness of the ignition system, so can be left there for a month or a year. When the engine's running, the bulb will flicker. When you're cranking the engine on a cold, rainy morning, you can watch to see if there's spark. If you have a similar test light attached to the fuel pump, you can see if the pump's powered.

Cap and Rotor. B2XX engines come with rear-mounted distributors (between the valve cover and the firewall) and block-mounted distributors as in the photo to the right. The latter are prevalent on Rex-Regina powered cars, mostly 94 or 95 vintage.

B230 Engines. [How do I remove my cap and rotor: it appears to be right next to the firewall? [Response: Various] Carefully pull off the spark plug wires from the cap. They will be stuck due to heat, so use a gently twisting and pulling motion on the boots. You may need to pry up a little on the boots t

Side-mounted distributor on Regina B230F

unstick them. Use an 8-mm wrench and remove the three bolts securing the cap. Pull the cap straight back and off. The rotor is tightly secured by press fit on the shaft and usually must be pried off with a large flat-bladed screwdriver. Remember the rotor orientation. To install, press the rotor back on, inserting it so that the keyway fits, and make sure it bottoms on the shaft. Reinstall the cap. Using silicone dielectric grease, coat the inside of the wire boots and reinstall. Press down firmly on the boot tops until the wire "clicks" into the cap.

B234 Engines. [Jeff Saeger] Removing the cap and rotor with nearly zero clearance: Remove the wires from the cap; this gives more room and allows space for the screws to clear the head when the cap comes off. Make a drawing or mark so you get them back on correctly. I use a box or open end wrench on the "screws". This allows getting at them from the side. I think there are 3 screws, but one is in an apparently low or difficult to see spot. To get this one I loosen the bolt which allows the distributor to rotate, careful that you mark the spot (althhough it was obvious from dirt makes and all on mine, so you can get the timing back on. By rotating the distributor you can get that last bolt.

Plug Wires. [Editor] While people are welcome to try the variety of plug and coil wires on the market, many of which promise miraculous power gains, the only brand that consistently works, fits perfectly, and lasts a long, long time is the OEM wire set from Bougicord. Buy these from Volvo (in which case you get the upgraded Class F with thicker silicone insulation) or from a specialty Volvo retailer such as IPD, RPR, or FCPGroton who all sell the Class E versions. Other wire sets (especially "performance" brands) may lack proper interference suppressors, in which case you may interfere with radios, air bags or ABS modules. Anecdotes on Brickboard show disapproval of Magnecor and approval for Kingsborne wire sets.

Firing Order and Reinstalling Plug Wires:

B230F/T or B234 Four Cylinder: Firing order 1-3-4-2.

- Rear distributor: Left-to-right terminals are 4-3-1-2
- Side distributor: Front terminal is 1, thence clockwise around to 3-4-2
- Plugs: Front-of-engine-to-back: 1-2-3-4

B280F Six Cylinder: Firing Order 1-6-3-5-2-4

- Rear Distributor: Front passenger side terminal is 1, thence clockwise around to 6-3-5-2-4 ending at front driver side terminal
- Plugs: Passenger side front-of engine-to-back: 6-5-4; Driver Side front-to-back: 3-2-1

Wire Grades. [Rick Tilghman] Bougicord makes two spark plug wire grades: grade E and grade F. The grade is stamped on the wire. Volvo OEM wires are Grade F. According to Bougicord's website the following distinguishes the two grades:

- grade E: max temp = 160c, min temp = -30c, thermal overload = 220c
- grade F: max temp = 180c, min temp = -30c, thermal overload = 250c

Installation. [from Bougicord] To replace your ignition wires:

1. Make sure the engine has cooled down before attempting to remove any of the ignition leads.

2. To assure correct firing order, remove and replace only one ignition lead at a time, starting with the longest lead first. The numbers on the leads match to the cylinders and assure a correct firing order.

3. Remove any clips and wire separators, and then grasp the ignition lead end terminal and boot, do not pull the cable. Remove with a steady rotating pull. (Avoid the use of pliers, screwdrivers, or other tools to remove the spark plug boot.) Clean off any excess grease found on the spark plug end or coil tower with a soft cloth and isopropyl alcohol.

4. [Editor] Insert a small amount of silicone dielectric grease into both boot and nipple and coat the insides of them with this grease to keep out moisture/ dirt and ease removal.

5. Attach new wire to the spark plug. Reattach clips and route the new wire back through the separators again to the distributor cap or ignition coil. This will assure that you have followed the original wire routing which is designed to keep the wires away from all linkages, the exhaust manifold, other hot surfaces, and any sharp edges.

6. Place distributor end terminal and nipple over the distributor cap or ignition coil and firmly attach new wire.

7. Installation tip: When you attach the wire end onto the spark plug, distributor cap, or coil, listen for and feel for a click. This click indicates that the snap lock terminal has fully engaged.

Ignition Function:

Bosch or Rex-Regina Ignition? [Inquiry] How do I tell which ignition system my car has? [Greg Shutt/Bob/Don Foster] Open your hood and look for the coil. If it's a Bosch system, the coil will be a cylinder mounted on the passenger-side firewall. If it's Rex/ Regina, the coil will look more like a square transformer thing mounted on the driver's side strut tower. The "air mass meter" is another difference. The Bosch air mass meter attaches at the air cleaner box and has a large hose going to the intake manifold. It should have a 5 wire connector. Regina system has a similar looking device which is an intake air temperature sensor attached to the air box with a hose going to the intake manifold. Instead of a 5 wire connector, it has a 2 wire connector. The illustration to the right shows the Rex-Regina system components. See also Fuel Injection.

Rex-Regina Coil and Air Temp Sensor

Note that the components for Regina differ from Bosch and you need to keep that in mind as you read FAQ notes. For example, the Rex system integrates the ignition power stage amplifier into the coil; Bosch has a separate unit.

Basic Operation and Troubleshooting of the EZ 117K [Don Willson]

This discussion is based on my 3 cars all of which have the EZ-117K Jetronic Ignition which is for the 4 cylinder engine, with distributor on the rear of the cam shaft, the timing signal is from the Hall effect sensor within the distributor or an RPM sensor on the flywheel, air is measured by an air mass meter, it has a knock sensor, and throttle position switch.

I have had three 740s and though I am not a professional mechanic I'm a pretty good DIYer. I seldom use a dealer or independent shop unless time or tools require it. I am an engineer and like to know what's wrong and how that affects the engine My basic reference are the Volvo shop manuals, especially the electrical, engine and ignition manuals. [Editor's Note: see the section on Maintenance Manuals for more details on how to obtain the correct versions for your car.]

I will try to show a systematic approach to based on a chronological order where applicable.

Starting: Turn key to “run”
Power is supplied to the IGNITION CONTROL UNIT , hot side of the COIL, POWER STAGE, and most accessories.
Turn key to “start”
Power is removed from most accessories and applied to the STARTER SOLENOID. (if the car is equipped with automatic transmission it must be in Neutral or Park)

The starter pinion gear meshes with the ring gear, the high ampere connection made and the starter motor operates.

Engine turns over. The sequence of events is as follows.

IGNITION CONTROL UNIT (ignition computer) sends power to the DISTRIBUTOR.
The HALL EFFECT sensor in the DISTRIBUTOR (LH2.2 systems) sends a square wave electrical signal that varies from 5 to 0 volts back to the IGNITION CONTROL UNIT. As the signal rises from 0 to 5V the control unit starts to compute the timing of the next ignition pulse. As the signal falls to 0V the control unit commences ignition countdown and delivers ignition pulse as computed. [Editor's Note: this is true for pre-88 cars; newer Volvos with LH 2.4 use an RPM SENSOR at the flywheel for the same effect.]
When the IGNITION CONTROL UNIT gets this signal it says “the engine is turning over, let’s give it some fuel and spark” (I presume this is a safety function so that in case of an accident the fuel will not be delivered to a dead or damaged engine.). It sends the appropriate signal to the:
POWER STAGE (ignition amplifier). This feeds the coil which then send high voltage to the center tap of the distributor where the distributor sends the high voltage on to the correct spark plug.

FUEL CONTROL UNIT (LH-Jetronic.) This unit collects signals from the AIR MASS METER (AMU), COOLANT TEMPERATURE SENSOR, THROTTLE SWITCH, OXYGEN SENSOR (Lambda sond), and:

> grounds the FUEL RELAY which (hopefully) turns on both the IN-TANK FUEL PUMP and the HIGH PRESSURE FUEL PUMP.
> Fuel then flows under pressure, in the 30 to 40 PSI range (though the pump is capable of pressures up to 80 PSI), into the fuel rail. At the front end of the fuel rail is a PRESSURE REGULATOR that maintains a pressure in the 30 PSI range though it varies according to engine vacuum. A higher vacuum, as when idling or running lightly, allows more fuel to flow back to the tank and the pressure is reduced in the fuel rail. When under higher pressure or even turbo boost the pressure in the fuel rail is higher and more fuel is delivered for the same amount of injector open time.
> Opens the INJECTORS for the appropriate time. Note, since this is not a sequential fuel injection system, all INJECTORS fire at once and timing is not an issue other than that they fire each half resolution, so that fuel is in the intake manifold ready for any intake valve to open.

Now the engine starts, however, there is more to it.

> If the engine is cold, like the first start in the morning, the AIR CONTROL VALVE opens and acts like a fast idle cam on old non fuel injected cars. The controlling signal on this is the COOLANT TEMPERATURE SENSOR. Generally only a few seconds is needed for this to be open, however, under some conditions it closes, the idle speed drops significantly and it opens again.
> There is no choke but since the choke only forces a rich mixture the FUEL CONTROL UNIT will open the injectors more times and/or for longer periods.

As the engine warms up various signals are supplied to the FUEL CONTROL COMPUTER to modify the INJECTOR open time. For example:

> The COOLANT TEMPERATURE SENSOR sends a signal to the FUEL CONTROL COMPUTER that less enrichment is needed (like a choke backing off)
> The AIR MASS METER supplies the engine load as it measures the amount of air being delivered to the engine, as a function of the THROTTLE position, and sends this signal to the FUEL CONTROL COMPUTER for use in determining the optimum mixture
> The OXYGEN SENSOR warms up and begins to send a signal to the FUEL CONTROL COMPUTER that in real time varies the mixture to maintain a mixture that delivers power with minimum emissions.
> The KNOCK SENSOR ‘listens’ for the characteristic sound of a knock and sends a notice to the IGNITION CONTROL UNIT which retards the spark in steps of 2.8° up to 10° to 16°, until knocking ceases. Then it advances the spark in steps of 0.37° until, if possible, it return to the normal advance.

After fully warmed up and running the COOLANT TEMPERATURE SENSOR is continuously monitored and if it indicates an overheat condition it advances the timing by 13° if the throttle is closed on the B230FT engines.
The THROTTLE SWITCH senses when the THROTTLE is closed, foot off of the gas, on of two things happen:
If the engine is turning over rapidly, above idle speed, the spark and fuel are adjusted to give the maximum engine braking.
When the engine drops to near idle speed the spark is retarded so as to provided a smoother idle.
After Shutting Down
One item occurs after the key is turned off, that is that a voltage is sent to the AIR MASS METER to burn off contaminants that have accumulated.
[Courtesy of Don Willson]

Using OBD Codes to Troubleshoot EZK Ignition Problems in Later Bosch LH2.4+ Systems. See Engine: Diagnostic Codes for instructions on how to read both ignition and fuel injection computer trouble codes from the diagnostic boxes in later Bosch LH2.4 systems.

Using Diagnostic Outputs to Troubleshoot EZK Ignition Problems in Earlier Bosch LH2.2 Systems. Despite not having a diagnostic box, you can still read some trouble codes using an LED diagnostic reader. See Engine: Diagnostic Codes for instructions. You can also follow the steps below, depending on your ignition model, to test various ignition components and pinpoint faulty units using simple electrical tests.

Measurement Test	OK if:	Diagnostic Notes
Renix-F (B200K)		
at Connector A:		
Terminal 3 & Ground	>= 9.5V	Check fuse #12 and connector at A-pillar
Terminal 2 & Ground	<= 0.1 ohms	Check connector at LH wheel housing
at Connector B:		
Terminals 4 & 5	220ohms +- 60 ohms	Check/replace pulse generator
at Connector C:		
Terminal 8 & Ground	should have voltage w/ ignition advance relay engaged (car	
at Control Unit:	in drive or A/C engaged)	
Terminals 3 & 9	<= 0.1 ohms	Check/replace unit
at Coil:		
Primary coil windings:	0.6 +- 0.2 ohms	
Secondary coil windings	4000 +- 1500 ohms	

Measurement Test	OK if:	Diagnostic Notes
EZ 117/118 Series for Bosch LH2.2		
at Power Stage Connector:		
Terminal 1 & Ground	12V w/ ignition on when rotor is firing	Check fuse #12 and connector at A-pillar
Terminal 4 & Ground	12V w/ ignition on	Check connector at LH wheel housing
Terminals 1 and 4	Resistance matches coil specs	
Terminal 2 & Ground	0 ohms	
Terminal 5 & Ground	2V w/ leads disconnected from coil terminals 1 & 15, when operating starter motor	
at EZK Hall sensor wiring:		
Terminal 3 (red) & Ground	12V w/ ignition on	
Terminal 2 (blue) & Ground	5V w/ ignition on	
Terminal 1 (black) & Ground	0 ohms	
EZK coil resistance:		
EZ-102K	0.6-0.9 ohms (pri), 6500-8500 ohms (sec)	
EZ-115K	0.6-1.0 ohms (pri), 6500-9000 ohms (sec)	
EZ-117/118K	0.6-0.9 ohms (pri), 6500-9000 ohms (sec)	
at ICU Connectors:		
for EZ-102K (B23FT)		
Terminal 1 & Ground	12V w/ ignition on	

Terminals 1 & 11	12V w/ ignition on (#11 is ICU ground lead)	
Terminal 5 & Ground	no continuity (test connector)	
Terminal 4 & Ground	0 ohms w/ throttle closed, increased resistance w/ throttle open (TPS)	
Terminals 8 & 15	continuity w/ leads at knock sensor connector jumped	
Terminal 14 & Ground	approx 11V w/ ignition on (load signal from ECU)	
for EZ-115K (B280E/F) / EZ-117K (B230F/B230FT) / EZ-118K (B200E/ B230E/K)		
Terminal 6 & Ground	12V w/ ignition on	
Terminals 6 & 20	12V w/ ignition on (#20 is ICU ground)	
Terminal 20 & Ground	0 ohms (ground)	
Terminal 3 & Ground	no continuity (test connector)	
Terminal 7 & Ground	0 ohms w/ throttle closed, non-zero w/ throttle open (infinite resistance should not be seen at the ICU) (throttle switch)	B230FT, B280 only
Terminals 7 & 11	0 ohms w/ throttle closed, infinite resistance w/ throttle open (throttle microswitch)	not B230F/FT
Terminals 11 & 25	1900 ohms w/ coolant at 22C Terminals 12 & 13: continuity w/ leads at knock sensor connector jumped	B230K only
Terminal 8 and ground	approx. 11V w/ ignition on. (load signal from ECU)	B230F/FT, B280 only
Terminals 10 & 23	500-600 ohms (crank position sensor)	B280 only
Terminal 2 & Ground	proper resistance for coolant temp (coolant temp sensor)	B280 only
Terminals 12 & 13; 24 & 25	continuity w/ knock sensor connectors jumped	B280 only
Terminals 18 & 19	0 ohms (Cyl #1 sensor)	B280 only

Troubleshooting:

Car Won't Start; Ignition Diagnosis. [Problem:] This morning my 86 740 GLE (B230F) started and ran for approx. 30 seconds then died and will not restart. No spark exists at the coil (replaced coil with new one no change). The fuel relay does kick on after taking the ignition switch from start to run. [Response:] Ok let's go thru a general no start fault trace:

1. Is the transmission in a gear other than "Park"?
2. Is there gas in the tank?
3. When you turn the key on does the pump run for about 1 second? From your post I would assume that the answer is yes. This indicates that the fuel pump runs and the relay and ECM are capable of turning it on.
4. When you put the engine to crank does the pump run during the cranking? Again you said yes, as you deduced this indicates that the hall switch is working
5. Iis there spark at the coil itself? (to test pull the coil wire part way out and have someone else crank the engine) If the answer is yes then the problem is in the distributor secondary (cap, rotor, wires) If the answer is no continue.
6. Is there voltage present at the coil low tension terminals with the key on? (and are all the wires connected?) If no fix, if yes continue
7. Is the power stage connected? yes? remove the connector and examine the terminals on both the power stage and connector if they are corroded they will need to be cleaned. Still no start continue.

Regina-Equipped Cars: [Chris Herbst] The coil, which is an expensive beast ($200), will (here is the voice of experience) cause random no-starting though not stalling. See Bosch vs. Regina for identification.

Ignition Failure after Hot Soak: Won't Re-start. [Symptom:]My 1988 744 Turbo with EZK 117 ignition starts and drives fine with A/C on in 95 degree Maryland weather for about 30 minutes. It won't start once it is turned off. A strobe test shows no spark. It sits for several hours (cools down presumably) and then starts right off. In its disabled state there is system voltage registered at both sides of the coil and at terminals (1) and (4) of the Power Stage amplifier.

Diagnostic Tips. Next time you have a hard ignition failure pull a plug wire, insert an old spark plug, ground the outside and check for spark. If you don't have it, go to the coil center high tension lead and check for spark. Next ground the coil's high tension lead and put a meter on the coil's 12v terminals. No 12v switching? Since most systems apply 12v and switch the ground lead, if there is no 12v at all, check the power lead to the ignition, wiring, fuse etc. If you do have 12v but no switching then check the Hall sensor in the distributor. Disconnect the leads from the reluctor (in the distributor) from the ignition module and measure with a sensitive DMM. You should see some small voltage as you crank. At this point you've checked the power to the ignition module, the sensor, and the spark delivery path. That means the only thing left to do is repair/replace the ignition module.

Diagnosis: LH 2.2 Systems. First, check for a cracked and/or oil-contaminated harness connector on the side of the distributor. If this is okay, then replacement of the Hall Sensor in the distributor is the fix. Heat rises in the stopped engine and increases temperature of the rear-top-mounted distributor. A weak Hall breaks down and ceases to send pulses to ignition control module; hence, no spark. Be careful not to bung-up the rivet holes in the distributor body when you drill out the Hall attachments; you need a good lip for the new sensor rivet ends to crush against. Mount two bolts in a vice and use them as supports for the inner ends of the rivets as you mash the outer ends with a drift. [More on Hall Sensor:] Best idea when replacing the Hall Sensor is to take the whole unit (just the bracket) to a dealer and ask them to drill the old one and put the new one in. The rivets on the Hall are harder than the aluminum bracket plate so if your drill slips out you will have to buy a new distributor cause you can not buy just the bracket. If you replace it yourself, you will need the help of a second person to put the sensor back on. It has 2 rivets that need to be drilled out. When you place the new one on you need a second person to hold it squarely over a punch so you can peen the rivets in place. There are instructions in the Volvo manuals. Be sure to note the way the collar with ears comes off. [Contrary Opinion on Hall Replacement:] Although Volvo sells the Hall sensor separately from the distributor assembly, a new distributor is usually more cost-effective for two reasons: First, installing the mounting rivets in a new sensor is awkward, tedious work . Because the sensor location prevents you from getting a straight shot at the rivet heads, it's very difficult to drive the rivets in securely. Second, bushing wear is common in higher-mileage Volvo distributors. You can usually feel the wear-lateral movement in the distributor shaft-with the distributor removed from the engine. A sloppy distributor shaft usually goes hand-in-hand with distributor oil leaks, especially through the seal protecting the inside of the distributor.

Diagnosis: LH 2.4 Systems. No-hot-restart problems are almost always due to failures in: fuel injection relay, radio suppression relay, or rpm sensor.

Does My Car Have a Hall or RPM Sensor? You can quit worrying about the Hall sensor if you have a 89 or later non-turbo or 90 or later turbo. The Hall sensor is gone in favor of the RPM sensor on top of bell housing. In these cars, there is no plastic wiring connector on the side of the distributor plate and no wires into the distributor other than the high-tension spark leads to the cap. The illustration shows the Hall Sensor distributor and the arrow depicts the sensor.

LH2.2 Hall Sensor Distributor, Courtesy FCPGroton

Testing Hall Sensor. *Failure Modes.* The Hall Sensor distributor can fail through broken wiring insulation, a broken wiring connector at the side (this embrittles over time due to engine heat), or a failed Hall Sensor.

Quick Hall sensor test:[Note from Dave] the tachometer needle does jump slighty as you crank engine over if the Hall sensor is working, but the needle lays dead if the sensor is not working.

Full Hall Sensor Test: Undo the distributor connector. When the ignition is ON the Voltage between positive terminal (red lead -Nr. 3) and ground should be approx. 11V. Voltage between (blue lead - Nr.2; middle one) and ground should be 5V although if you put it on a scope you would see the sharp rise and fall from 12v to ground as the distributor rotates. Pulse frequency varies as rpm is increased. . Resistance between (black lead - Nr. 1) and ground should be close to zero Ohms. Undo connector from the control unit (above the brake pedal) and remove the sealing washers (plastic inserts on the side of the connector). Replace connector without cover or sealing washers.

- Disconnect the/red and blue leads from ignition coil. - Measure voltage between terminal 24 at rear of control unit connector (blue lead) and ground. NOTE: Connector must be attached to control unit. Switch on ignition. Turn crankshaft by hand. Voltage should indicate OVER 1.8V each time a vane passes Hall generator. Instrument should read approx."0" (0 - 0.7V) each time an opening passes Hall generator. The correct voltage is less than 0.7V or more than 1.8V.

Replacing RPM or Hall Sensors.
RPM Sensor: If your car is a non-turbo 89+ or turbo 90+ model then it has a flywheel reading RPM/Position sensor that is down below the rear of the cylinder head, mounted on the bellhousing through a bracket retained by one bolt that should be a 10mm head on a 89. It is connected to wires above the engine on the firewall.CAUTION: [Chris Herbst] Never pry the RPM sensor out of the flimsy internal bracket to which it is attached. Spray a tiny bit of penetrant around it if you have to, but not enough to leak down on the clutch if it's a manual trans car. And if you have the trans out for any reason, take the RPM sensor out--whether or not you reuse it--and coat it LIGHTLY with a film of grease. That will avoid the problem, should the sensor need replacement in the future. See Crank Position Sensor for more information.

Hall Sensor: If it is 89 turbo or pre-89 NA then it has a Hall switch that is in the distributor to sense engine rotations. The Hall switch is tough as it requires that you knock out a pin and pull out the shaft, then VERY carefully drill out a couple of pins that retain the hall switch. Then you have to be very careful about supporting the distributor base while bradding the retainer pins to retain the new hall switch. If you slip while bradding the pins then you punch out a hole in the base and then you need a new distributor. [Response:] Changing that is not for the novice. It is riveted into the distributor. Some dealers offer rebuilt exchange on the distributors. Before you jump to the hall sensor, carefully examine the wires from the firewall to the distributor, which sometimes break inside from years of flexing. These can be repaired with a little work. Also, check the brittle plastic connector where the wires go into the distributor. This can cause intermittent shorting. The plastic fitting is Volvo PN 1346793, about $3.00 as I recall. If you are going to remove the distributor for any reason, carefully scribe a mark to return it to its exact former position so as not to change the timing (the holes in the distributor are slotted). Finally, check for any shaft wear on the distributor: wobbling is abnormal.

Removing the Distributor Shaft. [Response: John Sargent] The hardened pin in the drive dog can be tough to remove in order to take out the shaft and tigger wheel. I have a drill press vice which has a V-groove in it for gripping shafts. I clamp the shaft in the drill press vice, and drive the pin out. You will have to have a good pin punch of the right size. You may break or bend a pin punch that is too small. Take carefull note of the previous post regarding the rivets. The pot metal base is easy to damage. A good alternative is to buy the base complete with Hall sensor and seals from IPS in Boise for just under $100. The Hall sensor runs over $60 from Volvo, and RPR quoted me about $90. [Jim] Mark the slot drive in relation to the rotor notch- it can be installed 180 degrees out. Punch the retainer pin out- use a good punch and a solid surface to support the drive. The pins can be quite tight. Remove the drive, collect and count the thrust washers, remove the shaft from the housing and collect those washers too. There may be some fiber washers which are not replaceable. There is a serrated steel washer peened into the aluminum housing- pry it out, trying not too bend it too badly- It can be straightened with a hammer if need be. Pop the seal out, clean the housing, push the new one in, carefully tap the steel washer in (don't worry about peening it in- it can't go anywhere anyway. Assembly is reverse of removal.

Replacing the Hall Sensor. [Response: Jim] Plan to use a Dremel or die grinder to grind off the two rivets or you will punch out the thin aluminum of the housing, and will be buying a new distributor. [Response:] I've done few of these. Never alone, however. Drill out the old rivets carefully and pry out the sensor. Next, have an assistant you can trust with approximately $ 70.00 hold the new sensor in its proper place on the distributor plate. Place a steel punch of roughly same diameter as the rivets into the bench wise. Have the assistant hold the D. plate in such a way that the rivet is directly over the punch. Now, YOU, using the second punch and a hammer CAREFULLY hit the top part of the rivet. It will take MANY hits since these darn rivets are made of steel. The key here is steady hands, and frequent breaks. One wrong move, and you are done. Simple physics tell you which, steel or aluminum will crack first under

constant hammering. This is akin to putting a horse shoe onto an a hard boiled egg, possible but very nerve wracking.
[Response: Jim] To rivet the new sensor in place, take a 5/16 bolt about 5 inches long and drill a depression in the end of it to just fit over the end of the rivet in the new switch. You also must grind the end down in diameter so it is only supporting the rivet, and not touching the plastic. Grab the bolt in a vise, get a friend to hold the distributor in place, and carefully peen the rivets. I have a very small chisel that works well, or a centerpunch will do the job. Don't overtighten the rivets- all that is needed is to keep the switch solid.
[Response: DanW] Don't let these warnings scare you off. It is really not a difficult job. When I replaced the hall effect sensor on my daughter's car, I followed the advice of my local mechanic and instead of peening the rivets I used JB Weld to fasten the new sensor in place. There are two or three O-rings that you should also replace. Replace the sensor connector and plastic ring which keeps the wires out of the rotating sensor wheel. My own caution: There are steel and fiber washers on the shaft. Keep track of their order and be very careful with the fiber washers. They are fragile (Don't ask.) and no one seems to have replacements. This is not a tough job. Just be careful and you can save yourself about $200 in parts alone. I bought new plugs, wires, cap, and rotor when I did this job. Total cost was about $200.

Reliability Tip. I would throw in a junkyard distributor to get back on the road, rebuild the original distributor with a new sensor, seals etc. at my leisure, and then swap in the rebuilt unit. This is one of the very few failures that can stop your 740 completely, so a big confidence boost can be gained by having a good spare distributor on board. It's hard to reach, but a practical road-side repair to change distributors.

Hall Switch Distributor Connector. While replacing the distributor cap and rotor on the 87 764T the Hall switch connector at the distributor cracked off some of the old plastic and wouldn't stay on the distributor base. Didn't crack any wires/insulation. This distributor is used at least through 90 (my 90 740T has the part) and so did an 86 B230FT engine I used the long block on the 87. (Illustration courtesy of Mike Ponte)

Distributor with Hall Sensor Connector

Removing the Wires. [Jim] The black wire retainer is usually broken away from the housing. I have found the best way to get the wires out is to VERY carefully grind the plastic away, finishing with the wire wheel, until the tab holding the individual wire in is free. Don't mix the wires up- the new housing is marked + and -. The white wire holddown will come off with a little screwdriver work.

Repair. The repair was quick and dirty...I mixed up some loctite filled epoxy and glued in the connector. The stuff sets up quickly and I baked it at warm (lowest possible setting) in the kitchen oven for 5 minutes. Seems to be working since I put it together and am driving the car. If it blows I still have the distributor from the 86 engine with the unbroken connector. [The plug is available at the dealer. I got one a year ago. I think I paid $6.00.]

Wiring at the Connector. [Tip from John Sargent] Here is the correct wiring at the sensor connector in case your wires came out. Looking down on the top of the distributor, with the Hall effect connector down, left to right: black, green, red.

Distributor R&R and Shaft Seal Replacement. Oil leakage from the distributor on engines with camshaft-mounted distributors usually originates at the distributor shaft o-rings. High engine temperatures can cause these o-rings to shrink. There are three seals: two outer o-rings and an internal shaft seal under the drive dogs. [Editor's Note: See Michael Ponte's excellent illustrations at http://www.mikeponte.com/volvo/dist.htm These picture a pre-89 distributor with a Hall switch, but are similar to newer ones as well.] Copies below:

[Inquiry:] I have the beginnings of an oil leak at the distributor o-rings (just beneath

Rear of Cylinder Head

Distributor O-Ring (Two are present)

the shaft on the B230F distributor.) According to Chilton's, it's easy to pull the cover, cap and rotor, remove the shaft, and pull the distributor out to replace both the big dust cover o-ring as well as the smaller o-ring inside on the shaft. Has anyone actually done this? Is access a problem? How about replacing the distributor: do you have to pay close attention to shaft alignment? [Another Related Inquiry regarding Timing:] My distributor appears to be seeping a small amount of oil on my 93 940 (sohc engine). I noticed this while doing the 90 kmiles service. I also noticed the PO or his mechanic ditched the plastic dust shield. First thing Monday, I'll get the dust cap as I'm thinking it will keep the rotor and inside the cap clean. But I'm thinking maybe its time to replace those nasty o-rings. Just one question, my book claims the timing is not adjustable. I'm kind of wondering how do I set the timing, if I pull the distributor and replace those o-rings? I can't find any info on this in my books.

Removing the Distributor: [Editor's Note:] The spark plug high-tension leads will probably be tough to remove if you did not use dielectric grease on the boots last time they were installed. Gently pry up the boots about one centimeter with a blunt blade that won't scratch the cap, then pull them off while holding the tops of the boots. [Response 1: Don Willson] Mark the spark plug wires and the Hall connector down below (if your car has one) and push the connector "hair pin" in and pull down. Remove the three cap screws with an 8 mm metric open end wrench. The screws in the cap are captive and will not drop out. [Hall switch distributors: Mark the position on the locking screws on the adjustment slot. Non-Hall distributors have a self-aligning plastic device, but you may want to mark the location of the distributor on the cam anyway] Pull the cap straight back. Remove the two 10mm distributor plate bolts. Pull distributor straight out the back, noting the position of the plate, rotor and offset eared drive cog. Draw a diagram so you can reinstall everything correctly and not 180 degrees out of alignment. Now is the time to test for shaft wear and wobbling.

O-Rings:
There are two outer o-rings on the distributor shaft visible when you pull out the distributor. [Kevin Lawlor] The small o-ring fits on the end of the shaft and the large o-ring fits on the housing. Use a little Vaseline to install easily. [Tip from JohnB] There are three O-rings, but the inside one (the center shaft seal, see below) is almost impossible to replace, just forget it. The big O ring on the housing is generally the leaker and the little ring on the shaft helps to keep oil out of the distributor itself. [John Sargent] According to Volvo TSB of March, 1988, you should use the green o-rings made of improved elastomer rather than black rings.

Distributor Shaft Seal Kit

Center Shaft Seal There is a center shaft seal inside the distributor plate that dries out and leaks oil. This shaft seal is hard to find.
Where to Find Center Shaft Seal: [Tip from John Sargent] If you have distributor shaft seal leaks in the 700 series with B230 engines (cam driven distributor on rear of head), the distributor o-rings are available from Volvo, but the shaft seal is not. A few weeks ago I even looked in the parts manual, and the shaft seal is not shown. Jim found that Honda part #91205-KF0-003 is a replacement for this seal. It works perfect. However, it is not stocked by many Honda mower dealers, and some want a $7.50 service fee to order a non-stocked part. The seal is about $2.50 US from Honda (#91205-KF0-003 Honda or Transcom #12X20X4TC). This seal is simply a metric seal, 12mm X 20mm X 5mm. It is for a 12mm shaft, it is 20mm OD, and 5mm thick. It is also a rubber coated (that's good) seal with two lips. As near as I can tell, the original seal Volvo used came both rubber coated and non-coated, and appears to be a single lip seal although I can't tell for sure. Now for the substitutions. Chicago Rawhide seal 4701 is exactly the same with a single lip. Transcom seal #12X20X4TC is a double lip seal, rubber coated, that is 4mm thick. That is what is in the distributor in my wife's 745T. When I installed the seal, I set it with the outer edge flush with the distributor housing. There is a 1mm gap behind it which won't hurt anything. You could also set it all the way back in the housing, and it should also be fine. It fits tight, and I doubt that it would ever move out against the seal retainer. The Transcom seal cost $1.82 US from a local bearing sales house. For those of you who can't get those brands of seals, simply contact a bearing supply company and tell them you want a 12mm X 20 mm X 5mm seal, preferably rubber coated with double lips.

How to Replace Center Shaft Seal: See John Sargent's excellent illustrated procedure to understand how to do this. [Procedure from Jim] To do this job, you need the seal (see above). Most likely, this is a good time to change the Hall sensor as well: see below.
Here are the basic instructions- ignore the bits about the parts you are not changing. Remove the distributor cap, rotor, and plastic shield, and remove the distributor from the head. Mark the slot drive in relation to the rotor notch- it can be installed 180 degrees out of alignment. Punch the retainer pin out- use a good punch and a solid surface to support the drive. The pins can be quite tight and it takes some determination with a pin punch to drive it out. For a special tool to do this, see the Special Tools FAQ section. Remove the drive, collect and count the thrust washers, remove the shaft from the housing and collect those washers too. There is a serrated steel washer peened into the aluminum housing- pry it out, trying not too bend it too badly- It can be straightened with a hammer if need be. Pop the seal out, clean the housing, push the new one in, carefully tap the steel washer in (don't worry about peening it in- it can't go anywhere anyway. Assembly is reverse of removal. [Contrary thoughts from Chris Herbst] Can I make a logical suggestion straight from the shop? Replace the whole distributor. On an 89 it is not an expensive proposition because there's no hall effect sensor on the distributor. The distributors for the later models are much less expensive, and you will drive yourself crazy trying to repair the inner shaft seal in the distributor as it is now. I hate that job and have since given in to replacement, which is often against my basic principles. In this case, it's such a breeze to replace the whole distributor that it wouldn't make sense to replace the center seal. *Fiber Washers.* If you have fiber washers in your distributor and you break one or more during removal, go to Home Depot, buy some similar washers, and drill or file and hand-sand the inner hole until it fits the shaft. The dealer will often be of no help with these small parts.

Orientation: Mark all removed pieces and their orientation. The cogged driver can be installed 180 degrees in reverse and the car will not start.

[Pin Removal Tip from Tom Irwin:] The solid pin should be much easier. Generally, pressing the pin out with static force works better than shock force. Use a vise with a counterbored block of solid material in the rear jaw to support the shaft against compressive force, then at the front jaw, use a hardened pin or drill bit as a drift and squeeze it up gently. A large nut in the rear jaw should be all the fixture you need, maybe Dremel it out to roughly match the contour of the shaft. When the pin extends enough out of the shaft, grab it up with a vise grip and yank it out.

Older Distributors using Hall Sensors: Wiring Connector Repair. While the distributor is off check the 'housing' carefully...that's the official Volvo part name for the little black connector that has three blades in it that connects the Hall effect sensor to the wiring harness. It's about $3.00 or so and breaks down in 10 years of oil and heat and engine washes. It's fairly difficult to reinstall...strong fingers and a pliers required. Needle nose maybe to pull the blades entirely into the housing once the housing is on the distributor body. But the housing replacement is thoroughly gratifying if the connector was just hanging there. FWIW, I tried to repair/replace the housing with epoxy and it just didn't hold. [Tip: JohnB] The black plastic housing for the ignition trigger connector is replaceable...you don't need to get a new distributor to replace it. Highly recommend you replace it.

Distributor with Hall Sensor Connector

Older Distributors using Hall Sensors: Hall Sensor Replacement

Fix or Buy? [Tip from Bruce] The procedure requires some skills (see Jim's remarks below.) If you can locate a Bosch aftermarket source or an independant Volvo repair center try to get a complete new distributor, cap and rotor as one unit. They are not cheap. Price out the Hall switch, o-rings and cap and rotor. You may not be much less that the price of a complete new unit. Shop around for a Bosch service center or and independent Volvo repair center who may sell you the complete Bosch unit cheaper that a Volvo brand unit.

Hall Sensor Replacement Procedure. [Tips from Jim] If you rebuild the distributor shaft seals, then it may be a good time to change the wire connector for the hall effect switch, Volvo p/n 1346793, and the hold-down for the wires to keep them fron hitting the rotating parts, Volvo p/n 1346794. In case you are not aware of it, the hall effect switch is available separately from the housing for a bunch less money than a whole distributor, too. Volvo p/n 1346792. A few blacksmithing skills are needed for that part of the job, but it is not too tough. I have found the only way to check the hall switch is with a lab scope, but also find that a car with 250,000 km or more almost always runs better with a new one. I guess after it has turned on and off a couple of billion times, the magnet or transistor or whatever starts to get weak,

and won't give a clean voltage change.
The black wire retainer is usually broken away from the housing. I have found the best way to get the wires out is to VERY carefully grind the plastic away, finishing with the wire wheel, until the tab holding the individual wire in is free. Don't mix the wires up- the new housing is marked
+ and -. The white wire hold-down will come off with a little screwdriver work. To change the hall switch, there are two tricks- the first is to use a Dremel or die grinder to grind off the two rivets. Otherwise, you will punch out the thin aluminum of the housing, and will be buying a new distributor. I know this, because I have a test unit at the shop with the switch epoxied in! The other trick is to take a 5/16 bolt about 5 inches long and drill a depression in the end of it to just fit over the end of the rivet in the new switch. You also must grind the end down in diameter so it is only supporting the rivet, and not touching the plastic. Grab the bolt in a vise, get a friend to hold the distributor in place, and carefully peen the rivets. I have a very small chisel that works well, or a centerpunch will do the job. Don't overtighten the rivets- all that is needed is to keep the switch solid. For this part of the job, somebody who has riveted things in the old days with a hammer can be a useful ally.

Newer Distributors using RPM Sensors: [Response: Abe Crombie] The ignition system uses a crankshaft reading RPM sensor for timing. The distributor has no bearing on timing. Take note of the position of distributor by looking with a mirror at the relative length of distributor adjustment slots where bolts go in. You may not need to do this as there should be a plastic piece in one of the bolt holes that positions the distributor housing. The distributor only goes into cam in one possible position due to the offset slot that drives distributor via an offset eared piece. When you pull distributor shaft out to replace the shaft seal take careful note of position of the eared drive cog so it can be put back in the same place and not 180 degrees off.

Re-installing the Distributor: Put new O-rings on (big one on housing and little one on shaft lubed with Vaseline) and use antiseize on the aluminum housing bolts. Use antiseize paste on the aluminum body of the distributor, just a fine film will do...helps to get it out next time.
[Editor's Note: the newer distributor uses a black plastic alignment insert in one of the mounting flanges that centers a 10 mm fastener - setting it right for both sides, to ensure the distributor is re-installed correctly. Don't move this fitting when you disassemble the distributor] The rotor is installed in one direction only, matching the slot on the shaft with the ridge inside the rotor. [John Sargent] Take the cap off before installing the distributor. Use engine oil as a lube on the distributor base and o-ring. When you turn the rotor to where the drive cog matches the cam, the distributor will slide into place. Push it in using your fingers positioned near the inner circumference of the distributor, not the outer portion. If it does not slide into position, the cog is 180 degrees out of phase. [Tom Irwin] If you didn't have the plastic fitting or failed to mark the location of the distributor on the head, don't worry. The ECM will make enough correction to get around almost anything you have done. Try and look at the surface of the flange and see if you can tell where the clamping bolt was seated. Aim for that. If all else fails, you could disable the electronic advance and base time the thing. I really don't think it will matter much. If in doubt, aim for the middle.

Make sure you have a dustcap installed under the rotor....it serves to keep crap from the hall sensor innards as well as oil from the engine from getting to the inside of the distributor cap. I found out a year after the dealer had re-O-ringed the distributor and replaced the ignition wires (don't ask...I now do my own O-ringing there) that the clown had left off the dust cap. It's a few bucks at the dealer too...un-obtainable at auto stores. The dust cap is pre-installed on Bosch caps.
Use silicone dielectric grease on the spark high-tension lead boots to make both installation and removal easier. Use your finger to align the metal lead in the boot into the cap, then push down hard. It snaps home when correctly installed and you cannot easily pull the lead back off. If it won't snap home, then make sure you have not bent the metal connector.

Re-installing the Hall Sensor Distributor: Check your timing when you put it back...I found out mine was at 5 degrees BTC vice the 12 in the manual...makes a noticeable difference in bottom end torque when you launch!!!

Engine Hesitates When Humid. [Inquiry:] During periods of great humidity while driving at normal operating temperature, engine cuts out and then after a second or 2 (sometimes more) it picks back up or stalls. If it stalls sometimes it will start back up sometimes it won't; In this situation (not starting back up) engine turns over but absolutely no ignition. This model is a 760 with turbo and intercooler.
[Response:] The secondary ignition parts are the first suspects for your trouble. The rotor can develop a hole from spark hunting a place to go. The hole will be from center of rotor where distributor cap contact touches through to underside

where it sticks onto shaft. This effectively shorts out spark. If, when you say "no ignition" you mean no spark out of coil wire, then you needn't look at cap, rotor, & wires. Then look for arcing coil top. The coil can develop an internal short where the hole where coil wire inserts gets a crack that allows the spark to jump to one of the other leads killing spark. OR your hall switch is defective. If the hall switch or the hall switch (hall switch= sensor assy. inside dist) connector is the problem then you will see tachometer die INSTANTLY when problem occurs, i.e. tach drops to 0 before the engine actually quits turning. Corrosion at the power stage connector (black and gray unit wire connector behind and a few inches below headlight level on driver's side inner fender behind air cleaner if it's a non-turbo) will cause it to die with instant tach loss also.

Distributor Shaft Wear. [Andrew Smith] After noticing stumbling and misfire, I discovered that my distributor had mechanically failed at 110k miles: the shaft wobbled and allowed the rotor to contact the cap. A new distributor solved the problem. Check for this whenever removing the distributor.

Ignition Amplifier (Power Stage) Failure.

Ignition

Engine Stops Dead at 60MPH. [Inquiry: driving down the highway at @ 60mph with 1/4 tank of gas in 100 degree temp in well kept 84 760 Turbo; car just dies, engine turns over but will not start] [Response:] Well, when my '84 760 Turbo died for no apparent reason as you describe, it was in the freezing dark, going over Donner Pass. Everything on the car worked except no spark and the engine wouldn't run. It turned out to be the ignition module, which is mounted on the inner driver's side fender well, above the battery, close to where someone else mentioned the ballast resistor was located. It's easy to get to and replace. If that turns out to be the culprit, shop around before buying the new part. Volvo dealers charge several hundred $$$ for this thing, but I found one from an independent parts distributor for about $90 - the identical part made by BOSCH with the same part number on it.

Intermittent Ignition Failure. Symptoms. As you are all well aware, intermittent problems are a b*tch to correct. However, last night, the car started fine but stalled halfway out of the garage and would not restart as has happened several times before. I've always suspected an ignition fault rather than fuel as the engine dies instantly when it happens. No sputtering, rough running or anything like that, it's like the key was turned off. *Other Symptoms Which May be Related to This Failure Mode:* The car will start and then die, or refuse to start again until it's cooled off, or just not start period. or just randomly die or misfire under load. However, note that no-hot-restart problems are usually related to failing fuel injection relays, rpm sensors, or radio suppression relays.

First thing I did was hook up my timing light and had one of the boys aim it at me while I cranked it over. No indication of currant flow in the plug wire. Now I can dismiss the fuel/fuel injection system (I think). Next I connect my Fluke Meter to ground and the positive lead to the positive side of the coil and switch on the ignition to the run position. No Voltage! I ran back into the house to get a jumper lead - I was going to run it directly from the battery to the coil but when I tested for voltage again it was there. Get in the car and it started right up and died before I could put it in gear. Open the hood and check for voltage at the coil and it's gone. Now, w/o touching the key (I'd left it in the run position), and without "tapping" anything with a hammer or "jiggling" any wires, I test both sides of the coil for voltage again. I test the positive side of the low tension ckt and it's 0 volts w/ respect to ground, test the other low tension lead and it to is 0 volts w/ respect to ground. Test the positive side once more and the voltage is back! Get in, start the car and it runs fine. Anyone know what might be causing this? [Response: Randy Holst] From a similar experience I had with my (now departed) '84 760T, I would suggest that it is the ignition amplifier module, which is mounted on a heat sink on the inner driver's side fender well behind the headlight. At a very inopportune time and location, mine quit working when I closed the hood while the engine was running. The engine immediately quit as though someone had turned off the ignition. The result was no spark, no juice to the coil and no amount of fiddling around would change anything. (Long story about having the car towed, isolating the problem and having a replacement part flown in omitted.) Replacing the ignition control module cured the problem and it never reoccurred. [Editor] Test the ignition coil if this occurs to make sure it did not cause the failure.

Engine Stops: Loose Power Stage Amplifier Fails Due to Overheat:
[Tips from Ian Afford/Peter Day] A month ago my 740 (B230E) died on me. The RAC man diagnosed a faulty Ignition Amplifier Module. He also pointed out that it was slightly loose on its mountings, which he suspected might have

caused it to fail, the module uses the bodywork to conduct the heat away keeping it cool, and because it was loose it might have been overheating. So I suggest that you find this module (on my Bosch-powered engine it is fixed to the side of the engine compartment next to the air cleaner box) and check it is secure, it might also be worth removing it and cleaning the mating surfaces in order to achieve a good thermal contact. In order to allow the power output stage of the ignition amplifier to cool correctly, you need to apply some heat sink compound (thermal grease) to both the flat mating surfaces between the amplifier case and the fender to improve cooling.. This will allow an even heat dissipation and prevent the transistors in the amplifier from overheating. You can buy the grease at Radio Shack or at an electronics supply store. *Rex/Regina Note:* In these systems, the power amplifier is integrated with the coil. See also the symptoms described in the Engine: Performance section under Power Stage Failure.

Very Poor Idle; Power Stage Overheating: [Tip from Stephen C] After the engine heated up or when under hood temps are high, it would idle like crap and die frequently. I took a water hose and cooled the power stage down and it would idle great for 10 min+. Worth a try, just to see. [AlexZ] The power stage can fail in weird ways, resulting in odd running. Considering its price and ease of installation, you may as well replace it.

Engine Cuts Out; Tach Drops. [Inquiry:] I was on a long trip today, and my normally fearless 760 (270K) actually shut down on me a couple of times. Once I got it up to 70-75 mph, the engine cut out and the tach needle bottomed out until I took my foot off the throttle and restarted the engine, at which point it ran fine. It had an episode where it would get up to hwy cruising speed, start to cut out, the tach needle shaking all over the place, and then smoothing out once I took my foot off the gas. Does this sound familiar to anyone? [Response: Abe Crombie] Two things come to mind when you have an cut-out with an instant tachometer drop chaser: 1. the rpm sensor behind and below cylinder head that reads perforated surface on flywheel is going open 2. the ignition power stage has a faulty connection or is faulty.

Failure to Start; Flywheel Sensor Bad. [Inquiry:]My 1990 740GL Bosch LH 2.4 has been having trouble starting for the last few months. I replaced the cap, rotor, plugs and fuel pump relay. The wiring harness looks fine. Today it refused to start at all. Cranks fine, but no spark. I unplugged and re-plugged the flywheel position sensor at the firewall and it started! The contacts looked OK, but I cleaned them and put on some dielectric grease. Now we'll see if that did it. Question: I remember some talk on the list awhile back about a recall or TSB on faulty flywheel position sensors (impulse sensor) on late '80s 740s. I can't find the message on my hard drive. I seem to recall that the model with a yellow band was either the good one or the bad one. Mine is yellow. [Response:] The newer kind has a white band, as opposed to the older style yellow band. Replacement takes about 10 minutes.

Timing Unstable; Harmonic Balancer Failing. [Inquiry:] While checking the timing with my timing light, the timing mark on the flywheel keeps moving counter-clockwise all the way around the flywheel. No Kidding! Looks like a slow pinwheel or something. The only thing I can think of is the distrubutor (hall sensor) is changing value. Has anyone ever heard of such a thing? [Response: Abe Crombie] Your harmonic balancer is slipping. The timing mark is carried on the outer pulley which is rubber mounted from the inner crank bolted piece. You will need to replace it in order to get a correct timing adjustment if it is slipping while you watch as you describe. Chalk mark the inner piece and watch and see if the mark placed there does in fact stay still to confirm the balancer failure. [Response: Don Foster] I think you mean the front pulley, not the flywheel. It's a "sandwich" assembly, with the outer portion (having the timing marks) attached to the inner portion—which is firmly engaged to the engine—by a rubber vibration isolator "donut." When the rubber-to-steel bond finally fails, the outer portion of the pulley can slip away from alignment with the crank, giving the appearance of wandering timing. Certain repair procedures, such as grabbing the pulley with a strap wrench, can tear this bond. [Editor:] See Harmonic Balancer Failure for more information.

Timing Off; Ring Gear Out of Position. [Tip from John Sargent] If your flywheel has been replaced and you are experiencing timing problems, check the position of the ring gear which determines timing. To check this, remove the starter and position the engine on TDC for number one cylinder. There are 58 holes on the timing ring, with a void of two holes (room for 60 holes, total). The void will be at the bottom of the starter opening if the ring gear is installed properly. See other timing tips in Engine Performance.

Ignition Coil Failure and Testing. [adapted from Import Car Magazine, Feb 03]

Why Coils Fail. Because worn spark plugs and open-circuit spark plug wires force ignition coils to operate at maximum output, neglected ignition system maintenance is the most common cause of modern ignition coil failure. As the spark plug air gap widens due to normal erosion, increased voltage is required to create a spark in the combustion chamber. This increased voltage, in turn, demands more current flow through the coil's primary circuit. And, this increased primary current flow can overload the power stage primary transistor. The increased secondary current created by the ignition coil also can increase to the point that it perforates the secondary circuit in the coil itself. Defective ignition coils are also notoriously sensitive to extreme changes in ambient temperature and humidity.

How to Test The Coil. All ignition coils may be tested by measuring, a) open-circuit spark output, b) passive resistance in the primary and secondary coil circuits, and c) the current rise or "ramp" through the primary windings. The open-circuit spark test indicates a good coil when it produces a bright blue spark that jumps a 1/4-inch gap on a spark tester. This test simultaneously tests the integrity of the triggering system and ignition coil. If spark isn't present, measuring for a switching action at the negative primary coil terminal is the next step. Because a conventional test light may not detect triggering durations or "dwell times" of as little as seven to 10 degrees of crankshaft rotation on modern ignition systems, the triggering or switching action should be measured with a lab scope or digital multimeter. Although the resistance test is not a definitive measure of a coil's electrical integrity, a coil should be replaced if the resistance values don't fall within specifications:

Volvo coil specs for resistance in the windings:

Ignition Type	Primary Resistance: Terminals 1 & 15	Secondary Resistance: Terminals 1 and High
Bosch EZK (Bosch coil p/n ending -005)	0.6 to 0.9 ohms	7.0 to 8.5 k-ohms
Bendix Rex 1/Regina) (coil p/n ending -004A	0.5 to 0.6 ohms	5.0 to 7.0 k-ohms

Using a low-amperage current probe to measure the current "ramp" through the primary ignition circuit is perhaps the most definitive method of determining the electrical integrity of the coil and the quality of the triggering action. Many defective ignition coils, for example, will pass a resistance test, but fail a current ramp test.

When to Buy a New Coil. Consider a new coil if your power stage fails and the coil fails these tests; if your ignition wires fail and the coil fails these tests; or if you have an ignition-related failure that seems to be highly correlated with temperature and humidity. A coil should also be replaced if it shows traces of spark perforation, carbon tracking or overheating. Bosch coils seem exceptionally robust in service. Rex/Regina coils fail far more frequently.

Testing the Timing Using a Timing Light. [Mark Stites/Gene Stevens] The typical timing light will have three leads:,red that goes to battery positive, black that goes to battery negative, and a third lead will hook up to the number one spark plug. Most lights anymore are inductive, this simply means that the lead will just go around the spark plug wire. Older models or cheaper ones you will need to take the spark plug wire off of the plug and the lead will plug in between the wire and the spark plug itself. As far as reading it goes, if you are looking at your typical red engine B230 scale you will see that the scale is on the lower timing cover and that there is a small groove cut into the front pulley. Find the scale and the groove on the pulley, clean them, and put a little bit of white paint on to see the marks better. You may have to reposition the engine pulley with a short burst of the starter to find the notch on the rear lip of the pulley.

With engine still off, connect the wires to battery and spark plug wire, hold the timing light above the height of the engine and point the light toward the lower pulley. Move the light around as though you are using a flashlight looking for the right angle to point it. The light won't blink so you'll have to pretend. If any of the wires can drape near ANY pulleys, belts or the fan blade - reroute them under hoses or tie them away. VERY VERY IMPORTANT!... the strobe light will make moving things look like they are stationary. Get your fingers or tools too close and you will find out that they are moving. Do not lower the light any closer than the top of the radiator. If the distributor needs to be loosened to change the timing, do it with the engine off and leave the nut "drag tight" so you can turn it easily and it will stay there. Tighten nut with engine off and start engine to recheck. Do not put your tools above the radiator where the wire or your free hand could knock them into the fan.

The light will flash everytime the number one plug fires and it will give away the position of the groove in the pulley relative to the timing scale. If you look closely at the scale you will see that the "0" mark is actually flat on the front of the cover and that the rest of the scale is on a roughly triangular piece that protrudes from the cover, this piece starts counting at 5 but I believe the first actual number you will see is "10". Volvo timing scales are a little on the funky side compared to the rest of the world. You will want to set your timing at 12 degrees before top dead center. The engine rotates clockwise so the scale you look at only shows you numbers before the zero and none after. This is because your timing is set at 12 before and only advances past that i.e. 20 before, 30 before. So there is no need for an after top dead center scale. When you see numbers like 12 BTDC, the BTDC means Before Top Dead Center.

Learning is fun but you have to finish the job with the same number of fingers and eyes that you started with.

Ignition Switch:

Car Starts but All Electricals Are Dead: Ignition Switch. [Inquiry:] I can start my car but all the auxiliary electricals are dead. *Diagnostics.* [Rob Bareiss/Bruce] When the ignition switch fails, often the accessories don't all turn on. People report that the radio doesn't work, or the ABS light is stuck on, the starter won't disengage etc. These are normally turned OFF in the Start position (KP III) but then revert to ON in KP II. If the switch is sticky, it doesn't return fully to KP II. Or the ignition switch has a dead spot. Move the key toward start a little, from the run position, and you mayl find the dead spot. Replace the electrical part of the ignition switch.You'll probably be pleasantly surprised that the switch is not very expensive either. This is common for all 240's and 700's with the ignition key located in the dash, especially when people use a heavy key fob attached to their ignition keys.

Ignition Switch-Electrical Portion

Ignition Switch Replacement in 740/940.
Changing Rear Electrical Part of Switch. [Rick Tilghman/Bill/Jim/Editor] First disconnect the battery negative, then remove the instrument cluster. Disconnect the switch harness connector by pulling straight off the back toward the front of the car. The electrical portion of the switch is just held on with two 3/16 inch slot head screws, the lower of which is difficult to access. A real short 3/16 inch flat blade screwdriver (< one inch) or an offset ratcheting screwdriver is essential since a frame member is in the way. You have to work almost totally by feel because the screws face toward the front of the car. Also essential are a mirror, a lamp or flashlight, and a magnet to retrieve the inevitable dropped screw. Once you get the screws off, just pop the old switch off and the new one on and replace both wire and screws.
Changing Lock Cylinder Mechanism of Switch: Lock in Panel (740/940). [Response from Bob] You don't have to remove the steering wheel under normal circumstances. The method for removing the lock cylinder is to remove top and bottom steering column covers and the panel on the driver's side footwell under the column. Insert key, turn to position 2. There is a small pin in the lock casting on the top just behind the chrome front of the barrel (about 1" from end of lock cylinder). At key position 2, depress this pin and the whole barrel pulls out. If stuck, push it from the rear. If you have drilled out the lock, this method may or may not work. Try turning to position 2 with your screwdriver, press the button and see if it will come out. The button is brass colored, about 1/8 inch in diameter. It doesn't move very far. All it does is release the spring clip that holds the cylinder in. If you can't get it out, you may have to pull the column out and press off the whole lock assy.

Ignition Lock-Mechanical Portion

Lock in Steering Column (760). [Procedure from Mark O'Connell] I have replaced my lock on my 1989 765t with the lock in the steering column. Do this before the lock will no longer turn!!!!.....If it's like my 89 (with the ignition lock on the column) you have to turn the lock to the run position (position #1) and there is a small hole on the top of the cylinder housing (assuming you have removed the plastic shroud and unplugged the connector on the back side of the cylinder housing) insert a small drill bit into this hole and depress, this will release the lock cylinder, and it should pull right out. If you wait until the cylinder won't turn, you have to remove the cylinder by drilling and grinding..
Lock in Steering Column (960) [Greg Murphy] The removal procedure for the ignition lock follows:

- Disconnect the negative battery terminal Wait 10 minutes to be sure the SRS system is dicharged
- Remove 4 bottom screws that hold the plastic steering column/ignition cover pieces together
- Lower the steering column to its lowest setting
- Remove the top cover (it is not necessary to remove the bottom one)
- Rotate the key to the "II" position
- At the top of the switch housing there is a small hole. Use a small hex key to depress a latch (attached to the cylinder within).
  While pressing down, pull out the key and cylinder together.

Above Methods Fail and You Must Drill It Out. [Another Tip] It's a bit of a nasty job, designed that way so thieves will leave them alone. If you look up through the two holes on either side of the steering column at the level of the switch you will see tapered silver bolt heads with a broken looking circle in the middle. Carefully drill a hole dead center in the bolts, about 3/16 diameter, 1/4 or so deep. Any good ez-out will remove those two bolts as they are not really all that tight when the heads break off on installation. Next step is to loosen the lower mount, 2 12mm head bolts down by the pedals. That will let the column move down or up enough to remove two phillips head screws in the switch, which will allow you to remove the switch with a bit of work. If your key won't turn anymore, it may be a bit tough to get the steering lock out, but it should come. If you can't get it, you may have to remove the phillips screws that hold the metal crossbar from the center console to the side of the car- all the plastic trim around the steering column would have to come off to remove the crossmember as well. When you put the new switch back in, just use 2- 8mm bolts with heads on them. Nobody goes to that much work to steal a car anymore.

Ignition Switch Replacement in 960. [Tip from Tom Irwin] I've had a few requests to explain the few easy steps to switch out a bad ignition switch on a 95 964, and presumably other models as well. The symptoms that led me to diagnose a bad ignition switch were:

1. On hot days when you start the car and the key position returns from 3 to 2, most of the electrical will not work. Turn signals, headlights, power windows, the 'Ding-Dong' seat belt reminder etc. Wiggling the key a bit would cause everything to come back on.
2. Occasionally, while driving, if your right knee should brush against the key chain, the engine will shut off. It's a little disquieting to have that happen whilst supercruising at 90+mph, #1 lane, on the interstate. Time to fix...
That part is cheap by Volvo standards. Full Dealer Chump Price is only $37 bucks. Clayton, et al. will sell it for $26...

1. Disconnect Battery Ground cable. Wait minimum of 10 minutes for SRS system to de-energize its back up power supply. Volvo book says to pull some other panels and disconnect the SRS trigger wire. I never saw the need to do that so long as you respect that 10-minute wait. Remove the lower knee bolster cover, two screws, T-25 I believe, working from the transmission hump, up and over, unsnap 1, unsnap 2, unclip 3 over below the headlight switch. Slide the large plastic cover out towards you. Pay attention how it slides into the two receiver slots, it's easy to screw up on reassembly. Don't forget to unclip the electrical connector from the foot well light on that bolster cover. Look up underneath the shroud that surrounds your steering column, ignition key assembly. There are 6 screws. 4 of them hold the 2 plastic halves together. Remove them now. The last 2 secure the bottom plastic half to the steering column itself. Remove them too. Remove the lower plastic half, set aside. Lower the 'Tilt-Wheel' mechanism as low as it will go. Remove the upper plastic half, set aside. Put the key in, turn to #2 position. Looking at the left side of steering column, see the bundled wire harness attached to the ignition switch? Good. Slip a thin, flat bladed screwdriver between the harness connector and the switch body. Gently work your way around until it comes off of the switch body, then pull it aside. Remove 2 slotted screws that hold the switch assembly on to the steering column. Remove switch assembly and replace with new one.
2. Installation is the reverse of removal.

Ignition Key Broken Off in Lock. [Tip from Neal Wilcer] How to remove a key broken off inside an ignition lock: take a hacksaw blade (or a fine-tooth coping saw blade) and grind down the non-tooth side about one inch in until the thickness of the blade is about 1/16". Slide the blade in the ignition under the broken key. When you pull back, the teeth on the blade will grab the teeth on the key and pull the broken piece out.

Ignition Key Won't Withdraw or Won't Turn. *760-Specific Symptom.* [Inquiry:] My ignition key in my 89 760T is stuck in the cylinder (which I removed from the steering column with surprising ease). It all started with an erratic "start" condition. I attempted to clean the ignition switch with aerosol contact cleaner but the electric portion of the ignition switch is physically seperate from the key/tumbler area. The key goes in, but the key doesn't come out. [Response: Bob] The most painless solution would be to order a coded lock cylinder from the dealer and just replace it. You will also avoid the eventual "key won't turn" problem 760's are prone to. When that happens, you have to drill out the tumblers in order to replace the cylinder. Pick up a NEW cylinder and switch and be happy. By the way, if you don't mind having a separate key for the ignition, a non matching cylinder can be had quicker and a little cheaper.

Neutral Switch Problems. [Inquiry] Not only is the key stuck in the ignition, but the steering wheel lock won't lock. Wheel turns freely; no feeling in the key like it's trying to drop in. [Response: Roy Key] The problem is likely in your neutral safety switch. Are you sure the gear shift was put back into neutral? Check that first. I have seen this before and was able to disconnect a cable that goes into the back of the ignition lock assembly that comes from the neutral safety switch. Just pull on the cable and it will pop out, then a clicking sound, then the key will be allowed to complete its rotation and will come out.

Electrical: Engine Sensors [FAQ Home]

Abbreviations:

AMM	Air Mass Meter
ECT	Engine Coolant Temperature sensor
ECU	Engine Control Unit computer (either fuel injection or ignition)
FI	Fuel Injection
FPR	Fuel Pressure Regulator
IAC	Idle Air Control solenoid valve
TB	Throttle Body
TPS	Throttle Position Sensor
VSS	Vehicle Speed Sensor

Air Mass Meter. See FAQ section in Engine: Fuel Injection for AMM information.

Hall Sensor. See Electrical: Ignition for more details on Hall sensors in LH 2.2 and earlier distributors.

Engine Temperature Sensors. The B230F of the vintage discussed, 1989-1995 have in effect three temp sensors: the Engine Coolant Temperature sensor (ECT)- which has two sensors in one housing - and the temperature gauge sensor. Two NTC thermistors are combined in one ECT sensor housing with two connectors and ground through the housing into the manifold. One of the temp sensor "signals" goes to the LH fuel injection computer, the other to the EZK ignition computer. The third temp sensor is the one used by the temp gauge in the instrument cluster. It also has two connectors, one "signal", one "ground". For resistance ratings, see the link noted. The gauge sensor is at the front under intake manifold runner number two, just ahead of the knock sensor which is bolted in at an angle. Behind the knock sensor under manifold runner three is the ECT. When you remove any of the sensors, disconnect the battery negative cable.

ECT Sensor

Removing the Sensors. [Inquiry] How do I remove the *gauge temperature sensor*? [Mark Duval] This is the front sensor under intake manifold runner number two. I bought the "stubby" 19mm combination wrench and a 19mm crow foot socket. First tried the open end side of the stubby and although I could get it squarely on the hex head, I could not put enough force on the wrench to turn the sensor. Then used the crow foot socket with a long extension. This rotated off the hex and cracked the electrical connection at the top of the sensor. The answer all along was to remove the sensor's molded-on electrical connector (destroying the sensor) and gain access to the hex with an offset 19mm box wrench or a 3/4 inch socket. [Jay Simkin] Remove the old sensor and prep the new sensor by wrapping 1/2" wide teflon tape in two turns around the threads. Then apply grey pipe joint compound (not the white, teflon-loaded joint compound) in a collar of compound on the underside of the sensor's lip, above the threads. Keep the joint compound away from the threads. To reinstall, gently screw the prepped sensor into the opening in the block. Tighten snug using a 3/4" open end wrench. A 3/4" socket will not work, as the electrical connector housing is wider than the brass hex fitting used to secure the sensor. Check for leaks. Tighten gently if required to stop any leaks. Replace the knock sensor using a 12mm wrench to tighten it securely against the engine block. Replace both electrical connectors and reconnect the battery negative.

[Editor] It helps to first remove assorted tubes and pipes, including the IAC valve and the *knock sensor* nearby, which is merely bolted into the block. *Removing the Engine Coolant Temperature Sensor* (the rear-most of the three sensors) is a little tougher, since it is buried under intake manifold runner number three. [Tip from John Sargent] Removing the intake manifold makes it less than a 30 minute job. Trying to R&R without removing the intake manifold can lead to a broken sensor. The brass hex of the ECT is 19mm. The electrical connector is larger than the 19mm hex and a socket or box end wrench will not fit over the electrical connector, so you can only use an open end wrench to remove the ECT. The wiring harness connector can be very difficult to disconnect without removing the intake manifold. Save yourself on both agravations, just get an intake manifold gasket if the sensor needs to be replaced.

Diagnosing ECT Failures. [Response: Don Foster, adapted to 700/900 series by Editor] Your engine has two temp sensors -- one for the gauge (it's mounted in the head about under intake header #2, and one for the FI (it's mounted in the head about under intake header #3). The latter is the ECT sensor.
The sensor is an NTC thermistor -- negative temperature coefficient. As the temp drops, the resistance rises, and as the temperature rises, the resistance drops. Thus, if you have a broken wire, defective sensor, or bad connection (I've seen it happen) the resistance measured by the ecu will be very high or infinite. The ECU interprets this as minus a zillion degrees and pours in the gas.
The car I saw filled the oil with gas and certainly wouldn't run. And the problem was only a displaced spade lug in the plastic connector housing.
According to Chilton's (you may choose to disregard this):
"The coolant temperature signal to the control unit has a great influence on the computed injection period... For example, when the engine is being started and is cold, the amount of injected fuel must be relatively large. [Editor:] Too rich a mixture because of a failing ECT may lead to idle surges, high idle, poor warm running, or other symptoms of too much fuel. See Engine Tune and Performance; Symptoms for more examples.

"If the control unit receives a signal higher than 302F (150C) or lower than -40F (-40C), it will interpret the signal as a fault...the control unit will assume a substitute value corresponding to 32F (0C) on starting and 68F (20C) when the engine has started.

"With the control unit connected, connect a voltmeter across LH ECU terminals 13 and 5 (ground). This unit is in the passenger side footwell, under the plastic cover. Remove the cover of the large electrical connector to access the backs of the pins for the test. Turn the ignition switch ON.

> At 68F (20C) the voltage should be 2.0 +/-.5v volts.
> At 104F(40C) the voltage should be 1.2 +/- .3volts
> At 176F (80C) the voltage should be .5 +/- .2volts.

The resistance values between ECU pins 13 and 5, or between each of the pins on the sensor and ground, are (by eye from the chart):

> 32F (0C)-- about 6000 ohms within a range of +/- 10%
> 68F(20C) -- about 2300 ohms "
> 104F(40C) -- about 1300 ohms "
> 140F(60C) -- about 600 ohms "
> 176F(80C) -- about 300 ohms "
> 212F -- about 190 ohms "

[Response: Steve Ringlee] ECT resistance "cold" for LH2.4 systems should be around 6k ohms at 32 degrees F (0 deg C), 2300-2700 ohms at 68 degrees F (20 C), and 200 at 212 F (100 C). However, try checking your ECT wiring: Between pins 13 and 5 at the LH ECU (with sensor

DISconnected) resistance should be infinite. Voltage with the ignition ON and sensor connected, measured between pins 13 and 5, should be:

0 C=around 3 volts +/-.5v
20C=around 2 volts +/- .5v
100C=around .3 volt +/- .1v

If these aren't correct, check the connections in the ECT wiring harness. Check engine ground connections at the intake manifold. If the voltage is zero, your ECU is at fault.

ECT Wiring/Connector Failure. [JonP] my 1990 LH2.4 still ran rich, smoked, stumbled, and set codes 1-1-3, 2-1-3, and others refering to rich mixture. However, during disassembly I discovered the female connector for the ECT was damaged by one of the sensors spade pins when someone pressed the connector on incorrectly. The pin "missed" one of the female clips and mashed it. The local Volvo dealer parts manager has been very helpful: I described the ECT connector problem and he gave a new connector to me with a couple of insulated pinch connectors and his tips for how to make the splice....no charge. He did say if this splice didn't fix it then he thought it was a failed ground in the ECU (ECM) for the fuel injection. He said the bad connector could also cause a bad ground problem at the ECU.

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960 B6304 ECT Sensor Failure. [Tip from Tom Haywood] '95 960 B6304 with Motronic 1.8: the symptoms, in my case, were sudden very high idle surges (2500-3000 RPMs) while sitting at idle and hot-start problems. This engine has two coolant sensors; the rear coolant temperature sensor is Volvo#68 49 350 (SWF#602.101) and apparently plays a roll in fuel injection and various timing functions. It is similar to the front one (FRONT Volvo#35 45 031), but without the 5-inch connector wire. Testing the sensor in heated water indicated normal operating ranges until reaching 180deg.(220 ohms) .....at which point the circuit would open completely (infinite ohms). When the brass housing would heat up it would pull the connector pin away from the thermistor leg. I have further learned that these symptoms can also point to the wiring to this sensor, because of the location between the fire-wall and hot engine parts. I could suggest to anyone with this engine to keep a new sensor handy, because it looks like the car will be dead-in-the-water when it fails. This sensor is at the rear of the head and requires a mirror taped to the firewall and a 19mm "open-end" wrench for removal (drain the antifreeze and remove the heater hoses first). Work from the top of the engine, standing on a stepstool and using a pillow on which to kneel. It has a 2-pin D-type connector mounted right on the brass housing. The large size of the connector keeps you from being able to get a good "box-end" wrench on it, but mine was not very tight anyhow (just very hard to get to). [Tom Irwin] Those rear ECT's are a pain in the ass. The harness (surprise!) allows very little slack. As the insulation degrades, the tension on the wires just pops it off. Then the epoxy potting around the sensor starts to go.

Throttle Position Switch. [Editor] This applies to Bosch LH2.4.

Symptoms of Failure:
High idle at startup or uncontrolled idle above 750 rpm.
Diagnosis:
This switch is a simple device: at either extreme of motion, an internal switch is closed and you will see continuity between one outer connector and the middle ground connector. Disconnect the switch connector and jump from one side connector to the middle ground connector. If idle returns to normal, then the switch is at fault. The switch is not repairable.
Adjusting the TPS:
To adjust the TPS:

Throttle Position Switch, Courtesy FCPGroton

1. Remove the throttle body from the car and loosen the TPS adjustment screws
2. Hold the throttle plate and keep it from moving. Rotate the TPS clockwise, then counterclockwise until a click is heard. Continue rotating until it stops but do not cause the throttle plate to move. Secure the screws

   Proper adjustment is obtained when you open the throttle plate and insert a feeler gauge at the throttle stop screw:
   - When you close the throttle against a .45mm feeler gauge, no "click" is heard from the TPS
   - When you close the throttle against a .15mm feeler gauge, a "click" is heard.

Oxygen Sensor

Theory and Operation
1. Oxygen sensors should last over 100k miles under ideal conditions; various contaminants will shorten that considerably. For testing procedures and other info see:

http://www.f-body.org/oldfaq/html/tech/sect2.html#oxysensor

2. [Excerpts from Underhood Service magazine, Nov 2000, et al]
The O2 sensor is mounted in the exhaust manifold to monitor how much unburned oxygen is in the exhaust as it exits the engine. Monitoring oxygen levels in the exhaust is a way it gauges the

fuel mixture. The sensor "tells" the computer if the fuel mixture is burning rich (less oxygen) or lean (more oxygen).

Oxygen Sensor Components

Although O2 sensors are amazingly rugged considering the operating environment they live in, they do wear out and eventually have to be replaced. The performance of the O2 sensor diminishes with age as contaminants accumulate on the sensor tip and gradually reduce its ability to produce voltage. The aging process is caused by a buildup of contaminants on the sensor's zirconium sensing element. If the engine burns oil, phosphorus deposits may contaminate the sensor and catalytic converter over time. If the engine has an internal coolant leak (cracked combustion chamber or leaky head gasket), silicone additives in the antifreeze can become a source of contamination. *Contamination Caution:* If you use silicone-based RTV gasket material anywhere on the engine, especially in manifolds or valve covers, make sure the tube says "sensor-safe RTV compound". Silicone from the gasket can contaminate your oxygen sensor. According to the Robert Bosch Corp., replacing a degraded oxygen sensor with a new one will increase fuel efficiency by 10% to 15%. Don't use silicone sprays anywhere near the intake system. And Airtex Automotive reports replacing degraded oxygen sensors has the potential to reduce a vehicle's emissions of hydrocarbons (HC) by 23% and carbon monoxide (CO) by 33%. In fact, an EPA study found that 70% of the vehicles that failed an I/M 240 emissions test needed a new O2 sensor. Bosch recommends a professional service technician check a customer's oxygen sensor on a regular basis: every 60,000 to 100,000 miles for a "heated" three- or four-wire sensor.

The O2 sensor works like a miniature generator and produces its own voltage when it gets hot. Inside the vented cover on the end of the sensor that screws into the exhaust manifold is a zirconium ceramic bulb. The bulb is coated on the outside with a porous layer of platinum. Inside the bulb are two strips of platinum that serve as electrodes or contacts. Between the electrodes is a solid-state electrolyte made up of a zirconic ceramic material that acts like a galvanic battery electrolyte under certain conditions. When the sensing element is cold, the zirconia material behaves similar to an insulator. At elevated temperatures, the zirconia material performs more like a semiconductor, and can generate a characteristic voltage output on the sensor connections. The outside of the bulb is exposed to the hot gases in the exhaust while the inside of the bulb is vented internally through the sensor body to the outside atmosphere. Newer-style O2 sensors "breathe" through their wire connectors and have no vent hole. This is why grease should never be used on O2 sensor connectors because it can block the flow of air.

Bosch Zirconia Oxygen Sensor Function

The difference in oxygen levels between the outside air and the exhaust within the sensor is what causes voltage to flow through the ceramic bulb. The greater the difference, the higher the voltage reading. Typically, an oxygen sensor will generate up to about 0.9 volts when the fuel mixture is rich and there is little unburned oxygen in the exhaust. When the mixture is lean, the sensor's output voltage will drop down to about 0.1 volts. When the air/fuel mixture is balanced or at the equilibrium point of about 14.7 to 1, the sensor will read around .45 volts. When the computer receives a rich signal (high voltage) from the O2 sensor, it leans the fuel mixture to reduce the sensor's reading. When the O2 sensor reading goes lean (low voltage), the computer reverses again, making the fuel mixture go rich. This constant flip-flopping back and forth of the fuel mixture occurs at different speeds depending on the fuel system. Engines with multiport injection do this five to seven times per second at 2,500 rpm. The O2 sensor must react quickly to these changing fuel conditions in order for the computer to maintain the best average air/fuel ratio. As sensors age, they become sluggish and respond more slowly to changes in the air/fuel ratio. This may cause emissions and fuel consumption to rise.

Before it will start to generate a voltage signal, the oxygen sensor must be hot - usually from about 450d F to 600d F or even higher. The sensor incorporates an internal electric heating element to bring the O2 sensor up to operating temperature quickly (under 35 seconds). Internal heating elements usually operate continuously while the engine is running to maintain an operating temperature of approximately 1292 degrees Fahrenheit to 1472 degrees Fahrenheit. Heated O2 sensors operate at a more consistent temperature and allow greater flexibility of placement locations in the exhaust system. Three and four wire sensors have this heater installed: two wires for the heating element, one signal wire and possibly a ground wire. Oxygen sensors that are not equipped with a ground wire must have a well-grounded exhaust system to complete the sensing circuit. Basic electrical wiring circuit checks should be made to determine if the vehicle's wiring harness has good continuity and is free from short circuits.

The ECU will set an O2 sensor diagnostic code if the sensor does not produce a voltage signal, stays rich too long, stays lean too long, does not switch rich/lean (center too long), or does not switch rich/lean fast enough. If the sensor dies altogether, the result can be a fixed rich fuel mixture. The rich mixture therefore can cause the converter to overheat, resulting in severe damage and higher repair costs for the driver. As one aftermarket manufacturer points out, sensor checks come down to paying a little now or a lot later. One way technicians can test oxygen sensors is to see if the sensor's output voltage changes when the fuel mixture changes. When the mixture is lean, the sensor's output voltage should be low (down around 0.1 volts), and when the mixture is rich the sensor's output should be high (up around 0.9 volts). A steady low voltage reading or no voltage reading would indicate a bad sensor.

Making the fuel mixture artificially rich by adding propane into the intake manifold should cause the sensor to respond almost immediately (within 100 milliseconds) and go to maximum (0.9v) output. On the other hand, creating a lean mixture by opening a vacuum line should cause the sensor's output to drop to its minimum (0.1v) value.

Although a technician can read the O2 sensor's output with a scan tool or digital voltmeter, the transitions are hard to see because the numbers jump around so much. An analog voltmeter is better for viewing transitions, but may not respond quickly enough on systems with higher transition rates. So the recommended instrument for observing the O2 sensor's voltage output is a digital storage oscilloscope (DSO). A scope will display the sensor's voltage output as a wavy line that shows its amplitude (minimum and maximum voltage) as well as its frequency (transition rate from rich to lean).

A good O2 sensor should produce an oscillating waveform at idle that makes voltage transitions from near minimum to near maximum. If the sensor doesn't flip-flop back and forth quickly enough, it may indicate a need for replacement. If the O2 sensor circuit opens, shorts or goes out of range, it may set a fault code and illuminate the Check Engine or Malfunction Indicator Lamp. If additional diagnosis reveals the sensor is defective, replacement is required.

Specific Diagnostics and Tests

See the specific diagnostic procedures in the FAQ Fuel Injection section on Oxygen Sensor Diagnosis.

[Inquiry:] Anybody know what the resistance of the O2 sensor heater should be? mine says 2.2 ohms. With only the green wire connected to the ECU I get a pretty stable .52 volts, which I have read in the archives to be the ECU reference voltage. Hopefully all is well at that end. If I connect the heater (there is ~13.5v on the harness side, btw) the sensor voltage decays over about 30 seconds to .01 volts. At no time does voltage sweep from .3 to .7 v. Also, can you replace the heated one with non-heated? A Bosch Ford 5 litre sensor is $97.80 (cdn) at a local import autoparts store, the Volvo sensor is $280 something. [Response 1: Abe Crombie] That is the right resistance on the heater. Use a digital voltmeter with impedance at least 10 megohm. Before you replace the sensor warm up engine and attach the voltmeter positive probe to O2 sensor lead, the negative to chassis ground, and then momentarily pinch the rubber return line behind fuel pressure regulator. If the voltage of sensor goes to .7-.9 V then look for something other than the sensor causing a lean condition. A faulty sensor can give you the low V reading but an air leak or defective MAF sensor can do the same. With regard to heated (three wire), versus non-heated (two wire), yes and no. The heated sensors are used to keep the signal active while idling. Idling in cold weather primarily, the sensor will fall below its 600F temp at which the reaction that makes it output voltage begins to work. If it were to stay above this temp the non-heated would be okay. There are different sensors out there also. Most all the Bosch up to 92 have the same output voltage at the same O2 gradient. After 92 there are differences in some of the applications in this respect.

Regina vs. Bosch Oxygen Sensors

Regina Sensor NGK 25002

The Bendix/Siemens Regina fuel injection systems use a titania-type sensor which varies resistance and is ***not*** interchangeable with the Bosch zirconia units which create a varying voltage signal. This sensor does not work with a .5 V reference out of the ECM as do the Bosch versions. The Regina unit uses the heater power supply to feed a sensor circuit which responds to O2-level variations. The Bosch zirconia unit measures an electrochemical reaction and the heater merely maintains the temperature stability of the sensor and does not supply current to be modified and used as output signal. Compared to the more common zirconia O2 sensors, titania sensors have three advantages: (1) they don't need an air reference (there is no internal venting to the outside atmosphere to plug up); (2) they have a fast warm-up time (about 15 seconds); and (3) they work at lower exhaust temperatures (they won't cool off at idle and they can be located further downstream from the engine or used with turbochargers). See the notes below regarding the use of generic sensors in Regina cars. A direct replacement for the Regina sensor is an NGK 25002.

When is Replacement Recommended? [Tip from Import Car Magazine, Apr 2003] Replace if:

- Antifreeze contaminates oxygen sensors. Oxygen sensor replacement is highly recommended after replacing cracked cylinder heads, leaking intake gaskets or leaking cylinder head gaskets.
- Oil contamination also ruins oxygen sensors. Oil ash accumulating on the sensor thimble or wicking through the sensor wire may cause erroneous air/fuel ratio readings.

Other Conditions Causing Oxygen Sensor Malfunctions:

- Leaking exhaust manifolds and air injection systems contribute to faulty air/fuel measurements by the oxygen sensor because they dilute the exhaust gas stream with atmospheric oxygen.
- Leaking fuel pressure regulators or leaking vacuum hoses and intake gaskets often will cause a "no-switching" condition at the oxygen sensor.

Replacement Procedures:

Opening Caution. [JohnO] If doing it yourself, do it with a cold engine as many O2 sensors are more likely to cross-thread if done hot (although not so much so with Volvos). If you doubt your skills with this, just take it to dealer and pay them to replace it as it won't be that much for the labor (about 1 hour).

Tool Notes. Which tool do I use to remove the O2 sensor? [Paul Seminara] Us a crows foot or special slotted O2 sensor socket or "adapted" open/closed end wrench.

Replacement Procedure. [Editor: Tom's notes apply to a 960 but the procedure is similar for 740/940] [query] I'm planning to change my O2 sensor on my 960 wagon. Where is that thing? How tough of a time will I have in removing it because of heat-related seizing. [Response: Tom Irwin] OK, if you are w/o a shop and hydraulic lift, I recommend the following... FOUR JACKSTANDS Rated to 3,000 pounds apiece or better. I've been lifting the car under it's mid-chassis reinforcement with a large wide-saddle jack. A skinny jack will damage the underside of your car... Lifting the whole side, place 1 jackstand each under the corner lifting points, at FULL-EXTENSION... do the drivers side first... Ditto the passenger side, BUT LEAVE the jack in place and lower it maybe 0.5" so it is a back-up, in case the jackstands fail, but it is NOT bearing any load... (could cause they whole deal to shift.) Lay down a HEAVY piece of corrugated cardboard... Let's you SLIDE in and out from under the car real nice.
The O2 sensor is screwed in to the CAT, up on top, there are four wires. FIRST! Go open the hood and locate the O2 connector... it's kinda near the oil dipstick tube, about half-way down. It should be clipped to a metal standard...release it...there is enough slack to lift the whole assembly up higher for a better look. It is a BLUE plastic connector with a RED slide-Lock passing through it's mid section. Use a small thin screwdriver under the looped bail of the red slide lock and pry it gently to the side, extend it as far as it will go. Separate the 2 blue plastic halves make sure that the end of the harness that goes down below to the O2 sensor is not wire tied anywhere.
Go back Down Under the car, pull the wire down and cut any cable ties holding it to the dipstick

or elswhere. Now on the left side of the transmission there are 3 plastic snap-lock clips holding the wires to the transmission pan. Squeeze them from the inside with a thin nosed plier and release all three. On the UPPER, TRAILING EDGE of the transmission tail bracket, there are 3 10mm headed bolts holding the wire to the bracket. Remove all three.   A small 1/4" drive ratchet is great for this.   Then remove the ONE speed nut holding the wire up on a heatshield in front of the CAT.   Follow the wire... THAR she IS... sticking out of the top of the CAT, in front of the honeycomb.   It is a 22mm facet on the base of the sensor. Get a 22mm socket with the sidewall slotted out for the wire to pass thru (Editor: known as an "oxygen sensor wrench")... if you can... but I just squirted a bit of PB Blaster on the base and let it sit for a few minutes. I ended up using a 22mm spanner wrench open end to the sensor.. It cracked free quite easily... you may be so lucky.. Then you just un-screw it. I know this is trite....but...."Re-Assembly IS reverse order". REALLY! [Note from WBain] Use an anti-seize compound on the threads (if the sensor did not come with any.) It will make any future disassembly easier. [Caution from David Hunter] Also make sure you are not cross threading it - easy to do on the O2 sensor.

Replacement: Use of Generic Sensors.
[Editor] You can install a generic Bosch or other three-wire heated sensor instead of the more expensive Volvo OEM sensor in Bosch LH systems, but you will have to splice in the connector. Bosch model numbers 13953, 13942, and 13913 are reputed to work depending on your year and engine (same sensor listed as for Ford 5.0 V8 Mustang engine but different harness lengths: check the Bosch site for applications). If you have a Regina-equipped car, *use a sensor specifically engineered for Regina* systems. Regina cars through 1993 use a Volvo -394 sensor which is the same as NGK OTA4F-B. The Walker catalog lists 250-23811 as a direct fit replacement for Regina systems. *Note: many aftermarket sites, including FCPGroton, do not distinguish between Bosch and Regina and claim that the Bosch unit "fits all".* **Not true.** To be sure, buy the NGK unit for Regina which is listed at their website (they confuse 8 and 16 valve cars, but the correct Regina sensor is shown.) [Frank] In March of 1993 Volvo switched from a three wire O2 sensor to a four wire sensor. The three-wire generic sensors are **not** interchangeable with the newer four-wire applications. [Ken] To install the generic sensor, you will need to cut the wires on your harness and splice them to the sensor wire. Crimping is recommended, instead of soldering, because solder weakens stranded wire subject to heat and vibration by decreasing its fatigue life. The NGK website also recommends crimping using heat shrink tubing to protect the crimp. Buy 3M crimp connectors with integral heat shrink tubing (Walmart has these). Do not use silicone dielectric grease on the connection since silicone contaminates the sensor. *Note:* See the table of generic replacements compiled by Brickboard members.

Code 2-1-2 "Faulty Oxygen Sensor" in 960 Cars. [Rafael Riverol] If the check engine light on the dashboard lights up and you read OBD I diagnostic code 2 1 2 (faulty oxygen sensor (O2) signal) in your 960, undo the red and blue four way O2 connector near the oil dipstick and check inside. The metal spades in the male connector are surrounded by silicone like material which crumbles, particularly after you apply electronic connection cleaner or the like. The particles can fall within the male and female connection, even inside the female connector contacts, and cause a faulty O2 sensor signal. Take out the loose material with sharp tweezers. Make sure all contacts are clean and undistorted and connect back together WITHOUT using silicone dielectric grease because of low signal voltages. Clear the codes. This procedure should eliminate the faulty signal.

Crank Position or RPM Sensor.

B2XX Series Engines. *Symptoms of Failure: No Hot Restart.* Suppose the car already has the upgraded silver-terminal fuel pump relay but won't restart promptly after a hot soak. Take an educated guess on a weak crank position (RPM) sensor. If you have Bosch LH2.4, then replacing this permanent-magnet sensor located in the top of the bellhousing fixes many hot restart complaints on 700/900s. [Tip from HansW] Check the lead to the sensor: it can rub against engine components and expose the wiring. Newer sensors come with plastic cable holders to prevent this.

LH2.4 RPM Sensor, Courtesy FCPGroton

Testing Bellhousing RPM Sensor. [Inquiry:] I decided to find and remove my flywheel sensor. Externally it's in perfect condition. The cable and ends are pristine-looking. Is there a way to test it with a multimeter? [Response: Ivan K] Often these rpm sensors fail intermittently, usually when hot. This makes them hard to test. Since the sensor is cheap enough, just replace it. With high mileage cars, it's only a matter of time before they fail. [Response] Measure the signal while the sensor is still installed by unplugging the sensor at the cable connections at the firewall to the drivers side of the engine. Measure voltage here as the engine is being cranked. Use a low voltage setting on a digital volt meter, preferably in an alternating current setting if available in a low voltage setting. If no signal is detected, the unit is suspect. The other simple measurement is to unplug the unit (without removing it from its location behind the engine on top of the transmission housing). Check all 3 terminals for resistance or an open circuit. The new sensor measured about 160 ohms between the center lug and a side lug. My old defective unit had no continuity and no measurable resistance.

*Removal of Bellhousing RPM Senso*r. [Tips from Jay Simkin and others] The rpm sensor is awkward to access as it is below the cylinder head on top of bell housing. It can be removed by using 21" of 1/4" or 3/8" extensions, then a universal joint, a 3" extension, and a 10mm standard depth socket to turn the retaining 10mm hex head screw. First clean the area around the sensor using brake cleaner. Without inserting the ratchet in the extension end, pass the tools between the firewall and the aluminum-colored air-conditioning pipe. Once the tools enter the space beside the engine, bend the universal at 60 degree angle. Pass the tool string behind the engine block. There is a black cable that can be pushed out of the way. The 3" extension and 10mm socket will align pretty easily with the top of the hex head machine screw. Set the socket on the machine screw head. Gently, insert the ratchet into the extension string. Turn gently to remove the machine screw. Remove the tools. Use your left hand to grip the sensor. The sensor usually will come free as soon as the screw is removed. If it does not, grip it close to where it enters the housing - not at the top, into which the wire enters) - and pull straight up. Do not pull on the wire.

If the sensor will not come out, it may be needful to break any "seal" between the sensor base and the bell housing. Turn the sensor gently about 1/16" turn, in either direction. You may rock the sensor gently, but no more than 1/16", side-to-side. Do not use any tool or brute force and DO NOT PRY since the housing is plastic (see the Cautionary Note below). The sensor goes only about 3/4" into the bell housing. The sensor has smooth sides and no locking lugs, so it is removed by pulling straight up. If the sensor still will not come out, use a small amount of lubricant (WD-40 or PBlaster). Allow it time to flow along the sensor's sides. Rotate sensor slightly and try to remove. Do not use brute force: if the sensor snaps and plastic fragments fall into the bell housing, the transmission will have to be removed to allow removal of the fragments.

Caution: Some Cars Have a Flimsy Sensor Mounting Bracket. [Another Tip] Trouble started when I couldn't get the old sensor out of the hole into which it fits over the flywheel. Where it's located makes it hard to get much of a grip on it. I tried rotating it in the hole to free it and then prying it up with a screwdriver. To make a long-story short, it's not mounted in the beefy Volvo bell housing like I thought, but in a flimsy, Fiat-like, aluminum casting that bolts into the back of the block. And very easy to break, I've discovered. And designed so you need to separate the bell housing from the engine to R&R it!!! Moral of the story is go easy on a stuck sensor. [Chris Herbst] NEVER PRY the RPM sensor out of the bracket. The poor quality bracket that they use to hold the sensor is SO weak that can break if you force the sensor around. Prying side to side on the sensor can break either the bracket or the sensor, leaving you helpless to do anything but pull the trans back to replace the bracket. When you really pry that thing is usually when it breaks. But because those brackets are so flimsy, it can still get you when you don't expect it. Usually (99 out of 100) is a piece of cake. But when you're the one who has #100... it sucks. Just be careful and you'll be fine.

Turn it lightly back and forth to remove it, but don't force it at all. Wait until it moves. On a standard trans cars use a tiny bit of silicone spray to get the thing out, and work it gently back and forth until it gradually loosens. If it is an automatic, get an Easy Out screw extractor into it, then douse the thing with PBlaster penetrating oil and wait for it to work its magic. The penetrant won't hurt anything like the clutch on the standard trans car. On the other hand, you want to avoid harming the timing ring on the automatic, because it is not very strong. You still run the risk of demolishing the bracket if you pry at it too hard, so make sure you are patient and let any penetrant or silicone get in there before you pull it. Once they move side to side, they can gently be removed. This sometimes takes a while, but the rewards are that you don't have to pull the transmission. On installation, put a light coating of grease on the perimeter of the sensor where it contacts the bracket. That will make your life a lot easier when you go to get it out of there next time. And if you have the trans out for any reason, take the RPM sensor out--whether or not you reuse it--and coat it LIGHTLY with a film of grease. That will avoid the problem, should the sensor need replacement in the future.

B6XXX Series Six Cylinder Engines. [Tip: Rob Bareiss] The 960 (B6304) engine uses a sensor mounted at the back end of one of the camshafts. It's in the same position as the distributor on an 850/S/V70 5cylinder. Since the 960 has no distributor, it uses this thing instead. Also saves a bunch of space at the back of the engine. Probably should consider it a regular service item, as with the 4-cylinder models. Replacing it is probably cheaper than having the car towed one time... Removing it is similar to the B23X engines except for the wiring clip on the firewall. [DanR] To get the connector off the bracket, all you need is a fairly small flat bladed screw driver. Pry away the metal collar that surrounds the connector; it has a clip that snaps in place. The part that snaps in is on the underside of the clip. If you break the plastic shells holding it together, they are replaceable from the dealer. On reinstallation, make sure you insert correctly the two wires from the trans oil temp sensor.

Knock Sensor.

Symptoms of Failure. [Tips from Marc] The car starts fine and will run for 2 miles and then lose power. It never stalls just won't move. If I shut it off and immediately restart it, it will run fine again for another 2 miles and so on and so on. When it runs fine, with a timing light hooked up on acceleration the timing will retard 1 or 2 degrees before it advances. If I check it when the problem is occuring it will retard 6 or 8 degrees before it tries to advance. Solution: new knock sensor. [Other symptoms] Retarded timing, acting as though no fuel is reaching the engine.

Knock Sensors Used on Volvo Engines

Sensor Styles. [John Sargent] The knock sensor is located on the cylinder head under the junction between number two and three intake manifold runners. It is next to the two coolant temperature sensors also bolted to the head. LH 2.1, LH 2.2, and LH 2.4 all use the same knock sensor, offered in two interchangeable styles that may be used on the red engines. Type 1 is on the left in the photo on the right, and Type 2 on the right. The only difference in the parts is the torque for the bolt holding the sensor to the block. Type 1 has the flat top, and the fastening bolt is torqued to 8 ft-lbs (11Nm), and Type 2 has the domed top and the fastening bolt is torqued to 15 ft-lbs (20Nm). If you use anti-seize paste, reduce the torque setting by 30-40% to account for the lubrication by the paste.

Operation. [Inquiry:] How do I test the knock sensor? [Response: Abe Crombie] If there is not a fault code for it then it is okay. The ignition control unit tests it every time you exceed some thing around 3000 rpm with moderate to high throttle. If it is not torqued properly it might not be as sensitive as it should or be overly sensitive. Torque is 8-11 ft-lbs. It produces a high voltage pulse when it senses the shock wave in the range of combustion knock. The voltage level is proportional to the severity of the knock. It will read 1.5 or greater megaohms but this is not really an effective test, only the control unit detecting a sensor signal when the conditions would absolutely assure a signal would be made is the real check. The knock sensor test by whacking on block (better than on the intake) next to knock sensor (see Duane's note below) is only effective on early Chrysler systems with the throttle opened as the closed throttle signal is supplied

Knock Sensor, Courtesy FCPGroton

to Chrysler ignition ECU and it cancels knock sensor retard activity. If you have Bosch ignition systems you can't do the whack it and watch it test for knock sensor operation. The Bosch systems are cylinder specific and you would have to knock within a few crank degrees of a given cylinder firing and be monitoring the timing light attached to that cylinder's plug wire. I don't think any of us are that good. [Tip for Chrysler Ignition Systems from Duane Hoberg] On the right side of the engine, in the area above and to the rear of the oil filter, tap the block with a metal faced hammer while observing the timing with a timing light. The timing should retard 6 degrees then return. If not then the sensor or the circuit in the control box is bad. When installing the new knock sensor, use thread lock. Apply too much torque and the sensor becomes sensitive as it is prestressed and reacts to normal engine vibration. When this happens you will idle fine but above idle run at retarded timing all the time. Acts like poor fuel delivery and doesn't like hills.

Diagnosis. [Additional Tips from Dave Stevens] Procedures for dealing with suspected knock sensor problems for an LH 2.4 system with EZ116-K ignition. Tests for other systems will be similar. Check the wiring diagram for your particular model and year to verify connector pins and wire colors. When no knock sensor signal is detected the EZK ignition system defaults to full spark retard. (see also Engine Performance)

1. *OBD ignition trouble code 1-4-2 "Missing signal from knock sensor"*

   The ignition system control unit (ICU) isn't properly "seeing" the knock sensor.
2. *OBD fuel system trouble code 3-1-2 "Missing knock sensor signal"*

   The fuel system control unit (FCU) isn't getting the knock sensor signal from the ignition unit (ICU) at start-up.
3. *Poor performance and acceleration due to excessively retarded timing*

   Over-sensitive knock sensor possibly due to over-torqued or failed knock sensor.

   "Cheap" gas and heavily carboned engines may cause misfiring to the point that the knock sensor signal is not "believed" by the ECU. Wiring and the knock sensor itself are by far the most common sources of knock sensor problems. [Les Daniels] If this piezo detector fails, it goes open circuit and the ECU 'thinks' that a massive retarding of ignition called for - hence the drop off in performance. On carb models there can be backfiring as well.

Knock Sensor Testing:

The knock sensor can only be tested dynamically for proper waveform output with an oscilloscope. Unless it makes you feel useful, there is no point in tapping on the block to simulate knock sensor activity. The voltage output of the piezoelectric quartz is too small and brief for normal measurement and, furthermore, the newer ignition systems won't be fooled into changing the timing as they selectively only detect knocking that would coincide with a misfire.

Start by making sure any engine diagnostic codes are for real by resetting the trouble codes (or disconnecting the battery) and wait to see if they reappear. Then do the physical and electrical checks below. If all other tests check out you may want to swap in a known good knock sensor on spec. Failing that an ICU swap may be in order. Only in desperation should the FCU be swapped on spec.

Physical checks:

1. [Les Daniels] One fault with these detectors is that the plastic housing 'cooks' and then the detector basically falls to pieces.
2. Check that the knock sensor (on the block, left side, down below intake runners #2 and #3) is properly connected to the wiring harness. It's easy to leave this connector off if you've been working on the engine.
3. Make sure the wiring connector for the knock sensor (green with black or brown wire) has not been accidentally switched with the block temp sensor connector (red/black with grey/white wire). The connectors are alike.
4. Make sure all connections are making good contact (straighten bent/separated contacts, check pins are fully seated by pushing in from back side). Remember to check the associated connector block at the strut tower or firewall. Make sure all connections are clean and protected from oxidation. Inspect for deteriorated/damaged wiring. Use an approved type of electrical contact cleaner. Squeeze dielectric grease into both sides of the connectors before re-assembly.
5. [Charles Dinges] Make sure the wiring feed to the knock sensor is not close to the alternator: anecdotal reports of interference and retarded timing upon acceleration were solved by moving this wire. Some electromagnetic interference from the alternator is the likely cause.

Electrical Sensor and Wiring Checks:

Note that testing at the ECU connectors requires the use of a multi-meter and some skill in electronic/electrical testing. Accidents can be very expensive. To avoid connector damage, do not probe connectors from the end, probe only from the sides or back. When working with ECU modules and sensors, always keep the ignition OFF (KP0) and disable power to the electronic unit (by pulling all ECU fuses or disconnecting the battery) except when required during testing. This will help avoid accidental damage due to stray voltage or static discharge, especially when removing or replacing connectors.

1. At the ICU connector (EZ116-K, EZ117-K or RexI ignition control unit) check the wiring from the knock sensor.
    1. Remove the knock sensor connector.
    2. Remove the ICU connector and remove the shell to access the side of the connector for testing (note the pin numbers stamped on the connector).
    3. Measure the resistance between ICU pin 12 and ground and between pin 13 and ground. Both should be infinite (open). Anything else indicates damaged/shorted wiring.
    4. Place a jumper wire at the knock sensor connector (between pins 1 and 2).
    5. Measure the resistance between ICU connector pins 12 and 13. It should be zero ohms. Infinite resistance indicates an open wire or bad connector. Anything else

indicates a dirty connector.
6. At the FCU connector (LH 2.4 fuel injection control unit) check the knock sensor signal from the ICU (pin 4). Applies to EZ116-K ignition only.
7. Remove the FCU connector and remove the shell to access the side of the connector for testing (note the pin numbers stamped on the connector).
8. Re-install fuses. Turn the ignition to ON (KPII).
9. Measure the voltage between FCU connector pin 28 and ground. It should be approx +0.7 volts. Anything else indicates a problem with the ICU or its wiring.

Sensor Testing Procedure:
[Rafael Riverol/Andreas Lofgren] Connect test diode Volvo tool #5280 (or LED from Radio Shack connected in series with 750-1500 ohm resistor, which will work just as well for a couple of dollars) black lead to connector on drivers side of the car wheel housing near steering fluid reservoir (RED AND YELLOW LEAD). Connect red lead of tool or LED to battery or ignition coil terminal 15 where you find +12V. Use enough wire to run LED to passenger compartment or at least to hold it with windshield wiper where yoo can see while driving the car. Turn ignition on and diode should stay lit. Start the engine and run it about 900 rpm. Diode should now go off. Drive the car under light and heavy engine loads. If diode flashes 4 times, chech knock sensor wiring. If wiring checks OK, replace knock sensor and run above check again. If diode continues to flash with road test, you may have to replace the ignition control unit.

EGR Valve. *Service Requirements.* [Inquiry] what exactly is the "EGR"?. It is specified in the service manual that it must be checked / cleaned during the 90,000km (~60000 mi) service. [Response: Tom Irwin] The Exhaust Gas Recirculation (EGR) valve is located underneath the intake manifold. If it gets plugged, you can ruin an O2 sensor or get incorrect fuel metering; basically the engine will run like crap and use a lot of gas. To service the EGR, it will be necessary to remove the air induction apparatus for clearance. Removing the throttle body also helps and it is a good time to clean it out as well. The same is true for the IAC, Idle Air Contro valve. Once you remove the EGR valve, Take it to a bench and use a vacuum pump to check operation and hold open the

EGR System

diaphragm and valve, or follow the procedure below. Spray carburetor cleaner through it. Also spray into the tubes. A stiff wire might be useful if there is large debris or a plugged line. The temperature sensor electrical connector should be de-oxidized and protected with silicone dielectric grease.

EGR Valve Removal. [Procedure from Kevin] The EGR intake tube is held to the intake manifold via 2-10mm bolts and a flange. The exhaust side is screwed into the exhaust manifold with a 22mm acorn nut. Once the tubes are separated the valve itself is held in a bracket via a large thin nut, best removed with a large pliers. I found it took a good two-handed pull to break the 22mm acorn nuts free (the nuts that attach the pipes to the valve). Your only option here is to use a 22mm open-ended wrench (unless you happen to have such a thing as a 22mm crows-foot). Be real careful not to have the wrench slip and round off the nut. The valve gets hot in operation, so the nuts tend to seize to the valve fittings and take some persuasion to break loose. I sprayed PBlaster penetrating oil on the fittings and let it sit for 20 minutes before trying. This is a classic “knuckle-buster” situation, so it is a good idea to put on a pair of gloves. Access is limited with a big wrench like this one, but once the nuts are started you will be able to turn them 1/6-turn at a time till they are off. Once the nuts were off, I had to tap the inlet pipe with a hammer to get it loose from the port on the end of the valve. The compression fitting on the end of the pipe was kind of wedged in the port on the valve and did notwant to come off at first. I could not get the outlet pipe off of the side of the valve, so I took the valve off with this pipe still connected (disconnect the other end of the pipe from the intake manifold first). The valve is held on a bracket with a 25mm nut. I managed to get this off with a 1 inch AF open-ended wrench. Again, it took some force to break it free, and access is limited so it was 1/6 or 1/4 turn at a time to get the nut off. I had a difficult time getting the vacuum hose off the valve. the rubber boot at the end of the hose was in very poor conditon (rubber was breaking down and had taken on a tacky/gummy consistency) and was stuck to the vacuum nipple on the valve. I assume this is due to the high temps that this valve sees. I will be looking for a replacement as I do not think it is going to last much longer.

EGR Valve Vacuum Checking/Cleaning. If you don't have a vacuum pump to test operation, improvise: Insert an allen wrench or small screwdriver or other suitable “probe” into the inlet port (threaded opening on the end of the valve) until it contacts the valve seat. Keep one hand on this probe while maintaining a small force to keep it in contact with the seat. Place vacuum nipple in mouth and suck! You will feel the valve seat opening. The valve should hold open without any additional suction. If the valve fails to open, or if the diaphragm leaks when you do this, then the valve may need to be replaced. If you don’t want to put engine parts in your mouth, you can make a more hygienic mouthpiece from a couple of inches of scrap vacuum hose. When I cleaned my valve, it had very little carbon/dirt in the valve. Noticeable build up of carbon on end of the EGR discharge pipe, where it connects to the intake manifold. Cleaned this up with a stiff wire and several squirts of throttle-body cleaner

EGR Valve Reinstallation. I put a little anti-seize on the threads before replacement (don’t get any inside the ports though). I am hoping this will make it easier to get the nuts off next time. Place the valve in its bracket. Hand tighten clamping nut that holds it to the bracket. Start the threads on the two acorn nuts. Attach the outlet pipe to the intake manifold and tighten the nuts there all the way. Tighten the bracket clamping nut all the way. Tighten the two acorn nuts all the way. Put a spot of silicone grease on the vacuum nipple and replace the vacuum tube (again, I am hoping this will stop the rubber from “gluing” itself to the nipple. Reconnect the temp sensor electrical connector.

Pulsair Valve. [Tops from Tom F] Volvo introduced Pulsair system on B200/30A, E, and K-engines and on the US '94-'95 B230FD engines. The Pulsed Secondary Air injection system adds oxygen to the exhaust manifold to continue the combustion of unburned fuel in the exhaust system and provides additional oxygen for the catalytic converter, thereby lowering harmful emissions.

Pulsair Valve

PAIR Solenoid, on left strut support

It is independent of the EGR system and many cars have both. The pulsed secondary air injection solenoid or PAIR Solenoid, receives a signal from the ECU allowing the vacuum control valve to open. It is located on the left strut support between the EGR Converter and the OBD box. The PAIR valve (Pulsair valve), with permission from the ECU, allows oxygen in every time the exhaust valve closes, which causes an instance of negative pressure (the pulse) and introduces oxygen into the manifold. No air pump required. The photo shows the two Pulsar valves feeding the exhaust manifold and a vacuum control valve which get its a signal from the PAIR solenoid to allow air from the air cleaner box to pass through. If a valve fails, it can allow exhaust gas flow back, cooking the rubber hose. The hose is connected to a vacuum operated shutoff valve connected to the air cleaner. To test the pulsair valve, on a cold engine, place your hand over the valves, near enough to verify that air is being taken in and exhaust gas is not escaping. The action of the valve is a quick "pulse" corresponding to the opening and closing of the exhaust valves.

Regina Air Temperature Sensor. The Regina fuel injection system uses air pressure and temperature in the intake system to compute the air mass moving into the engine. The temperature sensor is located in the intake hose or pipe. The air mass passes through holes in the sensor and over a bulb which sends a temperature signal from the incoming air charge to the ECU. Information from this sensor is added to the pressure sensor information to calculate the air mass being sent to the cylinders. The sensor is an NTC (Negative Temperature Coefficient) thermister which means that resistance declines as the temperature increases. This sensor helps the ECU to determine spark timing and air/fuel ratio. You can check this resistance by connecting an ohmmeter between pins to read:

- -20°C (4°F) 15K ohms
- 20°C (68°F) 2.5K ohms
- 100°C (212°F) 160 ohms

Use a heat gun to change temperature. Problems may occur in the sensor, the connector, or the wiring leads.

Regina Manifold Air Pressure (MAP) Sensor. The Regina fuel injection system uses air pressure and temperature in the intake system to compute the air mass moving into the engine. The MAP pressure sensor is located on the driver's strut tower support. It is connected to the intake manifold through a hose and takes a reading of intake pressure. The sensor is piezo-electric and changes a voltage input to an output signal proportional to manifold pressure. The system calibrates atmospheric pressure when the engine is started and under full load conditions. To test, turn ignition "on" and test the back of the sensor connector or the pins on the back of the ECU connector (do not disconnect with the ignition "on"):

- Connector A or pin 6 is ground
- Connector C is the constant voltage input from pin 7 on the ECU and should read 5 volts to ground
- Connector B is the variable output signal from the pressure sensor to pin 11 on the ECU. Connect a hand vacuum pump to B or 11, apply vacuum, and read the signal. Voltage should drop from 5 volts to a lower number. If it does not drop, replace the sensor.

Problems may also occur in the sensor, the vacuum tube leading to it, the connector, or the wiring leads.

OEM and Replacement Parts. If you cannot find an OEM replacement MAP sensor (Volvo 1378162- $115), look at a parts store for an identical unit for a GM car using the same part (an early 90's GM 3.1 V6, ie. 1990 Chevy Celebrity w/ 3.1): Delco# 213-185 ($50); Standard Motor Products AS5 ($40); GP Sorensen ($30); Echlin ($55).

Abbreviations:

AMM Air Mass Meter

ECT	Engine Coolant Temperature sensor
ECU	Engine Control Unit computer (either fuel injection or ignition)
FI	Fuel Injection
FPR	Fuel Pressure Regulator
IAC	Idle Air Control solenoid valve
TB	Throttle Body
TPS	Throttle Position Sensor
VSS	Vehicle Speed Sensor

Identification and Maintenance:

Bosch vs. Rex/Regina. [Inquiry] How do I identify my fuel injection system? [Response: Chris Mullet/Chris Herbst] Many 1990+ non-turbos have Rex/Regina systems; most turbos seem to have Bosch. Between 90 to 92, all non-California non-turbos were Regina cars. There were some 89s and there were some 940s until 1993 if not later. The Regina cars are anything but rare. Regina systems are characterized by:

- Only one fuel pump which is in the tank, without a pre-pump; and this fuel pump is not as high a quality as Bosch (note: later 940s have Bosch LH 2.4 FI systems but with single in-tank Bosch fuel pumps) Note: some 1989 cars are reported to have Regina FI and two fuel pumps (in-tank and under-car).
- Ignition coil is a wierd sort of amplifier-looking thing on the LH strut tower, versus a standard looking cylinder-shaped coil.
- Uses an intake air temperature sensor and a manifold air pressure (MAP) sensor, instead of the mass airflow meter.
- Relays are often but not always similar to Bosch; see Electrical: Circuits and Relays for locations and applications.
- Idle air control valves are not interchangeable
- Oxygen sensors are not interchangeable, regardless of what many aftermarket suppliers claim. Buy only the Regina-specific unit which is usually more expensive.

Setting Base Idle Specs and TPS on Bosch LH2.4-Equipped Cars . [Adapted from Volvo Service Manual 32043/1]

Cleaning the Throttle Body: See the discussion in Engine:Performance for more information

Adjusting the LH2.4:

1. Adjusting Idle Linkage Rod.

Ensure that when the cable drum is pushed off its endstop with a 2.5 mm feeler blade, the gap between throttle lever and adjustment screw is from 0.1 and 0.45 mm. (This is the adjustment screw that mounts on the throttle lever, not the adjustment of the larger nut that attaches the lever to the throttle plate shaft). To achieve the above spec, adjust the throttle link rod (ball-socketed connection rod between drum and throttle lever)

2. Checking the Throttle Body (Plate and Throttle Position Switch) Adjustment

Connect an accurate tachometer then warm up the engine. Let it idle in Park with a/c off. Pinch off the hose between the air intake and the IAC valve (don't damage the hose with something sharp!) Idle speed should drop below 500 rpm, or the engine may stop: both are normal. If idle speed does not drop, adjust as below.

3. Adjusting the Idle Speed

On the front side of your throttle body, there is an adjustment screw. Loosen the lock nut. Start the engine and turn the adjustment screw until idle is 480-520 rpm. Switch off the engine and tighten the lock nut while holding the adjustment screw so it doesn't turn.

4. Checking the TPS Adjustment.

Check the gap between the adjustment screw and the throttle lever with a feeler gauge. Insert a .45mm feeler gauge. There should be no click from the Throttle Position Switch on the rear side of the throttle body when the throttle is closed. Then insert a .15mm feeler gauge. There should be a click from the TPS when the throttle is closed. If these are incorrect, then adjust as below.

4. Adjusting the TPS.

Loosen the TPS adjustment screws holding it to the throttle body. First turn the TPS clockwise (away from the electrical connector) until it stops. While keeping your finger on the throttle disk so it won't move, turn the TPS counter-clockwise (toward the connector) until you hear or feel a "click". Continue turning until it stops, then tighten the screws. Go back to step 3 above to check the adjustment.

Setting Base Idle Specs and Mixture on Bosch LH2.2-Equipped Cars.

A. LH 2.1, 2.2 Jetronic Cars. [Courtesy of MVP, Volvo performance parts suppliers]

Many driveability and running problems can be traced to improper base engine settings. Setting your base idle specifications is always the first step when trouble shooting any runability problem. By following the steps below the source of most problems can be identified

1. Check for air leaks by spraying carburetor cleaner on all intake hoses and gaskets. Any fluctuation in idle while an area is being sprayed means a leak. Repair any leaks you find. Don't spray carburetor cleaner on hot manifolds as it may cause a fire.
2. Remove and clean the throttle body, adjust the throttle plate open ¼ turn. Reinstall it using new gaskets. Make sure the throttle switch clicks as soon as you crack the throttle (adjust as needed).
3. Start your engine and let it warm up fully.
4. Set ignition timing to the manufacturer's specs.
5. Now use a voltmeter (with minimum impedance 10 megohm for a digital unit) to verify that your 02 sensor is working properly. Connect the red positive probe from the voltmeter to the 02 sensor wire where it is connected to the large green wire by peeling back the connector cover and backprobing the contact leaving the sensor still connected. Connect the black negative probe from the voltmeter to ground. A good 02 sensor will fluctuate between .2 and .7 volts if your mixture is anywhere close. Replace the 02 sensor if needed.
6. Go to the right inner fender well (740's) or the left inner fender well (240's) and find the red and white pigtail that sits besides the ignition ECU. This is your idle speed test point. [Note: wiring colors can vary: some 760s use red/black.Check the OEM wiring diagram manual; aftermarket versions may not have the correct colors.] Ground this connector and adjust the bypass air thumbscrew on the throttle body until the idle is 725 RPM's. Remove the ground from your test point; the idle should be close to 750 RPM's.
7. Next to the idle speed test point pigtail is a green and white pigtail. This is your carbon monoxide or mixture test point, which measures the oxygen sensor output. Using Volvo special tool part #9995280 (approx. $35) plug one end of the test LED to the fender well connector and the red connector to the positive terminal of the battery. A logic probe can be used in place of the Volvo special tool or if you are handy build the circuit below. Remove the tamper proof plug from the air mass meter by drilling two 1/8" holes in the plug about 3/16" deep and removing the plug with needle nose pliers or snap ring pliers. This will reveal the mixture adjusting screw. Adjust the AMM until the LED on the tester blinks on and off at equal intervals. Congratulations! You have just set your engine's base idle specs. Note: when the tester LED is off it represents a lean mixture, when it is on the mixture is rich.

CO Logic Probe Tester for LH 2.1, 2.2

LH 2.1 & 2.2 Notes. [Art Benstein/John Sargent] The LED adjustment procedure presumes everything affecting mixture is in the ball park to begin with. Stuff like vacuum leaks, fuel pressure, injectors will throw the mixture off more than that pot (screw adjustment) will correct. If the O2 sensor isn't working, e.g. clogged with soot from rich running, the LED test point will not switch. It is actually monitoring the output of the first circuit inside the ECU that handles the O2 sensor signal, so the flashing indicates the switching between lean and rich that occurs while the ECU is maintaining the correct mixture. Because AMMs are slightly different in response, an adjustment is given on the AMM to adjust the ECU to match it up until LH2.4 when the ECU became automatically adaptable to the slight variations in sensor output. A better procedure to use in replacing AMMs would have you measuring the voltage on the yellow lead (LH2.2) before you adjust or disconnect the old one. Then you could at least put the pot back where it was if needed or set the new one to the same value before installing it. You could measure the resistance, but it is much easier to backprobe the voltage as you set the pot-- it varies from zero to about 2.7V-- then you don't need to guess where you ran out of adjustment. The ends are very hard to feel. Turning the AMM adjustment screw CounterClockWise gives a lean mixture, so turning the screw ClockWise gives a rich mixture. The mixture setting method using the LED tool gives a slightly lean mixture compared to the more accurate exhaust gas analyzer probe. Turn the AMM adjustment screw 2-3 turns CW (rich) to put the mixture adjustment in the right range.

Instead of using the test port, you can put a multimeter (with minimum impedance of 10 megohm for digital units) on the O2 sensor output. You should get an oscilliting voltage from about 0.1 to 0.9 volts. If your O2 sensor is generating a fairly even duty cycle between .1 and .9V, the system is in closed loop and the mixture is correct. The test point, if you are on it (pin 22 on the -544 ECU) is an open collector output protected by a 511 ohm series resistor-- pretty hard to damage externally. You don't really need the 750 ohm resistor, and its value certainly isn't critical to the function; just protects the LED if you drop the ECU end of the probe on a ground. The LED just shows you what the ECU sees as crossings of stoich point (which you will see graphically if youI use a 'scope on the oxygen sensor lead and set the crossing for 450 mv) with a set of comparators a bit on either side of that midpoint. That having been said, it can take more than a few turns on the AMM pot screw to adjust it, and some just won't adjust no matter what.

B. LH 2.4 Jetronic Cars. Idle is monitored and controlled by the ECU, acting through the Idle Air Control valve, and is not separately adjustable.

Relieving Fuel Pressure When Opening FI System. [Tip from Charles Probst, "Bosch Fuel Injection & Engine Management", Bentley] The fuel system is under pressure even when the engine isn't running. To prevent fuel from spraying over yourself and the engine when opening a fuel line, there are three good ways to relieve pressure in the lines:

- Neat: pull the fuel pump fuse (number 1), then crank/run the engine until it dies.
- Quick: wrap the fuel fitting in a shop cloth and loosen it, but it can be tricky and messy manipulating two wrenches, the fuel line, and the cloth.
- Fancy: connect a hand vacuum pump at the pressure regulator; when you pump vacuum, the regulator will dump pressure to the fuel tank.

Always remember to remove the fuel tank cap to relieve pressure in the tank. Pressure in the tank can be enough to squirt fuel from the lines after they're open.

Fuel Injectors:

Injector Cleaning. [Editor's Tip: see Michael Ponte's excellent illustrated discussion of injector cleaning at http://www.mikeponte.com/volvo/injectors.htm]

Problems With Deposits. Because the fuel filter stops dirt before it reaches the injectors, the main cause of injector clogging is not dirt but fuel varnish. When tiny drops of fuel vaporize around the injector nozzle, they leave behind trace compounds that can buildup over time and restrict the nozzle opening. Gasoline is supposed to contain detergents to wash away these deposits and keep the injectors clean. But recent reports indicate that many cut-rate brands of gasoline don't contain adequate levels of detergent for this. Dirty injectors restrict fuel delivery and cause a lean fuel condition. The result can be rough idle, hesitation and stumbling when accelerating - and even lean misfire.

Injector Deposit Removal. [Inquiry: What is the best injector cleaner?] I've tried a few kinds but I found that removal and flushing of the injectors and replacement of the injector seals really is the best. I removed the injectors in my 85 245 Turbo (K-jet) and took them to a shop and they pressure tested and flushed them. Even with all the injector cleaner I ran through (some of it was pretty expensive), they were still really crudded up. After the flush they were like new. The flush and test cost $13.00, the seals (for my brick there was a thin one on the injector holder, and a fat doughnut one on the injector itself - not sure what your brick has) were $3.00 (?). Total cost is much less than bottles of injector cleaner that are (in my case) of limited help. I guess in really bad cases a new injector may be required, but not with my brick. Injector removal and installing was pretty straightforward - and I'm not all that handy with tools. [Tip from Shane] As for sending them out and getting cleaned, look in the back of Turbo Magazine for RC Engineering. They're an injector specialty place, and can do everything but downsize an injector (clean, blueprint, balance, flowmatch, enlarge, anything!). [Lyle Domico] I was able to use a Mityvac to backflush my injectors with straight FI cleaner. Pull the injectors and strip off o-ring seals. Pour a little cleaner in a spray can cap. Set up your Mityvac with the brake bleed bottle attached. Wrestle the Mityvac hose onto the top fitting of the injector. Set injector upright in the cap of cleaner and pump up the vacuum. "Gently" press down on the injector to open the needle valve on the bottom and the cleaner will start to flush up through the injector, effectively backflushing it, including the screen.

[Response 2:] I used expensive injector cleaner with marginal success - so I did an injector overhaul. There are some shops that do a "complete flush" without removing the injectors using some technique, but I decided to do it myself. Removing injectors was straightforward - just keep things clean. I took the injectors to a shop and they did a pressure flush ($15). There are other home ways to do this like using bicycle pump with pure injector cleaner - but after a few attempts I decided not to try. They were badly crudded but after a bit of flushing, were good as new. After 220 K km, the shop said they were just fine. I also replaced the 2 rubber o-rings. One around the injector (fat doughnut type) and one around the injector holder (skinny ring type). The o-ring around the injector holder was brittle - so the new rings sealed a big vacuum leak. Use silicon lubricant to ease the o-ring replacement. All this took a couple of hours. Made a big difference at idle. [Editor] Numerous shops will clean and test injectors. One Internet shop is witchhunter.com charging around $15 each with quick turnaround.

[Tip from Ed O'Briant] My experience with a rough idle still present after a tune up and TB, IAC cleaning, etc., on higher mileage cars has been this (assuming no vacuum leaks, etc.): dirty, clogged, sticky, leaky, and otherwise compromised fuel injector operation. If you haven't done it, pull the fuel rail and the injectors. Either bench clean them yourself or send them off to the proper folks. Chemicals in the fuel tank don't cut it! They may help somewhat but in no way replace pulling those bad boys! On our '90 745T with 115K miles, I found that all four of the injectors had LOUSY spray patterns-streaming fuel instead of atomizing it. Also, two of the injectors were leaking-when power alone was applied to the leakers, without compressed air, the injectors just dripped cleaner when they should, of course, be tight. Leaking injectors cause a very lumpy idle! Hard, brittle, cracked injector o-rings are also antithetical to smooth engine operation.
After cleaning, none of the injectors leaked and they atomized the cleaner so well that the vapor hung in the air for a minute or more. Idle is now incredibly smooth. Smoother and faster acceleration/deceleration, no hesitation, as well. A testament to this is my wife's attempting to start the car TWICE since the injector cleaning, which is not normally a problem, except the car was already running!
Remember this if nothing else: There is NO such a thing as a clean, optimally performing fuel injector on a high(er) mileage engine, despite whatever the injector manufacturers/oil refinery folks may say about modern injectors and fuel blends, making injectors all but impervious to getting crudded up. It just ain't true.

Combustion Chamber Deposit Removal. See the FAQ section in Engine: Mechanical for a water-based technique that works as well as the section in Engine: Performance for gerneral notes on fuel intake deposit cleaning.

Injector Seals. [Tips from Tim Curry] These seals are very simple to install. Disconnect the battery, this will shut off the fuel system completely and reduce chances of an impromptu BBQ under the hood.

Relieving Fuel Pressure.
[Editor] To relieve fuel pressure at the rail, remove the fuel pressure regulator vacuum line, attach a vacuum pump, and apply vacuum. This dumps excess pressure into the tank.
[Tip from Brian] I wouldn't bother disconnecting the pump unless you want an arm/face and a garage floor full of gas. There is fair amount of fuel in the lines, and you would have to plug the line, or you'd just syphon all the gas out of your tank. Disconnect the high pressure line at the injector rail (with a cloth handy). Disconnect the return line as well, and tilt the rail to drain it. Otherwise, when you fight with the injector and it comes flying off in a hurry when you finally win, you might end up flinging fuel all over the place. Cover the open lines until you are ready to reconnect them. And keep that trouble light - hopefully with a compact flourescent - far away. They don't call it trouble for nuthin'.

Removing the Injectors.
[Tip from Norfleet] Be careful when you remove the fuel rail hold down bolts. There are thin washers beneath them that are easily dropped. Be careful when pulling out the plastic holders, you can break them (pull straight up, do not use a pry bar/screw driver beneath the wing).

Replacing the Seals.
The fuel rail is the thing that holds the injectors in place and provides fuel pressure, unbolt it. The metal u-shaped clips which attach the injector body to the fuel rail just act as snap rings. They are pushed on from the side and lock the fuel rail to the injector. Most likely, the rail will have to be separated from the injectors before you try removing them. They just push into place with finger pressure (into the rail and manifold), but can become stuck with age, grunge and dried rubber. Carefully, wiggle pry or pull the injector out of its hole in the intake manifold (one at a time please). [Tip from Gene Stevens] CLEAN the junk out of the injector hole before you pull them: blow the dirt out of the area around the base so it won't fall in. A straw will do if you don't have compressed air. LUBE the hole with some WD-40 or a few drops of ATF. The O-rings can bond themselves to the opening but if you wiggle them around a bit, the lube can coat the surfaces that get exposed, then it'll slide right out. If you let WD-40 evaporate before you're done, re-wet the area.

Use the seals in the kit (Bosch injector kit, import parts house, o-rings) with a small dab of grease, vaseline or lubriplate and install them where the old ones were. Note that the kit may have extra parts that don't fit your injector. There is a plastic cap that protects the injector's tip which can be replaced as well. The old one will be stuck so you may need to gently break it loose with a pair of vise grips, adjusted to just barely crush the cap slightly. If you need to reuse the plastic caps on the ends, warm them up with very hot water before removing, or they will break. Make sure to use a dab of vaseline on the end of the injector before putting the plastic cap back on, or it may split. I used a block of soft wood (pine scrap) with a hole drilled in it so the injector needle wouldn't be damaged when pushing the tip back on. Don't bugger the end and needle, or you will be buying a new injector ($$$). [Tip from Gene Stevens] LUBE the bottom O-rings and the receiving holes before you jam each injector back in, LUBE the top O-rings and the holes before you try to get the fuel rail on and it will all slide together like the parts were made for your car. Again, WD-40 or ATF works great. Grease stays around and just holds the dirt, so liquid lube is better for servicing.

Put the injector back in its hole (again, small dab of lube) and go to the next one. Do all of them or you will cause leaks. Put the rail back in place, set the clips, tighten bolts, attach fuel line. Make sure no parts are left over. Check everything again for tightness. Attach battery. Start car. Check for leaks.

Be careful, take your time. Its not hard to do, just think and keep parts in a container as you go.

[Tip from Brian] If you are only changing one set of seals, my preference is to pull the rail with the injectors attached. This way there is less risk of crud falling into the exposed inlets and ruining otherwise good injectors. And if you remove them from the rail do it on your bench with the injector nozzle facing up, for the same reason.

Injector Specs. [Tip from Shane] There's only two different EFI injectors used on Red Motor Volvos: 270cc/min (LHJet 2.2), and 300cc/min (LHJet 2.4). Wiring, connection to rail, and everything else is the same, just a difference in delivery.

Injector Diagnosis.

On the Car Diagnosis. Your Volvo's engine uses "port fuel injection" firing all injectors simultaneously with some cross-over occurring within the plenum. The injection pulses can vary considerably, and Volvo FI set-ups fire the injector twice per revolution (keeps the valve wet between intake cycles) to prevent hardened deposits from forming on the valves. This often results in enough fuel being present for near-normal engine operation on three injectors. All four injectors fire at the same time on +12V current supplied from the radio suppression relay (later cars) or the car's power supply. The injectors fire when the FI ECU grounds the circuit. Basic diagnostic tests for injectors include:

- Using a volt meter to measure the voltage being supplied to the injectors: place the + terminal in the + supply wire to each injector and the - terminal on an engine ground. This will verify that the injector is receiving power.
- Listening for injector opening/closing by placing a screwdriver against the base of each injector when the engine is running. Placing an ear close to the handle of the screwdriver should allow a faint "clicking" to be heard. This is the injector solenoid opening and closing.
- Using a noid light to verify that the injector pulse is occurring. A noid light is a small, resistive lamp matched to the injector that is inserted into the injector harness and flashes each time the ECU grounds the injector. It won't tell you much beyond the presence/non-presence of a pulse, but if one injector harness has a weak flash, that tells you there is a circuit problem. If there are no flashes and you've verified that each injector has +12V supplied to it, then the ECU is not grounding the injectors and you have an ECU or wiring problem. Buy a noid light specifically matched to Bosch PFI ("ported fuel injection") systems from any one of a number of online vendors such as IPD or a local NAPA store. Cost=$10.
- Pulling the plugs for observation of combustion conditions within each cylinder. Dark grey/brown indicates normal "burn". Light grey/white indicates lean "burn". Black and oily usually means a rich "burn" or oil control problem.
- Using a digital graphing meter or digital storage oscilloscope to see the waveforms. These meters are not cheap, although a used two channel DSO may be found on EBay for US$100 or so. For a good discussion about using a digital scope (Fluke 97a or the like) to diagnose injector and fuel pump problems, see Dave Goldberg's article on "Scope Use for Volvo "in the form of a pdf file.
- Checking the Injector Grounds on the Intake Manifold. [Don Willson] Injector ground wires on the intake manifold are frequently corroded. Just cleaning them and tightening the bolt is not enough. The wire must be soldered to the crimp lug. The internal resistance of this crimp increases until injectors start to missfire, the O2 sensor sees too much oxygen and feeds the engine much too much fuel. Mileage drops to 10 mpg with smoke and no power.

Off the Car Diagnosis. You can remove the injectors and supply a similar voltage to test them. To verify operation of the injectors, measure the spray pattern and throughput of each using a graduated plastic beaker. Should one or more injectors be inoperative, and if your engine has considerable mileage, replace all injectors & fuel filters (including the small catch screen in the main fuel pump). Those on a budget may try to clear the injectors using concentrated cleaner, but this method has hit-and-miss results, especially if there is a foreign object clogging the injector. Don't expect a disconnected injector on # 2 or # 3 cylinder to result in a change in engine note (at idle).

Cold Start Injector. [Inquiry] What are the symptoms of a failed cold start injector? [Chris Herbst] The cold start valve adds more fuel to the start and cold run mixture for better performance when starting and first started. Then it shuts off. By the way, don't let "cold start valve" and "cold start injector" fool you. They are the same thing. Symptoms often include failure to run without foot on the pedal, and failure to keep running at cold idle. If it fails, it could cause you to have to crank longer on cold starts, although similar conditions on warm start would be less abnormal and more likely to be a fuel supply problem. First see if you read line voltage from the wiring harness to the cold start injector when cranking after the car has sat overnight in cool weather. If the "3-2-1" diagnostic code persists, the cold start valve is faulty.

Cold Start Injector Problems on Regina Cars. If your car has a Regina fuel injection system and you have starting difficulties, see this note about a Technical Service Bulletin 23-135 fix for the problem.

Homemade Fuel Injector Cleaner. An article in performance engineering recommends 1,1,1 trichloroethane and a stiff bristle brush to clean the outside. Don't immerse the injector, just scrub at it. An ultrasonic pen or jewelry cleaner and fuel injector cleaner (Chevron Techron) to clean the outlet. Stand the injector up in the cleaner so the outlet is in the solution and run the cleaner to 10 minutes. Run a half n half mixture of mineral spirits and injector cleaner thru the injector on the bench to clean the inside. [Another:] He showed me a very interesting way to clean the injectors while in the car. We took an air compressor line water filter with the filter removed, and filled it with straight fuel injector cleaner (like what you would buy at K-mart). We then tripped the inertia switch on the fuel pump to shut off fuel flow and connected one end of the 'water filter' to the schraeder valve on the fuel rail. The other end of the 'water filter' was connected to a simple air compressor regulator which we regulated to around 35 psi and then turned on the air. We started the car and ran the straight fuel injector cleaner through the injectors. Apparently, this is in essence the same way garages and dealerships use to clean the injectors while on the car (using perhaps slightly less kludged equipment). Although it doesn't account for backflushing or screen replacement, it did make an excellent difference in the idling and off-idle performance of my car. Not so much in power but in smoothness. All done with probably $15 worth of hardware (providing you already have an air compressor).

[Another:] A two line flush system is a must. I was selling and training the CarbonClean unit way before Motorvac hit the street. The Motorvac is a spin off the carbon clean . Any unit that uses the two line flush method is worth having done. The GM top engine cleaner and the Ford factory stuff is great chemical and should be used at a 5 to one mixture rate with the gasoline. We have done tons of reasearch on the chemicals and these passed with flying colors. Keep watching our web site for my article " fuel service of the 90's" will post at : http://www.lindertech.com/

Troubleshooting:

Vacuum Leak Diagnosis and Repair. [Inquiry]Anyone know of a good method of test for and locating vacuum leaks in the the air intake system?

- *By Listening.* [Response: Don Foster] Find or buy a 3' length of new fuel hose. Stick one end in your ear and snoop around the intake system with the other end listen for any pronounced "hisssssssing...". [Warren Bain] I was able to isolate a vacuum leak with a mechanic's stethoscope with the probe removed and only using the tubing to get very close to the gasket and follow the contour of the manifold. You can also modify the stethoscope for locating vacuum leaks by replacing the probe with a length of plastic hose or fuel line.
- *Spraying With Liquid.* Another trick, for small leaks such as loose intake manifolds or shrunken injector seals, is to spray them with carb cleaner. This will temporarily seal a leak and a rough idle will smooth out for 10-15 seconds: you will hear the change in idle rpm.
- *Using Propane to Alter the Mixture.* [Tip from Bruce Young] I use Propane to test for vacuum leaks It's as safe (or safer) and less messy than spraying carb cleaner or other flammables . Take the nozzle tip off a propane torch and replace it with some snug fitting rubber hose about 2 feet long. Practice with the valve to get a moderate gas flow (not a roaring blast). With the engine at a warm idle, open the gas valve and poke the end of the hose around each injector for a couple of seconds. If the seals leak, you should hear an RPM change when the propane gets sucked in and burned. Do the same around any other suspected areas, like hidden vacuum hose ends and the intake manifold gasket itself. To block the breeze from the fan, lay a piece of cardboard from the fan shroud to the engine.
- *Using Smoke to Locate Vacuum Leaks.* Filling the intake system with slightly pressurized smoke from a smoke generator will allow you to see leaks where the smoke emerges.

[Tip from Joe] Remember when looking for air leaks that it isn't always the hose or connection that fails: don't forget the diaphragm that is being sucked by the hose you're checking. ie.. EGR diaphragm. If you find a leak in the intake manifold gasket, replacement instructions are in Engine: Mechanical. And don't forget vacuum hoses either: they can often split at the ends and allow vacuum leaks that are tough to detect.

Repair of Air Intake Hose. [Editor] If your large plastic intake hose tears in a non-turbo engine, you can repair it using several wraps of 3M Super 33 electrical tape or aluminum duct tape. If your pressurized turbo hoses tear, use the aluminum tape for a temporary repair but make sure you replace the hose as soon as you can.

Vacuum Hose Replacement. To replace your rubber vacuum hoses (not the hard tubes), buy the following quantities (1 inch=2.54 cm):

Hose Inner Diameter	B230F Normally Aspirated	B230FT Turbo	Application
4.2mm (Volvo p/n 976734)	112 inches	134 inches	All else underhood
6.6mm (Volvo p/n 976736)	26 inches	26 inches	Cruise Control
9.5mm (3/8 inch)	12 inches	12 inches	Brake booster

If you use the Volvo OEM hose, you can re-use your spring clips that secure the ends of each segment. If you purchase another brand with different OD, then buy new spring clips at a plumbing supply store (Home Depot, Lowes) in the small brass fitting section. [Gary Horneck] I replaced all my vacuum lines underhood with silicone hoses from BoostController.com. They sent me samples of both the 4mm (inside diameter) and 6mm to test and they fit great. The blue hoses have a 2.54 mm wall width (thicker than the stock hoses), are 100% silicone. I used high-quality 3M cable ties to secure the hoses since it was not clear the OEM clamps would still fit the thicker hoses. Now all the vacuum lines are in a contrasting color in the engine bay. Car runs very smooth and the hoses should last virtually forever.

Repairing Rubber Tubing Ends. [Inquiry] How do you replace the rubber ends on the hard plastic vacuum lines? I had one come apart and the rubber vacuum hose I have (Volvo original) fits the manifold fitting perfectly but is too large an ID to grip the hard plastic vacuum line. I know I can just replace the whole line with rubber, but I wanted to keep the plastic line. [Robert Ludwick] I've used some of that liquid rubber stuff that they sell for use for sealing electric fittings, it works great.

B6304 Vacuum Hose Replacement [Jim Bowers] I just went through replacing all connections at the vacuum port on my 960. I attempted to get everything from the dealer as in my opinion that system is one of the poorest designs in the car and correct sizes/orientations are critically important. There are about 4 different plastic line sizes and several port sizes for the various destinations. Some need to have a right angle and others are straight. On top of that, the parts illustrations for these little vital parts are very poor in the parts system. I spent a lot of time at the parts counter with many trips to the car to get all the right connectors with the different size ends. Only one connection at the port is made with a section of straight vacuum hose with equal size at each end! My feeling is that getting connectors with the right size ends is important for reliability. When rubber is over stretched is starts cracking real soon. If the connection is loose the obvious will happen.

Fuel Pump and FI Relay Diagnostic Tests. Here is a procedure to test the operation of the fuel injection relay and the operation of both fuel pumps. The 3 main things to check in the fuel circuit are the fuel pump relay, and the 2 fuel pumps.

1. *Fuel Injection Relay Test*. There are 2 relays inside the fuel injection/pump relay. One of them should turn ON when the ignition is turned on (without turning over the engine), and the other relay (which actually turns the fuel pumps) should come ON when the engine turns over/runs. You can check the 1st relay by putting your fingers on the relay module and turning the ignition on and off repeatedly. You should feel the relay click on every time. If it doesn't, that relay isn't working. And you'll find the car doesn't start if the relay did not come on.

   [Tip:] To check for possible fuel pump relay failure go between center of cig lighter plug and fuse 11, should be less than .5 V (<500mV). Excessive resistance creates voltage drops that will exceed these values. The volt drops will be high due to poor contact points in relays or the solder joint problems. It is best to check these volt drops after it has run for a while as that is when the failures usually occur.

2. *Fuel Pump Diagnostic Tests*. On the 740, the fuse-box + relay box can be pulled out a little to facilitate inserting/removing relay modules. So pull it out as much as the wires will allow. Pull out the fuel injection/pump relay module. Now take a small piece of wire to jumper terminals 30 and 87/2 on the relay board (the terminals are identified on the relay module pins. The 2 terminals are the nearest left and middle right pins on the relay board). This should make the car act like the fuel pump relay is ON.

   Now turn the ignition ON (without turning the engine). You should hear a whirring sound right from where you are. That will be the main fuel pump. Now go to the gas tank and unscrew the cap. Put you ear to the hole and you should hear a smaller whirring sound. That will be the in-tank pump. If you hear both noises, the fuel pumps should be OK.

   To check the pumps individually, you can pull out the in-tank fuel pump fuse after you do the above test, and repeat the test. You should not hear any whirring at the tank, but you should be able to hear the main pump.

CAVEAT: The main fuel pump is not designed to be run without the in-tank pump "on", so get the second part of this test over quickly. You should not need to keep it running in this condition for more than a few seconds to complete this part anyway. For information about which fuel injection relay you have, see correct application.

Idle Air Control Valve. See the FAQ section under Engine: Performance, Symptoms for information about cleaning, diagnosing, and rebuilding the IAC valve.

PTC Nipple in 90+Turbos. [Inquiry] What is the sensor or valve, with two wires and a vacuum hose connected to it, is that is attached to the turbo intake hose on my Mitsubishi turbo? [John Sargent/Dave Armstrong/Abe Crombie] This is the heated crankcase vent nipple (also referred to as the Positive Temperature Coefficient heater nipple) used on 90 and later where the air heater tube is deleted. The PTC nipple is mounted in the cold air intake pipe that runs from the air filter box to the turbo. It is in the elbow of the pipe, nearest the turbo. It has one or two vacuum hoses connected that run back to the oil trap. There is also an electrical connector about the size of a spark plug. Volvo decided that the preheat system which was thought would prevent throttle icing would not work on intercooled models due to cooling effect on air through the intercooler before it goes into the throttle. The heater is to vaporize the moist air that comes out of crankcase after start up and while driving in very cold weather. The LH fuel injection system on that car doesn't use the Intake Air Temperature sensor. Occasionally one can experienced a pressurized manifold with too much pressure in the crank case, causing oil to blow from the filler cap or the seals. This can be caused by the PTC nipple valve which can clog. All of the turbos since 1990 have a PTC and they tend to get clogged during cold weather.

Fuel Pressure Regulator. For theory of operation, effects of failure, and diagnostic tips, see the FAQ file.

Testing or Repairing Bad Fuel Injection Relay. I had a similar no-restart problem on my '89 780, and the problem was, in fact, the fuel injection relay. Try this. If the car quits and won't restart, try banging your fist on the left side of console, at about ash tray height while cranking the engine. If it starts, the relay is probably flaky. It sounds weird, but that's how I found my problem. If you want to be more sophisticated, use a volt meter to check the voltage to ground at the injection ballast resistors. You should see 12 volts when you turn the key on. If not, thump the console. If the voltage comes on, it's the fuel injection (pump) relay.   [Response 2:] The Bosch relays can be resoldered very easily by anyone handy with a soldering iron and soldering gun. And a little experience. Remove the plastic relay cover and examine the foil side of the printed circuit board (on the flip side from the electronic components). With a magnifying glass

Fuel Injection Relay

you'll probably see the solder cracked, crystallized, and overheated around the heavy connections to the actual relay -- they look like little "buttons" coming through the silvery solder. I use a soldering gun the heat & resolder these heavy connections, and a small 25 Watt iron for the other connections. Be very careful not to form a "solder bridge" between adjacent foil traces. You might consider drilling several holes in the plastic case for ventilation -- a good idea. [Tips from John O] What I've seen occur with some of those relays isn't cracks but sticking contacts, like any electrical contacts do with time and use. That's why I just replace the relay. Otherwise, try soldering it and filing the contacts if possible but for $50, I don't think it's worth the gamble in my humble opinion. Also look at the terminal at the relay box for discoloration as they sometimes get so hot that they melt the plastic. [Editor] If you've replaced the relay, make sure it is the correct application.

Radio Suppression Relay

Radio Suppression Relay. [What is the Radio Suppression Relay and where is it?] The radio suppression relay (as it's called) is in actually a fuel injector relay. The pre 1986 injectors were supplied constant + power to one terminal and supplied a timed ground to the other terminal via the ECM. The constant + power used to come from the fuel pump/injection system relay. In 1986 Volvo decided to isolate the fuel injector circuit because of some radio interference created by the pulsing circuit around the relay tray inside the passenger compartment and near the radio. The solution was to energize a relay - the radio suppression relay - with the pump/system relay feed instead of using the passenger compartment-mounted fuel injection relay to power the injectors directly. The radio suppression relay then supplies the + power to the injectors. The timed ground still comes from the ECM. The reason Alex can't find his radio suppression relay is because it's located on the other side of the engine compartment behind the power steering reservoir, (relay closest to the engine of the two relays mounted there Alex). For the most part the non-turbo engines had the radio suppression relay mounted on the right side (pass) of the engine compartment on or near the coolant reservoir or near the ABS unit. The turbo engines had the radio suppression relay mounted on the left side (drivers) of the engine compartment on or near the shock tower or the inner fender. Not set in stone just as a general rule. The radio suppression relay was used from model years 1987 until 1995 on almost all LH injected 4 cyl and V6 engines and many Regina cars. There may be a couple of exceptions. The 5cyl and straight 6cyl engines do not use one. When it's bad or missing, the radio will work fine, but the engine will not run. Remember even though it's called a radio suppression relay it's function is to supply + power to the fuel injectors.

Problem diagnosis: When this relay fails, it can cause:

- Hot start problems (car won't restart until it cools down)
- Failure of fuel injector system (no injector pulses)
- Backfiring or balky acceleration (insufficient or inconsistent injector pulses)

Test 1. If you suspect that your radio suppression relay is faulty *try switching the leads* with the electric cooling fan relay if your car is so equipped. These relays are often identical up to the 940 series and in many car lines are located right next to the radio suppression FI relay. If your fan stops and your engine starts, then you've isolated the problem. In 940 cars, the cooling fan relay is different and is located behind the left front headlamp and will not substitute for the RSR. See also Hot Start Problems. The usual relay failure is caused by solder cracking which can be repaired. Note that in cooler climates, the electric fan may be so infrequently used that the coolant fan relay is corroded and broken. *Test 2.* A further diagnostic test is to *jumper the two larger wires* leading into the radio suppression relay connector. If the fan starts, you've jumpered the wrong connector. If the engine then is able to start, your relay is defective. If not, your problem is elsewhere.

Oxygen Sensor Diagnosis.

Oxygen Sensor Simple Diagnostics. [Herb Goltz] You don't need to remove the sensor or jack the car up to check it. You need a digital voltmeter with an impedance of at least 10 megohms to prevent damage to the ECU. First, trace the leads from the sensor up to the firewall. For your model there will be 3 wires, two of which go into a connector. They are just wiring for a heater to get your sensor up to temp quicker. The wire you are interested in is a single shielded wire-- depending on the model, it will have various colors. There will be a spade connector underneath a bullet shaped black cover. Just pull the cover back. Warm the car up to operating temperature. Uncover the spade connector-- leave all the wires plugged in and the car running. Set your multimeter to DC volts, and the range to <2V. Ground the negative probe of the multimeter to chassis ground (like the strut tower) and the positive to the connection at the O2 sensor. You should see voltages oscillating regularly from around 0.1-0.9V. If voltage is steady or zero then you likely have a bad O2 sensor.

Oxygen Sensor Problem Diagnostics.

a. Bosch Diagnostics: Test for a rich mixture as follows:

- Disconnect the sensor lead to the control unit.
- Run the engine at 2500 rpm
- Artificially enrich the fuel mixture on electronic fuel injected engines by removing and plugging the vacuum line to the fuel pressure regulator.
- If the voltmeter rapidly reads .9 volts, then the oxygen sensor is correctly sensing a rich mixture. But, if the voltmeter responds sluggishly, or if it stays below .9 volts, try running it at 3,000 rpm for a few minutes, then check again. No improvement means you buy a new sensor.

  Test for a lean mixture as follows:

- Induce a small vacuum leak
- If the voltmeter rapidly drops to .2 volts or below in less than a second, then the oxygen sensor is correctly measuring the lean mixture. But if the voltmeter responds sluggishly,

of if it stays above .2 volts, give it the 3,000 rpm treatment and try again.

- If no improvement, then the sensor should be replaced.

Test dynamic performance as follows:

- Reconnect the sensor lead and tap your meter into the signal wire
- Set the mixture to specification.
- Run the engine at 1500 rpm.
- You should see rapidly changing readings that average somewhere around .5 volt as the computer keeps adjusting the blend. The sensor output should fluctuate around .5 volts. If it doesn't, replace the sensor. Deciding whether or not response is slow enough to justify replacement requires some judgment. A common rule of thumb for minimum activity is eight trips across the rich/lean line in ten seconds, and sometimes you can find specs for cross-counts.

Regina Diagnostics: [Bruce Young] The above apply, but know that:

- The white and red wires in one connector are the heater circuit; the black wire in second connector is the signal.
- Red is +12V; white is ground
- Black (connected w/engine running) should cycle rapidly between 0.1V and 1.2V
- Black (disconnected w/engine running) should "after a while" rise to 1.2V
- Replacement is NGK 25002, not a "generic" sensor.

For more information, see the FAQ Engine Sensor section on Oxygen Sensors.

Air Mass Meter Diagnosis.

Setting Base Idle and Mixture on Bosch LH2.2 Cars. See the FAQ section above for tips on base specifications.

Simple Functional Diagnosis of AMM. [Editor] The classic test of AMM failure is to disconnect it; if the car runs better, then the AMM is at fault. But here are the OEM tests per the OEM manual for Bosch 2.4 (the-016 AMM):

1. Check the ground point of the AMM:

- ignition off; disconnect AMM
- connect ohmmeter between ground and terminal 1
- should be 0 ohms
- if not 0 ohms, check the ground point on the intake manifold

2. Check signal from AMM:

- clean off sensor connector, removing any corrosion
- -start engine
- connect voltmeter between ground and back of terminal 3 on back of connector
- should read approx 2.3 volts.
- if not approx. 2.3 volts, substitute another AMM

Testing AMMs and Calibration. This is a response from Python Injection (rebuilders of AMMs) to a question about testing AMMs.
From: Joe Evert, Director of Engineering, Python Injection
Subject: Re: Technical Question about AMM
The reason the OEM doesn't give a test procedure for calibrating the air mass meter is two fold. First of all BOSCH Hot Wire Air Mass sensors are not linear devices like a throttle position sensor. The output does not change the same amount for a given air change. To make it short, most linear sensors will give you say... 1 volt for 100cfm air flow, 2 volts for 200cfm air flow, 3 volts for 300cfm airflow etc. This is a linear device. Bosch hot wire sensors are not like this. They change a great deal at low air flows but once the air flow increases past a certain point, say 50% of what the engine can draw, they change very little. This makes the sensor very accurate at low to moderate air flows and good enough at high air flows. Just a small amount of inaccuracy at low RPM and the vehicle will run terrible. If the voltage for a given air flow is off by 100 milli volts at low RPM the car will barely run. At high RPM A 100 milli volt deviation will not even be noticed. Because of this it makes it next to impossible for the technician to accurately diagnose the air mass in the field. We use a calibrated flow bench that measures the exact CFM air flow to then compare the voltage to. This is not practical in the field because temperature, altitude, humidity and the mechanical condition of the engine will affect how much air the engine is drawing in. So just to say that the Air mass should have xx.xx volts at idle would be completely false since all these parameters must be accounted for. Also even if a range is given just a small amount of deviation in the output causes poor performance.

So what are you to do? For on-vehicle diagnoses the best way is just unplug it at idle; if the vehicle runs better it is most likely bad. This is because if the air flow sensor is off voltage at high RPM it will also be off at idle. Also if you are experiencing repeated failures you probably have a defective air box thermostat. This little thermostatic bulb is located in the air filter box and controls the hot air into the engine. When this fails it fails in hot air mode and routes hot air from around the manifold into the air intake. This will destroy the air mass meter in no time.

Bosch Air Mass Meter Sensing Wires

Contaminants on Heated Sensor Wire. [Editor] It is rare but possible to see contaminants build up on the tiny sensor wires inside the Bosch air mass sensor due to dirt, spider webs, a disintegrating air filter, etc. In some instances, the hot burn-off cycle will not remove these contaminants. When this happens, it skews the ECU transfer function such that the MAF overestimates airflow at idle (causes the fuel system to go rich) and underestimates airflow at high airflow (causes the fuel system to go lean). This means that Long Term Fuel Trim will learn lean (negative) corrections at idle and rich (positive) corrections at higher airflow and may be the cause of high NOX readings on test. To remedy, spray the sensor wires inside very carefully with carb or brake cleaner to remove them, then reinstall and turn the engine on and off to activate the burnoff cycle.

Cleaning Later 960 Mass Air Flow Meters. [John Roberson] Post-1996 960/90 cars use a hot film mass air flow sensor. This can become dirty. To clean it, follow the instructions.

ECU Failure. See the FAQ file with much more information about symptoms, diagnoses, and repair.

Air Box Thermostat Change. Note: Non-turbo cars have a thermostat inside the air box that shifts air intake from heated air to cold air when the engine is warm. This is done to improve combustion at cold starts. Early turbos also had this thermostat, ending around 1988; later turbos do not. [Inquiry:] Can I change the air box thermostat in 7xx/9xx cars with an integral lower air box/thermostat combination? [Response: Steve Seekins] You can change just the thermostat element on any of the cars that are equipped with it. You only need to change the flapper if the hinges are worn or broken, or if the gaskets are destroyed. See below for instructions on thermostat removal on 90+ cars with integral air boxes. [Editor] You can buy a replacement thermostat from an aftermarket supplier for about $10.

Air Box Thermostat

[Editor] Spring is an appropriate time to test the function of your airbox thermostat and change it if needed. The thermostat can seize, allowing hot air to enter the air mass meter and dramatically reducing its lifetime. Note that many turbos do not have these thermostats since the turbo itself adds heat to the intake air. [Tech Tip from Walt Posluszny] I stuck a wireless household thermometer in the airbox of our 95 960 (152,820 miles) today. The outside temp was 70F and the temp in the airbox steadily rose while we were driving up a fairly constant 4 percent grade for 4.5 miles. Halfway up the road the thermometer registered 160F before it literally melted down. I pulled the air mixing box, and jammed the air door to open/cool air, replaced the still-operable remote thermometer, and took it up the same grade. The temperature declined to 73.5F in the airbox even though I was climbing the same 4% grade. Lesson: check your airbox thermostat and replace it if needed.

To test the thermostat:

1. Remove the air intake pipe from the grill hole to the air box extension.
2. Start your engine. As the engine warms up, the flapper inside the hole should move to the fully closed position in moderate to warm weather. If it does not, then you need to change the thermostat. See the FAQ section for test temperatures and flapper positions.

To change the thermostat in a 90+ car with the assembly inside the airbox :

1. Remove the air box from the car.
2. Spray PBlaster around the air pipe joint where the extension tube enters the airbox. This

joint will be very tight.
3. Gently depress the tabs and twist to loosen and remove the extension tube assembly holding the thermostat mechanism. Be careful that you don't crack the tube or the box while working on it.
4. Once this is free, you will be able to see and access the brass thermostat.
5. Depress the spring using either plier jaws or a two-pringed body clip remover tool. Push this down sufficiently to expose the thermostat piston rod.
6. Pop the thermostat out and insert the new one in its place. Make sure the rod goes in the hole at the top of the spring.
7. Make sure the flapper assembly operates correctly.
8. Clean everything up, lube the assembly with non-silicone lube, and re-assemble.

The only risks are being a little too brutal and cracking the plastic, or breaking an air box clip on removal. Be careful.

Engine Storage/Used Engine Notes. [Tip from Linder Injector Services] If you have installed a salvage yard engine, depending on how long it has sat it may have clogged injectors or fuel rail. The ones that I have seen require the injectors to be serviced off the engine. This will ensure that the inlet filters are clean (new) and their flow is correct with the appropriate spray pattern. The rail was flushed or ultrasonically cleaned. The pressure regulator had to be replaced on a couple of systems due to a lot of sediment. Most of the time this was a simple process that was fairly inexpensive.

Component Identification:

Brake Caliper Identification.
Front Calipers:
[Editor:] Volvo 700 cars use a variety of calipers, rotors, and pads on the front hubs. Prior to working on the brakes, carefully identify which components you have so that you can acquire the correct parts.
[Inquiry:] Does anyone know if there is a way to tell which of the two caliper types (ATE or Girling) my 740 GLE is using without removing the wheels? [Response: Paul Grimshaw] Refer to the product plate (located above passenger front headlight or in the trunk or door jamb). Go to position "E" (end of the second line on the right). The following codes apply:

2: Girling Front, ATE Rear
3: DBA/Bendix Front, ATE Rear
4: Girling Front and rear
5: DBA/Bendix Front, Girling Rear

ATE calipers are ONLY used on rear wheels. Note that DBA is the same as Bendix. The best way to identify front calipers is to look thru the wheel for a large iron bridge that reinforces the caliper body (with a slot on either side i.e. two slots):

Bendix caliper is in the left photo, Girling in the right. [Photos courtesy of IPD, a retailer of Volvo brake components]

Caliper Piston Size Stamping (40mm)

[Tip by Guid] Take special note, if you determine that you have Bendix calipers on your pre-1987 700, whether the two-piece hub/rotor conversion was performed on your car. When I bought my '86 (used), it had been converted. If so, you'll have to order pads for an '88+ to fit.
The quick way to tell the difference: if you have the one-piece (original '86) design, your pads will have flat tabs at the top (REPCO 536 picture below). If you have the converted ('88+) design, the pads will have the added spring pins (REPCO 1169 picture below).

Rear Calipers:
[Another Inquiry] I'm close to needing rear brake pads on my wife's 90 740. Peeking through the rim, I see the capital letter "A" in sort of an Italic script, followed by a couple more smaller characters that I can't make out, cast onto the caliper. Can anyone tell me what kind of brakes they are, given such weak info? Now the bonus point question....what would the Volvo P/N's be for the pads? (Not that I would necessarily use Volvo pads. [Response: Ted D'Orazio] Your rear calipers are ATE. The p/n for the rear pad set is 271824. [Editor] Note that the rear calipers came with three piston sizes: 36mm, 38mm and 40mm, stamped on the caliper-see the photo. Replace with the identical size. Often the markings are obliterated due to rust or mechanical damage. You can measure the diameter of the piston when the pads are removed or measure the imprint on the back of the steel shim plate. Wagons generally use 40mm pistons.

Brake Pad Identification.
[Inquiry:] When I went to get a set of front disc brake pads for my 740t there were two types listed. Does anyone know which type I would need or how to tell Bendix from Girling? [Response: JohnB] The Bendix pads have two tabs on the outer edge of the backing plate, some versions quite large, about 3/8 in by 3/16 in with a round cylinder welded/brazed on each tab, others with two vestigial nubs....both types come with slightly different anti-vibration springs so don't mix them. The Girling pads have a single big tab with a post on it and the anti-vibration spring wound around the post. Rotor size matters....the 11.25 in rotor works on Girling and Bendix brakes with separate rotor/hub. Make sure you know what hub/rotor you have. Finally, your minimum permissable pad thickness, when you are checking pads, is 3 millimeters per Volvo specs for the front pads and 2 millimeters for the rear.

Here is a visual guide to brake pads used in various caliper configurations in 700/900 cars, courtesy of RPR where each pad set can be ordered on-line.

Front Pads:		
REPCO 536	rep_536.gif (3721 bytes)	700 w/ Bendix -87 original front. Volvo supercedes 83-87 Bendix pads to 88- Bendix pads. Order REPCO 1169 further down the page and update kit 3516813

REPCO 508	rep_508.gif (3906 bytes)	700 w/ Girling w/o ABS front 900 w/o ABS All front
REPCO 1169	rep_1169.gif (4868 bytes)	700 w/ Bendix (update) -87 front 700 w/Bendix 88-on front
REPCO 1198	rep_1198.gif (4248 bytes)	740 w/ Girling ABS 91-92 front 900 w/Girling ABS 91-on front
RearPads:		
REPCO 102	rep_102.gif (1826 bytes)	700/900 w/ Ate rear
REPCO 3067	rep_3067.gif (5162 bytes)	760 Girling w/ IRS rear 900 Girling w/ IRS rear

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Brake Rotor Identification. [Editor's Notes:] Volvo 700/900 series brakes came in a number of configurations: one-piece hub and rotor versus separate rotor and hub; solid versus ventilated rotors; various calipers for ABS and non-ABS; various rotor diameters and thicknesses. In addition, early 700 series may have been converted to two-piece hub and rotor configurations or to later "jumbo" rotors. Be very careful when replacing the rotors. The only sure test is to **measure** the diameter and thickness or look for a stamping showing the diameter on the hub and order the corresponding replacement from a knowledgeable parts department. The data in the two tables below are courtesy of VolvoCars and RPR a retailer of Volvo aftermarket parts. Note that they do not mention 10.25 inch diameter rotors which were fitted to a number of Girling-equipped cars. See the type chart for guidance on matching the rotor to the caliper (one or two pistons)

Brake Rotor Types:					
Rotor	**Type**	**Diameter mm**	**Diameter in**	**Thickness**	**Caliper**
Version 1	Solid	280.0	11.00	14.00	2-piston
Version 2	Ventilated	262.4	10.50	22.00	2-piston
Version 3	Ventilated	287.0	11.25	22.00	2-piston
Version 4	Ventilated	280.0	11.00	26.00	1-piston

In the following chart, the "Absolute Minimum" thickness is the thickness at which replacement is mandatory. The "Minimum" thickness is used when you replace pads: if the measured rotor thickness at the points of pad contact is less than this number, replace the rotor. Conversion: 262.4mm= 10.5 inches; 280mm= 11 inches; 287mm= 11.25 inches. One inch =25.4mm.

Brake Rotor Identification Chart:				**Rotor**	**Rotor Thickness**		
Car Model	**Year**	**Brake Type**	**Rotor Type**	**Diameter**	**New**	**Minimum**	**Abs. Min**
Front Rotors:							
700	83-84	Bendix	Single rotor and hub	287.0	22	20.8	20.0
				262.4	22	20.8	20.0
700	83-84	Bendix	Separate rotor/ hub	262.4	22	20.8	20.0
				262.4	22	20.8	20.0
700	83-84	Girling	Single rotor and hub	280.0	14	12.3	11.5
				262.4	22	20.8	20.0
700	83-84	Girling	Separate rotor/ hub	262.4	22	20.8	20.0
700	to 87	ABS Bendix	Single	287.0	22	20.8	20.0
		(updated)	Separate	287.0	22	20.8	20.0
700	85-87	Bendix w/o ABS	Single	262.4	22	20.8	20.0
			Separate	262.4	22	20.8	20.0
700	85-87	Girling w/o ABS	Single	262.4	22	20.8	20.0
			Separate	262.4	22	20.8	20.0
740	88-90	Bendix w/o ABS	Separate	262.4	22	20.8	20.0
740	88-90	ABS Bendix	Separate	262.4	22	20.8	20.0
				287.0	22	20.8	20.0

740	88-90	Girling w/o ABS	Separate	262.4	22	20.8	20.0
740	88-90	ABS Girling	Separate	287.0	22	20.8	20.0
740	91-92	Bendix w/o ABS	Separate	287.0	22	20.8	20.0
740	91-92	Girling w/o ABS	Separate	287.0	22	20.8	20.0
740	91-92	ABS Girling	Separate	287.0	22	20.8	20.0
760	88-90	ABS Bendix	Separate	287.0	22	20.8	20.0
760	88-90	ABS Girling	Separate	287.0	22	20.8	20.0
900	91	Girling w/o ABS	Separate	287.0	22	20.8	20.0
	92 on	Girling w/o ABS	Separate	287.0	26	23.8	23.0
900	91 on	ABS Girling	Separate	287.0	26	23.8	23.0
Rear Rotors:							
All	All	Live Axle	Separate rotor/ hub	281	9.6	8.9	8.4
All	All	Multilink IRS	Separate rotor/ hub	265	10	8.5	8

Fluid and Pad Maintenance:

Pad Wear Indicators? [Inquiry] Are there pad wear indicators to tell me when my brake pads are wearing out? [Editor] No! You have to inspect pad wear through the caliper slots to make sure you have adequate pad thickness. Unlike other cars, there is no noisemaker to let you know when you need new pads. And if they wear out? You may score the rotor, which will then need to be replaced.

Brake System Fluid.

Why Flush Brake Fluid Every Two Years?: Remember that brake fluid absorbs water vapor from the air. This water contributes greatly to poor stopping performance and to the decline of your hydraulic cylinders and brake components. In addition, high brake temperatures accelerate the rate at which the corrosion inhibitors in brake fluid break down. As the fluid ages, oxidation eats away at metal surfaces creating dissolved acids and sludge that are carried with the fluid as it surges back and forth with every application of the brakes. The contaminants are abrasive and increase seal, piston and bore wear in the calipers, wheel cylinders and master cylinder. They can also attack and damage ABS solenoid valves and cause these valves to jam and stick. For these reasons, Volvo recommends that you flush hydraulic systems every two years. This is most important for your brakes' hydraulic system. [Editor's Note: See Brake Fluid Flushing Procedures below for complete instructions. See http://www.phxsyss.com/ for information on "StripDip" brake fluid test strips.]

Which Fluid Should I Use? [Inquiry:] My friendly Volvo parts person says that my Volvo needs DOT 4+ brake fluid. Of course dealers use Volvo-labeled fluid. Is this equivalent to Castrol GTLMA which "Exceeds DOT 3 and DOT 4 specifications"? [Response: Bob] The Castrol fluid is fine as long as it meets DOT 4. Use a pressure bleeder for most effective flushing. [Editor: See Brake Fluid Comparison for more information.]

Silicone DOT 5 Fluid Acceptable? Absolutely NOT: under no circumstances add or use in any way DOT 5 silicone-based fluids, which are completely incompatible with the materials used in Volvo brake systems. However, the new DOT 5.1 glycol fluids are fully compatible with your system.

Brake Fluid Flushing Procedures. [Digested from the Volvo Manual] Flush the fluid in your braking system at least once every two years to remove water and contaminants. The manual notes that you should de-pressurize the pressure flusher after doing each wheel, then operate the brake pedal several times, before going to the next wheel.

Master Cylinder Reservoir:

Place plenty of paper under the master cylinder.
Separate reservoir from master cylinder by gently pressing sideways and pulling out.
Clean reservoir with denatured alcohol or brake fluid. Inspect seals and replace.
Fill reservoir with fresh fluid.
Connect power bleeding unit to reservoir (E-ezibleed or Power Bleeder, above.)
Jack up car and remove wheels.

Rear Wheels:

Remove or press back pads on one rear wheel. [Editor's Note: Clamp off brake rubber line and open bleed screw on ABS-equipped cars so you don't force contaminated fluid back to the ABS unit. See Brake Job Tips: Hose Clamp.]
[Cars with multilink axles: Connect tube to lower bleed screw on caliper]
Open bleed screw and drain off fluid until it runs clear. Tighten.
[Cars with multilink axles: Close off bottom screw and bleed top screw to remove trapped air.]
Repeat on the other rear wheel.
Reassemble.

Front Wheels:

[Cars with Girling Single-Piston Calipers:]

Connect tube to bleed screw, open one turn and press piston to bottom of caliper by pressing outer pad. [ABS-equipped cars: See Brake Job Tips: Hose Clamp]
Open bleed screw and drain off fluid until it runs clear. Tighten.
Repeat on other front wheel.

[Cars with Bendix and Girling Two-Piston Calipers:]
Connect tube to lower bleed screw. Open both screws about one turn. Place paper around upper screw.
Press pistons to bottom of caliper. [ABS-equipped cars: See Brake Job Tips: Hose Clamp] Close upper screw.
Open bottom screw and drain off fluid until it runs clear. Tighten.
Connect tube to upper screw and repeat to remove any trapped air.

After doing all four wheels, operate the brake pedal several times. Pedal travel after 3-4 depressions (as if braking very hard), with the ignition off, should not exceed 55 mm for older cars and 50 mm for 1995 and up 900 series (all 960 and mid-year+ 940: see Service Bulletin 5-51-908 Jun 95)

Need to Flush Before Replacing Components. [From RPR:] When changing components that use brake or clutch fluid, be sure to use the proper fluid (usually DOT 4 brake fluid for Volvos). It is also necessary to flush the lines *before* installing slave cylinders, calipers etc. Many people simply pull the old unit off and then "slap" the replacement unit on which causes any old fluid or contaminants to damage the replacement when the lines are bled. Our experience with clutch slave cylinders went from a return rate of approximately 50% to less than 5% by simply advising installers to follow these simple instructions.

Brake Bleeding.
Basic Brake Bleeding Procedure. [Tip from Abe Crombie] All you need do is obtain a piece of 1/4" I. D. clear vinyl tubing and a coke bottle. Have 2-3 pints of the proper brake fluid on hand. IF you are changing a part and air is already in system, then the order is important. IF you are doing a flush/bleed then the order is not important. Remove the master cylinder reservoir and dump it out and add a bit of fluid and agitiate it and dump it out to get all the old fluid out. Install resevoir and then fill with fluid. Go to whichever caliper you care to do first and loosen the bleeder 1/8 turn. Attach the clear tubing and place end in coke bottle. Add just enouigh clean brake fluid to coke bottle so that tube is below the fluid level. Get in car and pump pedal slowly about 1-1/2 inches 10 times. Don't exceed this extension or you will press the master cyclinder seals into corroded areas within the master cylinder and ruin them. Get out and check/top up fluid. See if the fluid in tube is clear, if so close bleeder and remove tube. If not, pump five more times. Go to next caliper and repeat until all have been done. The bleeder screw opening should be just enough to allow fluid to pass out. This can be determined by feeling resistance as you push pedal. If the pedal goes to floor w/o resistance then you should turn in bleeder screw 1/16 turn. The idea is to do have resistance to the master cylinder suction pulling fluid back in through tube. This way the fluid will be pulled from reservoir on upstroke of pedal and you will not need to do the pump x times, hold, open screw, close screw, pump x times thing. I have done this for 25 years and never had a problem and never had arguments with girlfriends, co-workers, family members as I didn't need their assistance. IF you have a buch of air in system then you will have to do the pump-open-close pump routine. For ABS-equipped cars, see the notes on Brake Fluid Bleeding/Flushing Procedures for Cars with ABS. If you have lots of air in the lines and master cylinder, tap them as you bleed to loosen adhered air bubbles.

Brake Bleeding Sequences. [Editor's Note: These sequences apply to all cars per the Volvo manual]

Bleed the brake lines in this order:

> Cars without ABS and 1988 or later models with ABS:
> > LR, RR, RF, LF.
>
> Cars with ABS up to and including 1987:
> > use the reverse sequence: LF, RF, LR, RR.
>
> On Volvo models with 2 bleeder screws (upper and lower) on the front calipers, use upper nipple.
> On Volvo models with 3 bleeder screws on the front calipers, open all bleeder screws simultaneously.
> Highly recommended: use a pressure bleeder as noted below at Brake Pressure Bleeder

[Inquiry:] I've never bled calipers that had TWO bleeder valves --- What is the bleeding order? Is is special for the 740 wagon? It is a 91 and it has ATE on the rear, no problem, but dual Girling calipers (?) vented rotors on the front w/ two bleeders ea. The Chilton manual is not helpful with the dual system. I can't find any other repair manual for the 740. [Response: Steve Seekins] An interesting dilemma - the manuals vary on the correct bleed sequence. According to some, when you have an inner and outer bleed screw on a caliper, you should bleed the outer first, then the inner, however, my engineering sense would tell me to do the inner (closest to the MC first, then the outer. That way no old fluid or air would get into the outer after bleeding it. In any event, I suspect that it is not critical, and I always recommend going around twice - first time until all air/old fluid is out of system, second time to check for any air. Expect to take about 1.5 quarts for a complete system flush. On the non-ABS systems, it is pretty clear that the LR is first, but on the ABS systems, manual says to do the fronts first, then the rears. [Editor's Note: when bleeding, use the uppermost nipple to expel any air. When flushing fluid, use the lower nipple, then close and check the upper nipple for any trapped air. See Brake Fluid Flushing Procedures]

ABS-Equipped Cars: See Brake Fluid Bleeding/Flushing Procedures for Cars with ABS

Rusted Bleed Screws: Tips for Removal. [Tip from iadr/Cliff Pope] Here is a tip that's saved me a couple times when removing screws that the P.O. has not thought to lubricate- take a small ball peen hammer and give the bleeder screws the hardest hit you can without mushrooming the tip where the fluid comes out. To clarify, pretend you are diving them into the hole they are threaded into: don't hit them sideways. This seems to loosen the rust on the threads. Once you get it moving even a fraction, you have done it. Move it cautiously back and fro, until it will screw freely. Needless to say, try using PBlaster penetrant and a good six-point socket before going to extremes. Just be aware that too much torque can break off the hollow screw. If you snap it off you are in real trouble. I have never succeeded in extracting a broken one, so you will need a new caliper.]
[More Tips from Motor Magazine] Penetrating oil has a better chance of being effective in loosening a seized bleeder if you wire-brush rust/scale away from the caliper's bleeder bore before applying it. Be sparing, though. You don't want petroleum-based penetrants contaminating brake fluid. Also, filling the bore in the bleeder itself with a snug-fitting drill bit helps reinforce the bleeder against twisting forces as you try to unscrew it. We don't recommend heating the caliper casting with your torch to loosen seized bleeders; the heat may not just boil away brake fluid, it may damage seals or boots. Keeping the bleeder capped definitely helps prevent seizing; vacuum caps often make acceptable substitutes if actual bleeder caps are unavailable.

Master Cylinder Bleeding. If you need to bench bleed a rebuilt master cylinder, see Rob Bareiss' simple bench bleeder tool made from lengths of brake line.

Brake Pressure Bleeder.

A pressure bleeder works by pushing fluid into the reservoir at pressure to force the old fluid out the caliper nipples rather than suck it out from the nipples. Brake systems are pressure systems and are better able to deal with even this small pressure than a vacuum system which will always suck a little bit of air in at the nipple. These pressure bleeders are inexpensive and make brake system fluid maintenance very easy.

1. Eezi-bleed Brake Pressure Bleeder:

EeziBleed Pressure Bleeder from IPD

[Editor's Note: purchase from IPD at http://www.ipdusa.com][Inquiry:] How well does Gunson's Eezi-bleed work? [Response:] Eezibleed works great - I have found that 25 psi works fine vice the recommended 20 psi. If you use pressures recommended (~20psi), you will not be in any danger of blowing off the fluid reservoir. I routinely use 25psi with a pressure reducer and have never had a problem. Just don't try to hit is with a spare pumped up to 45psi, or hook up to a 150psi air hose! In this case, it will surely come apart somewhere! Only drawbacks: under heavy - i.e., daily use, the gaskets on the reservoir bottle got funky and required replacement, as did the gasket on the master cylinder reservoir adapter cap. After a lot of heavy use and regular cleaning of the system after use with brake system cleaner, I found that the gasket on the adapter cap seemed to have expanded and would not lay flat in the cap - hence I had trouble sealing the cap. Also, after lots of use, the adapter cap failed and began leaking - threads would not hold. The cap itself seemed to either wear or stretch such that the threads would not hold tight and would slip. The result is that there was a very fine line between tightening the cap and having the cap pop up one thread resulting in lots of fluid (like a whole container) being blown out around the cap threads. My solution was to purchase a machined aluminum adapter cap from a local automotive tool supply house for about $30 and use it in place of the supplied adapter cap.
For complete system flushes, I find that the supplied reservoir bottle may be too small. However, for the owner with 1-4 Volvos that get flushed every 1-2 years and the occasional new master cylinder or caliper, you can't beat the $30 price for the system. You will never go back to the pump and bleed or vacuum bleeder systems again. For serious use, I built a similar system with a commercial machined aluminum adapter cap and quick connect fittings, a larger Nalgene reservoir bottle, a pressure reducer and connections for an air compressor tank. The Volvos cannot be gravity bled, and even with the pressure bleeder, you may need to use the pedal occasionally when bleeding the rear brakes on those cars with rear brake pressure limiting valves (non-ABS systems).
[Response 2: Martin Landusky] The system is very easy to use, just as it says in the instructions. I used my temporary spare with about 26 lbs. of pressure in it and hooked up the system to the reservoir to test for any leaks. After I found none, I added the fresh brake fluid to the EZ-Bleed system and reconnected. Then I followed the bleeding sequence in the manual. Careful not to round off the edges on the bleed nipples when you open them up. I just used a regular open end wrench and it worked fine. It doesn't take too much bleeding before the fluid runs clear. Close the nipple and go on to the next one (have your car up off all four wheels). Check the EZ-Bleed fluid container after bleeding a couple of lines and keep it topped up. That's it and basically it's that simple. [Response 3: Paul Seminara] Ignore the 20 psi warning. You can and may have to pump the brake pedal (1/4 stroke or so) get the rears really good and a rock hard pedal.

[Tip from Steve Seekins] I have had a few complaints and problems with EEzibleed. Specifically, the adapter cap provided is a 'universal' cap designed to fit several different threads including the ATE reservoir used on the Volvos, BMWs, and others. However, because the threads do not fit precisely, I found that the cap would not screw on tight and eventually, it blew off under pressure with the resultant brake fluid mess all over the engine compartment and fender - lots of rapid washing and cleaning involved to get it off the paint ASAP (brake fluid makes great paint stripper!). The other problem is the small size of the fluid reservoir - doesn't hold enough to do a proper flush of the entire brake system.

2. Power-Bleeder Brake Pressure Bleeder:

PowerMotive

[Tip from Steve Seekins] I recently received, tested, and reviewed a new product -

Brake Bleeder

Power Bleeder from Motive Products: http://www.motiveproducts.com/ or IPD. The price is about the same, however it comes with a specific ATE reservoir cap adapted with a fitting and hose, has a large bottle which holds 2 full quarts/liters of fluid sufficient for a complete flush, and has built in pump and pressure gage. [Editor's Note: this is a great product for $49.95. They are located in Berkeley, CA.]

3. MityVac Vacuum Bleeder:

[Editor] The MityVac vacuum (not pressure) bleeder works, but you have to use care to ensure that air bubbles are not sucked in around the bleed screw nipple. [Tip from Mike] I've used a MityVac a couple of times to bleed my brakes. It's very time consuming (about 2 hr.) and a bit messy if you are not careful. Also, your hand will get a workout squeezing the damn thing. Be sure you have the proper sized nipple to fit over your bleeder screws or it will take you more time. And don't let your brake resevoir get below 3/4 full during the bleeding process. If you start to suck air, you of course have to start over and you may have to bleed the reservoir as well. [Tip from Dan] Use the hose on the bleed screws to avoid air bubbles.

4. Home-Made Pressure Bleeders.

[TV Pierce] You can make your own pressure bleeder. Power Motive's is nothing more than a garden sprayer with a brake reservoir cap attached to the end of the tube instead of a spray nozzle (they also add a pressure guage -- but it's not really necessary). The sprayer is about $10 at Home Depot, and a new reservoir cap should be $2-$3 at FCP Groton. Drill a hole through the cap, epoxy a tube fitting through the hole, then cut off the spray nozzle, and attach the reservoir cap. [Gary Gilliam] I made mine out of a cheap all plastic 4 liter (about $13) garden sprayer, and an old master cap. I cut the hose just above the sprayer wand, attached a 5/16" brass fitting that is commonly used for repairing air lines: it is barbed on one end to stick inside the hose and has 1/4" NPT threads on the other. This was secured to the hose with a stainless hose clamp and a 1/2" hole was drilled in the extra master cylinder cap to receive the other end of the fitting. The fitting was secured to the cap with a 1/2" long brass NPT straight connector, adding a rubber washer on both sides coated in RTV for good measure.
I was going to add a pressure gauge, but never got around to it. It seems to work fine with just enough pumps to get things moving a bit.

Pad Replacement:

Brake Pads

Pad Selection. What I've found over years and years of experimentation with different types of brakes ranging from soft OEM pads to full-on race pads is that there is NO SUCH THING as a completely dustless pad. Generally speaking however, the harder the compound, the less dust per mile accumulated on your wheels. Organic compounds (particularly older asbestos based pads) are about the worst. The Axcess nee PBR nee Repco pads are better than stock but the organic versions still have more dust accumulation than the Metalmasters. Of course, you get a significant increase in braking performance with these so what's a little dust when you can stop in 15% (guesstimate) less distance. Might save one's life one day.On that note, someone mentioned a tradeoff using metallic pads versus softer OEM type pads and their relative effect on rotors (wear). In my type of driving (90%+ freeway), I'm not on the brakes much which owes to my getting 90k + miles per set AND original rotors after 221k miles. If you are driving more stop/go type traffic scenarios, there will be some additional wear on the rotors but not so much as to worry. (Either way, you're going to replace them anyhow...) [TechTip from C. Smith of Stoptech] There is no such thing as an ideal "all around" brake pad. The friction material that is quiet and functions well at relatively low temperatures around town will not stop the car that is driven hard. If you attempt to drive many cars hard with the OEM pads, you will experience fluid boiling, pad fade and friction material transfer - end of discussion. The true racing pad, used under normal conditions will be noisy and will not work well at low temperatures around town.

Uneven Pad Wear. [Tech Tip from Wagner Brake] While inspecting for excessive pedal travel, brake linings appear worn in a tapered pattern, even though the pads have not reached minimum thickness. SOLUTION: Uneven pad wear is not normally related to excessive pedal travel, but it's not unusual to discover one problem while investigating another. Linings with tapered, uneven wear should be replaced if the difference in thickness from one end of the pad to the other 1/8 inch on floating calipers. This remains true even if the linings have not reached minimum thickness because this condition can result in pads becoming wedged in the caliper. If the pad that contacts the caliper piston is worn much more than the one on the other side of the rotor, something is interfering with the necessary sideways movement of the caliper. This may be corrosion, contamination, or improper assembly. Possible causes of excessive pedal travel are low fluid level in the reservoir, air in the hydraulic system, an open bleeder screw (avoid the use of Teflon tapes or pipe thread sealants which do not help seal and may cause contamination), improperly positioned pads, …, piston seal damage in one or more of the calipers, a leak past the piston cups in the master cylinder, excessive rotor runout or a bent rotor and bad or excessively loose wheel bearings.

Pad Break-In. [Tech Tip from C. Smith of Stoptech] Follow proper break in procedures for both pad and disc. All after market discs and pads should come with both installation and break in instructions. The procedures are very similar between manufacturers. With respect to the pads, the bonding resins must be burned off relatively slowly to avoid both fade and uneven deposits. The procedure is several decelerations with a brief cooling period between them. After the last stop, the system should be allowed to cool to ambient temperature:

> *HighPerformance Metallic/Ceramic Pads.* Typically, a series of ten increasingly hard stops of increasing severity from 60mph to 5 mph with normal acceleration in between should get the job done for a high performance street pad. During pad or disc break-in, *do not come to a complete stop*, so plan where and when you do this procedure with care and concern for yourself and the safety of others. If you come to a complete stop before the break-in process is completed there is the chance for the non-uniform pad material transfer to take place and the results will be what the whole process is trying to avoid. Fortunately the procedure is also good for the discs and will relieve any residual thermal stresses left over from the casting process (all discs should be thermally stress relieved as one of the last manufacturing processes) and will transfer the smooth layer of pad material onto the disc. If possible, new discs should be bedded with used pads of the same compound that will be used going forward. Again, heat should be put into the system gradually - increasingly hard stops with cool off time in between. Part of the idea is to avoid prolonged contact between pad and disc.
> *Street and Organic Pads.* [Ken Crossner] Per PBR's pad instructions, use a similar technique as above, but subject the pads to a series of moderately applied brakes slowing from 30-35 mph down to 5 or 10 mph, and then accelerate gently up to 30-35 and repeat about 6 to 10 times. You are trying to only gradually warm up the components. Again, *don't come to a complete stop* during the exercise.

Brake Pad Replacement.
Rear Brake Pad Replacement:
[Tips from Andre] Changing the rear pads on ANY Volvo since the 70's is pretty much identical. You will need a hammer and a long narrow punch (a large dull nail works in a pinch). Since your car is new you don't have

to worry about rust so everything will come apart easily. If the car is more than 3 years old, it is generally good to replace the hardware (i.e. pins and retaining clip).

Rear Brake Hardware Kit

To Remove:

- Take off wheel
- Tap out the two pins
- Remove retaining clip
- Use large screw driver to lever the pads out using their mounting ear holes.
- Pull pads out.
- Check that the pistons are angled correctly.

To Install:

- Place a hose on the bleeder; open the bleeder and at the same time squeeze the pistons back using either adjustable pliers. Use an old steel shim to cover the the piston surface beneath the plier jaw to prevent boot tears. [Peter Penguin] If you have a tough time squeezing the piston back, remove the top caliper guide bolt, swing the caliper back and down (carefully supporting it with a bent coathanger so it does not place a strain on the brake hose), and either use a c-clamp or place a wood 2x4 in the caliper space and use a pry bar to lever the piston back. Tape a plastic zip-lock baggie onto the end of a 10" plastic hose connected to the bleeder valve. Then it can spin around without any spillage and it's easy to inspect it the old fluid for debris. If you have ABS brakes, place a hose clamp on the brake hose above so old fluid is not pushed up the line.
- Either re-use or replace the anti-squeel shims behind each pad. One is stainless steel, the other is teflon-coated fiber. The shims are there to minimize squeal. Either clean them up and re-use them or drop by a dealer for some new ones. Cleaning works well for the stainless steel shim. If you have teflon coated and the teflon is damaged, replace. They come with new volvo OEM pads, but usually not with aftermarket pads. Apply synthetic brake grease to both sides of the teflon shim or, if you have no shim, to the back of the pad, to prevent squeel. Install the teflon shim between the pad backing and the steel shim, which goes next to the piston. Apply brake grease to metal-to-metal contact points between pad back and caliper.
- Apply some anti-seize on the pins and insert them. Don't forget the spring clip, which is oriented so that the pins hold it in place. The first pin will go in very easily. The second pin will be a minor pain since the clip is in place. I usually use some pliers to help line it up with the receiving hole and then tap the pins in place with a hammer until the rubber seals are firmly in place in the caliper holes.
- Install wheel. See Anti-Corrosion Advice for tips on preventing stuck wheel bolts and wheels. Torque wheel nuts correctly.
- Be sure to seat the pads correctly. This is very simple and there should be instructions with the pads. Basically take the car up to 30 MPH and stop with even pressure. Repeat a few times.

Front Brake Pad Replacement. [Tips from Andre]

To Remove:

- Remove wheel
- Remove the two bolts on the back side of the calipers holding the caliper guide bolts in place. Note that there is a lock nut next to the rubber caliper pin sleeve, which requires a thin 17mm wrench to hold while you rotate the bolt at the back. A bicycle wrench is perfect for this. You can now pull the whole assembly away from the rotor. Due to wear, the old pads may get slightly stuck in a groove. Insert a large screw driver between the caliper and the rotor and lift... it will come off pretty without too

much trouble.

- The spring pad retainer at the back of the caliper slides out. The pads can be removed.
- Place a hose on the bleeder; open the bleeder and at the same time squeeze the pistons back using either adjustable pliers or a c-clamp. Use an old steel shim or tape on the jaws to prevent boot tears. [Peter Penguin] If you have a tough time squeezing the piston back, place a wood 2x4 in the caliper space and use a pry bar to lever the piston back. Tape a plastic zip-lock baggie onto the end of a 10" plastic hose connected to the bleeder valve. Then it can spin around without any spillage and it's easy to inspect it the old fluid for debris. If you have ABS brakes, place a hose clamp on the brake hose above so old fluid is not pushed up the line.

To Install:

- Install anti-squeel shims or anti-squeel paste to back of pads. Apply brake grease to metal-to-metal contact points between pad back and caliper.
- Install pads
- Insert anti-rattle spring clip. Make sure this is correctly oriented to hold the pads in place. If it isn't, the pads will rattle.
- You can get the caliper lined up in the holes with pliers, and give it a gentle tap with a small hammer to seat it in place.
- Lubricate the caliper guide pins and inspect the rubber boots.
- Slide the whole assembly over the rotor and insert the bolts back in place.
- Install wheel. See Anti-Corrosion Advice for tips on preventing stuck wheel bolts and wheels. Torque wheel nuts correctly.
- Be sure to seat the pads correctly. This is very simple and there should be instructions with the pads. Basically take the car up to 30 MPH and stop with even pressure. Repeat a few times.

Brake Lubricants:
[Tip from Brake and Front End Magazine, Nov 01] Use a synthetic moly or PAO-based lubricant for metal-to-metal contact points and a synthetic silicone brake lube for caliper assembly with rubber parts. Do not use white lithium or chassis grease in brake work. In disc brakes, lubrication points include the caliper slides and bushings, self-adjuster mechanisms on rear disc brakes with locking calipers, and the parking brake cables and linkage. Brake grease can also be used to dampen vibrations between disc brake pads and caliper pistons. But, it should not be applied between the pad and any noise suppression shims that may be used. Use it on the back of a bare pad or between the pad shim and caliper. One place you never, ever want to get any grease on is the friction surface of a brake lining — which is another reason for not using low-temperature or petroleum-based lubricants which can melt, run off and foul the linings. Grease-contaminated shoes or pads will be grabby and usually cause a brake pull to one side. The only cure is to replace the fouled linings with new ones. Cleaning is out of the question because solvents and cleaners can adversely affect the linings, too. [Fitz Fitzgerald] The brake lube is intended to be used at every point where the brake pad contacts another metal part,except the rotor:

- Apply a ring of lubricant to the back of the pad where the piston pushes against it.
- Apply lubricant to the spots where the edges of the metal backing plate touch the caliper housing (clean these areas first, both on the caliper and the pad).
- Apply to the caliper glide pins.

  Should any grease (even a greasy fingerprint) get on the pad or rotor material, be sure to clean it off with brake cleaner.

Additional Replacement Tips:
[Inquiry:] Any hints on front/rear brake pad replacement? [Response:] Be sure to remove the sliding pins on both front calipers. Inspect them and replace if worn or badly rust pitted. Otherwise, clean them, grease with silicone based brake grease, and reinstall. Clean caliper sliding surfaces with small wire brush and blow

clean (use a mask!!). Check to see if new pads are beveled on leading and trailing edges. If not, consider putting a 45 degree bevel on them. Use the brake grease on the backing plate, the anti-squeal plate and the edges of the backing plate that contact the caliper. Install the pads carefully so that the anti-rattle springs do not get broken (the springs on the new REPCO pads are much heavier than the earlier pads, so should not break like they did before).
I prefer the plain stainless backing plates rather than the black rubber coated ones. The rubber, though it may be thin simply adds a bit of softness to the pedal feel, as does any of the 'rubbery' anti-squeal treatments. I have found that just using the Volvo brake grease seems to solve the squeal problem as long as you clean rust off the caliper contact and sliding surfaces. The backing plates should have some slots or holes in them - creates a slightly of center contact surface for the pistons which apparently helps prevent squeal.

If you are replacing the rotors, clean the protective oil coating off the new ones with brake cleaner so you do not contaminate the pads. And remember that when you first get in the car after replacing pads, you will have to pump the brake pedal several times (not all the way down: just an inch or so) to move the caliper pistons back into position.

Brake Squeal. [Brake and Front End Magazine, Aug 04] Brake squeal is caused by high frequency vibrations. When the brakes are applied and the pads contact the rotors, tiny surface irregularities in the rotors act like speed bumps causing the pads to jump and skip as they scrape against the rotors. This, in turn, causes the pads to shake and vibrate in the calipers and against the caliper pistons. It also causes the calipers to shake and vibrate on their mounts and bushings. The greater the play between all of these parts, the greater the amplitude of the vibrations and the louder the squeal. [Tips from Raybestos to eliminate brake squeal. These tips are generic and not specific to Volvo.]

- Before disassembly, mark the rotor-to-hub mounting position, to assure a remount in the same position.
- Clean the mounting surface of the rotor before mounting it on the disc brake lathe. [Editor’s note: Volvo recommends NO TURNING ON A LATHE.]
- Apply a non-directional finish to the rotor with 120 to 150 grit sand paper, using moderate hand pressure against the sanding block in an up and down movement for approximately one minute per side.
- Wash the rotor thoroughly with soap and water.
- Clean the mounting area of the hub for a perfect hub-to-rotor fit.
- Inspect, clean and lubricate all possible metal to metal contact areas of movement between the caliper halves.
- Lubricate all sliding and floating hardware components with a high temperature sliding caliper grease. Use new hardware whenever possible.
- Properly apply new shims to the pads.
- Lubricate contact areas between the shim and caliper piston, between the anti-rattle clip and caliper housing, between the shim and contact area on the caliper housing, and between the pad’s locator buttons and caliper housing. Also lubricate any possible contact areas between the pad’s plate and the caliper housing or bolts.
- Torque the caliper mounting bolts and the wheel nuts to specifications.
- Bed in the pads with 8 to 10 brake applications with moderately applied pedal pressure, from 40 mph to a complete or near stop about a quarter of a mile apart. If a good pedal feel and proper stopping distance is not achieved, continue the stops until the desired results appear.

While these procedures will not guarantee against a noise-related comeback, they will reduce the odds significantly. Moreover, these methods have been developed in the field by brake technicians and approved by others using the same techniques.

Brake Pad Anti-Squeal: Pastes and Shims. *Brake Pad Anti-Squeal Treatments.* [Inquiry:] What's your experience regarding brake pad anti-squeal treatments? I've looked at the following:

> Lucas foil stick-on shim pads
> Permatex spray-on elastomer for the back of the pads
> Various glue-like treatments that leave a ribbon of elastomer on the back of the pads
> Other techniques such as beveling the edges of the brake material, rounding off the metal backings, etc. My 740 Girlings do not use pad shim springs. I have had good luck with the foil shims, but how have you fared?

Shims. [Response: Don Foster] Try using the stainless shims (available from Volvo) behind the pads. Also, there are Teflon sheets (also from Volvo) you can insert between the stainless shim and the pad metal backing. Be sure the piston bears against metal. If you're truly climbing-the-walls desperate, there's some "goop" you can put on the back of the pads to dampen vibration (squealing). I've used it, it works, it's messy. But the shims are better (but from Volvo, not too cheap). [Response: Benjamin] I too, tried the Lucas foil backings, with no success at all. What finally worked on my Slaab was some cheap rubber-like adhesive shims from NAPA. They cost about $3 per wheel, and stuck to the back of the pad like the Lucas foils, however these were rubber, and work great. This is the only thing I've tried that works. I tried the Lucas foils on my MetalMasters when I got them from SAS, with no results. I then put these rubbers ones on the MM's, and presto, the first squeal-free Saab I've had in over 7 years of owning different Slaabs.

Caution: Aftermarket Pad Shims. [Editor] Several anecdotes have been received about Beck Arnley pad shims, which can come loose and score a groove in the rotor which may lead to rotor and wheel failure. If you use stick-on shims, make absolutely certain the pad backs are clean of grease before installing the shims: spray them first with brake cleaner. Loose shims need to be carefully installed in the calipers before finishing the job so they cannot migrate loose. Consider using paste or grease instead of a shim or stay with the Volvo OEM version.

Synthetic Grease. [Response: Phil] For squeaky brakes get some synthetic brake lubricant or Dow Corning compound 111...it's a heavy silicone grease...real heavy and tacky...melts at 500 degrees F. Put a layer of this on the back of the pads. It won't wash off and they'll never squeak again. Don't get any on the pad braking surfaces or you may not squeak again either. Lubricating the caliper mounts, shims and bushings is also recommended to dampen vibrations here. The lubricant acts as a cushion to dampen vibrations. It also helps the parts slide smoothly so the pads wear evenly (uneven pad wear is a classic symptom of a floating caliper that is sticking and not centering itself over the rotor). How to apply grease: use a visible film of brake caliper lube on all pins and other contact surfaces (yes, even ss shims coated with nylon, etc.), both sides of the shims, and the backs of the pads in contact with the pistons. Don't worry about the stray dab on the pistons' outer edges, just make sure the grooves on the clips on either Girling or ATE calipers in which the pads slide are in place and properly lubricated. Your brakes should be fairly quiet
Anti-Squeel Paste. [Response: Ceferino Lamb] For anti-squeal, for about 10 years now I've used that thick orange or red anti-squeal goo in the squeeze bottle. I've had no brake squeals since 86, when I sold the Pig-0-Steel (Nissan 280ZX), so the goo seems to work well, and is universally applicable. I always change my own pads and disks. You can buy it at almost any large auto parts shop (Pep Boys, Grand Auto, Kragen, etc), under several brand names. [Tom Francis] The secret of using this stuff is letting it dry for about an hour before the pads are installed.
Change the Pads. Semi-metallic pads and those with a high metallic content tend to be more noisy than low-metallic pads or those with little or no steel or iron content. The best results are usually obtained by installing premium pads. Most premium pads also have chamfers and slots to reduce noise. [Adam] Try removing the pads and chamfering the all of the edges as well as removing any accumulated dust. A Dremel works well.

Rotors:

Brake Rotor Replacement

Front Brake Rotor Replacement.

Does the Brake Rotor Need Replacement? I have just replaced the front pads on my 740. When I was changing out the pads I noticed that the rotors had a lip around the outer edge. The metal sticks out approx. 1/16 inch beyond the rest of the rotor. This is the area above where the pads normally contact the rotor. The rotors do not seem to be warped. Should grind this outer edge off so that the entire rotor is of uniform thickness? Does this mean that the rotors are worn down too much and therefore I need to replace them? My new pads seem like they are too loose in the calipers. [Suggestions:] Regarding the lip, you don't really need to worry about this, unless the pads are riding on the lip. But, it sounds like it's time for new discs. If memory serves me right, new thickness of a ventilated disc is 22mm, min thickness is 20mm (for a solid disc this is 14 and 11.5mm, respectively) so if you have 1/16 inch lip on each side, that's 1/8 which is 3mm, so that'd put you at 19mm. How much can only be determined by measuring them with a micrometer and comparing measurements with minimum standards.

Replacing the Rotors. Changing the rotors is very easy. With wheel off, remove the caliper (2 -13mm bolts) and hang it up with a wire so it does not strain the brake hoses. Then remove the caliper mounting bracket by removing the two 10mm allen or Torx-style bolts. If the latter, use a 3/8 drive or larger socket as they tend to be difficult to turn. Unscrew the wheel locator index pin. Whack the rotor a few times with a mallet to loosen it and pull off rotor. [Tom Irwin] Hit the hubs with a wire cup brush chucked in a drill motor, cleaning off all corrosion everywhere the rotor mates with the hub. To avoid mismatch and subsequent vibration, the hubs must be shiny clean EVERYWHERE that the rotors touch, even around the wheel studs. Wipe the new rotor with solvent-based brake cleaner to remove its protective oil coating, Then replace the rotor, the caliper mount, and the caliper. When reinstalling the wheel, see Anti-Corrosion Advice for tips on preventing stuck wheel bolts and wheels. [Editor] While the manual suggests that you use new brake caliper mounting bolts, general consensus is that this is unnecessary. They can sometimes stretch causing them to come into contact with the inboard rotor surface. For peace of mind, use Loctite on the bolts when reinstalling.

Brake Rotor Identification. [Tip from Larry Jacobson] When I bought front disks for my '91 744T the Volvo dealer said there are three disks that are stock on that car and they all look the same. The only surefire way to get the right disk is to tell them the *exact* diameter and then they can match the part. When disks are bought from an aftermarket source it's a crapshoot unless you haul in the old part and carefully compare it to the new part.

Brake Rotor Balance. [Editor] See the note below to match the balance lines on rotor and hub and minimize runout.

Brake Rotors: Premium versus Economy. [Tips from Counterman Magazine, August 2001] What's the difference between "economy" rotors and "premium" rotors? Besides price, there are also differences in rotor quality, performance, fit and finish. Premium rotors typically follow the design of OEM rotors because rotors are engineered to meet certain noise, cooling, friction and performance characteristics. If a replacement rotor does not meet the OEM criteria, it may take the brake system out of compliance with FMVSS105 or FMVSS135 government safety standards.
Economy rotors may not meet these requirements and may decrease braking effectiveness and increase pad wear. Because of this, some suppliers of premium rotors now "certify" their rotors as meeting all OEM requirements. One reason for these differences is the metallurgy of the rotors. Economy rotors are typically

made in a less controlled environment, which results in poorer grain structure in the casting. This, in turn, affects the hardness of the metal, pad wear and noise. Economy rotors may also contain unwanted impurities, which can form hard spots, pits and pores in the casting. Premium rotors, by comparison, are made using higher quality control standards. This results in better castings with consistent strength and hardness.
Another difference between economy and premium rotors is that the former may not use the same number of cooling fins or a different configuration. This may reduce cooling and increase the risk of pedal fade under hard use. Surface finish is another difference that's hard to see, but affects pad break-in and stopping performance. If a rotor does not meet OEM requirements for surface finish, it should be resurfaced before it is installed. This shortens the life of the rotor and increases the risk of installer error or a comeback if the rotor is not turned properly. Dimensional accuracy is also critical. This applies not only to rotor runout and thickness variation (which can cause pedal vibrations, shudder and comebacks) but also all machined surfaces including the size, location and centering of the hub opening, the lug holes and the overall diameter and thickness of the rotor.

[Tips from Brake and Front End Magazine, Apr 2003] We have very good results installing slotted front rotors as well as a cross-drilled style, as the factory doesn’t offer a heavy-duty rotor. The slotted rotors that we use undergo a factory three-stage heating process that prevents warpage. They cost a few more dollars than other brands, but they are well worth it when comebacks for this problem become history.

[Note from Tom Irwin] There is some evidence that Volvo OEM brake rotors for 960/90 cars are of lesser quality; buy aftermarket for better quality and lower prices from reputable suppliers such as IPS, FCP, IPD, RPR.

ABS Sensors. Do NOT remove or adjust the ABS sensors while changing pads or rotors. See Brake Rotor Removal on 740 with ABS . But DO clean them and the behind-the-rotor reluctor wheels off with a soft brush.

One-Part Hub/Rotor Versus Two-Part. In 1988, Volvo changed the front brakes from an integral one-part hub and rotor to a separate two-part hub/rotor system. In changing rotors while looking at a Haynes manual it's easy to get screwed up on the later two part hub/rotor. The manual suggest that there may be some problems removing these and that a puller may be necessary. No puller is necessary (just use a mallet on the back of the old rotor. You do have to remove the caliper holding bracket...remove the calipers and hang them with a piece of coathanger wire out of the way. Use a long bar and socket wrench to remove the two bolts that hold the caliper bracket on. Put them back with proper torque and blue loctite. You DON'T need to use new bolts unless the bolts won't torque up. Remove the conical wheel locating pin: it holds the rotor on. Make sure the new rotor and the hub/rotor mounting surface are clean when you put the new rotor back on.

Rear Brake Rotor Replacement. [Tip] Because the parking brake drum shoes are inside the rear brake rotor, make sure the handbrake is NOT applied when trying to remove the rear rotors. Corrosion can cement these in place so be prepared to knock them off. See below.

Brake Rotors Rusted On. [Inquiry:] I need advice on removing a rear brake disc that rusted solid on its hub. The parking brake is off, and I am able to manually rotate the disc, so I know its not the drum brake holding it. More than a few whacks with a mallet didn't help. I've sprayed penetrant wherever I could.
[Response:]
1. If you DON'T plan on changing your rotors (only for re-surfacing):

- let some penetrant (Liquid Wrench, PB Blaster) soak on the lug nut studs for as long as you can (where the studs meet the rotor). This is the location of most of the trouble. If you plan on keeping the rotors, don't get any on the "pad area" of the rotor.

- remove the wheel, replace the lug nuts back on the bolts for a couple of turns (so the top of the bolt doesn't show through the nut) and tap the head of the nut swinging towards the car. Ddon't use a hammer on the pad-area rotor. You can medium-tap the circumference of the center portion of the rotor as you spin it, also. It takes patience (My 1985 BMW 325es rears took me 2 hours). Editor's note: use a soft-faced mallet.

2. If you DO plan on changing the rotors:

> Follow the steps above, but with increasing force. If it is STILL stuck, crawl under the car (which must be properly on jack stands), face outward and spin the rotor while WAILING on the outside edge of the rotor with a mallet/hammer (outwards). It WILL eventually come loose.

Just try not to have any part of your body under the rotor when it pops off (usually you can tell it's about to go). Editor's note: use a thin coat of anti-seize on mating surfaces between hub and rotor to easy later disassembly.

Brake Rotor Installation Techniques to Minimize Pulsation.
[Editor's Note] Per the Volvo manual, match the balance mark on the rotor (a short line at one spot on the hub portion of the rotor) with the balance mark on the hub, a short line on the shoulder of the hub bearing cover. Look closely through the rust: it's there! This matches the rotor and hub and minimizes runout. Make sure you have removed all rust from the portion of the hub that contacts the rotor.

[Tech Tip from Wagner Brake] If the balance lines are not present or are invisible when replacing or removing the rotor, refer to the following service procedure to minimizes hub/rotor "stacked" runout:

1. Completely clean the hub area contacting the new/turned rotor.
2. Install the rotor on the hub, securing it with at least three lug nuts tightened to 20 lb. ft. (27 N-m) for testing.
3. Using a dial indicator, determine the total runout of the system. The total rotor and hub runout must not exceed .002" (.05mm).
4. If the runout exceeds .002", proceed as follows:
   - Remove the rotor and rotate it clockwise until the next hole lines up with a stud;
   - Secure the rotor in the new position, reindexed as described in Step 2; and
   - Repeat the checking and rotation (reindexing process) until the system measures .002" or less total runout.
5. If .002" (.05mm) or less runout cannot be reached, the hub should be replaced and Steps 2 through 4 repeated when the new hub/rotor is installed.

Make sure you reinstall the wheel lug nuts with proper torque values.

Rotor Turning and Torque.

Should I Turn My Rotors? Volvo does not support or advise re-machining of brake rotors, ever. If you look at the machines most shops use to do this work they decide where to clamp the rotor down by eye-ball. When it goes back on the car it is usually worse than when you started. And when you get new rotors - DO NOT let anyone turn them before installation in order to "true them up". They are new, and in the best condition they will ever be in. Don't let anyone screw them up before you ever use them. If your turned rotors are pulsating, I suggest you throw them away and start over with a new set.

Wheel Torque and Warped Rotors. Volvo rotors will warp like crazy if the wheel nuts are over-tightened and/or not tightened evenly. If you see someone use an air wrench on your lug nuts when installing your wheels - warped rotors are just a few miles away. Our 1988 760 has gone through several sets of rotors. The problem has been solved since I now insist on a torque wrench being used after the lug nuts are hand tightened. Current rotors have over 40,000 miles and are living well. When you have work done at a tire shop they are there to do what you need done, not what is the fastest for them. Let them use the air tools on someone else's car.

Calipers and Guide Pins:

Caliper Guide Pins: Maintenance

Guide Pin Discussion. In the Girling front brakes there is a retainer cage that fastens to two "ears" on the axle assembly. There are 2 hex socket bolts that hold this retainer on. At the back of the retainer are two sockets that each receive a floating locating pin encased by a rubber sleeve. The caliper is bolted to these pins so that it is free to move sideways a centimeter or so. The pins have to be lubricated and free to move. In my case one of these pins on each side was frozen and not moving. Thus when the brakes were applied the pistons were able to push the inside pad out but the caliper was not able to move in and pull the outer pad into firm contact. This caused noise and pulsing. [Tip] The front caliper is held by two floating guide pins which move within a bushing fitted into the caliper. Often this bushing shows corrosion and the pin can not be moved within the caliper. If so, the brake performance decreases as the two calipers cannot press the disc properly. To inspect the functioning of the brakes: remove the guide pin bolts and pull the caliper up and away from the guide pins. You should be able to easily move the guide pins in and out. If not, the pin or bushing is corroded or in need of lubricant.

Removing Caliper Guide Pins. [Tip from John B] On Girling it's pretty straightforward: remove the fixing bolt, pry the collar on the rubber boot from the caliper and then the boot and the guide pin should come out. Lube the new pin with synthetic brake grease and insert it, put the new boot over the lip and press the collar on so that the ridge on the rubber collar fits in the recess on the pin. On Bendix, it's a little more difficult, you have to ensure the ridges on the boot inside mesh up with the indent on the boot mounting ridge. [Tip from Randy] Unless they are seized the guide pins simply slide in and out after removing the brake pad. If they are seized a good soaking with Aerokroil (or your favorite penetrating liquid) along with the application of the correctly sized socket to add torque and a hammer to add vibration will help. Clean the hole thoroughly and apply an anti seize compound before assembly. I actually sprayed a lot of Kroil into the boot and let it soak. The best aid in having penetrating fluid work is TIME- as in long soak time. [Chris Herbst] One effective way to free the pin is to turn it back and forth while trying to extract it. It's not the easiest thing to do, and if it doesn't work, you are going to be in the market for a caliper carrier, which is not expensive.

Lubricant Recommendations. [Tip from Motor Magazine] Most brake lubricants suitable for use today are silicone-based; petroleum-based lubes may cause some newer rubber components to swell. [Editor] Use a brake lubricant specifically made for use on the guide pins; most will say "synthetic" or "silicone". Replace any torn rubber covers. Check the operation and lubrication of the guide pins at each pad change.

Rebuild Kit. Volvo has available a repair kit for the lower caliper guide. Cost for the Bendix version is approximately $30 US. Repairing the damaged caliper guide with a kit may be preferable in some circumstances for some owners. The heart of the rebuild kit is a new guide pin with a different design from the old one. Actually, there are two guide pin rebuild kits: one for the lower guide pin only, and one for both upper and lower. The lower guide pin is the one that is most often jammed. To determine whether either of the guide pins are jammed, remove the wheel and brake pads, and pivot up the caliper. The caliper should move freely and easily back and forth on the upper guide pin. The lower guide pin should easily move in and out. If a guide pin is stick in position, it needs to be repaired or replaced. Since the rebuild kit for the lower guide pin is only around $25, I recommend it.

Guide Pin Bore Maintenance. [John Sargent] To remove light corrosion from the caliper guide pin bores, use a 10mm rifle or .410 gauge shotgun bore cleaning brush in a drill to clean them. When replacing the pins, lubricate with the high temperature silicone brake grease noted above and make sure the rubber boots are in good condition.

Caliper Guide Pin Troubleshooting:

Pulling Brakes or Uneven Wear: Caliper Guide Pin Wear or Corrosion .

[Symptom 1: My 740 '86 had just turned 100K mi. but it seems to me that every time I step on the brake the car pulls towards the right.] [Symptom 2: Abnormal or unequal pad or rotor wear.] [Diagnosis 1:] It turned out that the caliper slide pin was stuck. The left disk got very hot, because the outer brake pad was constantly pressing the disk and that's why the left front brake was more effective than the right one (because the disk and pads were cold). Also the outer pad wears faster than the inner pad if you have this problem. I simply sanded the rust off the slide pin bore so that the slide pin moved easily and then lubed the slide pin and reassembled the caliper. It might also be a stuck brake piston. So check the pistons, they should move quite easily. I have also rebuilt all four calipers because some pistons were stuck. In my case the pistons were in excellent shape, but the bores in the calipers were not. So I just removed the rust from the bores and rebuilt the calipers with new gaskets and dust boots.

[Diagnosis 2:] Your problem might be the same as on my '87 745: the guide pins on your calipers may have worn or corroded, which causes them to grab the pads and hold them against the rotors. Voila, premature pad and rotor wear, as well as poor acceleration and gas mileage. The guide pins are a fairly inexpensive fix, and the difference on my wagon was attention-getting.

[Diagnostic Note:] I have found that a damaged lower guide pin is easily detected. One may not need to completely reassemble the caliper to perform the check. If the guide pin is badly damaged, as mine was, the lower guide will be frozen in place with no in/out play. You can remove the bushing from the caliper carrier by pushing with an appropriate tool (a 13mm socket). Lots of force may be required if this bushing has not been removed for long time. Clean bushing AND inside caliper with fine sandpaper or a rifle cleaning brush. Put copper grease on the bushing and slide the bushing inside the caliper. This should be possible without force. Make sure the bushing allows the pin to slide freely and is not too loose. Mount the caliper without the brake pads, and check if the unit slides easily left and right. (Lower bolt to be fixed). Re-mount the brake pads. Mount the wheel and spin it around. Put some Locktite on the thread of the lower bolt and tighten the bolt to 25 ft-lbs. [Assembly note: A common cause of damage to the lower caliper guide pin is over-torquing the guide pin bolt, common when replacing brake pads.]

[Cautionary Note:] Repairing or rebuilding a stuck caliper guide pin may not cure the problem of pulling under braking. Anything that causes a major mass to suddenly shift under braking can and will cause the car to pull. Examples of things that can cause this are worn or broken engine mounts and worn out suspension bushings. So, when you're working on your Brick's brakes, check the condition of the motor mounts and suspension bushings. You may find that you need more than brakes. Of course, this makes a perfect excuse for a set of IPD bars as part of the suspension rebuild.

See also the discussion of caliper binding and brake hose deterioration. **Pulsing Brakes: Caliper Pins**

Seized . [Report: Don Willson] Pulsing brakes fixed. 1989 765T with ABS and 135,000 miles. I have not seen this solution discussed though there has been plenty of comment on the problem and other remedies. The symptoms were a pulsing of the brakes when light pressure was applied. I thought that it might be the over tightened wheel bolts or a warped rotor. So I jacked up the front and started investigating. Yes the wheel bolts were too tight but the rotor was true, they had been turned last June. What I found was a retainer locating pin was frozen in place. In replacing pads about 4 times on my wife's 744 or my previous 745 I had never realized that there might be other problems though if it had been a snake I'd have been bit.

One locating pin was free to move, I could push it in and the grease seal bellows would push it back out. However the other was stuck. With about a half of an hour of twisting and prying I was able to remove the pin without damaging the retainer though the pin was trash. At Volvo I found that you can only by a kit, 4 pins, 4 bellows, 4 caliper holding bolts and a tube of grease for $98. I objected but bought the kit.

Reassembly was simple though I did clean out the pin sockets and polish the inner diameters with Scotchbrite on a stick on a hand drill, or use a cheap brass rifle cleaning brush. Reassembly was simple with a liberal supply of grease and properly fitting the bellows. Then locating the brake pads and slipping the caliper over the pads and fastening the caliper bolts to the locating pins. Since these pins are free to rotate a thin 13mm open end wrench comes in handy to restrain the pin while tightening the caliper bolts.

Since I had the pins I decided to check the other side. I was not so fortunate, one pin was stuck so hard it twisted off and I had to get a replacement retainer, $10.

My recommendation is that when replacing pads and or disks you check both retainers by pushing them to the outside of the car. If they do not move freely remove the retainer (2 hex socket bolts) and get to a vise where you can work the pins out. Replace the pins and bellows. Even if the retainer moves smoothly it might not be a bad idea to remove the pins, careful not do damage the bellows, clean the socket of old grease and any water and relube the pins. I suspect the grease is a silicone as it is water white (about like KY).

[Editor] See the notes under Caliper Corrosion and Brake Hose Deterioration for similar symptoms caused by deteriorating rubber hoses.

Brake Calipers Rattle: Guide Pin Wear. [Tip from Dave Stevens] TSB 51907 dated Feb/94 covers '83-'91 700 series with Girling (Lucas) 2-piston front brake calipers. It simply mentions that excessive wear between the caliper guide pins and their bores might, in some cases" cause a rattling sound and that a guide pin replacement kit is available (P/N 271854-2) containing guide pins, bushings, dust seals and mounting bolts. Obviously this was not a totally uncommon problem for Volvo to have even bothered writing up the TSB.

As you and the others notes, a much more likely cause for front brake rattling noise is a broken anti-rattle spring on one of the brake pads. You can inspect these without removing the pads. If you're going to change the pads you should always pop the dust covers, clean and lubricate the caliper guide pins using high temp silicon grease. Use the same grease between the back of the pads, the stainless anti-rattle plates and the piston faces to help minimize any tendency for your brakes to squeal. If you've got ABS, now is also the time to clean up the tips of those sensors (check the 740 FAQ and archives for notes on this).

At every pad change you should check each guide pin in its bushing -mine wiggle a little and this is probably normal, but slop is not. This gives you a chance to properly clean and lube the guide recess. Shoot with spray brake cleaner and use a rifle cleaning brush to clean the inside of the bore. When removing a caliper, hang it up with a length of coat hanger wire or a plastic tie to prevent damage to the brake lines.

Sticky Caliper: Internal Corrosion. [Inquiry] Despite replacing componens, I still have what seems to be a

bit of pad drag (very intermittent, comes and goes). Should I suspect a sticky caliper piston?
[Response: Gene Stevens] Jack up the car and take the wheels off. Have an assistant push the brake pedal down firmly while you carefully watch the piston when the pedal is released. By design, it is the soft piston seal reforming itself to a square cross section that draws the piston back slightly. It does not take much interference to keep that from happening. Remember, there are no return springs on a disc brake. A bad caliper will not "walk" back and forth with pedal pressure. (FYI, it is the piston finding its position on the pressure seal, and taking in fluid when the pads wear, that make disc brakes self-adjusting.)
The NUMBER ONE reason for piston drag is moisture getting behind the dust seal, collecting at the bottom, and causing a slight buildup of rust on the land between the dust seal and the pressure seal. The rust actually touches the piston and keeps it from free movement. These seals are usually damaged DURING service (carelessness when sliding the caliper over the pads or the use of spray goo on the inner pad). That's why the "bad" caliper symptom often appears shortly after the first rain after pad replacement.
If the pistons move nicely, rebuilding the calipers probably won't fix your problem (but it is good P.M.). I had a similar problem with the same single piston setup on mine, and found the stainless steel guide plates and preload springs had little dings in them from years of service, causing a grippy surface for the pads to ride on, so they didn't slide as freely as they should. A $12 hardware kit fixed the problem.
If you DO rebuild the calipers, scrape any rust buildup you see on the thin area between the seals. If you find signs of rust BEHIND the pressure seal, it means there was moisture in the fluid and it was not bled every few years. Caliper bore surface is NOT critical, so scraping is allowable, but piston surface must be perfect. Scored or pitted pistons must be replaced.

Rebuilding Calipers

Rebuild It Yourself or Buy a Rebuilt Caliper? [Tips from Editor/Chuck Jeckell] The shop I worked in insisted on rebuilding calipers in-house. 60% or so had pitted pistons and/or bores. Caliper repair kits don't come with pistons or sleeves, so I'd buy the rebuilt calipers from a reputable rebuilder. Consider the cost and quality of doing it yourself: you do not have the tools or the expertise to extract rusted bleed screws, re-tap threads, polish pistons and bores to correct dimensions or insert sleeves, and make the caliper leak-and-seizure-free. Buy a rebuilt unit with a guarantee.

Quality Checks on Rebuilt Calipers. [Tip from Larry] Most rebuilders of Volvo parts are up to speed on the necessary quality of the cores they rebuild. However, Girling placed a cast-dimple at the bottom of each "half" of the front calipers. Mis-matched, incorrectly-rebuilt front calipers will have a dimple at the bottom and a dimple at the top. The resulting internal cross-directed hydraulic pressures will cause bleeding problems and weird failures of an otherwise sound brake system: remember a Volvo without ABS has 2 separate hydraulic systems. Second, take metric wrenches with you to the parts store make sure the bleed screw threads in the caliper are capable of holding the bleed screws, and while you're at it, do a visual inspection of the threads and seals in the caliper. Occasionally a Volvo owner/mechanic will break a brakeline as it enters the caliper. Rebuilders have been known to ruin the caliper threads when they remove the broken flare-nut from the caliper body, so you gotta look there also. The test will come when you install them and bleed the brakes: look for leaks and piston seizures. Often the brake pads used in rebuilt sets are at the low end of the quality scale; you may want to replace them. In any event, make sure the new pads will fit the rebuilt calipers: sometimes the rebuilder refaces the inner surfaces and does not leave room for the pads. Avoid these problems by purchasing only high-quality rebuilds from a reputable retailer who will back the parts if problems arise.

Removing Caliper and Installing a Rebuilt Caliper. The only difficulty installing a caliper is likely to come from corroded brake pipe or line fittings. See the notes below for tips. To keep fluid from escaping the master cylinder with a brake line open: 1) Disconnect battery negative (or pull relevant fuse) to keep brake lights off. 2)Connect a bleeder hose to the caliper (hose routed to waste container). 3) Open the bleeder, then slowly press the brake pedal to the floor and block it there till you are finished. 4) Slowly press the caliper piston back to expell as much fluid from caliper as possible. 5) Close bleeder and remove caliper for bench work.

Ignore the Above and Rebuild Them Yourself? Check This Advice First. [Tips from Dave Stevens] Here are some caliper re-build tips from my own experience with my '95 940 (Lucas-Girling jumbo type 2 w/ABS). Unless you have access to compressed air, before removing the caliper and disconnecting the line, pop the piston almost all the way out using the brake pedal. Use the backing plates of old disc pads (or something equally thick) as a guide to how far you can safely push the piston out before it is about to go past the seals and spill fluid all over the caliper. To fully remove the piston, I prefer to do it on the bench to minimize the mess, but you can also swing the caliper away from the rotor and wrapping it in a towel use brake pressure to push it out. When removing the caliper you can clamp off the hose using something wide that won't damage the hose and its interior lining -a section of heater hose or a wound rag with locking pliers works fine for most people. Once on the bench you can usually easily blow the piston out with air (a tire pump with one of those tapered plastic fittings will often do the job). If you have trouble getting the piston out it's best to put it back on the car and use pedal pressure. Although not recommended, you can twist and pull the piston out, but you mustn't risk scratching the outside of the piston with anything like pliers. Either grab the rough inside of the piston with expanding pliers or try something like wedging in a single jaw of a large pair of channel lock pliers or use something fairly benign like an F-clamp with those plastic jaw covers or a smooth faced c-clamp wrapping a few turns of protective tape around the protruding piston.

The front caliper repair kit from Volvo includes two sets of piston dust covers, seals, guide pin dust covers and guide pin brake grease. Take this opportunity to replace the seals as well as the dust covers. It wouldn't be a horrid idea to do both front calipers to keep them performing evenly -a sticky piston can cause some initial pulling during braking. The caliper seal grooves are slightly tapered to aid in sealing and retraction. It's sometimes hard to tell, but the seals (at least the ones I've encountered) have a slightly tapered cross-section to fit these grooves. Use calipers (the measuring kind) or try to stand the seal on edge on a smooth level surface to determine which, if any, would be the narrow edge of the seal -it installs as the leading edge. Lubricate all mating surfaces with lots of clean brake fluid as you go, especially the inner seal and the back edge of the piston. Pull the new dust cover onto the back of the piston. It will fold inside out as you do this, just fold it back so the lip is sticking out and can be inserted (pushed) into the caliper slot.

Now you're ready to push the piston back through the dust cover lip. Although not usually a problem with this caliper design, to avoid damage to the seals press the piston straight in and not at an angle. Advance slowly. Apply force in the center of the piston using something like a large c-clamp. If the piston or clamp walks to the side immediately back off and straighten out. Initially it may seem like you're using a lot of force, but as long as you remain lined up it will suddenly pop into place and move in easily. Once it's pushed in all the way make sure the front lip of the dust cover is properly seated over the piston.

When re-installing the caliper, lube and check the caliper guide pins for wear and replace as needed. After the hose is reconnected, remount the caliper loosely and perform an initial bleed (note that DOT4 fluid is called for). Then remove and hold that caliper facing down at an angle and tap the caliper vigourously with a mallet to dislodge any air bubbles that may be clinging to the walls inside the caliper, on the piston and around the seal so they will float to the top. Re-mount the caliper and bleed some more until this process runs clear. Torque the caliper mounting bolts properly to 105 Nm (930 inch-lbs). FYI it's 30 Nm (265 inch-lbs) for the guide pins and an even 90 Nm (63-65 ft-lbs) for the wheel nuts. Read the FAQ sections on bleeding. Replacing the fluid and then pressure bleeding is certainly the best way to go and doesn't need a helper.

Rear Brakes:

Rear Ate Caliper Pins. [Inquiry] When replacing the rear Ate brake pad securing pins, is Loctite required or would spring tension be sufficient to hold them in place? [Response 1: Tom Irwin] No way dude! Loctite there will ruin your day. As you install the pins, notice the truncated, conical sleeve that is at the head of the pin. I usually give each one a light kiss with a hammer to seat them a bit more firmly. However, the tension springs are designed to retain the pins. [Response 2: Alan Carlo] Spring tension holds the pins in place. I put a light coating of anti-seize compound on the pins to prevent them from rusting in place. I have been doing it this way for many years without a problem. Inspect the pins though and if they are badly rusted or the spring on the end is damaged or missing replace them. I usually seat the pins with a pair of channel lock pliers as the spring makes it hard to use a hammer and punch.

Rear Brake Disk Removal. [740] Chilton's repair manual tells me to remove the center grease cap when replacing my rear discs; but it does not appear to have grease caps and is not obvious to me how to remove. [Response:] Had mine off last week. The disks fit pretty snugly over the axle hubs and a bit of rust can glue then in place. Try knocking them loose with a few hammer blows. Also, you may need to loosen the handbrake adjustment (inside the car) to let the disk clear the shoes.

Rear Brake Piston Rotation. [Inquiry:] I'm about to attack one of the ATE calipers on my wife's 740 to cure a squealing brake problem. I've been thinking it must have a stuck piston, but in doing a little pre-reading in Haynes (good illustration) and Chiltons (well....), they talk about the pistons being in the proper rotation and its effect on brake squeal. It seems there is a little step in the piston surface that meets the pad, and it is supposed be oriented to 20 degrees. I never noticed they were built that way. Does anyone know if it is very likely that they ever get rotated out of the proper position, and if so, what's the effect? [Response: Jim Holst] The ATE piston is supposed to be oriented in the bore so that the part of the piston in the direction of the forward rotation of the rotor is slightly higher than the other side of the piston to reduce brake squeel. The piston notches are angled 20 degrees from front to rear. According to the manuals, you use Volvo special tools 2919 and 2918 to measure and turn the piston. Not having the special tools, I just replace the pads and assume the piston hasn't moved in the bore. To turn the piston in the bore you need a tool which will fit inside the piston and expand to grip the piston. Sort of a c-clamp in reverse. [Response: John B] There's supposed to be a stainless steel shim between the piston and the pad...the shim has two punch-outs that fit in the rear caliper pistons at the proper angle. Although you can use the special Volvo tool or make one yourself, I've been satisfied with eyeballing the angle using the shim....the piston can be rotated with a needle nose pliers or a screwdriver tip...be careful not to tear the rubber dust cover/seal.

Parking Brake.

Adjustment:

[Inquiry:] How do I adjust my parking brake? [Response: John Kaiser] Remove the rear center ashtray from the console and the plastic mounting plate behind it by prying slightly on the two locking tabs on the bottom using a thin knife or screwdriver. Adjust the cable housing with wrench or pliers so that the handbrake lever can be tightened to 7-8 notches of which the first two must be free travel. Braking action should be felt at the fourth to sixth notch. To tighten, rotate clockwise. Also check cable at rear differential left side. Sometimes the cable pivot wears and comes loose. You may have to check the parking brake shoes by pulling rear rotors if you cannot procure satisfactory p-brake adjustment. [Response:: Leo R.] Adjustment: If you remove the ash-tray-holder behind the lever cover you'll see an adjustment for the whole brake. In cars without "multi-link" (the majority of 740's, it is common that one of the 2 brake cables is going to fail due to broken strands or a loose or rusty fastening which couples the right cable to the left. Easily seen when you lift up your car a little.

Cable Replacement:

Replacing One Side of the Cable. [Inquiry] How do I replace one side of my emergency brake cable? [Response: Peter Fluitman] Remove the right wheel and the caliper (no need to break into the hydraulics). Then pull off the rotor which is secured by the screwed-in guide pin. Remove the handbrake shoes. The cable is held in by a pin in the actuating mechanism. Assemble the cable in the mechanism and feed it through the backplate. Remember to put the rubber boot back. Feed the cable through the 2 loops on the axle casing. Then attach the other end of the cable. You'll need to slacken the cable off inside the car underneath the centre console (you shorten the outer cable). You'll need a couple of new R clips for the clevis pins. I normally remove both, clip the link to the new cable, then stick it back onto the pivot on the axle. Re-fit the handbrake shoes, the disk and the caliper Adjust by setting the cable back to give you 5 or 6 clicks on the ratchet.

Replacing the Long Cable Assembly to the Console. [Tips from Ken] A few months ago, the little 'peg' on the end of the cable that goes into the parking brake lever broke, leaving me with no parking brake. Not a big deal since the car is an automatic, but something I still like having the use of. The job started out by opening up the center armrest/console area and removing the rear ashtray and ashtray mounting fixture. Loosen up the cable to the max by turning the plastic adjusting nut as much as possible.

Loosened the lugnuts of both wheels (just in case) and jacked up the rear of the vehicle (after chocking the front wheels on both sides from rear and front... THIS IS A MUST) and placed it on jackstands. Herein lies the troubles that I encountered: I do not have a nice floor jack. I have a bottlejack. What happened is that the bottlejack brought the vehicle up to a nice height, BUT when I lowered the car back down on jackstands located under the axle, the car would lower even more since the weight was still on the suspension. This resulted in a very low clearance. Not the ideal situation for getting under the vehicle. You need a good amount of clearance to comfortably get under the vehicle to disconnect things.

Second problem. The long cable goes to the LEFT parking brake. I removed the left wheel and rotor and removed the brake shoes. Removing the parking brake shoes is a huge pain because of the strong springs. While I was at it, I banged out the wheel studs because they needed replacing. Figured it was a good time to take care of it. I threaded the leftside cable back towards the center of the vehicle where there was a little mounting piece and started disconnecting things. There are 2 cotter pins and R-type retaining clips there. This is where my second problem occurred. One of the pins and clips came off with no problems. I chose to save and reuse the clip. The other clip came out without a problem but the pin was rusted in there pretty solidly. This pin held the rightside cable in. Great, time to break out the PBlaster spray. After wiggling and banging at the pin for a good 10 minutes, it came out.

Finally, with everything disconnected, I threaded the cable back. About 1/2 between the rear axle and the hole into the console inside the vehicle, there is another retaining bracket. In order to remove the cable, you have to undo the bracket, at least I think you do. This requires a 10mm wrench for one side, and a 10mm socket for the other side. Finally, a little yanking and tugging and a lot of bad words later, I got the cable out. Putting the new cable in was very, very easy and you basically just do everything in reverse.

So, what have we learned? If you have a lift and power tools, this job will take you all of 15 minutes. If you are like me, it will take you 2.5 hours including cleanup time. On the plus side, I have a working parking brake again, and it feels much more smooth and consistent than it used to before!

960 Cable and Shoe Replacement

[Tips: Paul Golden] In a 960 with independent rear suspension, the rear e-brake hardware and shoes and dust shields were all gone and the cable from lever to axle was broke, all thanks to extensive rusting. There was no way I was taking out the gas tank to access the cable above. I was able to replace the cables by removing the exhaust system behind the catalytic converter as well as the heat shield. There is a cable clamp close to the heat shield that holds the cable off the heatshield to prevent rattles. I removed the center console and fished the new cable from inside. The two other cables were not fun. The aluminum had oxidized around the steel sleeve and made the cables very hard to remove, but with patience, lots of PB Blaster, and a pair of vise grips on a slide hammer I was able to work them out. I cleaned up everything and made sure the cable routing matched the original installation. The new dust shields were quite difficult to replace: they do not fit over the rear hub. I had to make a small cut in the new shields and remove the studs from the hub to get the job done. Installed new springs, hardware and shoes, put the studs back in hubs, installed rotor and brakes, adjusted hand brake and reinstalled the center console, heat shield and exhaust. Total job was over 7 hours and not fun. But if I had followed the manual it would have been much longer. [Tip] In my case, the cable was caught above the gas tank. One can barely get a 1/4 drive wrench above the axle to remove the cable clamp. I had to undo the corroded nut on the exhaust side and all the nuts in the front and back, the latter of which are the worst to access. If you have to replace the cables make sure to buy the clip that holds the left rear cable to the end of the front cable.

[Inquiry] I have a 95 960 sedan that has a parking brake that went south. The handle and shoes don't respond.[Response: John Shatzer] My experience with the V90 is that the shoe assembly rusts out, not the cable. When this happens, the brake level is loose (no resistance). Replace the parking brake shoes.

Shoe Failure Due to Rust.

[Jim Bowers] Most cars need to have a working handbrake to pass state inspections. I had already replaced the shoes on the right side as the friction material broke off when I opened it up for inspection to see why they wouldn't adjust very well. On the driver side the friction material was loose for about half the length on both shoes. Rust had separated the friction material from the shoe. This happened to my on the 745 as well. I guess if you live in the "salt belt" you should plan on replacing handbrake shoes every 8 years or so. By the way, in replacing the friction shoes, getting the return spring in place took several tries using different approaches. Finally, a big screw driver resting on the hub lifted the end into the shoe's hole. Easy once you have a viable method, but almost impossible otherwise.

Shoe Replacement Tips.

[Inquiry] After replacing my parking brake shoes, I can't get the rotor back on. The adjuster is full loosened. [Herb Goltz] There are a couple things to check-- first, did you free up the actuators that the cables connect to? They should pivot at two points, not just one. I live in the "rust belt" and have yet to encounter a set that weren't at least partially seized on my last 3 Volvos. Antizeize is your best friend once you get them moving again. Your car probably won't have the star adjusters in it, rather it will have a piece of flat stock with notches in each end. Make sure that the new shoes fit all the way into the notches in the flat bar (I have had to do fine fitting with a small file on two cars). The other possibility is that your cables are seized in their sheaths-- you can check their operation once the shoes are in place but before the rotors go back on. One final thing that I have encountered is cooked return springs on the shoes. [Mark] I like many others couldn't get the new rotor back on. I called the dealer and a mechanic gave me the BIG HINT. He said it was a two person job: one person pulls the cable towards the brake to allow sufficient slack to compress the shoes. He also said remove the center console and make sure that the cable was "Real Loose" by adjusting the hand brake adjuster out. I asked about the expander and if it should be replaced: he said they last a long time and to just clean and lubricate it. So I put the long spring on the shoes: stretch the spring out by first clipping in the bottom end and then with a long thin flat head screw driver, using the small hub and axle as a lever, get close to the upper notch and then push it in using another screw driver in the other hand. I placed the disc on the wheel lugs and while hunched over the brake I pulled the cable towards me while using my knees to press on the rotor. It went on like a charm.

Master Cylinder:

Don't Ruin Your Master Cylinder While Bleeding. [Editor] Master cylinders can develop a corroded bore outside the area swept by the seals. If you bleed your brakes using the brake pedal, press the pedal only as far as it normally travels and no farther. If the seals enter the corroded area, they will almost instantly tear and the master cylinder will be ruined.

Replacement and Bleeding. [Editor] To replace your master cylinder:

1. Spray the brake fittings under the master cylinder with PBlaster. Place rags under the master cylinder to protect your paint (brake fluid dissolves paint).
2. Disconnect the brake fittings and 7mm master cylinder mounting nuts.
3. [Manual transmission cars] If you have a hydraulic clutch, disconnect its hose from the reservoir and block the hose connection.
4. Remove the master cylinder
5. Don't consider rebuilding it: buy a rebuilt unit from an auto parts store
6. The end of the servo pushrod should extend slightly beyond the face of the servo body by the following amounts:

	Models to 1991		**Models from 1992+**	
	10"	2 X 8"	10"	2 X 8"
Without ABS	2.5mm	2.5mm	2.5mm	2.5mm
With ABS	0.5mm	33.4mm incl spacer	2.5mm	2.5mm

7. Install master cylinder and tighten nuts to 23 Nm or 17 ft-lbs.
8. Reconnect brake fittings and clutch hose.
9. Bleed brakes. To bleed the master cylinder, pressure bleed the system WITH THE OLD PADS until the fluid runs clear, then press the pistons back in the calipers without loosening the bleed screws and install new pads, thereby reverse bleeding the master cylinder. Don't do this on ABS-equipped cars.
10. Pressure test by pressing hard on the brake pedal for 30 seconds and inspect the master cylinder for leakage.

Brake Hoses

Brake Hose and Line Replacement. [Inquiry:] Can anyone explain the details of replacing brake hoses and lines on a 1985 740? How long can I expect the factory originals to last? Do the hoses suddenly fail when old? [Response:] It is very unlikely that the original hoses will suddenly fail at ages less than 15 or 20 years unless the hose had been subjected to abrasion, cutting, or severe stretching/bending while working on the car. The mode of failure is usually loss of rigidity allowing the hose to 'balloon' under pressure so that the brake system pressure is not completely transmitted to the caliper - result - soft pedal. The other potential mode of failure is that the inner liner of the hose becomes soft and collapses inside the hose - the brake

system pressure is transmitted to the caliper, but when the pedal is released, the hose collapses and acts like a check valve keeping pressure on the caliper - result is dragging brakes, overheating and warped rotors, and excessive rotor/pad wear. If your car is more than 10 or 15 years old, check those rubber lines carefully. If there are signs of deterioration, or if you can feel the line expand at all when someone steps hard on the pedal, then it is time to replace.
You can buy the IPD DOT approved stainless braided brake lines for about the same price as the Volvo replacement parts.

Tool Requirements. DON'T USE A WRENCH that DOESN'T FIT PERFECTLY!! Don't use an open end wrench, an English 7/16 size, or the wrong metric size (most fittings are 11mm or 14mm); don't proceed until you get a wrench that fits right/tight on that particular fitting. Buy tubing fitting (“flare”) wrenches - here it is worth avoiding the cheap grades of flare wrenches, since they are not thick enough and will spread enough to round the nut. Buy a good professional set - they will work a lot better, and even though they may cost more than the inexpensive brand, if it saves you one or two fittings, they are well worth it. Also, if there is evidence of steel tube twisting as you attempt to loosen, put on more penetrating oil and work it back and forth a very small amount lots of times. It will gradually work loose because the torsion of the tube inside the fitting will crack the rust. Takes lots of patience, but almost always works.

Removal Tips and Frozen Parts. Replacement is straightforward EXCEPT that you need high quality tubing nut “flare” wrenches (most fittings are 11 and 14mm). First clean off the fittings with brake cleaner to expose the threads as best you can. Then soak all fittings with good penetrant like PB 'Blaster' or 'Kroil' several times for a week or so prior to trying to remove. This may save some of the fittings and hard lines that you might otherwise have to replace due to frozen fittings. Often the copper tubing seizes in the threaded fitting, a result of corrosion and the soft copper binding. Often breaking the threads loose is the source of rounding or breaking the fitting hex flats, while the line frozen in the fitting causes twisting and failure of the line.. Usually, if I can break the threads free, I can get the fitting loose from the line with persistent back and forth motion and plenty of penetrating oil.
[Caveat:] I just finished replacing ALL the metal brake lines in my 740 since I couldn't get the rubber lines off. Soak before trying - but even on my '89 w/original lines I couldn't get them off with a flared open end wrench (they still spread a tiny bit and the old nuts weren't perfect) and rounded a few and the others actually CRACKED off leaving the threaded nipple part inside the rubber line. If you’re committed to doing this (i.e., you don't mind going through the hell I went through to replace the metal lines - a lift would have at least helped greatly with the rear ones, but it's the right front caliper lines that are the real PITA) then you can cut the rubber lines on the car near where they connect to the metal lines and then get a socket over what's left to help get a better grip at least there. The big problem is the nut on the metal line. I did manage to get ONE of them free by using PB and heating with a torch. BUT even after I got them off the threads on the nipple weren't very healthy and seemed to thread rather loosely onto the new rubber hose, so I replaced that line too.

[Tip from Mike Missailidis] I can tell you that I successfully removed all six flexible brake lines without ruining even one hard line or flare nut. How? I used a Mac Tools 11mm flare nut wrench, started soaking the fittings once a week for two weeks with PB B'Laster prior to doing the work and used a propane torch to heat the fittings and let cool twice, spraying more PB B'Laster between heating and cooling and tapping on the fittings with a small hammer. Even so, it wasn't easy. [Rhys] I wire brush the crud away from the line fittings, and then use a small oxy-acetylene flame to heat the fittings - not to a visible heat of course - just heat them to expand them a bit. Normally I let them cool for ten minutes, then heat them a second time. A high quality flare nut wrench is then applied, and tapped with a hammer. If they move at all, then I apply a penetrating oil, and tighten and loosen the fitting to work the oil into the threads. If that doesn't do it, I tear the lines out and get to work, and make new lines myself.
[Inquiry] How do I disconnect and reconnect both redundant brake hoses on the front brakes of a non-ABS 740? The hoses don't appear to be able to pivot, and when I turn one, it curls up like a telephone cord. I'm thinking this can't be good for the hose. [Response: JohnB] Look back up the flexible hose to where it attaches to a solid line. Chances are there's a male fitting that screws into the female end of the rubber hose.

You first unscrew the male fitting and release the rubber hose from the bracket (generally just pull a U-shaped sheet metal tab. Then you can unscrew the hose(s) from the caliper.

[Caveat:] If you run into problems, you can cut the metal line close to the nut and re-flare it at the end using a new metric European (not Asian) fitting. Two new nuts could be taken off of each short line you purchased and cut (available in 12" lengths.) The line has what is called an "ISO double flare". I remember that it can be duplicated with a normal flaring tool but takes a bit of talent and practice. It involves a two step procedure. You need a special double flaring tool to do the lines - the normal single flare tool will not do the job. And even with the tool - it takes a bit of practice to get them to come out right consistently. It is a lot easier to use the tool on the bench than it is under the fender of the car on the end of the brake line. It is well worth spending a few hours with penetrating oil and careful working back and forth of the nut than to try to repair a broken line. After replacement, the entire brake system will require flushing/bleeding (Use pressure bleeder like Eezibleed).

ISO 57.5 Degree Double Flare

Installation Tips for New Hoses. [Zee] Pretty straight forward. I found it good to

1. Place a plastic membrane under the fluid bottle cap for extra suction to prevent fluid from gravity draining as fast while each old flex hose was loosened/disconnected. Open a bleed screw, block the brake pedal down with a wood stick, then close bleeder—to stop fluid loss from the master cylinder while lines are open.
2. It helped to loosen each end of the hose (fitings) to make sure they will let go. If one joint will not, you'll be better off tending to that before loosening or removing any of the others. I didn't need to soak the unions very long in penetrant [but see the cautions above about frozen fittings].
3. Unclip the ABS line (if you have ABS) from the flex hose. It will give you more room to work. Undo the upper end of the hose before the lower end. This makes it easier to unscrew the lower end because you can stand up the hose and rotate the thing.
4. You'll need two 14mm wrenches and an 11mm. Use quality flare wrenches to prevent rounding the fittings.
5. Use a large catch basin and some cardboard under it on the floor. You won't expel a lot of fluid, but this does leave a mess. [Art Benstein] Insert a sharpened golf tee in the end of the line or hose to prevent fluid loss.
6. First remove the hose at the brake line end, then at the caliper side.
7. Think about a way to "fill" the new hose with brake fluid before bleeding that column of air into a perfectly bled caliper. Even though you need to screw the lower end onto the caliper before joining the top end to the flare nut hard line, you can leave the lower end loose, connect the top, then let gravity bleed some brake fluid into the new hose to fil it just before tightening it to the caliper. It will minimize the amount of air you will introduce to your system. Clean up the caliper area later with a shot of brake cleaner.

Replacement Brake Lines. [Rob Bareiss] Volvos and almost all European cars use the ISO 57.5 degree "double flare" lines- the end flares out and back in. It almost looks like a rivet. The fittings are European (not Asian) metric. When sourcing new lines, it's best to have the old lines in hand unless you're sure what you're looking for. Dealers, most auto stores and Internet Volvo aftermarket retailers stock straight lengths of made-up brake lines as well as the correct hoses. [Editor] The Volvo OEM lines are

Measuring Brake Line and Fitting Angles

Bending Brake Lines

made from cupric-steel which is softer and easier to bend. [Adapted from Brake and Front End Magazine, Aug 04] Most jobbers stock precut lengths of tubing with a flared connection on both ends. These precut lines can be used to fabricate a replacement. With the proper tools and practice, the damaged lines can be duplicated from the precut tubing. Tube bending is part tool and part black art. The tool part is a bender that has the three following components: a bending die, a following die and a latch or fixture to hold the tube to the bending die. The purpose of the bending and following die is to maintain the diameter of the tube as it is bent to a specific angle. The black art is measuring the length between bends and bending to the correct angle. The length and bend at the flared fitting connection is important to prevent cross threading the fitting. You can "eyeball" it and use your bending tool to fabricate the line. When using this method, bend a little and compare a lot. Angles at the flared end of the tubing can be measured using a protractor and a piece of bar stock or a miter gauge. Brake fitting threads, by the way, are 10mm x 1.00mm pitch.

Brake Hose Deterioration and Brake Binding. [Inquiry] My front brakes are dragging - both sides and quite severe. On the right side the pads are worn evenly and the pistons move freely. How can I check the brake line for internal swelling/collapsing? [Tip from Herb Goltz] An old brake hose acting like a one-way valve is a very common problem. The inside of the hose rubber deteriorates, creating a flap internally that blocks the return of fluid when the brake pedal is released, causing dragging brakes, warped rotors, and pad wear. Many "dragging" calipers get replaced for this reason. [John Randstrom] The easiest way to check for a bad brake hose is to pump and release the brake pedal, then open the bleeder screws on the caliper. If pressurized fluid escapes the hose is bad. I have had quite a few hoses that were bad that caused a caliper to drag. [Colin] Apply the brake a few times to get the brakes binding and then slacken the bleed nipples. If you get a spurt of fluid and the brake frees off you have a restriction preventing fluid returning back to the master cylinder resevoir. This could be brake lines or master cylinder. Do the same again but slacken the lines at the master cylinder this time, instead of the bleed nipples. If both brakes are binding equally it`s more likely to be a master cylinder problem.

Brake Hose Failure

Troubleshooting:

Low Pedal and Soft Brakes Problems.
Low Pedal After Pad Change: [Inquiry] I recently replaced the front pads on my Volvo. Now I have excessive travel of the pedal. I've tried bleeding the system with no luck. I assume there is air in there somewhere but can't find it. Can anyone tell me if I'm on the right track or if there is some other cause for this. [Response: Bob Dietz] Usually the wear lip on the rotor holds he pads away from the braking surface. Until the pad wears in the pedal will stay low. Additionally different brake pad compounds have a different pedal feel.
Bleeding for Soft Pedal:
[Excerpts from "Low Pedal Blues" by Bob Freudenberger, Motor Service magazine, Feb 00] You can find out all you need to know about the master cylinder by removing the lines, screwing brass or plastic plugs

(either ISO or double flare) into the outlets, then applying the brakes. If the pedal's high and hard now, the master's properly bled and its seals are okay because, as we said, the pedal would sink gradually if it were bypassing. You have also confirmed that the booster's okay.
Continue in this process of elimination by capping lines or clamping hoses to isolate the wheels (clamp with a suitable rounded-jaw tool, please, not sharp-toothed Vise-Grips, or at least use heater hose to pad the jaws of whatever type of squeezing device you choose). Releasing one at a time should locate the problem.
When it comes to the bleeders at the wheels, we know most of you just open them and let the fluid squirt. But that's thoroughly uncraftsmanlike. Not only will it make slippery puddles on the floor, it can shoot farther than you might expect (how about the 2,500+ psi of line pressure on some ABS-equipped cars?), perhaps ruining the paint on the car in the next bay. We use a tube and transparent bottle (which attaches to the chassis with a magnet) half full of fresh fluid because it's neat and it lets us see what we're getting out. Also, it eliminates the need for a helper if we're not using a pressure bleeder.

Hard Pedal Problems and Brake Booster Diagnosis. [Inquiry] My turbo's brakes feel like there is no engine assistance because the pedal is very difficult to push with minimal effect.[Response: Colin Shepherd] it sounds as if the servo/booster is not working . To test it, turn the engine off and pump the pedal half a dozen times to exhaust any residual vacuum. Then, maintaining a steady pressure on the pedal, start the engine. The pedal should sink about 1/2" as the vacuum does its work. If nothing happens, carefully pull the white vacuum check valve on the front of the booster out of its seal and see if there is vacuum at the servo/ booster side of the valve with the engine running. If you don`t have vacuum there, either the valve is stuck shut, or you have a blockage in the plumbing. You should be able to get the valve as a separate part. Be very careful pushing the valve back in as the seal can be pushed back into the inside of the servo. If it turns out to be a faulty servo then it`s time for a a second mortgage, or a trip to the breakers yard !!!

Brake Booster Check Valve

Brake Vacuum Booster Check Valve

[Inquiry] My 740GL has a soft pedal and air noise (like air escaping) in passenger cabin when pedal depressed. How do I diagnose a brake booster or check valve problem? I understand these are rare. [Response: Bob & KSwan] First, visually inspect the vacuum hose and the check valve on the brake booster inside the engine compartment for damage. The valves are plastic and can get brittle over time. Next, pump the brake pedal 5 or 6 strokes to bleed off any vacuum. Now hold the pedal to the floor, and start the car. The pedal should drop a bit as vacuum builds. Hold pedal down and stop engine. Pedal should stay down. If it tends to push against your foot, you have a leak. If you can hear it inside, odds are the booster diaphram is leaking. But try the check valve route first. Note, NEW boosters are $400-500. They fail rarely so a used one will do.
Leaking or Missing O-Ring. [Tip] My car always suffered from hard pedal, but after investigating I found a missing o-ring between the master cylinder and the booster. Replacing this 5cm o-ring solved the problem.

Brakes Pull When Applied: Control Arm Bushings. [Inquiry:] Brakes seem to pull for an instant upon first application giving the steering wheel a small jerk when brakes first applied. Recent brake pad replacement and rotors turned seemed to help somewhat but did not cure problem. [Response 1: Steve Seekins] This is the classic symptom of bad radius rod to control arm bushings. There are 2 cone shaped bushings at the front end of each radius rod where they connect to the control arm. Easily replaced, be sure you get the newer more durable ones. Also, when replacing, be sure to clean out the holes in the control arm of ALL corroded metal and rubber residue from the old bushings. Also, do not do final tightening of the bushing bolts at either end of the radius rod until the car is on the ground and the suspension fully loaded and settled -

otherwise you risk premature failure of the new bushings. See Radius Arm Bushing Replacement

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Brake Calipers Rattle on Mounting Bolts. [Inquiry:] I have a '89 745GL with 226K miles and the brake calipers on both front wheels are rattling. I can jiggle them ever so slightly with my hands. The Volvo dealer says that this is a wear sign with so many miles on the car; I have only had the brake pads replaced when needed throughout the life of the car and I am the original owner. The dealer said that over time the bolt holes attaching the calipers to the car wear and get larger; it is not a safety concern but the only cure for this 'rattling' is to replace the calipers. This seems like an expensive fix and when I suggested that we get bigger bolts, they laughed. Any advice? [Response:] There is an updated set of caliper pins, at least for Girling front calipers. I know, since I installed them on my car. As I recall, they meant to fix rattling calipers (and perhaps something else as well.) There was a Technical Service Bulletin to this effect, which is how I found out. Talk to a different mech/dealer. Sounds like your current mech/dealer is perhaps not aware of this fix. [Editor's Note:] This is Volvo TSB 51907, Feb 94. See also TSB 518910401, Apr 91 if you have Bendix calipers.

Pulsating Brakes: Runout in Hub and Rotor. [Tip from Don Willson] For 9 months I have been fighting pulsing brakes with 2 rotor turnings and freeing up the caliper pins. I was about ready to go buy new rotors but first I thought I would see how "wobbly" they were. I put a dial indicator on and found they were 0.006 inch and 0.008 inch runout. I cleaned the hub and inside of the rotor. Then I put the rotor on and tightened it down in each of the 5 positions, and on the opposite wheel. I found a position where the runout was least, about 0.003 to 0.004 inch, and reassembled the wheels. On a run around the block if felt good, I'll go make a highway run and see if it helped. The Volvo spec is 0.003 inch maximum runout. [Response 2: Ross Gunn] I am a believer in the the importance of careful torquing of the wheel nuts. Regardless of the shape of the discs, I still believe that over-torque or uneven torque can preload the discs and then when they are heated through heavy braking, they can take a permanent set. This is just a conclusion I have come to after experiencing new discs that were OK for the first while and then began to wobble after some use (1000 or 2000 km.) I also have used a dial test indicator to find the best position of the discs and agree to the effectiveness of this method in getting a smooth feel. Sometimes a piece of aluminum foil added strategically between the hub and the wheel can help. Too bad the hubs can't be manufactured truer (more true? - more truly? - with less runout!).[Editor's Note: See also Brake Rotor Installation Techniques to Minimize Pulsation]
[Response 3: George Downs] My second 122 had BENT front hubs! I had them trued at a machine shop which brought the runout from 0.080 down to about 0.010". The disks were perfectly true. I finally got them down to 0.001" runout by sticking pieces of feeler stock between the disks and hubs in a trial and error method. I have not the faintest idea how they got that way but the PO had given up on ever having reasonable brakes.

Brake Rotor Pulsation: Causes. [Comments from Wagner Brake div. Of Cooper Industries:] Brake rotor thickness variation causes brake vibration due to changes in the braking force as thick and thin portions of the rotor pass between the pads. Eric Smith, Senior Instructor for Wagner Brake at the Moog World Training Center in St. Louis, says technicians sometimes pin the blame on a defective rotor, but often it's due to excessive system run-out, which has not been checked by the technician.
Smith says the run-out will cause the rotor to wear itself out of parallel, and is why turning or replacing the rotor won't solve the problem. System run-out can be caused by poor mating of flanges between the hub and rotor when assembled as a unit (by excessive rust, preventing a clean fit of the rotor on the flange), excessive run-out and even improper torqueing of the wheel bolts. Once the rotor heats up during operation, if one lug is a little less tight that the others, the rotor will expand at that point and cause run-out, says Smith. Compounding this is the fact that the brake might only have run-out when the rotor is hot.   When the customer takes the car back to the shop, it's cooled when checked by the technician and by that time the run-out disappears. If not corrected, though, it will eventually have a permanent run-out, and be worn out of parallel.
Make sure rotor run-out is below specifications before reinstallation; also make sure the hub is clean and rust free before installing the rotor. System run-out should be checked after installing the rotor (new or turned). If

run-out is above spec, the solution may be as easy as re-indexing the rotor one stud at a time, until run-out is within spec. It may also be necessary to replace the hub assembly. And see below for tips on front end shimmy and vibration, which can feel similar to brake problems.

960/90 Series Pulsation Problems: Runout Issues. [David Aidnik] I have two '94 960 wagons, and I have been less than satisfied with the pulsations during braking that are more or less notable on the two cars. Over the years of browsing this board for clues and answers, I have seen various possible causes, most of which allude to warped rotors or front control arm bushings.
These are true and reasonable clues, but the real culprit is the design itself: the braking force of the front brakes is transmitted directly to the car body through the control arm in compressive force. This direct transmission of the braking force straight through the axis of the control arm makes for a harsh transmission of road shock and any uneven forces of the pads/caliper and rotor. The requirements of measured runout at the rotor are quite stringent to minimize any pulsations.
Measured runout of even 0.0005 inch can be just barely discernable as pulsation in some conditions. This leads me to the conclusion that to do the brakes right or well when you replace the pads on this design requires that you have an indicator and a magnetic base to hold it to enable you to accurately measure the rotor runout.
After you take the caliper off the wheel mount, mark the hub & rotor positioning so you know how they were lined up before. Then take the rotor off the hub & clean both the mating faces of the hub & the rotor as best as possible using a wire brush & steel wool. While you're there, you can also clean out the wheel sensor magnet and the brake dust off the hub. Then measure the runout. I started with the original position and tried several others of the five possible positions. At each, you make sure that there is no dust or dirt on the mating surfaces of rotor or hub, then carefully push it straight on and put three lug nuts on, snugged without moving the rotor. Then measure the runout near the center track of the brake pad. Hopefully you can find a position that gives 0.0005 inch or less.
You can reduce runout by careful cleaning of the rotor and hub mating surfaces: I reduced mine from 0.0015 to 0.0005 just by cleaning.
Volvo manuals show a machine for double-grinding of rotors on the car. This is an indication of the sensitivity of this design to rotor runout.

Intermittent Brake Failure: Bad Sensor Seal. I was losing brake fluid because the brake failure sensor block's switch *seal* had deteriorated. The brake failure light had never illuminated and the entire brake system was in excellent working order. I'd noticed the fluid level in the reservoir dropping slowly; eventually would have aerated the master cylinder with consequent problems. The brake system has been fine and leak-free for the last 20K miles. [Also:] the whole 8-way distributor/brake warning thing is very expensive. The plastic plug/switch is not intended to seal against the hydraulic pressure, that is done (or not) by seals on the piston, changing the plastic plug will not stop the leak.

Wheel Shudder: Diagnosis. [Inquiry:] Has anybody ever had a problem when a steering wheel shakes anytime you brake on speeds higher than 30 mph? It seems to be brake rotors' uneven wear. [Response: Paul Grimshaw, alt] Shaking under braking is usually associated with warped rotors. In Volvo cars, warping normally occurs if the wheel lug nuts have been improperly torqued or brakes have been over-heated or if they have been subjected to a number of heating and cooling cycles after having been machined. For this reason, it is always best to resist having the rotors turned and purchase new rotors anytime symptoms like you described are noted. Uneven wear on the rotors can only be confirmed by a dial caliper, just as rotor thickness can only be accurately judged by using a micrometer. For handy reference, Volvo rotors have the minimum rotor thickness value stamped on the rotor hat -- any rotor that has become thinner than specified should be replaced.
Uneven or excessive torquing of the wheel lug nuts can also warp rotors. One should always tighten the wheel nuts with a torque wrench to avoid over stressing the stud/nuts (900-series and older) or bolts (800-

series and higher). See the procedure tips in Wheels.
Although brake rotor faults are the most common cause of what you describe, worn bushings, tie rod ends, ball joints, or even tire faults cannot be ruled out either. See the FAQ reference.

Brake Shuddering and Suspension Bushings. One reason we got some shuddering on braking our '90 745 was that the suspension bushings were shot. Those conical rubber bushings on the lower control rod where it enters the main lower suspension arm take a beating under braking, and eventually allow quite a bit of fore and aft movement of the wheel. Maybe the rotors are warped, but, especially if you get shaking without brake pedal pulsing, could it be bushings? They're cheap, and take about an hour to do.

Wheel Lockup. [Problem:] I am having the left rear wheel lockup when braking hard on wet pavement. [Diagnosis:] Calipers are a common source of sticking brakes. On rare occasions this has been caused by degraded brake hoses. If your 740 is still running its original brake hoses now would be a good time to replace them before bleeding the brakes. What sometimes happens is that the inside of the hose swells up enough to form a rubber one-way valve where there should only be straight hose.

Brake Light "On" After Bleeding. [Inquiry:] I just replaced the front brake pads on my 1988 740 GLE wagon. I bled the front brake lines and the brakes seemed to work well except that the brake light came on during hard stops. So I bled the entire system and replaced the entire volume of brake fluid. The brakes work very well now except that the brake light is on constantly. What is going on? [Response 1: Stefan Schader] During your bleeding process you probably created a pressure imbalance in the dual brake system setting off the light. This light is activated when the floating balance piston moves to one side. Then a plunger drops activating the light and preventing the piston from going back to it's neutral position. To reset this, unscrew the brake failure light sensor and then press the brake pedal to reset the piston to neutral. Then remount the sensor switch. [Response 2: Peter James] You will need to undo the brake failure sensor switch and allow the piston to centralise before refitting the switch. If there is fluid present when you remove the switch from the junction block (in front of the passenger on the inner guard down towards the bottom) on RH drive cars (drivers side US) you will have to dissasemble the block and renew the 2 "O" rings, tightening the switch will not work!

Front Brake Squealing on 92-95 940/960. Volvo has come up with a shim kit (Part No. 272187-6) to correct this. Before installing the kit, though, here are a few things to check: If the caliper piston doesn't spring back when pressed in, replace the caliper; if the caliper dust seal has been corrupted and dirt got in, either rebuild or replace the caliper; if there's rust on the caliper, especially the guides, clean it up. Finally, install the shims to the upper section of the brake pad backing plates where the piston makes contact.

Brake Reservoir Seal Failure. Here's an interesting old car failure, perhaps something to put on the 10 year list and/or an FAQ for bricks:

The brake fluid in my master cylinder reservoir kept going down slowly over a few weeks...wouldn't leak fast enough to tell where it was going so I just kept adding fluid and looking. Now I see it appears to be coming from the seal(s) between the master cylinder reservoir and the master cylinder. Since this type of construction seems to be more and more the norm (a lot of old cars had integral reservoirs but that weighs a lot more) this is something to look for. The seals cost about $7 apiece on my application (need 2) so it looks like a little job this evening--one of the few jobs no tools required, if I'm lucky and the reservoir is self bleeding...If I may add a bit of cautionary advice to this, especially for older cars where the reservoir may be becoming somewhat brittle:

- Never lean on the reservoir or grab a hold of it to anchor yourself when applying wrench torque to something else under there.
- If your seals have begun to leak, be *very* careful when you remove the reservoir since it can be brittle.
- Until you get around to doing it you might find that two plastic zip ties over the top of the reservoir and under the master cylinder with a third horizontally around the reservoir (to hold the other two so that they do not slip off of the ends) will temporarily stop the leak.
- Push the reservoir over to one side to get it started, rather than prying straight up. Carefully pop the reservoir out and replace the seals.

Upgrading:

Stainless Steel Braided Lines.

Part Compatibility. IPD lists the stainless brakes lines for 740/760 1983-1987. Also for 740 with ABS from 1988-1991. As this excluded BOTH my '90 745 and '92 745T I asked them why. Basically the reply was, because they had an omission in the catalog (for the non-ABS models) and couldn't find a cross-reference for the ABS model. The 1983-1987 option, IPD model CG5205(non-ABS) is actually good up to model year 1992, and is printed that way on the lines (at least, since I'm guessing the 940's shared brake lines with one of these two categories of 740s). On the 1988-1991 w/ABS models, IPD model CG5206 was compatible with Volvo part number 1329611 (front) and 1329594 (rear). If anyone knows if these two Volvo parts correlate to other/later brake lines in the 7/9 series, please let me know.

Upgrading Older 7XX Brakes to Big Brakes or Later 9XX Jumbo Brakes. [Inquiry] I've heard that fitting the "Jumbo" brakes from the 900 series on my 88 740 Turbo will help/cure the"warping problem". Three questions: a) Does anyone have a detailed parts list for the job ? b)Is there a reason NOT to do this ? and c) Can anyone supply step-by-step instructions for the job ?

Background. [John Sargent] There are two kinds of large-capacity brakes: "Jumbo and "Big" brakes. Jumbo brakes only came on ABS cars and they are all single piston/single brake line calipers using 11 inch, one-inch-thick rotors and larger pads. Big brakes (11.25" diameter) have different calipers, caliper holding brackets, and smaller pads than the Jumbo brakes. To upgrade an ABS car with either 10.25" or 11.25" rotors to Jumbo brakes you need calipers, caliper holding brackets, pads, and rotors, as noted below. The brake calipers do not bolt directly to the strut: a caliper holding bracket (or Jumbo Brake Bracket) is needed to mount the caliper to the strut. To upgrade a non-ABS car to Jumbo brakes, you need the same parts and two brake master cylinder plugs. You will be removing two brake lines and hoses, noted in the second section below. Jumbo Girling brakes with 11 inch rotors use the 1198 brake pad. The Girling brakes for both 11.25 inch (we call them the Big brakes) and 10.25 inch rotors take the 508 pad. ABS makes no difference on the pad use for Girling 11.25" and 10.25" rotors. [Tim] If you visit a pick-n-pull boneyard for parts, remember to take along a 10mm allen socket to pull the 2 bolts that hold the caliper brackets in place.

Conversion for Cars with ABS:

[Response: Abe Crombie] I have done this to my parents' 88 764 turbo. It requires left and right calipers from a 92-94 960 or 92-95 740/940. It requires two rotors. The hubs are the same and the brackets on a complete caliper with slides/mounts will bolt with no mods to your struts at the same attaching points. The

brake hoses are a direct fit to the newer calipers. I'm not so sure that the bigger brakes will fit if you have 14" wheels though. All jumbo brake 700/900 have 15" wheels and there are some references in parts catalog to differences in 91 and older with 14" brakes and 15" brakes. Their car does seem to have better brakes and it has had no trouble with brakes in the 50-60K miles since swap was made. I got all the pieces from a salvage parts place from a front-end total that had no useable front suspension pieces and had just arrived and had not been picked over.
[Inquiry:] I assume all the 92+'s have ABS as my '89 does? How are the rotors different (mine currently has the larger of the two available sizes - do I still need to change)? [Response: Abe Crombie] The offset of the "jumbo" brake rotors are different and you will have to change the rotors as a result. The 95 to 98 960/s-v 90 are also different so don't get parts from one of those models.

Conversion for Cars without ABS:

[John Sargent] In order to upgrade your non-jumbo brakes to jumbos with larger rotors, you replace the calipers, rotors and pads with jumbo units from any of the following cars (as described above): a 1992 –1995 940; 1991-1992 turbo 740; 1992-1994 960. You will have to plug one brake line on non-ABS cars, since you are changing from a dual circuit to a single circuit for each front caliper. See the illustrations and procedures below. This conversion works whether you originally have Bendix or Girling brakes.

1. Re-Using Your Present Calipers and Installing Larger Big Brake Rotors

Girling Calipers. You can convert your 700 series cars with non-ABS Girling brakes to Big brake 11.25 inch rotors. These 700 series cars without ABS originally had 10.25 inch diameter discs. The 87 and earlier models were originally one piece disc and rotor, but many have been converted to 2 piece hub and rotor. If you have an 88, or later, you already have 2 piece hub and rotor. All you need are the caliper holding brackets from a 700 series with Girling ABS brakes (all ABS brakes appear to be 11.25 inch diameter, but a few early ABS cars have the 10.25 inch rotors), or the caliper holding brackets from a late model 700 series with the large discs, and new 11.25 inch diameter discs. You will use the same part number pads, but get some new ones. Remove the Girling caliper from your car. Now remove the caliper holding bracket from the strut, and discard it. Remove and replace the disc. Install the new caliper holding bracket from the donor car with Girling 11.25 inch diameter brakes. Reinstall the caliper with new pads. Wheel nut torque (63 ft-lbs) is very important on these cars. Uneven torquing will contribute to brake pedal pulse, and uneven wear of the disc.

Bendix Calipers. You can install the big brakes (11.25 inch diameter front rotors) on the early 700 series which are equipped with the small (10.25 inch diameter) rotors on the front with Bendix calipers. Assuming that you already have the separate hubs and rotors with your 10.25 inch diameter front Bendix brakes, all you need are the caliper holding brackets for Bendix and the larger (11.25 inch diameter rotors). It is quite easy and does not involve opening the hydraulic brake lines like the installation of the Jumbo brakes on my 1987 745T. If you don't already have the separate hubs and rotors, the separate hubs can be purchased inexpensively from a wrecking yard.

2. Replacing Your Non-ABS Calipers with ABS Jumbo Calipers, Pads and Rotors

The Jumbo caliper brakes do provide more stopping power than the larger rotor Big brakes. The Jumbo brakes weigh a little more than the Big brakes, so you have a little more unsprung weight which is a very slight drawback.

Parts Comparison: Jumbo to Regular Girling Brakes

Ordinarily a non-ABS Volvo has a dual master cylinder with dual front piston calipers. The pistons in these non-ABS calipers are hydraulically isolated from each other. Each brake ciruit in a non-ABS car takes care of a front piston on each side and one rear piston. The Jumbo brakes are single piston, single line calipers and you must disconnect and plug two brake lines which connect to the front calipers. When done with this conversion from non-ABS to Jumbo brakes, you have regular dual circuit diagonal brakes just like about every other car which I am familiar with.

Right Front Brake Line Plugged at Master Cylinder

Extra Brake Line Disconnected at Left Front Brake

Right Front Extra Brake Line Disconnected

Parts needed include two ATE brake port plugs part number 1387506; the 11 inch Jumbo rotors; the Jumbo calipers from a 900-series car; and new 1198 pads for the calipers. You must disconnect two brake lines, one to the right brake at the master cylinder and one to the left brake at the brake junction block. Plug these ports. See the illustrations for information. Then remove the existing calipers, brackets, and rotors. Install the jumbo brackets to the strut bottoms, then the new 11 inch rotors and jumbo calipers. Install new 1198 pads.

Volvo Maintenance FAQ for 7xx/9xx/90 Cars

Version 7.5

Maintenance:

Pad and Rotor Identification and Replacement. See the detailed tables describing pads and rotors for ABS brakes at Brake Pad Identification and Brake Rotor Identification.

Brake Rotor Removal on 740 with ABS. [Inquiry:] I have two new front rotors to install on my 1990 745T with ABS. My Chilton manual isn't very descriptive. From looking at the new rotors, it doesn't appear that I need to remove the wheel bearing. Is that correct? Are the ABS sensors difficult to remove?. The manual mentions an internal toothed ring which has to be removed from the old rotors and installed in the new. The manual suggest that there may be some problems removing these and that a puller may be necessary. What size puller works best if

necessary? [Response:] If yours is like my '90 740 GLE, forget about Chilton. The disc and hub are separate on your car, not like the setup Chilton is describing. Once the caliper is removed, the disc simply lifts off (after removing the locater pin). The ABS sensor is on the hub not the disc, so you don't touch it at all. 2 bolts hold the caliper - support it after removing the bolts so the weight will not strain the flex lines.
Cleaning Sensor Rings. [Tip from Tim:] While the rotor disc is removed, take the time to use a soft bristle brush and clean the ABS sensor area, and the toothed sensor ring that is part of the hub. It is usually pretty dirty with an accumulation of brake dust and magnetized sacrificial brake material. I did this with a fan blowing the ever toxic dust away from me, and out the garage door. Most of the stuff fell onto a newspaper for quick clean-up.

Brake Job Tips: Hose Clamp; ABS Sensors.
Forcing Dirty Fluid Back into the ABS:
[From Motor Service Magazine] We believe the biggest brake bungle techs are making today is forcing caliper pistons back without clamping the hose and opening the bleeder. Since the line comes in near the bottom of the cylinder where the sediment is, this forces debris up into the ABS unit, and that will likely result in a comeback for a glowing anti-lock warning light. Just opening the bleeder as you may have done in the past isn't good enough anymore. You've got to choke off that hose. [Editor's note: you can buy inexpensive plastic pliers with rounded jaws designed to clamp rubber brake hoses without damage, just enough to keep most of the fluid from passing through. Check your auto parts store. And don't squash the hose, just clamp it] And note there is some *controversy* about this: Ford and GM do not recommend clamping because of the potential for damage to the hose.

ABS Front Wheel Sensor, Courtesy FCPGroton

Wheel Sensor Damage:
Another thing to remember about ABS is that it's easy to damage those delicate wheel speed sensors while doing brake work, or to cause metal particles to attach themselves to the magnet. Either is likely to put the system into default, or make it go permanently into anti-lock mode (called "false modulation"), and turn on the warning lamp. On ABS, speed sensors are at the top of the list of failures. As far as the ABS problems are concerned, the first is speed sensors with metallic particles sticking to the sensor nose. This may cause system default, or make it constantly go into anti-lock mode called 'false modulation.'   Make sure the air gaps are correct, and the sensors and tone wheels are clean with no iron filings or debris in the vanes, which can give an erratic speed signal, set a code, and put the system in default.
Another problem on wheel speed sensors is an internal break in a wire. Be careful doing any wheel work because those sensors are delicate. The second thing is rust where the sensor mounts or in the wheel speed sensor bore, which makes the sensor hard to remove. As time goes on, we're going to see more and more corrosion in the electrical parts.   Another problem is moisture infiltration into speed sensor electrical connectors, which causes intermittents.

Anti-Lock Brake System Service Precautions from Raybestos [Courtesy 1998 Brake Parts Inc. & Online Technologies Corporation, Raybestos, all rights reserved]

1.Always refer to the appropriate anti-lock service manual before attempting to service any portion of the brake system.

2.Warning: Some ABS systems store brake fluid in an accumulator under high pressure. Failure to depressurize these types of anti-lock systems before servicing can cause physical injury! The majority of these ABS systems can be depressurized by simply turning off the ignition and firmly depressing the brake pedal between 20 and 40 times. Check service manual for exact number. [Editor's Note: Not true for Volvo cars: see Abe Crombie tips on bleeding/flushing below.]

3.Use the proper DOT 3 or DOT 4 brake fluid specified by the vehicle manufacturer. This can be found on the master cylinder cap or reservoir body. DOT 5 (silicone) brake fluid can **not** be used in any ABS system. [See Brake Fluid Comparison for more information.]

4.Do not hammer or pry on wheel speed sensors and/or sensor rings to adjust the air gap. These components are delicate and can easily be damaged!

5.ABS and other on-board computer can be easily damaged by high electrical system voltage. Do not attempt to jump start an ABS equipped vehicle with a gasoline powered booster or 110 volt type battery charger on the fast charge/ boost setting. Slow charge the battery first before attempting to start. If this is impractical, disconnect the negative battery cable before fast charging the battery.

6.All four tires must be of the same size and type. Failure to observe this rule can cause the ABS and/or Traction Control system to disengage and the warning light to come on. Follow the vehicle manufactures recommendations before installing any optional tire sizes.

7.Never unplug or reconnect any electrical ABS component with the ignition on. This can cause a current surge and damage one or more of the system components.

8.When installing any "add on" electrical accessories' (CB's, Telephones, Stereos, etc.), it is important that any antennas or other wiring be located away from the ABS computer and sensor wiring. A magnetic field is generated as current flows through this additional wiring. The magnetic field that is created produces electro-magnetic interference (EMI) that can affect the signals from the wheel speed sensor to the ABS computer.

9.When electrical welding on a vehicle, it is recommended that all of the computers be disconnected from the wiring harness to prevent possible damage. Care should be taken not to damage the connectors.

10.When replacing unitized wheel bearings, half shafts, steering knuckles, or any other component that could affect the air gap between the wheel speed sensor and sensor ring, then the air gap must be checked.

11.When servicing disc brakes, open the bleeder screws and vent the brake fluid, if it is necessary to push the caliper pistons in. There is sediment that naturally collects in calipers over a period of time. This sediment, if allowed to flow back into the master cylinder along with the brake fluid, can possibly damage the ABS hydraulic unit. [Editor's Note: see above notes on clamping the rubber brake lines.]

Brake Fluid Bleeding/Flushing Procedures for Cars with ABS.

Depressurizing Fluid?

[Tip from Abe Crombie] The ABS doesn't need to be "de-pressurized" on a Volvo. There are a few cars out there that have the master cylinder/hydro-boost/ABS pump as a unit. These are the ones for that precaution. You never get the fluid completely changed on ABS cars as some fluid is in a storage accumulator that is not accessible. If you periodically change fluid this is never an issue as the fluid left in these areas will be circulated eventually through much of the system and it will be diluted by the clean fluid and will pose no problem.

[Editor's Note: Consider a pressure flush of fluid instead of a mere bleed; highly recommended both to remove air as well as to purge and renew the fluid, required every two years.]

Using Line Clamps When Flushing/Bleeding:

[Tip from Motor Magazine] Add the step of line-clamping the brake hose to the caliper when you retract caliper pistons. If you don't, you may be forcing brake fluid from the caliper bore (where rust and other debris may have collected) and sending this dirty fluid upstream.

It's long been standard practice to open the caliper bleeder screws to give brake fluid a place to go while retracting pistons. However, sometimes the bleeders are partially blocked. In these cases, they may not let out all of the fluid that you meant to let escape. Instead, the fluid may take the path of least resistance - upstream. Nowadays, that's likely to send it to sensitive ABS components.

If the vehicle you're servicing has a blocked bleeder, you may get around the problem by cracking open the fitting where the brakeline attaches to the caliper before retracting the piston. For added assurance, you may also want to line-clamp the hose feeding the caliper with genuine clamps designed for this purpose.

Troubleshooting:

ABS Diagnostic Code Retrieval.

1984-1991 Cars without ABS Self-Diagnostic Capability. Pre-1992 cars lack any self-diagnostic capability for the ABS system. Fault tracing is done with a multimeter, circuit by circuit and sensor by sensor, according to detailed instructions in the Volvo OEM technical manual. A fault in the ABS unit will be indicated by an illuminated ABS lamp on the instrument panel and the ABS system (but not the normal brakes) will cease to function. The internal fault code may be cleared by disconnecting the battery.

1992+ Cars With Underhood Diagnostic Units. [Tip from Tom Irwin] To retrieve any ABS diagnostic codes which are stored and are noted by a lit "ABS" lamp, turn the ignition switch on to KPII and leave the engine off. Look under the hood to locate the Diagnostic Link Connector boxes. Your car can have one box ("A") or two ("A" and "B", 1992+). The "A" box has the diagnostic connector pigtail, the test button, and the LED readout lamp.

Put the Diagnostic Link Connector probe into Box A, Position 3. Push button on DLC for >1sec. and capture codes flashing in the red lamp.

To clear codes, place the DLC probe into position 3. Hold DLC button down for >5secs. Release for 3 secs, then press again for >5 secs. This will clear the codes.

The codes are shown in the table below. Note that these are generic; your car may not have two rear wheel sensors and thus the code will not apply. If you cannot pull any codes but the lamp still lights, see Diagnostic Unit Malfunction: Surge Protector Failure below.

Code	ABS System Diagnostic Information
Mode 1:	(40 km/h=25 mph)
1-1-1	No error code set
1-2-1	Left side front wheel sensor: faulty signal at speed less than 40km/h
1-2-2	Right side front wheel sensor: faulty signal at speed less than 40km/h
1-2-3	Left side rear wheel sensor: faulty signal at speed less than 40km/h
1-2-4	Right side rear wheel sensor: faulty signal at speed less than 40km/h
1-2-5	Signal faulty from at least one wheel sensor for a long period
1-3-5	Control Module (CM) faulty
1-4-1	Faulty pedal sensor: shorted to ground or supply
1-4-2	Faulty stop (brake) lamp switch: open circuit
1-4-3	Control Module (CM) faulty
1-4-4	Brake discs overheated
1-5-1	Left front wheel sensor: open circuit or short-circuit to battery voltage
1-5-2	Right front wheel sensor: open circuit or short-circuit to battery voltage
1-5-5	Rear axle sensor: open circuit or short-circuit to battery voltage
2-1-1	Left front wheel sensor: no signal on moving off
2-1-2	Right front wheel sensor: no signal on moving off
2-1-3	Left rear wheel sensor: no signal on moving off
2-1-4	Right rear wheel sensor: no signal on moving off

2-1-5	Valve relay: open circuit or short-circuit
2-2-1	Left front wheel sensor: ABS operation signal missing
2-2-2	Right front wheel sensor: ABS operation signal missing
2-2-3	Left rear wheel sensor: ABS operation signal missing
2-2-4	Right rear wheel sensor: ABS operation signal missing
2-3-1	Left front wheel sensor: signal missing
2-3-2	Right front wheel sensor: signal missing
2-3-5	Rear axle sensor: signal missing
3-1-1	Left front wheel sensor: open circuit or short-circuit
3-1-2	Right front wheel sensor: open circuit or short-circuit
3-1-3	Left rear wheel sensor: open circuit or short-circuit
3-1-4	Right rear wheel sensor: open circuit or short-circuit
3-2-1	Left front wheel sensor: irregular interference at speeds over 40 km/h
3-2-2	Right front wheel sensor: irregular interference at speeds over 40 km/h
3-2-3	Left rear wheel sensor: irregular interference at speeds over 40 km/h
3-2-4	Right rear wheel sensor: irregular interference at speeds over 40 km/h
4-1-1	Left front wheel inlet valve: open circuit or short circuit
4-1-2	Left front return valve: open circuit or short circuit
4-1-3	Right front wheel inlet valve: open circuit or short circuit
4-1-4	Right front return valve: open circuit or short circuit
4-1-5	Rear valve: open circuit or short circuit
4-2-1	Rear wheel circuit inlet valve: open circuit or short circuit
4-2-2	Rear wheel circuit return valve: open circuit or short circuit
4-2-3	Traction control system (TRACS) valve: open circuit or short circuit
4-2-4	Pressure switch for TRACS: faulty or short circuit
4-4-1	Control Module (CM) faulty
4-4-2	Pump pressure low
4-4-3	Pump motor/relay: electrical or mechanical fault
4-4-4	No power supply to valves in hydraulic unit

Diagnostic Notes on ABS Systems by Larry Carley, Import Car Magazine, March 2002, [adapted for Volvo RWD]

All anti-lock brake systems control tire slip by monitoring the relative deceleration rates of the wheels when the brakes are applied. If one wheel starts to slow at a faster rate than the others, it means the wheel is starting to slip and is in danger of losing its grip, locking up and skidding. The ABS system responds by momentarily isolating the brake circuit for that wheel, releasing hydraulic pressure and then reapplying the brake in rapid sequence until traction is regained or the vehicle comes to a halt.

Electrically operated solenoid valves in the ABS modulator hold, release and reapply hydraulic pressure to each brake circuit. This produces noise and a pulsating effect that can be felt in the brake pedal. All ABS systems keep track of wheel deceleration rates with wheel speed sensors. [Volvo RWD cars use]a common sensor in the differential … for both rear wheels (three-channel system). The common sensor for the rear wheels reads the combined or average speed of both rear wheels….

Dirty ABS Wheel Sensor

Wheel speed sensors consist of a magnetic pickup and a toothed sensor ring (sometimes called a "tone" ring). Wheel speed sensors generate an alternating current (AC) signal that increases in frequency and amplitude as wheel speed increases. Because the sensors are magnetic, they can attract metallic debris from semi-metallic brake linings and rotors that stick to the tip and interfere with the signal. If the ABS module doesn't see a clean WSS signal, it may think there's something wrong and set a wheel speed sensor code.

The distance or "air gap" between the end of a wheel speed sensor and its ring is also critical. A close gap is necessary to produce a strong, reliable signal. You don't want metal-to-metal contact between the sensor and its ring since this would damage both. But neither do you want too much clearance. An air gap that's too wide may produce a weak or erratic signal or, worse yet, no signal at all… [Per the Volvo shop manual, the required air gap is determined by an o-ring inside the sensor housing: make sure this is in place. If you need to measure gap,] insert a non-magnetic brass or plastic feeler gauge between the end of the sensor and ring... [Because wheel-speed sensors are magnetic, they attract metallic particles. If debris cast off from semi-metallic brake pads, rotors or drums ends up in the vicinity of the sensors and sticks to the tip, it will weaken the magnetic field and reduce the strength of the sensor signal. Gap and signal can be seriously distorted by steel particles picked up by the magnetic sensor: remove these at regular intervals.]

A good wheel speed sensor will generally produce an AC voltage reading of 50 to 700 MV when the wheel is spun at a speed of about one revolution per second. If the voltage reading is low or non-existent, check the sensor's resistance (with the key off). This can be done through a breakout box with a DVOM. Checking resistance through the breakout box will tell you if the sensor's wiring harness is okay. If you don't get the specified value [between 900 and 2,200 ohms for Volvo RWD front sensors and 600 and 1600 ohms for the rear sensor], disconnect the sensor from its wiring harness and check the sensor's resistance by attaching the DVOM test probes to the sensor leads. A resistance reading that's now within range tells you the problem is in the wiring, not the sensor. If the sensor has too much internal resistance (opens) or too little resistance (shorts), the sensor is defective and needs to be replaced.

Damage to the teeth on the tone ring can also upset the WSS signal. If one or more teeth are damaged, even slightly, it may cause enough of a variation in signal strength to confuse the control module. We're talking a difference of only .050 inches in tooth height in some cases.

Grounds or shorts in the wheel speed sensor cables can be found by checking continuity between the wiring connectors. If a defect is found in the wires that run between the sensor and the chassis, replacing the wires with new ones is a better repair choice than trying to fix or splice them. These wires undergo a great deal of flexing every time the suspension encounters a bump, so new wires will hold up better than ones that have been soldered, spliced or taped.

The operation of the ABS system can often be affected by electrical problems in the vehicle, as well as the ABS system itself. Underlying conditions that may cause trouble include: ·

- Low battery charge - A low charge can interfere with the operation of the anti-lock control electronics.
- Blown fuses - Check the brake control module fuse, main relay fuse and pump motor fuse.
- Corroded/loose connectors - The main relay, ..., fluid level sensor and control module connectors all must be tight and correctly installed.
- Water intrusion - The most common causes of excessive harness resistance are water intrusion and corrosion at the sensor to main wiring harness connector. Water intrusion can occur at the sensor can or at the harness connector.
- Bad grounds - Check body grounds, especially on the modulator and ABS module.

[Your Volvo reports diagnostic scan codes through the OBD-I diagnostic connector.] Once you have a code, you have a place to start your diagnosis. Refer to the diagnostic chart or procedure for the code, and follow the steps to isolate the fault. This will usually involve measuring voltage or resistance within various wiring circuits or components. You'll need a multimeter and possibly a breakout box to make these checks. [Recommended: Volvo OEM "green manual" for brakes/ABS].

Diagnostic Unit Malfunction: Surge Protector Failure. [Tip from IO333] This info pertains to Volvo 740/940 through 1993 model years. If your ABS light is on, and the DLC procedure for obtaining the codes from the ABS ECU produces no codes (no blinks after holding the button for >1sec with the DLC probe attached to #3 in the "A" unit, yet the DLC LED lights when the button is pushed), the transient surge or over-voltage protection relay may be defective. In later cars, this relay is located near the ABS control unit high under the kick-panel (you'll need to remove this), behind the instrument panel, to the left of the steering wheel. It is on the other side of metal bracket that holds the ABS computer (the large metal box with many wires going into it through a sturdy connector, very close to the left fender). In earlier cars, it is located in the well in the rear trunk that contains the ABS unit. The surge protector looks like a regular relay, except that there is a 10amp fuse pushed into the top of it. If you follow the wires coming from it, you'll see they lead to the main ABS computer. The relay can be removed from the bracket by pushing up and twisting the bottom towards the footpedals. Now first remove the fuse and check that it is OK. If it is, put the fuse back in the relay and obtain a voltmeter. Leave the wiring connector on the relay and switch the ignition on, start the engine and leave it running. The pins are labled 1, 2, 3, 4 on the connector (as well as inside the relay, but the numbers are hard to see). Pin 1 (red wire) should show +12V. Pin 3 (black wire) should show continuity to ground. Pin 2 (yellow/red wire)is the switched circuit, and should show +12V with the engine running, and 0V with the car switched completely off. If you are not observing this behavior from Pin2, the relay is bad, and needs to be replaced. The relay is essentially impossible to dissasemble without destroying it, so a replacement unit will be required. My dealership charges $85 for the part, and it is listed in their catalog as an "ABS over-voltage protection relay." Post -1993 cars do not have this device.

Intermittent "Check ABS" Lamp. [Inquiry:] I have a 1989 740GLE that sometimes has the anti-lock brake warning light on. The brakes are new so I know the're OK. Is there a connector somewhere that should be cleaned? [Response:] Check ABS sensors at front wheels, and clean them. Check B+ wires at the positive battery cable. Corroded positive terminal could be the problem.

[Another Inquiry about ABS Lamp On:] Found a 1990 760T in great shape; original owner with all the maintenance records. BUT: the ABS light stays permanently on. Am I facing a major repair, or just an adjustment / clean-up of the ABS sensors ? [Response 1: Roy-Magne Mo] I had exactly the same problem with mine. Clean the connector at the front wheels, and check the wires going to the connectors. The wires were the problem with mine. [Response 2: John B] I agree with Roy.....but you won't know until you have the system checked out. Before I bought it I would pay the $80 or so to get the car and the system checked out by a Volvo dealer. You DON'T want to buy a new ABS head for that car
[Response 3: RC] I should tell you that I had similar characteristic with my ABS. Luckily, a flush of the brake fluid did the trick. I can only hope that your fix is as simple; ABS repairs sound scary.

ABS Light "On": ABS Sensors/Wheels Dirty.

ABS Sensor Basics. [Inquiry:] During the snow here over last couple of weeks (UK) our 1992 Volvo 940 2litre turbo started flashing the ABS light up, and even now the snow's gone it came on once but brakes are all fine and the light hasn't come back on for week or so does anyone reckon we have anything to worry about, I reckon it may have just been the cold weather and snow, and surely if the ABS was faulty the light would have stayed on all the time? [Response: Paul Grimshaw/Bob Dietz] A common problem with ABS is that the sensors and reluctor wheels, used to measure and compare tire rotational speeds, can become fouled by dirt and brake carbon. This typically occurs on the front axle where the sensors and reluctor wheels attract a considerable quantity of brake dust shed by the front calipers. As the wheel turns an analog signal is generated from each sensor and monitored by the control unit. If the amplitude of the signal decreases due to iron particles accumulating on the sensor the control unit cannot accurately compute the wheel speed and begins to modulate the brake pressure to the wheel

whose signal has been lost. Since higher wheel speeds generate a higher voltage the problem does not occur at higher speeds since the differential value detected among the channels falls into an acceptable range. As accumulation of brake dust grows, heat fuses it into a carbon-like coating that attenuates the minute changes in reluctance measured by the sensors. This is interpreted by the car's ABS computer as a continuous difference in rotational speeds between one or more tires -- eventually exceeding a threshold value and triggering a "fault" light.
It is good practice to carefully clean the reluctor wheel and ABS sensors whenever the brake rotors are removed (usually during replacement of the rotors), as these parts lie inside the rotor "hat". Unfortunately (in this case), Volvo brake rotors last quite a long time. The result is considerable build-up -- and occasional fault light activation -- in otherwise functional systems. Three-channel ABS systems employ a rear wheel sensor in the differential housing. These are very reliable and need not be removed nor cleaned unless a specific problem is encountered. A variety of Bosch and Teves systems are of the four-channel type employing reluctors and sensors at each wheel; these are not used on Volvo 200/700 or 940 cars.

Cleaning Sensors. [Response: Paul Grimshaw/Bob Dietz] When cleaning the ABS sensors, it is best to avoid the urge to remove them from the dust shield as their plastic bodies can become brittle with age and crack if forced. A better cure would be to clean the wheel sensors by wiping them clean with a rag or soft brush. Another problem is the possibility of signal loss through non-waterproof connectors or cracks in the wiring or its insulation. I have seen cars where the rear wheel sensor anchor bolts were absent; with metal shavings on sensors that looked like a dead mouse (the sensor magnet is smaller than a pencil); or with broken wires inside intact insulation at the waterproof connectors both at the differential and shock towers. Most of the failures are very simple. The system isn't rocket science, which is probably why it works. But it needs to be maintained just as any high tech system needs to be maintained. [Chris Herbst] If you remove the sensors, make sure the o-rings are seated properly. I usually grease the O-rings a little bit on reinstallation.

Cleaning Reluctor Wheels. [Tip from Chris Herbst] Usually there is a big buildup of garbage in the sensor reluctor wheels that obscures the sensor from reading it. The more junk that is on the wheel, the less defined the impulses will be. I scrape them out usually with a small drift pin and then blow compressed air at them. Some of the junk doesn't blow off of the wheels with compressed air and you will need to scrape it off.You could also use an appropriately sized dowel or something with an edge that will scrape the debris from the wheels. Try not to damage them by putting surface scratches in them. If you use compressed air on brake parts, use appropriate precautions so as not to inhale the dust!

ABS Light "On": Rear Sensor? [Inquiry] Is there a ABS sensor in the rear somewhere? I have cleaned the 2 up front and sprayed them well with contact cleaner. It seems to light up when braking and hitting a bump then it just stays lit.. The wires that lead to the sensors up front look in good condition. [Response: Chris Herbst] There's a single rear sensor (single wire) that goes to the differential. The sensor sends the same signal to both speedometer and ABS units through one pair of wires leaves the sending unit. . The "over bumps" part is a good clue. That thing acts up over bumps first, and eventually breaks or becomes totally ineffective. Some days your system will work until you hit a bump and then BINGO- your ABS lite comes on and the speedometer fails! Play around with the sensor and connector and see if it might be your problem. It often is.

ABS Light "On" After Jump Start. [Inquiry:] On my 1993 940, I had to change the battery and after the car was started the ABS light was on and now doesn't go off. I checked all fuses at the fuse box, I read there's another one up by the ABS ECU? Please tell me there's another fuse to check, I fear this may be an expensive repair. What else can I check? [Response 1: Jim Bowers] A possible source of system overvoltage is a loose battery cable. If the cable disconnects, even for a few thousands of a second, while the alternator is charging, the alternator output voltage will jump to a very high value, usually killing the alternator diodes also. [Response: Abe Crombie] First, make sure the leads that attach to the bolt on the positive battery terminal are tight as one of these is the feed for the ABS modulator under hood. Second, there is a fuse on that year model (94 and later 900's don't have this fuse or the relay) on a relay under dash clipped to the bracket for ABS control unit. This control unit is high up on the left on 940 and over under the kick panel in right passenger's foot well forward of door on 960. It is a 10A push in fuse. The relay that the ABS fuse is located on blows the fuse if there is an over-voltage condition to protect from excessive voltage level to control unit. The usual reason that it blows is when you jump start vehicle.

ABS Sensor Replacement. If suggestions of cleaning the front ABS senders (sensor and pulse wheel) and associated electrical connectors doesn't stop the intermittent ABS fault then you may need new sensors. I found the original old style sensors (rectangular tipped) on my '89 were over-sensitive, especially at low speeds on very smooth surfaces. Your car may or may not have received the in-warranty upgrade to the less sensitive new style sensor (diamond shaped tip). If not, it would be a relatively easy DIY upgrade.

[Tips on Removing ABS Sensors:] How do you safely remove the ABS sensors? After removing the 5mm Allen screw mine seem to be seized in place. I don't want to break them so I'm looking to some experienced people for some advice. My ABS is pulsing inappropriately at very slow speeds. I have reseated both electrical connections on the inside of the shock towers. [Response: Abe Crombie] The sensors fit into the holes in the spindles with clearance to spare. Twist them as you pull on them and they should come right out. If they are the style constructed with two steel strips bonded to a magnet in the center to make the tip (made by VDO) then they will have a much greater tendency to have the low speed modulation as you have experienced. The other style (Bosch) have a diamond-shaped tip that is all steel.

ABS Pulses at Low Speeds. [Inquiry:] The ABS acts up when I'm driving at low speeds and applying hardly any pressure to the brake pedal of my 1990 740 GLE. The ABS lifts the brake pedal in the same way as if it was locking up. [Response:] You should remove and clean the front wheel speed sensors. To do this turn wheel full lock to one side and then remove the sensor from wheel that is turned out by undoing a 5 mm Allen screw you will see adjacent to arm where tie rod for steering attaches. Then turn wheel to full lock the other way and do the same on other side. Also unplug and then reconnect the sensor connectors that are in the

engine compartment near top of struts. This should effectively clean the connections. This can also cause low speed inappropriate ABS activation.
[Tip from Bob Dietz] Apparently when the waterproof connectors to the ABS sensors at the differential (rear) and shock towers (front) are molded on the sensor wire itself is under a lot of tension--I've found many of these with only one or two strands of wire left unbroken, even though the insulation looks fine. This can cause lost ABS signals. Volvo can supply replacement pigtails. It's a piece of white wire with the identical end molded on. I line splice and solder the joint, shrink tube over. Try to maintain the twist. All the signal cables for ABS are twisted pair. There is also the possibility of signal loss through non-waterproofed connectors.

Noise from 960 ABS System. [Inquiry: My 960's ABS system makes a strange noise on stops.] [Response:] The ABS does do a self test if you come to a complete stop for over a couple of seconds. This is in addition to the initial test that occurs on the first roll over 4-6 MPH. To verfiy that this is the noise, pull out the fuse for the ABS and drive (carefully so as to not need the now nonfunctioning ABS) in the conditions to see if the noise is gone. Putting in the fuse and switching ignition off and then restarting and driving again will turn off ABS warning lamp.

ABS Lamp Lights After Start-up. [Inquiry 1:] The Anti-lock light illuminates on my 1990 760 a while after I start driving, before that ABS seems to work OK. The light seems to become lit when I exceed 25 mph, but lately it seems like the speed has been higher, yesterday I had as much as 75 mph before it became lit. Can a slight shiver in the front wheel bearing cause this? [Response 1:] If the light comes on as you gain speed through 3-5 MPH then you might have a faulty pump motor relay. The pump is tested as you gain speed the first time after starting car. If it comes on after you have driven a distance and hit a bump then a problem with wheel speed sensor wiring is likely. The ABS system on that year model doesn't have fault diagnosis code feature. If it's a wagon with solid rear axle the wire from car to axle is subject to motion with every bump and will fatigue and break inside insulation. This usually is no sooner than 100 K miles unless the car is driven on poor roads a lot. If it were the cable it would predictably do it on bumps. If there is a severe build up of metallic particles on front sensors that can make light come on. If your wheel bearing has expelled grease that may have built up on sensor and made it retain the metal pad wear particles. That might be the place to look first. A bent pulse wheel (part of hub and runs next to sensor to create the signal , looks like a gear) can do the same. The system is designed to be a little forgiving when the signals from wheels are not equal as this could be due to normal things like having the mini-spare on car. If the signal is too different then the ABS lamp will light . The wheel bearing is a ball, not tapered, roller type that is not adjustable and must be replaced if it is loose.

[Inquiry 2:] The ABS light on my '90 740T Wagon came on as soon as I started the car after lunch today (very hot, very humid). And it stayed on after I drove it and after restarting the engine a couple of times. [Response 2:]If the light is on at start and doesn't go off then you likely have a problem with the surge relay next to ABS ecm or the solenoid valve relay on ABS modulator under hood. The fuse on the surge relay can come lose or relay can fail. The solenoid valve relay (the smaller of the two on ABS modulator under black cover) gets eroded contacts and will need replacement if that is in fact failed. Turn on key, start engine, check to see that ABS light is on and then tap on AS modulator, if light goes off then sol. valve relay is at fault. Otherwise check surge relay next to ABS ecm for loose fuse. See also Speedometer Relay and ABS Lamp

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Cooling System:

[FAQ Home]

Volvo Radiator Destructive Test Radiator Replacement Coolant Reservoir Replacement Engine Freeze Plugs	960 B6304 Coolant Loss: Coolant Cap At Fault Homemade Cooling System Pressure Tester

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Coolant and Maintenance:

Coolant Recommendations. See the FAQ File with more technical information about coolants. [Editor] Folks have tried various coolants in place of the Volvo Blue-Green, which is expensive. Your choice falls into three categories:

- Highly-silicated conventional green antifreeze (e.g., Prestone and many other brands)
- Dexcool orange with no silicates and organic acid corrosion protection (e.g., Havoline Dexcool and Prestone Dexcool)
- Glysantin orange-yellow with low silicates and organic acid corrosion protection (e.g., Zerex Extreme G-05)

My own experience with Dexcool has been positive with one exception: the solder in a Nissen brass radiator began leaking . Dexcool is known to have problems with high-lead solders, and is also sensitive to air levels in cooling systems. If you don't keep the system topped off to the "min" mark on the reservoir, it may cause scaling and rust precipitation. The last Glysantin alternative is new in the US, although well-known in Europe, and may be the optimal replacement coolant for Volvo. It has a small amount of silicates to improve corrosion protection for lead and aluminum, but not so much as to precipitate out, and in addition uses an OAT package.

Dexcool Coolant [From the AC-Delco site:] Neon orange in color, the coolant lasts up to five years or 150,000 miles, whichever comes first. Conventional coolants need to be replaced every two years/30,000 miles. DEX-COOL's benefits include: Lower maintenance costs, due to longer change intervals; enhanced component durability -- improved water pump seal performance and superior heat exchanger protection over regular-life coolants; recyclability. Note: DEX-COOL's unique orange color acts as a reminder not to mix the new formula with conventional coolant (usually green in color). Although it won't damage your car's cooling system when mixed with other coolants, DEX-COOL will lose some of its effectiveness. (Warning: Do not use DEX-COOL with Cooling System Seal Tabs, Radiator Fast Flush or Radiator Stop Leak.)
[Motor Magazine, Aug 2004] One of the coolant issues that may arise is the use of an aftermarket replacement radiator or heater core made of copper-brass with lead solder. We have in previous articles pointed out that today's coolant inhibitor packages contain a small amount of copper-brass protection, but may provide little protection if a radiator is made with

high-lead solder. Results of industry standard tests of the new Toyota extended-life coolant now show a substantial weight loss (corrosion), both in a 50-50 mix and in a 33% coolant mixture (solder corrosion is much greater in this more diluted solution). If you have to change a radiator or heater core, use aluminum. Or, if it's an older car and the owner wants the lowest-cost radiator, you might procure a soldered-together copper-brass unit. Conventional American coolant should provide better protection against solder corrosion, which can result in radiator tube restrictions and leaks. But no coolant provides perfect protection.
[Ywan Mason] Dex-Cool, according to a GM service bulletin only gives the extended life when it was used as the first and only coolant in the car. Residual amounts of conventional coolants left in the system even after careful draining require that the Dex-Cool be changed at the same interval as any other coolant, every two years. [Chris Herbst] Dexcool can cause problems if installed in a leaky system, or if it is used in a system run low on coolant. Also, it finds leaks where typically there may not be any (or one might not see any).

Zerex G-05. This is Valvoline's new Zerex coolant, known as Extreme G-05. From their website: Extreme G-05 is a low-silicate, low-pH, phosphate-free, formula that is designed to protect diesel engine cylinder liners from cavitation. Extreme G05 is safe for both gasoline and diesel engines and is approved by DaimlerChrysler for worldwide MTU applications. Utilizes hybrid organic acid technology to minimize inhibitor depletion; Low-silicate, low-pH and phosphate-free formula; Protects all cooling system metals, including aluminum

Makeup Water. [Tip from Prestone's Info Line] We would consider the order of preference for water to be as follows:

1. 1st choice: Type IV water- Both demineralized & Deionized.
2. Next choice: Distilled water
3. Next choice: Bottled water (like the type at a grocery store)
4. Last choice: Tap water

Draining Engine Coolant.

Which Coolant to Use? See the discussion on Coolant Recommendations .

Block Drain Plugs Location.

B230F. [Inquiry:] B230F - I want to flush the cooling system, but the only block drain I see is a threaded male plug on the RH side of the block (kinda high) below exhaust manifold runners 1 and 2. Is that all there is? [Response: Randy] Look for the block drain on the passenger's side of the block, #4 cylinder back just above the oil pan and in front of the transmission bellhousing. 13mm wrench will loosen, continue to turn counterclockwise and the coolant will flow out. You can attach a hose and run it into a container with about a 2 gallon capacity. If it hasn't been used in some time you may have to clean it out to get a good flow. You can also unscrew the entire drain. Open the reservoir cap to increase flow. You will not be able to remove all the coolant: it always seems as though about two quarts remains in the system. *On the 940Turbo:*

the coolant drain is at the end of the short hose leading from the oil cooler, about five inches behind the oil filter beneath the car. It points down from the tubing on which it is mounted.

Draining Coolant. [Inquiry:] I must be missing something here. My 944 needed an antifreeze flush and refill, so off I went. I set the heater on "high", disconnected the vacuum to the water valve to make sure it was open, disconnected the upper and lower radiator hoses and drained a large quantity of coolant out of the radiator, water pump and overflow bottle. The heater hose was stuck on to the firewall pipe; not wanting to cut the hose, I did not disconnect it, thinking that the upper radiator hose disconnection would encourage the head and heater to drain. I also drained the block via the block plug screw. After refilling and draining again once, I put in what I thought was exactly half (5 qts) of the system capacity in new Dexcool antifreeze. This filled the system, so I obviously had another five qts of undrained water sitting in there somewhere. Has anyone figured out how to drain the cooling system down to zero? Can the heater actually hold that much fluid? [Response:] You will never be able to get all the coolant out. Have you ever replaced an engine thinking you got all the fluids out only to have a mess all over the floor. The engine has areas that can't be drained unless the block is tipped over. You did as thoroughly as the job can be done. When refilling premix the coolant so that when you top off, the mixture is still 50/50 .

Engine Flush Procedure. [KenC] For a thorough flush, try this technique. You will need sockets for the clamps' nuts, a garden hose and a couple of feet of 1" I.D. RBU (reinforced with braided vinyl) or solid vinyl transparent hose (transparent, so you can see the quality of the water coming out). This hose is available in all hardware/plumbing stores, and it's external diameter lets it snugly fit into the upper radiator hose forming a good connection.

1. Turn the heater temperature control to "hot" to open the water valve.
2. Drain the cooliing system (preferably when cool, so there won't be a temperature shock or overheating to the engine). If you can reach the engine block drain, so much the better, but at least pull off the lower radiator hose where it goes in the radiator. Be careful pulling off this hose so you don't break the plastic outlet.
3. Remove the thermostat and then reinstall the thermostat housing without the thermostat. Don't worry about a gasket -- there's no pressure in this process, so just finger tighten the two nuts. And throw away the old thermostat -- treat the car to a new one and its gasket, after all this effort, it deserves it.
4. After draining, slip the lower radiator hose back onto the radiator's "neck", but don't bother with a clamp (again, no pressure).
5. Pull off the upper radiator hose from the thermostat housing. Now, stick the transparent hose into the housing, so that the transparent hose extends forward over the radiator (so discharged coolant doesn't fall into the engine compartment) -- later you'll be watching the appearance of the coolant in the hose before being discharged, a more reliable view than watching the stream of coolant. Be careful in this process that you do not lean on or crack the plastic upper radiator hose inlet: it can be brittle.
6. Wrap a little tape around the end of an ordinary garden hose, and jam it (gently) into the open end of the upper radiator hose -- it will fit nicely. Now, turn on the garden hose's water supply.
7. Watch as the fresh water circulates throughout the cooling system, flushing out the old stuff. Keep an eye on the color of the solution in the transparent hose before it spills out.

You can even turn on and run the engine (at idle, only) to use the engine's water pump to help circulate the fresh water and dislodge heavier debris. But don't rev the engine, as the garden hose usually can't keep up with the pump's needs, and you'll get pump cavitation.

8. After it's thoroughly flushed, drain all the "garden hose water" in the system by pulling off lower radiator hose and opening the block drains.
9. Re-attach proper hoses with tightened clamps, install a fresh thermostat, and then refill with a good quality antifreeze (about a gallon of antifreeze to similar amount of distilled water -- depending on your model engine.

An Alternative Flush Procedure. [Robert Ludwick]. You should have a block drain with a nipple on it on the passenger side at the rear of the block (or, for turbos, a coolant drain fitting in the bottom of the u-shaped hose near the oil filter). Go to the hardware store and get a piece of clear vinyl hose to fit it, a couple of clamps, and a garden hose end fitting and attach it to the hose. Remove the thermostat housing and the thermostat and replace the housing. Remove the coolant reservoir cap. Turn on the hose and the system will be flushed up and out the reservoir. To drain the system afterward, remove the block drain and the pump end of the lower radiator hose, bending it down to drain the water.

After flushing just hook the system back up and pour 1 quart of 100% coolant into the coolant reservoir (to mix with residual water in the block and heater core), then top up with a 50-50 coolant/distilled water mix.

Bleeding Air from the Cooling System. [Inquiry] After replacing a thermostat or water pump, how do I bleed the air out? [Response: Jim McDonald] Very little bleeding should be necessary if you put the thermostat in with the "wiggle valve"[air vent] in the right position[up]. Typically, I only have to add around a liter or so after running the car 'til the thermostat opens. [Editor:] I've experienced a clogged air vent. To make sure the head is filled with coolant and to prevent overheating after refilling, bleed air from the head by loosening the thermostat housing nuts and bleeding until coolant comes out.

Testing Coolant. [Tip from Rafael Riverol] Periodically, use an accurate multimeter to check voltage between coolant in expansion tank and engine ground. Volvo says to change coolant if you read 0.9 volts or more. You can also add compatible anticorrosion (and lubricant) treatment and run coolant forever. Generally, I read less than 0.1 volts on my two Volvos with a very accurate multimeter.

Changing Coolant on 960 B6300 Engines. [Editor] See the 960 file notes on coolant replacement and porous blocks for important information about IGNORING Volvo's "never change" recommendation and instead flushing, changing coolant and refilling with distilled water on a regular basis.

Thermostat Replacements.

Which Thermostat? [Editor/Bob] While you've got a choice, the Volvo specifications are:

Thermostat: begins to open at:

B 200/204/230F/FD 198º F (92º C)

B 230FTurbo/234 189º F (87º C)

B 6244/6254/6304 195º F (90º C) (changed from 87 for replacement thermostats)

D24/24T/24TIC 189º F (87º C)

How to Replace. [Top from Mike G.] Even with limited mechanical ability, you should be able to change a thermostat on the 4 cylinder Volvo (assuming the problem is a stuck thermostat). To remove you can simply undo the two nuts holding the thermostat cover on top of engine at front, the one with the big top hose from radiator connected to it. You will lose a little coolant, so have some new 50/50 ready to go. Remove thermostat with its rubber o-ring, note orientation, so that you don't put the new one in backwards or upside down (yes it matters; see the photo below). Put new o-ring on the lip of the new thermostat, put assembly in hole, put cover back on, tightened nuts snugly but don't tighten with all your might as the studs are in aluminum: tighten just enough to seal the o-ring. Fill with coolant, start car, check for leaks, check coolant level after all warmed up. I usually boil the new one before installation to note that 1. it actually opens, and 2. that it opens at about the correct temperature. Good luck. PS Don't buy a cheap thermostat at a cheapo supply place; go to a good aftermarket supplier or theVolvo dealer as they are cheap.

Installation and Troubleshooting Tips. Thermostats must be installed with the small venting nipple oriented upward. If incorrectly installed, an air pocket will form in the thermostat housing causing a reduction of cooling abilities. When you replace coolant, loosen the thermostat housing when refilling and bleed air from the system until the coolant appears at the thermostat, just to make sure you have no air bubbles.

Thermostat and O-Ring

For pitting on the housing or the head adjacent to the thermostat, seal it with RTV. IF this does not work, use JB Weld to fill the pits...clean them out a little with a dental burr or smallest carbide bit you can find and a Dremel tool, then use JB Weld, file/grind smooth. It sticks very well to aluminum. You can also use titanium-filled DevCon but it's hard to find... also has to be heated to around 125F and should solve any pitting problem. If the thermostat still leaks after installation, a light coat of RTV between housing surfaces will solve the problem (although it will make cleanup more difficult next time). Finally, you can purchase a new housing for less than $20.

Typical Failure Mode for Thermostat

The illustration at left shows the typical failure mode for thermostats, with the rubber seal split at "1" and the piston brace broken at "2". Either may occur.

960/90 Cars. For a preventive maintenance note regarding sticking thermostats in B6304 engines as well as complete replacement instructions, see 960 Too Hot or Cold: Stuck Thermostat

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Radiator and Cooling System Lifetime. Contrary to expectation, your cooling system is a "wear item" that will last about eight years with reliability. After that, you risk a catastrophic failure and a cooked engine. The solution is to change the radiator, hoses, water valve, and thermostat if you have not yet done so and drive a more reliable car. Water pumps tend to last longer and fail in a controlled manner.

Radiator Bug Screen. [Tip from Roland P.] For more than 20 years I have used fiberglass house screen in from of my Volvo 72, 81 and 91 radiators. This keeps insects from plugging air passages. Anything smaller than screen opening passes through; larger insects (leaves/dirt also) stick on there and fall down when engine stops. It seems to prevent these bugs from cooking in there. Radiators seems to last longer also.

Overheating: Radiator Fin Cleaning. [Tip from Pomp] My Volvo's been having all the same overheating symptoms I've been reading about on the board . . . running into the red and staying there. I too put in a new thermostat and did a flush but it still ran hot. I then sprayed out the radiator fins from the engine side out.   Yesterday we ran into 99-degree heat and it never once ran hot. [Tip from Michael] You can start by opening the hood and taking the grille off by pulling up on the spring clips at the top. To clean both the a/c condensor and main radiator it may be a good idea to unbolt the two top radiator clamps that hold the radiator in place and remove the top plastic air dam. Remove the electric fan and fan shroud. Now you can partially push the radiator rearward a little bit. Use a thin tool (such as a putty knife) to straighten the bent fins on both radiators. You can then use a brush to gently sweep away any debris stuck in the cooling fins. Spray it down with a mixture of dish soap and water. Let it sit for awhile, then spray off with a high pressure garden hose (you can find a high-pressure hose tip at a hardware or garden place). Spray from back to front to dislodge crud stuck in the fins. After all is clean place radiator back in place properly, bolt everything back up and you're on you way. I did this about a month ago and the car runs a bit cooler believe it or not. [Tip from Ed Lipe] I use compressed air. Always blow back to front with air. You run the risk of making a mud-pack if you just make a passing attempt with water. The generic blower schnozzle on the end of a compressed air line works well. You often get to nick your knuckles on the fan and shroud and other goodies down there. Yes, you do have to reach. I've made a modification to my blower. Usually there is a fitting screwed into the end of the blower, and it is usually 1/8" NPT pipe thread. I've added a 1/8 NPT x 1/4" tubing compression fitting with about 2 feet of 1/4" copper tubing or the stiffer brake tubing. With this, you can reach some tight places with little problem. I use mine nearly every day to clean coolers and radiators. I start from the rear and then go to the front and then again from the rear just to make sure it's clear. After a good blow out a hose down is also good, but the air is usually enough. Make it a regular part of your maintenance regimen.

Hoses:

Replacing Hoses. [Editor] Replace your hoses (radiator/reservoir/heater/oil cooler) and heater water valve before they fail. See the discussion of sudden loss of coolant below about the consequences of poor hose maintenance. The BEST quality hoses come from Volvo: they seem to last much longer than aftermarket hoses.

Radiator Hoses. Remember that you have THREE radiator hoses: upper, lower, and the hose to the reservoir. A fourth is the air vent from the top of the radiator to the reservoir, which seems to last forever. When replacing the radiator hoses, remember that the plastic side tank outlets are fragile (especially if they are old), so don't lean on them, bend or twist them. Rotate the old hose back and forth to ease its removal when pulling off; use a little silicone spray beneath to loosen them. The air vent hose is 6.2mm in inner diameter, about 87.5cm/34-1/2 inches long, and Volvo p/n 942700. And if you have a turbo, don't forget the oil cooler hoses near the oil filter.

Heater Hoses. When changing the heater hoses, study the orientation of the hoses before you pull them off so you can reinstall them and the heater water valve correctly. OEM hoses are often in one piece, designed to be cut in half to match two halves on the car. The heater water valve goes between the heater hose connected to the short pipe coming out the cylinder head and the heater hose entering the bottom tube of the firewall connector . The arrow on the valve points toward the firewall. The top heater hose goes to the red pipe behind the head leading to the water pump. One caution in this job is don't bend or break the throttle or kickdown cables, or any vacuum lines. There a several plastic clips that hold the heater hoses away from pipes to avoid abrasion; if you break one, the p/n is 6848221-5, costing about $2 each. CAUTION: Make sure that these plastic clips are attached to the hoses and doing their job! If the heater hoses contact the block or the hot EGR tubes, they will wear and leak.

Changing Heater Hoses: Procedure [Jay Simkin]

- *Access.* I used a 16" wide board (68" long and 1 1/4" thick) as a work platform. I put foam tape on the underside, at the ends (to protect the fenders) and laid the board over the engine bay. I made sure the leading edge (closest to the radiator) was not resting on the fan shroud. I made sure that the trailing edge (closest to the firewall) was not resting on the coil (Rex Regina coil sticks up). In this way, I was able to lay on top of the engine, and so to look down through the intake manifold branches, at the hose clamp, that secured the hose to the port on the side of the head, below the intake manifold.
- *Hose Removal.* Do one hose at a time so you can remember the orientation. Clamp removal: if the clamps are original (you will know this because the teeth are cut into - but do not go all the way through - the metal), use a 7mm/9/32" socket to loosen them. Loosen them completely. If the clamps are not corroded, put a bit of lithium grease into the screw, and re-use them. Make sure no grease gets onto the inside surface of the metal: wipe this area with a solvent (e.g., brake cleaner). The grease in the screw area will make it easier to re-install the clamp. To minimize the risk of cutting into the copper heater core hose ports conyeing water through the firewall and to the heater core, use a utility knife to CAREFULLY cut through the heater hose 3" from the firewall. Then, using the utility knife, cut towards the hose port, spreading the cut hose with your fingers, behind the blade. You will see the edge of the hose port, before the blade touches it. Starting at the leading end of the hose port (that closest to the front of the car), gently make a cut along the length of the hose that is still on the hose port, towards the firewall. Do NOT try to cut all the way through the hose: you will almost certainly cut into the soft brass nipple or hose port wall: that will give rise to a leak. Once you have made the first cut, deepen it, while spreading the hose from behind the blade, so that you can see how deep you've gone. Gradually deepen the cut. At some point - before you've cut all the way through - the rubber will give way, when you spread the hose. You will be able to remove the hose stub from the heater port, without the blade ever having touched the nipple or heater port wall. If you gouge the nipple, use sandpaper to smooth it so it does not result in a leak. Generally, you can simply pull the hoses off the other two ports - that on the side of the head (under the intake manifold) and that on the pipe, which runs behind the exhaust manifold and around the back of the head. These ports are not especially fragile. There is no easy way to access them with a knife blade. How you remove these hoses depends on your hand size. If you have a small hand, you will be able to grip the hose under the exhaust manifold. If you cannot do this, use a pliers to grip the hose, and pull it off of the port in the side of the head. You likely will need to wiggle the hose to "walk" it along the port.
- *Hose Re-installation.* Clean the hose ports with solvent - I used methyl ethyl ketone - to remove any grit, rubber particles, etc. This will ensure a tight seal. Do not forget to put clamps on the hoses, before you run the hoses to the port on the side of the head and to the pipe behind the head. First, do the lower hose (the one that runs to the port on the side of the head, and into which the heater valve has been installed). It should pass between the wiring harness (with the ridged cover) and the oil dipstick tube, on the passenger side of the dipstick tube. Making sure that the clamp screw will point upwards, install the clamp on the hose at the end, which is to go on the port, on the side of the head. If you're right-handed, it will be easier to secure this clamp, if the clamp is positioned, such that the screw is positioned on the right side of the hose (i.e., towards the front of the engine). Lubricate the inside of the hose with saliva, then reach under the

intake manifold, and push the hose to the point where the hose opening is just touching the edge of the port. Then, slowly work the hose along the port, until it is against the base of the port (as close to the wall of the head as it can go). Position the clamp 3/16" from the base of the port, and tighten the clamp, using the flexible shaft screwdriver/nutdriver, through the opening in the intake manifold branches. The upper hose should pass behind the 1" thick wiring harness (with a ridged covering), on its way to the tube, which is behind the head, and which runs along the side of the head, behind the exhaust manifold, to the back of the water pump. Position the hose clamp on the end of the hose, making sure that the hex head points upwards. Push this hose onto the end of the pipe, until it reaches the stop. Position the clamp 3/16" from the stop and tighten it. This hose should fit into a black plastic clip - with a swivel - which attaches to the fuel return line. When you slide the clamps over the hoses, before pushing the hoses onto the heater core ports, position the clamps so that the hex head of the clamp screws on the hose clamps, point to the passenger's door. Push the hoses all the way onto the port, until the hose contacts the foam gasket at the base of the port (closest to the firewall). Position the clamp about 3/16" from the end of the hose. Tighten the clamp until it is snug, using a flexible shaft screwdriver, or a flexible shaft extension, with a socket on the end. Connect the vacuum hose to the bottom of the heater control valve. Make sure to reconnect the hose from the side of the flame trap to the intake manifold, and the vacuum line to the cruise control actuator (if either has been dislodged). Refill the system will coolant/water (50:50) mix. Start engine, wait for it to warm up (temp indicator in the middle). Check for leaks where hoses attach to ports. If necessary, snug hose clamps. Turn the climate control setting to max heat. If you feel a blast of heat, everything is fine. If the air is only warm, there likely is an air bubble in the heater core. Turn the car around, so that the nose is pointing down (if the car was angled up before, or vice versa). This should allow the air bubble to escape. If you then get a furnace-like blast of heat from the vents, you're good for another decade, or so.

Turbo Oil Cooler Hoses. **If you have a turbo, remember that there are two coolant hoses to the oil cooler under the car that need to be replaced: they rot because of dripping oil from oil filter changes. Buy only the Volvo OEM hoses from the dealer for this application: they are curved to fit and made of special rubber to resist dripping oil. Do not use heater hose stock instead of the OEM hoses.**

Heater Water Valve: see the FAQ file

Water Pump:

Water Pump: Check out the file for detailed instructions and pictures from Cameron Price regarding a B230 water pump

Leaks. [Tips from IPD] The weep hole on the bottom of the pump snout is a common source of leaks. Inspect with a mechanic's inspection mirror. Leaks from here mean the bearing is beginning to fail and the pump must be replaced. If you see coolant on top of the pump, the top rubber seal between the head and the pump needs replacing. If you see coolant leaking from the delivery pipe coming out of the back side of the pump, the seal needs replacing. Coolant dripping or seeping from the base of the pump at the block indicates that the pump gasket needs replacing. Most shops prefer to replace the entire pump anytime the seals or gaskets leak, just to be on the safe side.

Replacement Brands. [Editor] Brickboard consensus seems to prefer, in order of descending quality and longevity, Volvo OEM pumps, then Hipu, then other brands.

Replacement Procedures: [Tips from Chad M, Cameron Price, Editor]

1. From beneath, remove the splash shield and loosen the bottom power steering pump mounting nut and bolt (this is almost impossible to loosen from above). Leave the belt tensioned. You will likely have to raise the car on ramps for this one operation.
2. Lower car. Disconnect battery. Drain coolant from system into a large clean pan beneath the lower rad hose. Remove the clamp, pull off the hose and drain the system; hopefully most will end up in the pan.
3. There are four small bolts (10mm) that hold the fan to the water pump hub. They also hold the pulley. Using a six-point 10mm socket, remove fan, leave pulley for now.
4. Loosen the top power steering fixing nut, back off the tension adjuster, and loosen the belt. Pull off the pulley and the power steering belt.
5. Remove the top timing cover: 2- 10mm bolts, one 12mm near the bottom, and a torx screw behind the top.
6. Now you can see the pump. Remove the hose. In no particular order remove the nuts and bolts around the pump body. All of them are 10mm. I suggest you place a rag under the bolt near the timing belt, otherwise the bolt and washer could drop into the bottom timing gear cover.
7. Examine pump. Are the vent holes on the shaft housing stained from coolant? Is there appreciable play in the pump shaft? Have the gaskets, (2 o-rings / 1 paper) failed? In any event, it will be fairly obvious.
8. Clean gasket surfaces to remove all traces of old gasket and grease. You will often find corrosion that can prevent a good seal. Clean the metal hose flange and the underside of the head with fine sandpaper, mild Scotchbrite, copper wool, or a brass brush, NOT steel

wool. A mirror and bright light help to see up under the head surface while it's being cleaned.

Use a razor blade scraper on the block. The paper gasket usually sticks to the block pretty hard. A small straight screwdriver tip cap get around the bolts.

Water Pump Seal and Elongated Bolt Holes

9. Install new flanged o-ring on the top of the new pump ("1" in the photo). Some people use a little silicone grease or Permatex Hylomar to help in installation. Install new o-ring on return line, using a small amount of silicone grease in the return line hole to help the o-ring slide into place. Spray both with silicone or place a little petroleum jelly on them to keep them from binding on reinstallation.
10. Hang new gasket on two remaining studs in engine block. The gasket goes on dry: NO sealant.

    But use antisieze on the bolt and stud threads.

11. Installing the pump. First off, get the pump roughly into place and fit the return line o-ring into the pump body. Tighten this return line nut and bolt assembly. If there isn't an Allen bolt fitted here already, do so. It makes tightening / loosening worlds easier.
12. Place the pump flush against the block in position. Two of the holes that fit the studs, as you have noticed, are oblong (see "2" in Colin Shepherd's photo). Put the nuts on loosely.
13. Find a 12-18" pry bar or screw driver. Levering against the bottom-most portion of the pump and the crankshaft pulley or power steering pump, lever the pump upward. You need to get compression on that flanged o-ring (see "1" in photo). You don't have to use terribly much force, but it should be very snug. Start the remaining bolts in their holes while levering upwards, using a small amount of thread sealer on several as they do protrude into the water jacket. Now tighten the two nuts, still while holding pressure, to 8-10 ft-lb (11-15 Nm.)
14. Tighten the rest of the bolts in a star pattern to 8-10 ft-lb (11-15 Nm.)
15. NOW IS AN EXCELLENT TIME TO CHANGE YOUR TIMING BELT and tensioner. You have to take off the other belts if you decide to do this.
16. The rest is just the reverse of removal. If your new pump did not come with studs, just reuse the old ones: take them off.

    Put a nut on the stud so that enough of the stud is sticking through the nut to place another nut on top of it. Cinch the 2 nuts together (not too tightly, but firmly) and now you should easily be able to get a box end wrench on the 2 nuts and extract the stud.

Do not forget to tighten the power steering fixing nuts.
Also since the system is drained, changing the thermostat (if it's been a while) is good insurance. Inspect the hoses as well for soft spots, cracked rubber on the ends, etc... If you're going to reuse the coolant strain it through a piece of fabric before you put it back (remove the bigger particles.) Bleed air out by loosening the thermostat housing. Give yourself a solid afternoon, this is an easy job if you're not rushed.

Pump Removal Notes:
[Inquiry] I removed the timing cover and the six visible nuts/bolts, and tried to pull the thing off. The pump is kept in place by two studs (nuts removed), one to the top left and one to the lower right next to the timing belt cover. But it won't come off. [Tip from LK Tucker]You did not list the bolt on the rear that holds that metal heater tube on. Did you remove it? Is there silicone at the pump to block gasket site, all around the pump body? Once you have that rear bolt off count the holes for missed bolts, double check the rear tube, and pry it off.
I suggest you remove the radiator. The water is already out and the room you get is excellent. Plus there is no chance you will accidentally hole the radiator while working on the pump. [Jon Scheetz] After removing all the bolts and nuts attaching the water pump, including the bolt/nut to the heater pipe heading aft along the block, I discovered I could not remove the water pump. It came loose from the block but was prevented from coming free due to an overlap of the lower section of plastic timing belt cover. To remove the cover, one must remove the crank pulley. My solution was to simply saw the offending corner off of the plastic cover with a hand-held hacksaw blade. The upper timing belt cover still covers the area of removed material so no belt protection is lost.

Pump Studs:

[Randy Starkie] If you strip a stud, use the studs from your old pump. Take one of the nuts and put it on one of the studs. Put another nut on top of that one so that there are threads through each nut. Hold the top nut with one wrench while tightening the other one against ("jamming" them together). Remove the top wrench and then loosen the stud with the wrench on the bottom nut. Simply take that stud and nut combo to the new pump and screw it in and snug it up with the a wrench on the top nut. Use the two wrenches to unjam the nuts and repeat for all the studs. [Colin Shepherd] If you do break a stud and do not have a replacement, you can replace them with M6x1.0 threaded bolts. Just make sure they are of the right length to prevent the threaded part going too far through the flange and hitting the pump body.

Installation Notes: Use of Sealer?:
[Inquiry:] On a typical water pump installation, is some kind of sealant, like RTV, needed, or, just the paper gasket? If, RTV is used, where does it go? On the gasket-to-pump, or gasket-to-head? [Response 1: Chip Hewette] Only use the paper gasket! Carefully align the paper gasket using the two studs on the engine block, then apply the pump. Tighten nuts and bolts carefully, snugging them down in a crossing pattern. The pump is aluminum, and you risk a seal failure if you tighten one bolt fully before all the others are nearly tight. [Response 2: Dick Riess] Use the paper gasket only AND clean mating surfaces, including the bottom of head mating surface. [Response 3: Don Foster] You ask different people, you get different opinions. I like to use a touch of (red) RTV on the top O-ring and on the heater pipe O-ring. In the past I've used Permatex aircraft gasket cement on the paper gasket -- it works, and I've never had a

failure. BUT it's a b*tch to remove next time around. So I install the gasket dry. Dick's caution about clean mating surfaces is critical, and Chip is absolutely right about tightening carefully and using a cross pattern. Don't forget to pry the pump up toward the head before tightening -- this compresses the top O-ring. Also, a touch of anti-seize on the bolt threads might make removal easier next time (but don't over-tighten). [Response 4: Randy] Make sure the surface of the block is scraped clean before installing a new gasket (razor blade) and don't ever consider reusing the rubber pieces. I use a light smear of silicone on the heater pipe before putting the o-ring on there and then another light coating on that o-ring before pressing the pump on (the silicone acts as a lube and helps prevent hanging up, tearing, or twisting; but don't use so much as to have it squeeze out inside) I put a coating of silicone in the groove that the large rubber piece fits in before installing it. I put a coating of silicone on the top of the rubber piece before hanging the waterpump on the two studs. After installing it, I try to wait overnight before adding the coolant to give the silicone a chance to set up. [Tip: John O] I wouldn't advise using any sealer like RTV, but spray a little silicone spray on the seals so the pump goes on easily, taking care of the small one on the water tube because it's easy to not notice it slipping out when moving the pump against it. [Evan] If you feel you need a sealer, use Hylomar HPF (from Permatex, et al) since it stays elastic forever and seals small indentations better.

Installation Notes: Tightening the Nuts:
[Tip from LK Tucker] The pump is installed by putting the studs through the two oval holes or one left hand bolt hole and one right hand oval hole and stud. Then lever the pump up to match the other holes and compress the heavy o-ring to the head. Since the nut is already on the stud there is no holding the pump in place while fishing to thread a bolt, just tighten the nut on the stud to 11-15 ft-lbs. [Tip from Randy] I start the remaining bolts before running the nuts on the studs down with my fingers. Using a hammer handle I apply upward pressure on the bottom of the waterpump to compress the large rubber ring. While maintaining that pressure I snug up the two nuts enough to hold the pump in that position, then I tighten the remaining bolts including the nut/bolt combination that holds the heater pipe in place. [Tip] When you tighten the belts, be careful about belt tension. I replaced a half dozen pumps on my cars until I started leaving the belt looser. Now, they last a long time. Watch the final tightening on the alternator bolt as it will almost certainly end up taking slack out of the adjustment as you give it your final snugging.

Water Pump Gaskets Won’t Seal.

Corrosion. [Editor/Art Benstein] Clean up any corrosion at the heater pipe, the block, and the head prior to installation of the new seals, gasket, and pump. Pay close attention to the pitting that sometimes occurs at the head. Use a mirror and make it real clean and smooth.

Use of RTV vs.Gasket Sealer. The Haynes manual advises to apply RTV sealant to the gasket. I understand RTV is to be used instead of a gasket. Is it absolutely necessary to use some kind of sealant with the gasket? [Response 1:] RTV may be used in lieu of the gasket but there's no real reason to substitute for a real gasket (I find RTV is more prone to leakage). The trick in putting in a new water pump is to adhere the gasket to the PUMP side only and leave the gasket-block interface free of Permatex (or whatever gasket sealant you're using). The gasket itself provides a great seal without adhesive but adhering it to the pump first assures that it won't slip when you're installing it. [Response 2:] I've replace 4 water pumps in over 15 years of Volvo ownership and never used Permetex or RTV on a pump gasket. I have used the gasket alone and nary a leak in the lifetime of the pumps. I insert two bolts to hold the gasket to the pump before mounting. after hand tightening all the bolts lever the pump upwards to allow the head to seal correctly with the rubber donut on top of the pump and torque appropriately. [Response: Dave the Volvo Tech] I use a dab (as in a little dab'l do ya) of wheel bearing grease to lube the hole for the tube/o-ring on the back and smear a little grease on the top seal. If you use a small phillips screwdriver in the bottom hole to pry up and start the bolt in the top hole, start the bolt in the left side, and then start the bottom bolt then tighten all of them before installing the two nuts, you shouldn't have any leaks. I've done a ton of pumps and only had leakers when I damaged the seals/gaskets. Silicone RTV is WAY overrated- as a professional wrench, I can open a tube and it goes bad before I use half of it. Make sure the sealing area of the head where the top seal goes is nice and clean. BTW, I can do a pump on a hot engine in 20 minutes. [Evan] If you feel you need a sealer, use Hylomar HPF (from Permatex, et al) since it stays elastic forever and seals small indentations better.

Re-sealing the Gasket After Installation. [Inquiry] Top of water pump connection gasket seeps anti freeze when overflow tank is filled. Is it possible to loosen and re snug waterpump and 90 degree connector to block cast piece back together or loosen the connection and put permatex on surfaces instead of completely removing pump? [Response] What you propose is not a good idea. You will always have a little drip out of there that will contaminate the RTV (Permatex) It will leak and make your belts squeal. IPS (http://www.importpartsspec.com) just sold me a complete re-seal kit for that application for like $2.50.

Water Pump Line Replacement. Any secrets for hooking the hard water line to the pump? I'm talking about the one that attaches to the block near the coolant draincock, and then runs around behind the block. When I install a water pump, I "lubricate" the seal on that pipe and the opening in the pump with a very thin coating of red RTV. In the 8-10 water pumps I've installed, I've never had a problem, leak, or failure. I'm sure others out there would object to this practice -- but it has worked well for me since my first Volvo, a 1972 142E -- and I'm on my 15th, or so, Volvo. When I say "lubricate" I do NOT really mean lubricate. That is, DO NOT use oil or grease. Let me repeat: DO NOT use oil or grease. The RTV adds a little extra sealing property to the O-ring, and while it's still gooey, it's slippery. I find it helps the O-ring fit and seat properly into the pump. Of course, both the female opening in the pump and the end of the pipe must be clean and dirt-free, and the O-ring must be new. By the way, that pipe carries the hot antifreeze to your heater. Because it bypasses the thermostat, you get heat in the car while the radiator's still cold.

[Editor] Check this line for corrosion at the welded bracket near the manifold. See the Loss of Coolant section below.

Radiators and Components:

Emergency Radiator Repair. [Tip from bl] Here is a temporary radiator fix for you bricksters who manage to break off one of the hose flanges on the crummy, OEM plastic radiators. It's not a matter of if this will happen, only when. Dad broke the upper hose flange off on his 90, 740 last week. Having sold plumbing parts for years, he came up with this fix that works like a charm and will get you back on the road in a few minutes. You need a short piece of 7/8" dishwasher drain hose and a 3/4" copper sweat coupling. Break off the remaining fragments of the hose flange. Take a 3-4" long piece of the dishwasher hose and force it in the hole in the radiator. It's a TIGHT fit but it will go. A little spit helps. When it's inside the rad about an inch, shove the copper coupling inside the drain hose. This just stiffens and expands the hose slightly. Reinstall your rad hose (it'll be a perfect fit), replace your lost antifreeze and hit the road. Needless to say, this is for emergencies only; you will need a new radiator very quickly.

Radiator Sensor Seal. [Inquiry] The temperature sensor on radiator popped out because the rubber seal loosened. I lost all my coolant. How do I reinstall it? [Response] The seals are supposed to be installed once and replaced when they fail or are removed. OEM seals are imprinted "one use only". Do not use sealer or adhesive while installing, but you need to lube it with a waterbased lubricant such as soap or rubber lube to install. To install, first seat the rubber gasket in the hole, them push in the sensor. It expands the gasket to a tight fit. Buy two seals and carry a spare. Since the seal might have popped out due to overpressure, now is the time to inspect the cooling system for any plugged hoses, failed thermostat, etc.

Radiator Replacement

B230 Engines.

Brass/Solder Replacement Units. You can buy brass/solder construction radiators from IPD, FCPGroton, RPR,or Internet suppliers, as well as local retailers. Nissens is one well-known brand, as is Modine. The units from Nissens seem to be quite robust and are perfect replacement fits. Average cost is around $150 for a two-row or slightly more for the heavier three-row. One caveat, however: Volvo coolant and Dexcool tend to eat the solder in these radiators. I'm now on my second one for that reason. This time, I'll be using Prestone.[Note: See Coolant Recommendations below.] [Comment:] The quality of aftermarket radiators varies considerably. The brand I use in my shop is "Nissens". One of the nice features of this radiator is the screw cap that holds the sensor in place. *Nissen All-Metal Radiator Composition*. [Tip from A. Sorenson at Nissens.dk] Our solder composition is 33% tin and 77% lead [Editor: thereby qualifying as "low-lead" but still soldered.]

Aluminum/Plastic Replacement Units. The OEM radiator is an AL-reinforced plastic composite and is very light as well as being made of aluminum, which tends not to corrode in the correct coolant. For an exact replacment, buy one at Borton Volvo. For a similar replacement made by Nissen, buy it from IPD or FCPG. This radiator has a lifetime of about eight years due to side tank embrittlement from heat.

Temperature Sensor Plug. Replacement radiators are generic for both Bosch and Regina-equipped cars. Regina and some Bosch systems use a temperature sensor that fits into a hole in the passenger side tank; it activates the electric fan. When you buy your replacement radiator, make sure you ask for the rubber plug that fills the hole if your system does not use the sensor. If your system uses the sensor, then ask for a new rubber seal to hold the sensor in place. Remove the sensor by pulling it from the gasket. It uses no sealants and relies on a friction fit. To install, first seat the gasket in the hole, them push in the sensor. It expands the gasket to a tight fit. Liquid soap helps. Do not reuse the seal: install a new one if you remove it.

Procedure: To remove the radiator:

- remove top support brackets and trim pieces
- remove electric fan and shroud if so equipped
- remove bottom airflow dam beneath the car which is screwed into the bottom of the radiator
- remove automatic transmission coolant lines; not much oil will drain out, so use a cloth under them to catch that which does
- disconnect and remove temperature sensor if installed
- disconnect lower and upper coolant hoses and reservoir hose
- disconnect air hose to reservoir from top left of radiator
- lift radiator out
- remove rubber supports on bottom and transfer to new radiator
- reverse the process for installation
- if your radiator has a coolant temperature sensor, use soapy water to install the rubber seal with the sensor in the middle. Don't throw the box out before making sure you have this seal.

Tips:

- don't overtorque the hose clamps on plastic radiator connections or the coolant line nuts
- use a backup wrench when tightening coolant line nuts
- now is a great time to replace hoses and thermostat
- loosen the thermostat housing nuts to relieve trapped air when refilling
- [Mike Brown/Walt Posluszny] if the transmission cooler lines won't thread, take off the clip that holds the two lines together back near the engine so that you have a little more flexibility in lining up the fittings. Then put a little ATFon the threads to lubricate them and move the trans line around with one hand to orient it 90 degrees to the fitting while screwing in the fitting with your other hand. It takes some patience.

B6304 Engines. [Rafael Riverol] Don't look for an "all-metal" replacement radiator. You do not want an all metal radiator in your 960/90 series car. You want a Volvo (Blackstone OEM) or perhaps Nissens aluminum and plastic radiator to avoid bimetallic corrosion of the engine through any voltage in the coolant, such as from bad grounds. You also want to put in new Volvo coolant mixed 50/50 with distilled water.

Coolant Reservoir Replacement . [Tip from Paul Seminara] I have found the source of disappearing coolant from a 1992 940T. The lower outlet on the coolant expansion tank is cracked. These rectangular tanks have a steel insert, presumably to prevent damage due to overtightening. Corrosion of this inset has lead to swelling and cracking of the plastic. I suggest that if you find a trace of leaking coolant at this point, you remove the hose and inspect this and not just tighten the hose clamp. [Brian Sullivan] My nine-year-old 945T developed a very small crack in the top of the reservoir... it bubbled a bit when the engine was hot. When I pulled the outlet hose off the bottom of the old tank, the bottom 1/4" or so of the plastic crumbled and fell in the hose. Also, one of the interior plastic walls had broken, and a chunk was floating in the tank. [Editor] These tanks will embrittle over time and should be changed as a "wear" item. Every eight years, at the same time as the radiator, is appropriate.

Typical Expansion Tank Failure

Engine Freeze Plugs: We in the great white north (Canada) refer to these casting plugs as "frost plugs"; they are intended to pop in the event that the engine is filled with water rather than anti-freeze and the temperature drops below freezing-they are sacrificial in order to save the block from cracking. The one below plug two is actually removable in order to insert a block heater, in fact these plugs and block heaters both corrode with equal regularity (about once every 150,000-250,000 kms) and fall out causing loss of coolant and if not detected, overheating... a quick and inexpensive repair in either case unless, of course, not detected in time. Keep watching those temp gauges.

Loss of Coolant and Overheating:

Coolant Loss: How to Diagnose? [Inquiry:] My Brick is losing coolant; is it the head gasket? How do I tell? [Response: Don Foster] Pulling the head is not a casual or inexpensive job and should not be done until you have eliminated all other leak candidates. First, look long and hard for the leak:

- Look for the obvious leaks first. These include:
  - *Radiator and radiator hoses*
  - *Heater hoses*
  - *Heater water valve*
  - *Water pump and gaskets/o-ring:* when the seal starts to leak, often antifreeze can "sneak" unseen down to the splash pan -- and if it's a slowish leak, you might not see a puddle 'til the leak gets worse. The antifreeze will escape only when you're driving.
  - *Overflow reservoir* (especially the pipe at the bottom which corrodes and leaks)

    - *Thermostat housing* which can corrode
    - Turbos: *Coolant hoses* to the oil cooler; coolant hoses to the turbo
- Less common leaks:
    - *Head Gasket.* If it were my car and I was worried about disappearing antifreeze, I'd carefully crack the oil drain plug, let the first few tablespoons drip into a bowl, and examine it carefully for antifreeze. It'll sink to the bottom, so should be the first out. Do this with a stone-cold engine (not run for several days). If the antifreeze has mixed with the oil in a running engine, it'll form a "dispersion" and the oil will take on a grayish, cloudy characteristic. Next, I'd pull each sparkplug and look for evidence of coolant in the cylinders. BTW, an engine leaking coolant into a combustion chamber will have an unusual amount of white exhaust smoke, particluarly on a cold day (steam). More typical, however, is that the combustion gasses are forced into the cooling system -- and can be detected with a simple instrument. Every garage should have one. I do. See Head Gasket Failure.
    - *Heater Core.* Another "invisible" (but problematic) leak might be the heater core. Or even the heater control valve. If you find something around the heater (and fix it) don't forget to get the coolant out from under the carpets -- they really should be pulled. Otherwise you'll be facing rusted floors in a year, or so.
    - *Transmission Oil Cooler.* If you have oil in your coolant or coolant in your transmission fluid, the transmission cooler on the right side of the radiator is leaking and must be replaced ASAP.

Cooling System Pressure Test. [Editor] The best way to diagnose cooling system problems is to pressurize the cooling system and look for either visible leaks or pressure drops. You can take the car to a shop with the pressurizing device or make your own. Pressurize the system to 9-12 psi (65-85 kPa) for 1984-86 cars or 22 psi (150 kPa) for 1987+ cars with B2XX engines. The pressure should not noticeably drop within three minutes, else you have a leak. If the leak is internal, you won't necessarily see it. See below for a homemade tester. This way you can accelerate any leak for you inspection without running the engine. [Editor's note: see Headgasket Failure for further notes on a cooling system pressure test: highly recommended that you have the correct equipment for this.]

Sudden Loss of Coolant and Engine Overheating Incidents. [Steve Ringlee] We recently surveyed the Brickboard and Swedishbricks lists for incidents of sudden loss of coolant and engine overheating. Here are the results:

Engine-Side Heater Water Control Valve behind engine in front of firewall

- *Plastic-bodied engine-side heater water valve cracked*; coolant was pumped out. In most of the incidents, drivers did not notice the loss because the coolant was pumped or blown under the car. In most cases, the first evidence was engine noise, slowing of the car, or other signs of serious engine damage. [Steve Seekins:] These valves crack longitudinally along the plastic center pipe. Note that heater-only equipped cars have a plastic valve inside the car on the left side of the center console. For replacement instructions see the link.

- *Heater hose fractured due to aging and internal crack*; catastrophic loss of coolant
- *Heater hose chaffed against block*, rubbing through and failing; catastrophic loss of coolant
- *Heater hose was not secured by plastic clip* and contacted EGR exhaust tube, melting it and causing a sudden leak
- *Water pump-to-heater tube corroded at welded support bracket and failed*
- *Radiator plastic side tank fractured*; catastrophic loss of coolant
- *Radiator hose split due to aging and internal crack*. Upper: loss of coolant; lower: catastrophic loss of coolant
- *Top radiator hose clamp was over-tightened, cracking plastic neck outlet*. Some coolant was pumped out and the engine temp gauge showed overheating but no damage occurred.
- *Hose clamp failed; lower radiator hose parted from radiator outlet neck.* All the coolant suddenly drained out of the radiator, leaving only the coolant in the block. Engine required a new headgasket.
- *Turbo oil cooler coolant hose became oil-soaked and failed.* Check these when you change your oil filter: they are below and behind the oil filter assembly.
- *Coolant reservoir hose became oil-soaked at the clamp and split.* All coolant was pumped out and the engine overheated.
- *Coolant reservoir bottom nipple broke off, the tank fractured, or the cap leaked,* causing loss of coolant.
- *Water pump seized due to a bearing failure around the pump shaft*, shucking one of the two drive belts. The remaining belt was sufficient to start the pump turning again, but this resulted in the cast iron pump impeller coming into contact with the back of the pump casing, smashing it and causing loss of coolant.
- *Electric frost plug engine heater leaked* due to corrosion of the anchoring device; slow leak.
- *Nobody mentioned a failed water pump shaft seal* as a cause of catastrophic loss-of-coolant, merely resulting in slow leaks.

In almost every case, the lack of an "idiot light" caused drivers not to notice the loss until too late. When the driver finally looked at the temperature gauge, it was invariably far into the red zone, indicating serious overheating. In almost every case, drivers attempted to drive to a convenient destination such as home, a gas station, or a freeway exit. This extended drive usually led to further engine damage. The least damage noted (except in the last instance) was head gasket; in many instances the engine required replacement.

Lessons learned:

1. Assume that your cooling system components have a limited lifespan. Replace them according to an intelligent schedule. I replace hoses and water valve every eight years and the radiator at year ten. I replace the water pump either at a convenient maintenance interval or when it starts leaking at the seal. For turbo cars, assume that the higher underhood temperatures will reduce component lifetimes, so that your radiator and water valve will last only eight years. Brickboard consensus is that the strong points in the cooling system are the OEM hoses; the weakest point is definitely the heater water valve;

and the plastic radiator side tanks are in between.

2. Give serious thought to installing a loss-of-coolant sensor and an indicator light wired into your instrument cluster. "I didn't notice until it was too late" was a universal experience.
3. If you notice smoke, fluid or other evidence of engine distress, STOP and see what the matter is before trying to go any further. Shut the engine off if you have a loss-of-coolant or oil. All it takes is about one minute of operation with no coolant to fry your head gasket. "I tried to get to a service station" are the last rites for many engines.
4. [Rob Bareiss] You should ALWAYS replace the heater control valve (water valve) on any 7/9 series car that has already had an overheating event. A failed water valve is probably the #1 cause of a secondary cooling system failure within 2 weeks after the first has been fixed (i.e. radiator, hose, water pump, etc).

Loss of Coolant Sensor for Volvo 740/940 Cars: [from Steve Ringlee]

Existing Loss of Coolant Indicator Lamp

These plans allow you to fabricate and install a low-coolant sensor in your car so that you can detect either slow or sudden coolant leaks and take appropriate action before your engine overheats. Volvo 960 and some 760 cars have these sensors already installed. Volvo 740 and 940 have the indicator position in the instrument panel, but no lamp or sensor (see the photo to the right). Note: Dick Riess contributed a plan for an easier-to-install warning light using a dash switch cutout instead of the panel. See the section at the end below.

Overall Plan.

a) Volvo 740 with Circular Oval Tank.

Using a Nohken normally open float level sensor switch, drill a hole in the bottom of the coolant tank and install the sensor. One lead is wired to the front grounding plane near the passenger-side headlight, the other back around the engine compartment, through the firewall, to the unused instrument panel lamp denoted "EGR Overheating (Japan Only)." When coolant is low, the switch closes, allowing 12V from the panel to travel through the switch to ground, illuminating the warning lamp. By the way, this is a great time to replace your coolant reservoir tank, which is at least eight years old and does not last forever.

b) Volvo 940 with Rectangular Tank

Volvo may have included a level float in this tank, but not the sensor. Buy a "Level Guard" sensor Volvo p/n 3547710 and wire as noted below. Remove the tank and shake it; if you hear the level float rattling, then it has a float. Check the bottom of the tank for the molded-in words "without float sensor": if you see. these, you need a replacement tank with the float. If you don't have the float, buy a new reservoir p/n 9122997 (around $30). Make sure you read all assembly instructions below first, especially to confirm you have the float inside the tank. There is a "Low Coolant" lamp position already in the row of panel warning lamps.

Bill of Materials:

740 Variant: Float Level Sensor Switch: Nohken LS-11P-0A, miniature 10VA switch (normally open) with polypropylene float, temperature rating above 100 C, and stem and flat flange face. This is known in the trade as a "liquid level switch".

STI Level Sensor

There are two sources: (1) Scientific Technologies Inc. at 6550 Dumbarton Circle, Fremont, CA 94555-3611, 510-608-3400. Order STI part number 22152; cost is approximately $15 plus a fairly hefty shipping charge. Web site is http://www.sti.com (2) Less expensive is the version from McMaster-Carr (part number 50195K74 for $19.55- get the "NO" Normally Open switch)

940 Variant: Volvo "Level Guard" p/n 3547710) approx $15 from Borton's Volvo, http://www.borton.com , FCPGroton, or from a junkyard off a wrecked 960 car. This device resembles a thin tube about three inches long. If you get it from a 960, take the electrical connector as well (the same connector as is on the brake and washer reservoir fluid sensors).

b) Volvo 12v 1.2w lamp for instrument panel: Volvo uses two instrument panels (Yazaki and VDO) and several kinds of bulbs and bulb holders for their panels. One is a replaceable bulb with wire leads, inserted into a holder that has a plastic locking ring. The other is a bulb soldered into a holder with metal locking tabs. You will probably have to pull your panel to determine which make and lamp type your car has. Dealer prices are quite high (~$3-4 per bulb and $5-6 per holder). Examine the bulbs carefully: in some cases, you can find them at Walmart (e.g., Yazaki 158 bulbs or Osram 2721).

- *740 with Yazaki panel*: Volvo p/n 2721 1.2w replaceable bulb with leads
- *940 with VDO panel*: Volvo p/n 966326-1 1.2w bulb fixed into holder
- *940 with Yazaki panel:* Volvo p/n 942327-8 1.2w bulb; Volvo p/n 9128743-3 Lamp socket. You have spares of this socket on your panel in unused slots.

c) Instrument panel female metal electrical connector inserted into "C" harness connector:

- *740 and 940 before 1994*: ell-shaped "C" connector uses Volvo p/n 949542 (likewise "L" shaped)
- *940 1994+:* flat "C" connector uses flat Volvo p/n 9148152

You can find these easily at boneyards: pull the panel, cut off the entire "C" harness connector, and re-use the metal connectors inside.

d) Electrical Supplies, all from Radio Shack (one each unless noted):

- Insulated Wire: 20 gauge stranded approx 25 feet p/n 278-1225
- Snap Connector 22-18 g, p/n 64-3085
- Quick Disconnect Connector, Female, .25 inch, p/n 64-4040
- Crimp Butt Connector, 22-18 gauge (quantity=2) p/n 64-3037
- Shrink tubing for insulating connections p/n 278-1611
- Option: Piezo buzzer p/n 273-059 (gives audible warning, but realize it will go off with merely cold, low coolant)
- Soldering iron with electronic solder

e) Mechanical Supplies:

- Wire ties for securing wire to existing harnesses
- "OxGard" conductive electrical grease (from hardware store)
- Silicone dielectric insulating grease (from auto parts store)
- *Volvo 940 applications:* None other required
- *Volvo 740 applications:* (from hardware store)
- Neoprene O-Ring O.D. 1/2 inch, I.D. 3/8 inch
- Neoprene Flat Washer O.D. 7/8 inch, I.D. 3/8 inch

f) Volvo wiring diagram to understand your panel connectors. Here is where Chilton's will finally choke you, and you will be motivated to buy the OEM wiring diagram which is absolutely the best on the market. Approx. $30 from Volvo NA at Volvo Technical Publications.

Assembly Instructions:

1. *Volvo 940:*
a) Drain coolant recovery tank and remove from car. Shake the tank to make sure that Volvo installed the magnetic float that activates the Level Guard inside the tank. (It rattles. If you can't hear the rattle, install the Level Guard and test it with a multimeter for resistance change as the tank is filled with water.) If your tank has the float, install the "Level Guard" sensor into the snap hole on the bottom of the tank. Insert the wire leads into the tank's wiring connector holder on the bottom. Continue below at step "e)".
If you don't have a magnetic float inside, you can either proceed as though you own a 740, or buy a new tank (p/n 9122997) with a float inside from Borton's for about $30. My experience is that the tanks that were installed at the factory in 940s did NOT have the magnetic floats.
Volvo 740:
a) Drain coolant recovery tank and remove from car.
b) Drill a 10mm hole on the flat surface of the underside, approximately one inch toward the center from the threaded cap. [Tip by John Sargent] After drilling the hole in the bottom of the coolant reservoir, I used a beveling tool to create a 45 degree shoulder at the start of the hole. The beveling tool has a 90 degree included angle. The purpose of this beveled shoulder is to create a slight recess for the o-ring to seat in. I turned the tool in reverse in my drill. The tool is quite sharp, and is much too hungry to use on plastic in forward rotation.

c) Remove the float and install it so that the switch operates in the "N.O." ("Normally open") position. Test the switch operation with the ohmmeter range on a multimeter: when the float is at the bottom of the switch (corresponding to loss-of-coolant) the switch should close and complete the circuit, reducing resistance from infinite to zero.
d) Remove the fixing nut on the bottom of the coolant sensor switch. Install the flat neoprene washer on the switch. Feed the switch wires through the coolant fill hole, then into the hole you drilled on the bottom of the tank. Pull the switch snug. Install the neoprene o-ring, then the fixing nut. Snug up the nut until the switch is firmly held without possibility of leakage. If your hole was oversize, use silicone RTV to seal the gap between the hole and your o-ring.
e) Cut a piece of wire sufficient to reach the grounding panel just behind the headlight. Using a short piece of shrink tubing and a .25 inch female blade quick connector, crimp the connector onto a stripped end of the wire and add some solder to ensure a long-lasting connection. Shrink the shrink-fit tubing onto it at the crimp to serve as corrosion proofing. Clean off the grounding plane connector, install the blade connector and the wire onto the ground, insulate it with some "Oxgard" conductive grease, then feed the wire up the lamp harness back to the coolant tank. (Maintenance note: this is a good opportunity to clean all your grounds and coat with OxGard to prevent future electrical problems. Don't use OxGard on any other connectors in the car aside from grounds.)
f) *Volvo 740:* Install a snap connector to one wire of the float switch and the ground wire. Again, solder it. Insulate any exposed wire on the connector with shrink tubing. This connector allows you to disconnect the level sensor easily.
Volvo 940: Using a razor knife and some pliers, cut down the diameter of two female snap connectors and squeeze them so as to fit very tightly on the Level Guard lead connectors. Install one of these snap connectors onto the stripped lead of the ground wire by firmly crimping it. Place silicone dielectric grease on the connection for corrosion protection and connect the ground wire connector to one of the Level Guard leads. If you are ambitious, buy the un-insulated version of the snap connectors, solder them onto the wire, and insulate with shrink tubing. [Alternative: if you visit a junkyard, cut the coolant sensor or brake/washer fluid sensors connector off a 760, 960 or 90 series car and use this instead.]
g) Cut a long length of wire sufficient in length to travel from the coolant tank, up the wiring harness at the top of the firewall, thence through the firewall rubber wiring conduit behind the driver-side strut tower, thence into the cabin with an excess of length to reach well beyond the panel.
h) *Volvo 740:* Strip, crimp, and solder one end of this wire (using a crimp connector) to the other sensor switch wire. Insulate where exposed with shrink tubing and apply silicone dielectric grease to the ends of the connector to prevent corrosion.
Volvo 940: Install the other female snap connector onto the stripped lead of the panel wire by firmly crimping it onto the stripped end. Place silicone dielectric grease on the connection for corrosion protection and connect the ground wire connector to the other Level Guard lead. Again, if you are ambitious, buy the un-insulated version of the snap connector, solder it onto the wire, and insulate with shrink tubing.
i) Snake the other end of the wire up to the firewall harness and to the lower firewall rubber wiring conduit just behind the driver strut tower. Use wire ties where appropriate.
j) Cut off one of the smaller rubber wiring conduits in the lower firewall connector just behind the strut tower. Feed the wire through the conduit into the cabin.
k) Remove the battery negative connector to disable the electrical system. Remove the driver side kickpanel (two plastic body mounts at the top, pull out.) Move both the turn signal and

wiper handles down, out of the way. Remove the instrument panel (740: remove plastic fascia plates covering the clock and rheostat knobs, then the two screws holding the panel in place.) (760: See Link.) (940: unclip using the two side slits midway up the sides of the bezel. See link.) Pull the panel straight out and rest it on the steering column.

l) Working from underneath, snake the coolant sensor wire from the back of the firewall wiring conduit up through the panel opening. Keep it away from the hood release mechanism, any sharp metal edges, and the ignition module, using wire ties as needed.

m) Pull the large 12-position "C" plastic wiring connector out from the rear top center of the panel. This connector is white and roughly "ell" shaped when looked at from the side (but is flat for later 940s.)

Instrument Panel Connector

n) Confirm with your wiring diagram which connector you will use for the warning lamp. In the 1986 740, this is position number 7, numbered on the connector itself, which is not used for any other purpose. In the 1990 740, this is position 12 on the connector, which connects to the unused "Exhaust Gas Temperature" lamp for Japanese applications. In the 1992-1995 940, this is position 5 or 9 on the connector which connects to the unused "High Engine Temperature" lamp. Check your wiring diagram. If this does not indicate the correct position, shine a small flashlight through each hole until you find it, then trace the circuit up the back of the instrument cluster to the connector and mark it lightly.

o) Cut the coolant sensor wire, leaving enough to reach well beyond the door opening to wire into the back of the panel. [Tip from John Sargent:] I deleted a fuse from the wiring. The fuse is not needed as the miniature lamp limits the current to the wire in the event of a short circuit. All you will get with a short circuit is an illuminated lamp. After all, the Nokia float switch simply connects the instrument lamp to ground, which is all a shorted wire does.

p) If you want to add a piezo audible buzzer, place it in-line between the fuse and the firewall, again using crimp connectors, solder and shrink tubing. Be very careful about soldering near the interior of the car: use a metal guard or shield to keep hot solder off plastic, fabric or leather components.

q) Install the special ell-shaped or flat Volvo metal wire connector p/n as in the parts list above (p/n 949542 or 9148152) to the end of the fuse wire. While this is crimped in place, you should also add a small amount of solder to secure it.

r) Record the colors and positions of the wires at the "C" connector. Snap open the back of the connector and insert the coolant connector at the correct position. Snap it shut, making sure all the wires go back appropriately.

s) Install the Volvo instrument panel lamp at the appropriate lamp position, again per your wiring diagram. On the 1990 740, the lamp is installed at the second in from the driver's side of the panel, in the unused position. In the 1995 Volvo 940, the lamp is installed at position 7 from the passenger side of the panel. If you are confused, use a flashlight and shine it through the empty lamp receptacle to confirm the position from the front. Just make sure from your wiring diagram that you correlate the lamp position with the wiring position in the "C" connector.

t) Re-install the "C" connector. Coil extra wire and install a tie to keep it out of the way, and tape it to a convenient support to eliminate rattling. Re-install the panel.

u) Seal the wire passage through the firewall conduit with silicone caulk.

v) Test the installation.

Volvo 740: open the coolant tank and place a pencil on the float so as to depress it to the bottom. Start the car. The lamp should go on. Demonstrate several times to wife and kids

what this lamp looks like and what they need to do if it goes on (stop the engine ASAP and investigate.)
Volvo 940: Using a turkey baster or a siphon, empty the coolant reservoir. Start the car. The lamp should go on. See note above.

Regular Maintenance. Because of the peculiarities of the wiring within the instrument panel, your bulb may not illuminate when you turn the ignition to KPII before starting. Hence, periodically test the installation to make sure that the bulb, the sensor, and the circuit operate correctly by performing test v) above.

[Simpler Design from Dick Riess] I varied the alert light design in the car. Being lazy and not having all the parts I led the wire from the sensor through the wiring area on the passenger side and brought it over to one of the switch knock outs. This is where the electric sunroof switch and rear defrost switches are. I had a vacant knock out which I removed. Drilled a hole in the middle and installed a small 12v panel light from Radio Shack. The wire from the level sensor was soldered to one pigtail. Another wire was soldered to the remaining pigtail and then brought to the switched cigar hot wire. This wire was piggybacked to the wire. Be sure to test before buttoning everything up as polarity on the lights I used is important, i.e., red goes to +, otherwise these lights don't work. The sensor works beautifully. When the engine is cold and levels are low the light will flicker when cornering. A good reminder to check.

Loss of Coolant and Possible Head Gasket Leaks. See Headgasket Failure

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Troubleshooting:

Oil in Coolant Bottle on 745 with B230F. [Inquiry:] I own a 1991 740 wagon, 125,000 kms, B230F engine, auto, not driven particularly hard. The problem is this: On Sunday I discovered oil in the radiator expansion bottle. But no oil in the radiator! And no sign of oil (frothy or otherwise) on the dip stick. I have taken the car to the local service station thinking that I have a blown head gasket. This afternoon the mechanic has shown me the dismembered bits. No blown head gasket. He is sending the head for a compression test. So what do you think? [Response: Steve Seekins] On this particular car, the problem is likely the oil cooler. Check at the oil filter housing. I think that your car has a sheet metal oil cooler mounted on the oil filter extension housing just forward of the oil filter. It should have two water lines attached. These have a history of developing leaks - it may simply need to be replaced. You can remove it and perform a pressure test on it. If you have the older style cooler, there will be a cast piece there with OIL lines vice the sheet metal piece with WATER lines. The earlier cooler adapters have no water interface so cannot leak water, but do develop oil leaks from worn O-rings. [Solution: Owner] The problem turned out to be a leaking radiator ATF cooler. I replaced the radiator and it solved it.

Temp Gauge Acts Oddly: Leaking Headgasket? See Temp Gauge Acts Oddly: Leaking Headgasket?

Heater Core Leaks. See the FAQ section for details. Replacement is covered in this section.

Heater Core/Radiator Repeat Failures: Electrolysis or Head Gasket Leaks. [From Bob Savasta, Motor Magazine, Nov 2001] If you have repeated heater core or aluminum radiator failures, consider one possible source to be coolant breakdown and electrolysis due to combustion gases from head gasket leaks. The Automotive Engine Rebuilders Association (AERA) just recently put out a bulletin for its member shops alerting them to the possibility of combustion leaks causing higher-than-normal electrical charges in the cooling system. Like the information I provided in my May column, AERA advises its shops to first use a DMM and measure the voltage potential of the coolant. Anything over about 100mV is cause for further investigation, says AERA. If the integrity of all grounds is sound, fresh coolant has been added and you've still got excess voltage, the association then recommends looking for combustion leaks as a major contributor to the problem.

[Radiator Reporter August 1998: "Electrolysis Problems Continue to Mount", excerpted] Cooling system electrolysis is becoming a frequent problem. Electrolysis occurs when electrical current routes itself through the engine's coolant in search of electrical ground. Current can be introduced into the cooling system in many ways, but the two most common causes are a poor ground to the radiator's electric cooling fan, or a poor ground from the starter motor and engine block to the battery. Any vehicle with accessories bolted to the radiator support or to a nearby component is also a good candidate for electrolysis. Electrolysis is a fast-acting menace that attacks not only radiators and heaters, but can destroy an entire engine in a mere 20,000 miles. Though a small amount of measurable voltage can be detected in most engine cooling systems, due to reactions between the coolant and cooling system metals, the detected voltage should never exceed a tenth of a volt in vehicles equipped with aluminum engine blocks and/or cylinder heads…A poorly grounded engine and starter motor can zap enough current through the cooling system to blast apart a heater or radiator in a matter of weeks or even days, depending on how often the vehicle is started. A partially grounded electric cooling fan, on the other hand, may only shoot a small percentage of its supply voltage through a cooling system, and the effect may take months to reveal itself. Evidence of electrolysis includes unexplained and/or the recurring pinhole leaks in a radiator or heater. Pinholes may form anywhere along the tubes or tank walls, but damage is often concentrated at tube-to-header joints, or in the tube walls near the center of the core, where the electric cooling fan mounts come in contact with the core. To test for electrolysis, connect the negative probe of a digital D.C. voltmeter to the battery's negative post. Then submerge the meter's positive probe into the coolant at the filler neck. Be sure that the positive probe does not touch any metal. Next, note the meter reading, which should be no more than 0.10 volts. If a higher voltage is detected, methodically shut off or disconnect one electrical component or accessory at a time while watching the voltmeter. When the voltage reading drops to zero, you've pinpointed the electrical component with the defective or missing ground. Since electrolysis might occur only when a certain component is energized, have a helper switch each vehicle component on and off while you observe the voltmeter readings. To check components or accessories that don't have an on/off switch, use a long jumper wire connected to the battery's negative post to provide a temporary ground to each electrical accessory. Ground each component with the jumper wire and watch the meter. If the jumper wire restores a missing or faulty ground, the meter will drop to zero. Be sure to check for intermittent voltage surges generated by the starter during cranking. To do so, watch the meter as you crank the engine. Any jump in voltage during cranking indicates a loose, faulty, or missing engine ground. Any electrical device with a huge current draw, like a starter motor or radiator cooling fan, will chew up a cooling system far faster than a trickle of voltage from a poorly grounded underhood relay or other low-amperage device… One telltale sign of electrolysis and/or electro-chemical corrosion is discoloration of the affected area. Aluminum components usually turn black and pitted, while copper/brass components are likely to develop a blue-green corrosion byproduct. Unfortunately, bad coolant can cause similar discoloration, so a blackened PTR core doesn't always mean electrolysis is to blame, but it should raise the possibility in your mind during diagnosis. [Tip] You can solve the problem for particular components by adding redundant ground wires of 16-gauge copper mounted with hose clamps on the component and a screw to body sheet metal.

Gauge Shows Overheating. [Symptom:] My temp gauge started going almost to the red (I always shut the car off to avoid a boil over) and gave readings (now that I think about it) that were generally high and also sporadic. [Diagnosis:] I pulled out my Bentley manual and it was plain as day (consistently high sporadic gauge readings) that it was the voltage regulator. I took out the voltage regulator for the temp gauge cleaned the four contacts and voila...no more "overheating."

Temp Gauge Shows Intermittent Redline. My temp gauge would almost redline for a couple of days but then be normal for a week or a month and then repeat the symptoms. This doesn't feel like an engine that's over-heating. [Fix:] Try loosening the block gauge temperature sender a quarter turn then tighten. Slight corrosion at the sender's threads may interrupt circuit grounding. Worked for me anyway.

Overheats with A/C On. [Inquiry: 1991 740 B230F station wagon. Normally the car can sit for 10 20 or 30 minutes at idle and the temp gauge will stay in the normal spot.
However, when I run the A/C the car will over heat even if I'm running at 70 - 80 mph.]
[Response 1:] Before you go any further you should wash out your radiator to clear it of any accumulation of bugs and dirt. Many Volvo radiators are replaced for this reason and it does fix them as a new radiator is obviously clean. It could be a thermostat, bad fan clutch, head gasket problem, etc., etc. but the radiator being obstructed is an easy thing to try. Get your garden hose out and wash from the fan side towards the front of the car. If you see a lot of debris then it is worth the trouble to remove fan and fan shroud and continue to wash but more thoroughly. It helps to use Fantastic or Formula 409 as that will get more dirt off the fins of radiator and

condenser. [Response 2 for B230FT:] If this has the oil cooler that is mounted off to the side, you need to clean it too. Remove one bolt at the top; it sits in a molded rubber fitting. Be careful of the hoses! I found this to be totally clogged when the radiator was cleaned. You can't remove it without disconnecting the hoses and having a mess, but you can get at the nooks and crannies where the crud is. Don't spray at an oblique angle, because you will bend the fins.

Coolant Sensor Loose in Replacement Metal Radiator. [Symptom:] I had a metal radiator installed in my 87 765T and have had nothing but problems trying to get the temp sensor sealed in the tank (uses a rubber grommet). Just started leaking again today. Someone mentioned a screw fitting to hold the sensor, but I have been unable to rind one. I believe my radiator is a Nessen and has threads where the holes is for putting the sensor in. [Fix:] I did two things when I replaced my oem rad with a metal one. I used a brand new grommet and I pulled a wire tie through the rad and around and across the temp sensor between the two spade connectors (it needs to be a pretty long one.) This will prevent the sensor from popping out, not an unheard of scenario. [Fix 2:] I recently installed a metal radiator from RPR, I believe it is a Nessen brand, and the temp tensor fitting has a metal screw on 'lid' (with a hole cutout in the top of it) which screws down on the temp gauge after it is pressed into the rubber grommet and keeps it snugged down in it's bung (couldn't help myself). Contact RPR, they may be able to help you find a lid...

Thermostatic Fluid Clutch Fan. The performance of a thermostatic fan clutch will degrade over time by about 200 rpm a year due to fluid failure inside. Eventually, the fan clutch reaches the point where effective cooling is no longer possible and overheating results. Since they are not easily repairable, you throw away the old clutch and install a new one. Symptoms of a defective fan clutch include: oily streaks on clutch housing; play in the clutch bearing (wobbling); freewheeling (a good fan should not turn more than one to one-and-a-half turns if spun by hand); and binding (frozen). Simple tests for the fan clutch: the fan should roar when car is first started cold engine. Within 5 minutes the roar should stop/die down. When radiator warms up, the roar should start again. For the thermostatic one (post ~1980), run engine, hang blanket over grille. If the fan starts to get loud and blow more air before the temperature gauge gets too high, the thermostatic clutch works. To check slippage (at normal engine temperature), Volvo suggests using a strobe light with adjustable frequency. You put a timing mark on the fan with chalk, and figure out the fan speed for a few different engine rpms. The chart of engine vs fan speed is in all the different repair manuals.

To Remove the Fan. The four nuts from the water pump pulley come off, and the two screws that hold the top of the fan shroud get removed. Grab the fan and wiggle the fan (with the clutch still attached) and remove the fan and shroud together. Transfer the blades and reinstall.

Tropical Heavy Duty Fan Clutch. [Dave Barton] I live in a area that easily gets over 100 degrees F in the Summer. I wasn't completely confident in trying a new "stock" type fan clutch as I figured it still might not handle the high Southern California summer heat so well, so I decided to try Volvo PN 1357433, the tropical (heavy duty) version of this fan clutch. It's an original Volvo item, made by Aisin. I was pleasantly surprised by the result... it pulls noticeably more air when needed. This clutch is only slightly higher in price than a standard type. Buy it from Dave at Barton Harness.

Electric Cooling Fan Operation.

Electric Main Cooling Fan Basics. [Dave Stevens] For 900's the two speed electric cooling fan is always controlled by the AC pressure sensor switches whether the ignition is on or off. When the engine is running, the electric cooling fan (low speed and high speed) is primarily controlled by the ECU using the block temp sensor for input. You won't find any fuses at the dash, it's only fuse protected at the battery junction box.

For the 700-style system the ECU is not involved, it's a single speed fan directly controlled by a coolant thermal switch (upper passenger side of rad). All it needs is the ignition switch at KPII: when the ignition is off, the fan should not run at all. The 700-style system is fully fuse protected at the dash (typically #7 for the fan motor and #9 for the relay control).

Electric Fan Won't Turn On. [Symptom:] Engine overheats in 940 while sitting in traffic. I have an electric fan on the front of my radiator. I have never seen it come on - What triggers this fan to come on? [Diagnosis:] Before you buy a new fan be sure the fan is the problem. The engine "will" overheat standing still in traffic if the fan doesn't turn on to keep the water temp cool enough, especially if the A/C is on. Make sure the fan has not seized first . In 740s and some 940s, there is a thermostat switch on the top of the radiator on the passenger side with two wires attached to it. One wire should have voltage to it at all times (engine running). The other wire goes to the fan. If the one wire is hot touch the two together or carefully short them with a screwdriver and the fan should turn on. If the fan works then you probably need a new thermostat switch. If the fan doesn't turn on and it has a proper ground then you probably need a fan. Or remove the connectors,, clean and reconnect them. In later 940s, the coolant fan is controlled by either the high and low pressure air conditioning sensors on the condensor outlet and the ECU block temp sensor: there is no independent radiator fan sensor. If the fan fails, check the fan relay behind the left side headlight first.

Electric Fan Will Not Shut Off.

[Dave Stevens] On the 900's the electric cooling fan is supposed to run after engine shutdown if the engine compartment remains hot. Depending on how hot it is under the hood, this shouldn't last for more than a minute or so (it may be intermittent). There are two pressure sensors together on the bottom end rail of the AC condenser (passenger side, behind the bumper skirt). They're ceramic and look a lot like an injector. One is for low speed fan operation (the greyish one) and the other for high speed fan operation (the brownish one). Note that if the AC system has lost its charge then the fan will not operate after engine shutdown. This shouldn't be allowed to continue as the cooling system pressure can rise, unnecessarily stressing the radiator and enough to vent at the reservoir cap and slowly lower the coolant level. If you can't find these pressure sensors and the owner's manual indicates the fan relay is in the relay tray then you have the earlier 700-style system.

For later 900's, if the fan continues to run forever after engine shutdown then that's normally indicative of a bad (shorted) relay, but there's always a slim chance a pressure sensor switch has failed, a relay control wire is pinched and shorting to a ground wire in the harness or to chassis ground, or a connector is on the wrong pressure switch. The relay control wires are Blue-Black (low speed) and White-Black (high speed) running from the relay to both the ECU and to the AC pressure sensors. Pulling the center connector off the relay will remove the ECU from the equation as well as the pressure sensor switches. This will diagnose a bad relay if the fan continues to run, otherwise start isolating relay control wiring problems including bad pressure sensor switches. Pulling the connectors off the sensor switches will diagnose a bad sensor switch. Make sure neither connector with the above mentioned wire colors has been accidentally connected to the violet colored AC pressure switch on the same rail.

For the 700-style system, if the cooling fan runs at all after shutdown then that's almost certainly a bad relay. For 900's the relay (black, with three connectors going into the bottom) is under the hood on the rad housing near the battery (driver side for turbo's, otherwise passenger side). For early 700's the relay should be leftmost in the front row of the relay tray or later 700s on the passenger strut tower. In all these scenarios we're only talking about a bad relay that's stuck open or internally shorted. A bad relay could also be dead resulting in no cooling fan at all -the dash temp needle will climb into the red zone in such a case.

Diagnosing Radiator Temperature Sensors in 700 and early 900 Models. [Response: Bob] Check the temp sensor in the corner of the radiator(pass side) with an ohm meter. With cold engine it should be open. Sometimes they stick closed. If it's bad, be sure to use a new seal when replacing. [Response: Chris Mullet] If you disconnect the wires at the radiator sensor and the fan stops, then the sensor is bad as Bob described. If it keeps running with the wires disconnected, then it is probably the relay. That relay is one of the two mounted on the forward side of the RH shock tower or in later 940 cars, it is a larger relay mounted behind the left side headlight. The other identical relay on the shock tower is the Radio Suppression Relay which feeds juice to the ignition system.

Auxiliary Electric Fan. [Inquiry] I've had my 1989 740 for a year and just yesterday at the muffler shop, while the car was up on the lift, I peeked in the front end, and lo and behold there, in all its glory was an electric fan in front of the A/C radiator. However it never has turned on, that I know...How do I test it to see if it works?, where is the wiring to the sensor that turns it on? [Response: Abe Crombie] On an 89 740 model that fan is triggered just for overheat by a switch in tank of radiator that turns on relay on strut tower that feeds power to fan. If it is a 760 then the relay can be triggered by the aforementioned switch or by a ground out of air conditioning control unit if the outside temp is over 92 F +/- and you are below 8 MPH and the a/c compressor is engaged. To test the fan, find the switch on right radiator end tank and pull back the rubber sleeves covering wires and short the two terminals together with a small screwdriver. Key must be on. If this doesn't make the fan start then go to the relay and check for power supply on one of the two large gauge wires (one is feed and one is to fan motor, so one should be hot). If power is found then disassemble and inspect for cracked solder in relay and repair as needed.

Electric Fan Conversion. [Procedures and results:] installation in a 87 745 ti:

Selection: I bought a Mr. Gasket high performance electric fan, 16 inch, heavy duty plastic with ring shroud. this was about 95 bucks. I also bought an adjustable thermostat kit for about 25 bucks. It had a name brand, I think Flex-a-lite or Therma-cool, but it was universal in its application. some members suggested getting the fan and related items from a new 92 or newer 7/900 but i did not have the time to investigate and I do not know of any u-pick-it type salvage yards in the New York Area (anyone know of any?? i would love to check one out.) The fan I bought pulls 1900 cfm on 10 amps. Similar options are the Flex-a-lite, or Perma-cool. A high end option is the Spal fan which pulls 2300 cfm on 23 amps and has a thermostat that connects directly to the cylinder head but the cost is higher, 155+55... I don't know if one needs this kind of air pull but your call.

Swap:

- I first slackened the tension of the water pump belt.
- Then I removed the clutch fan. there are four 10 mm nuts. I had to loosen each one before I could pull the fan away from the pulley sufficiently to be able to spin the nuts completely off. remove two screws holding shroud to top of radiator. Off came the fan and shroud.
- I removed the four studs and replaced them with 6 mm x 1.0 bolts, 12 mm length, 10 mm head. with a lock washer, these bolts fit perfectly. If you never removed a stud before, put two nuts on the exposed thread (do not use the original nuts as the flange prevents good wrench grasp). tighten the nuts against each other. then try to remove the inner-most nut. since it is tightened against the other nut, turning it forces the whole stud to turn and spin out.
- Tighten the belt.
- I disconnected the inlet and outlet of the intercooler and the radiator/intercooler hold downs. out came the intercooler.
- Position the fan closest to the middle of the radiator in hope of being able to re-install the oem shroud (I cannot see how this could hurt). test fit the shroud. if it will work, keep the shroud in place as you install the fan or better yet reinstall the shroud and then the fan. (Once the fan is in place, it is a tough fit to get the shroud back in place.)
- The fan I bought had the four nylon rods with nylon lock washers that push on. they work like a two piece zip-tie. Once one, they cannot come off without breaking them. Position the fan and slide the nylon rods thru the fan holds and through the radiator. slip on the lock washers. Use the rubber gaskets as required to protect the radiator on both sides.. do not over tighten. four snug nylon connectors will hold the fan very well. i used them years ago when i added a tran-cooler to my 72 mustang and it held without a problem. Others have suggested facing a better bracket. Your call.
- Once the fan is in place, re-install the inter cooler, hoses, and radiator hold down brackets.
- Regarding the thermo, my understanding is that there are three main types. One contacts the coolant in the cylinder head or thru the radiator, one is just a probe that extends thru the rad fins, and one (like mine) has a probe that gets inserted into the upper rad. opening, bends around the opening and gets sandwiched between the opening and the rad house. They supplied a rubber gasket that has a grove in it. The gasket goes against the rad. neck, and the copper tube attached to the probe lays in the groove. the gasket makes for a smoother transition around the tube in an effort to prevent a leak around the tube. It also protects the tube as one tightens the hose clamp around the radiator hose

and neck. The probe tube is attached to a thermostat which I connected to the radiator rail to the right of the radiator behind the lights above the battery. Mine is an adjustable thermo from 180-240 degs. I am still playing with the setting.
Wiring: attach the fan ground wire to the thermostat. Get the wires straight, one is for power, one is for ground depending on what direction you want the fan to turn, i.e., puller or pusher. From the thermo connect to any good ground. you have options regarding the power supply.
Connect to a constant power supply if you want the fan to work regardless of ignition key position. This will allow the fan to continue cooling after you have shut off the car. if you have the thermo set low or it fails, the fan could drain the battery. Or, connect to a power supply that is only powered when the car is running (actually when the key is in the run position...) With either power supplies, use an in-line fuse (I am not sure how one decides the fuse amps to use. maybe a reader can advise)

Other options: include a switch to customize when the fan will or will not work depending on where it is positioned and whether or not it provides its own power supply.

See also Dave Barton's discussion of electric fan conversions in 240 and 740 cars.

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960 B6304 Coolant Loss: Coolant Cap At Fault. [Inquiry:] I'm a little concerned about the accounts of casting porosity in the 6 cyl block or head. This would certainly explain my regular loss of coolant. No external leaks, no WP seal or gasket leaks, heater core seems OK (no smell in car, no coolant in condensate rain) no coolant indications in engine oil or ATF. Runs fine so far. Could it be leaking outboard of the exhaust valves and vaporizing in the manifold? I assume this would kill the cat or O2 sensor after a while. But no white smoke shows. Coolant has to be going somewhere and it is doing so at the rate of about a pint a week. In winter. Perhaps more. This engine would fry and bend like a hot dog if it ever got seriously dry. Any ideas? [Response: Tom Irwin] Relax! The block porosity issue was limited to about the first 10,000 units off the line in model year 1992, only! If it was leaking into the oil, your crankcase would be full of mayonnaise, right? Per chance, Greg, do you have a Grey plastic pressure cap?? Hmm? If so, you need a Green one. My wifes 940 and my 960, each with grey caps, failed within 6 mos. of each other. They tend to get little hairline cracks in the threaded portion. They spittle and sputter and ooze coolant ONLY when at temp. and pressurized. Check it out carefully. FWIW, Stant company is selling the new green Volvo caps for half what the dealer wants, under their own name. Also, you change your coolant right? Volvo Type C blue only? Don't believe the "Perma-Fluid" crap in your manual.

Homemade Cooling System Pressure Tester. Here's what I've rigged up for both pressure testing the cooling system and bleeding the clutch and brakes: I found an old bottle cap that has the same threads as the coolant reservoir. Then I bought $1.00 worth of tank valves and screwed one into it. If you don't have such a cap, then an old coolant reservoir cap should work even better. When I need to use it, I take the gasket out of the coolant reservoir cap and use it in my "pressure cap". I connect a $5.00 bicycle pump (with built in pressure gauge) to the cap and presto. Since the brake reservoir has the same type orifice, it can also be used to pressure bleed the clutch and brakes.

Test specs: 12 psi(85 kPa) for up to 1986 cars; 22 psi (150 kPa) for 1987+ cars with B2XX engines. Pressure should not drop noticeably in three minutes.

Note: For further information about specific symptoms, fuel injection and ignition components, and sensors, see the relevent FAQ files.

Abbreviations:

AMM Air Mass Meter
ECT Engine Coolant Temperature sensor
ECU Engine Control Unit computer (either fuel injection or ignition)
FI Fuel Injection
FPR Fuel Pressure Regulator
IAC Idle Air Control solenoid valve
TB Throttle Body
TPS Throttle Position Sensor
VSS Vehicle Speed Sensor

General Notes on On-Board Diagnostics in Volvo RWD Cars. Volvo started using self-diagnostics on its Bosch LH 2.4 engine management systems in 1988 on 700 series non-turbo cars and in Regina-equipped cars. Earlier Bosch LH 2.2 and Turbo cars until 1990 had very limited self-diagnostic capability using an LED tester. In LH 2.4 cars, If a system fault occurs, then the "check engine" lamp will illuminate, signifying the presence of a fault code. For every model year using LH2.4 up to and including the '95s (except 200 series DLs and GLs), you can flash out fault codes, as well as perform input and output testing, through the OBD-I diagnostic connector unit simply by inserting a little self-contained probe and pressing a button. You do not need a special scan tool to read codes. As electronic systems were added to more Volvo models, more socket options and even more diagnostic connectors were added. Unfortunately, you cannot use a generic code reader on any of these OBD-I cars: you have to manually extract the codes from the systems as noted below. 1996+ cars have the entirely different OBD-II system which requires a computerized code scanner to read codes through a special data link.

The diagnostic connector units for OBD-I systems are small black rectangular boxes mounted in front of the left-side(driver-side in LHD countries) shock tower. Earlier cars have only one unit ("A"); later cars have two ("A" and "B"). Diagnostic connector "A" contains the test terminal probe (the wire mounted on the side of the box in the picture) used in both A and B along with the test button and the LED readout lamp. In diagnostic connector A, socket 1 is for the electronic transmission (if your 960 or

90-series car has the AW30/40), socket 2 for fuel injection or Motronic, socket 3 for ABS, socket 6 for ignition and socket 7 for the instrument cluster. If the 1992+ car is so equipped with connector B, socket 1 is for the climate control, socket 2 for cruise control, socket 5 for the SRS and socket 6 for the memory seats.

For later 1996+ OBD-II equipped cars, the diagnostic connector was changed to an electronic data link and moved from under the hood to in front of the shifter in the console. As a result, you need a computerized scan tool to do everything from checking for codes to resetting the maintenance light. Maintenance light resetting, by the way, was returned to a push-button method in the very late '90s.

Note that 200 series DLs and GLs have self-diagnostic capability only for fuel and ignition control. All other systems except 1990-93 SRS require a proprietary tool. For '90 to '93 models with air bags, just jump a terminal to ground to get codes out of the system.

Can't Obtain an OBD Code? [Inquiry] I tried obtaining a fuel injection diagnostic code and can't even get 1-1-1. [Response: Chris Herbst] I have run into a LOT of Volvo products with bad diagnostic readout units, usually caused by corrosion. While it is possible that there is no signal TO the diagnostic unit, it is just as likely that either the connection in the terminal, or the connection TO the unit from the ECU computer, is bad. You should try cleaning those connections, and if necessary you can jiggle the connections until you DO get proper readings. I've never had it where I wasn't able to at least read codes and reset the computer, although sometimes it was when I was squeezing the connections into the diagnostic readout unit, or jiggling them around. While your problem could be the ECU, more likely it is corrosion or a bad connection, especially if the engine is operable.

Does the OBD Code Pinpoint All Problems? [Editor] Absolutely not: the earlier OBD-I systems are quite crude and provide a hint only. Coolant temperature and knock sensors, for example, can fail without any OBD codes being set and the only real test is further diagnostics.

Fuel Injection and Ignition Diagnostic Procedures in Bosch LH-Jetronic 2.4+, Regina, and EZK 116/REX 1.

The following section describes the onboard diagnostic codes for the Bosch LH2.4 and Regina fuel injection and EZK 116/Rex1 ignition systems used on later 1988+ 2XX, 7XX, and 9XX Volvo cars. If you have the Bosch LH2.2 or earlier systems, you do NOT have OBD capabilities and will have to diagnose sensor and performance problems using traditional manual techniques.

The later fuel injection and ignition systems incorporate a built-in diagnostic subsystem that is able to test various sensors and fuel injection or ignition components and report the results. This diagnostic system is located behind the driver's side strut tower in the engine compartment with a readout box with several functional modes. 940 cars have two boxes: "A" and "B"; the former is used for engine diagnostics and ABS; the latter for SRS and cruise control. If fault codes related to the emission system are registered, the "Check Engine" lamp on the instrument panel is lit. The test cable is mounted to the side of A.

There are three OBD diagnostic test modes (DTM):

1. DTM 1. The fuel injection ECU continually checks the following when the car is being driven: ECU internal functions; oxygen sensor and mixture; ECT sensor; AMM; battery voltage; TPS; rpm sensor signal from the ignition ECU; speedometer signal; knock signal from the ignition ECU (except B230F and B204FT); IAC valve. The ignition ECU continually checks its own functions; the knock sensor; fuel system load signal; rpm sensor; ECT sensor; and EGR controller and temperature sensor signals. A fault in any of these causes a trouble code in DTM Mode 1. If it is emission related, then the "check engine" lamp is illuminated on the dash.
2. DTM 2. The ECU control module, activated through the diagnostic test box button by pressing it twice, tests specific signals from sensors when it is activated with the test box button: TPS in full load or idle positions; engine speed signal from ignition ECU; air conditioning control and compressor OK; engine speed compensation for auto tranny OK. The diagnostic box responds with a flashing code if it receives the signal when the sensor is activated.
3. DTM 3. This mode, when it is activated through the diagnostic test box button by pressing it three times, tests the signals to various control components: engine fan half and full speed; injectors; IAC valve; carbon filter solenoid; cold start valve. Whether the component is operating is ascertained by listening or feeling it.

To operate the diagnostic system, open the A box cover and insert the end of the test cable mounted on the side of the box into either socket 2 for LH 2.4/Motronic 1.8/Regina fuel injection diagnostics and component or sensor tests or socket 6 for EZK 116 ignition or California EGR diagnostics. Place the ignition key in the ignition lock and note where key position II "KPII" is on the switch. To operate the system:

1. Diagnostic Test Mode 1: Fault Code Retrieval

- Place the cable into socket 2 (LH2.4/Regina/Motronic 1.8fuel injection test) or 6 (EZK116 or REX1 ignition test) as above
- Turn the ignition ON to KPII without starting the engine
- Select Mode 1 by pressing the button once and holding for more than 1 second but less than 3 seconds
- The LED lamp will flash in successive series of three digits followed by a three-second pause. If there are no fault codes stored, it will flash 1-1-1 indicating the fuel injection system is operating correctly. (If nothing flashes, see No Code.)
- Count the successive flashes and record the fault code.

- Press the button again.
- Record the fault code. If it is the same as the previous one, then no additional codes are stored. Repeat until all the codes stored are retrieved (maximum of three.)
- Refer to Table 1 for the interpretation of fault codes from the LH2.4 Fuel injection System and Table 2 for codes from the EZK 116 Ignition System.
- Move the cable into socket 6 (for ignition codes from EZK116 or REX1) or socket 2 (for fuel injection codes from LH2.4/Regina) and repeat the above.

2. *Erasing Fault Codes.* After you have retrieved all the Fault Codes in step 1 above, you should erase the system memory.

- Repeat step 1 above and read the fault codes again
- Press and hold the button for more than five seconds, then release it.
- When the LED lights, press the button again for more than five seconds and release. If the LED goes off, then the memory is cleared.
- To test that memory is cleared, press the button again for >1 second and <3 seconds. If code 1-1-1 is returned, then the memory is cleared.
- Repeat step 1 above with the other cable position mode (2 or 6) to erase FI or ignition codes.
- If you cannot erase the code, yet you feel the problem has been fixed, then turn the ignition off and disconnect the battery ground for a few seconds. This will clear all the codes. After starting the engine, if the code does not reappear, then you've fixed the problem. If you obtain another code, then you've still got the fault.

***3.* Diagnostic Test Mode 2: System Sensor Signal Test**. This tests whether signals are received from certain sensors and switches. If they are, then a code flashes so indicating it.

- For vehicles equipped with air conditioning, turn the a/c control to "on."
- Turn the ignition ON to KPII and install the cable into socket 6 for ignition-related tests.
- Press the button two times for >1 and <3 seconds each. The LED lamp should flash rapidly. (If nothing flashes, see No Code.)
- Check the throttle position switch by turning the throttle pivot wheel slightly from within the engine compartment. The LED should go out and then flash code 3-3-4 which indicates proper operation of the TPS. If no code is flashed and the lamp keeps flashing, the TPS is faulty.
- After the tests, the LED should keep flashing.
- Remove the ignition coil center lead and crank the starter motor; the engine will not start but it will turn over. The LED should go out, then flash 1-4-1 for the RPM sensor. If no code is flashed and the lamp keeps flashing, the RPM sensor is faulty. Reinstall the coil lead and turn the ignition key ON to KPII.

- Install the cable into socket 2 for fuel injection-related tests.
- Press the button two times for >1 and <3 seconds each. The LED lamp should flash.
- Activate the following sensors. If the LED diagnostic code shown (*note: this is not a fault code*) is present then the sensor or component is OK:
  - TPS OK in full load position (when throttle is moved from full load) 3-3-3
  - TPS OK in idle position (when throttle is moved from idle) 3-3-2
  - RPM sensor signal from ignition OK 3-3-1
  - A/C control on/off OK (when a/c switch is depressed or released) 1-1-4
  - A/C compressor start OK 1-3-4
  - Engine idle speed compensation for automatic tran OK 1-2-4 (depress the brake pedal, move the selector to **D** and then to **N**.)
- Exit Mode 2 by switching off the ignition.

4. Diagnostic Test Mode 3: Injection System Component Activation Test

- Turn the ignition ON to KPII and install the cable into socket 2 for fuel-injection-related tests.
- Press the button three times for one second each time (waiting between >1 and <3 seconds before pressing again)
- The diagnostic unit then sequentially tests the following components: engine coolant fan (if equipped), fuel injectors, idle air control solenoid valve, carbon filter solenoid valve (if equipped), cold start valve, radio suppression relay and fuel pump. No code is produced: you have to listen or feel each in turn to make sure it is operating.
- Exit by switching off the ignition.

5. Diagnostic Test Mode 3: EGR System Component Activation Test (if so equipped)

- Turn the ignition ON to KPII and install the cable into socket 6 to test the EGR system controller.
- Press the button three times for one second each time (waiting between >1 and <3 seconds before pressing again)
- The diagnostic unit then tests the EGR system controller which you can hear or feel. No code is produced.
- Exit by switching off the ignition.

Table 1: **Bosch LH2.4 and Motronic 1.8 Fuel Injection Fault Codes** (* denotes Check Engine lamp goes on). Where the Motronic 1.8 codes are different from LH 2.4, the *differences are shown in blue italic.* Read these from socket 2. See Table 3 below for Regina fuel injection codes.

Fault Codes	LH 2.4 Fault Condition	LH 2.4 Causes of Fault	LH 2.4 Symptoms	*Motronic 1.8 Fault Condition*	*Motronic 1.8 Causes of Fault*
1-1-1	No faults	N/a	N/a	*Same*	*Same*
1-1-2	Fault in FI control unit	FI module fault	None	*Same*	*Same*
1-1-3*	Fuel trim (lambda control) too lean or rich	Mixture incorrect; O2S wiring fault	High fuel consumption	*Fault in Injector 1,2,4*	*Fuel Injector*
1-1-5	*Not applicable*	*NA*	*NA*	*Fault in Injector 3,5,6*	*Fuel Injector*
1-2-1*	Faulty signal to/ from Air Mass Meter	Wiring fault to or in AMM	Various driving problems; fuel consumption	*Same*	*Same*
1-2-3*	Signal missing to/ from coolant temp. sensor	Wiring fault to or in ECT sensor; grounds corroded on intake manifold or engine	Difficult to start engine when cold	*Same*	*Same*
1-3-1	Ignition system RPM signal missing on starting	Wiring fault or RPM sensor bad	Engine will not start	*Same*	*Same*
1-3-2	Battery voltage too low/high	Poor battery or charging system	No faults evident	*Same*	*Same*
1-3-3	Throttle switch idle setting faulty or grounding fault	TPS failure or maladjusted	Above-normal idle speed	*Same*	*Same*
1-4-3	*Not applicable*	*NA*	*NA*	*Front knock sensor signal missing or faulty*	*Front Knock sensor*
2-1-2*	Signal missing/ faulty from oxygen sensor	Wiring fault to heated O2S sensor	High fuel consumption, driving problems	*Same*	*Same*
2-1-3	Throttle switch full load setting faulty or grounding short	Wiring fault to TPS or TPS failure	No faults evident	*Same*	*Same*

2-1-4	*Not applicable*	*NA*	*NA*	*Ignition system RPM signal missing sporadically*	*Wiring fault or RPM sensor*
2-2-1*	Fuel trim (lambda control) too lean at part load	Lean; air leak; low fuel pressure; bad AMM	Engine stops when starting from cold; high fuel use	*Same*	*Same*
2-2-3	Signal missing to/ from idle air control valve	Circuit fault to IAC or faulty IAC valve	Engine difficult to start; low idle speed	*Same*	*Same*
2-3-1*	Fuel trim (lambda control) too lean or too rich at part load	}If too lean: air leaks, low fuel pressure, bad sensor	}Engine stops when starting from cold; high fuel use or	*Fuel trim (lambda control) too rich at part load*	*Oxygen sensor*
2-3-2*	Fuel trim (lambda control) too lean or too rich at idle	}If too rich: high fuel press., leaking injector	} various driving problems	*Fuel trim (lambda control) too lean at idle*	*Oxygen sensor*
2-3-3	*Not applicable*	*NA*	*NA*	*Idle control outside range*	*Idle speed control*
2-4-1	*Not applicable*	*NA*	*NA*	*EGR system flow too low*	*EGR vacuum booster*
2-4-3	*Not applicable*	*NA*	*NA*	*TPS throttle switch signal absent or faulty*	*Throttle position switch (TPS)*
3-1-1	Signal missing from speedometer	Speedo wiring or instrument cluster wiring faulty	Idling problems	*Same*	*Same*
3-1-2	Signal missing for knock-related fuel enrichment	Wiring break between EZK terminal 4 and FI #28	No faults evident	*Same*	*Same*
3-1-4	*Not applicable*	*NA*	*NA*	*CMP camshaft sensor signal absent or faulty*	*Camshaft position sensor (CMP)*
3-2-1	Cold-start injector signal shorted or missing	Wiring break to cold-start injector or fault in injector	Cold-start problems	*Same*	*Same*

3-2-2	Air Mass Meter wire burn-off signal absent or faulty	Wiring break between FI terminal 8 and AMM #4	Various driving problems due to dirty AMM wire	*Same*	*Same*
3-4-4	EGR temperature signal absent or faulty	Wiring break or fault in sensor	B 204 FT/GT engines only	*Same*	*Same*
4-1-3	*Not applicable*	*NA*	*NA*	*EGR temperature sensor signal missing or faulty*	*EFG temperature sensor*
4-3-3	*Not applicable*	*NA*	*NA*	*Rear knock sensor signal missing or faulty*	*Rear Knock sensor*

Table 2: **EZK 116 and Regina Rex Ignition Fault Codes** (* denotes Check Engine lamp goes on) (REX 1 ignition system codes are shown in italic.) Read these from socket 6:

Fault Codes	Fault Condition	Causes of Fault	Symptoms
1-1-1	No fault detected	N/a	N/a
1-4-2*	Control module fault	EZK ignition control module faulty	Engine runs in limp-home mode
1-4-3*	Knock sensor signal absent or faulty	Faulty wiring to/from/in the knock sensor	Poor acceleration, low power, high fuel cons.
1-4-4*	No load signal from fuel injection system	Bad fuel injection relay; faulty wiring from LH to EZK; bad LH module	Engine lacks power; stalls; doesn't start or is jerky
1-5-4*	EGR system flow too high	Faulty EGR valve or controller, wiring; engine thermostat	Engine idles unevenly
2-1-4	RPM sensor signal absent intermittently	Faulty RPM sensor, wiring or incorrect installation	Engine will not start; runs rough; overheats
2-2-4	Engine coolant temp (ECT) sensor signal absent or faulty	Faulty wiring or ECT sensor	No fault symptoms evident
2-3-4	Throttle Position Switch (TPS) idle signal faulty	Faulty wiring or TPS; TPS adjusted incorrectly	Poor hot starting; poor idling; limp-home operation
2-4-1*	EGR system flow too low	Faulty wiring, EGR, EGR vacuum or controller; EGR temp sensor	Poor idling

4-1-3*	EGR temperature sensor signal faulty or absent	Faulty EGR temp sensor or wiring	No fault symptoms evident
3-3-4	*Throttle Position Switch (TPS) in idle position (REX 1 only)*	*Faulty wiring or TPS; TPS adjusted incorrectly*	

Table 3: **Regina Fuel Injection Fault Codes.** Read these from socket 2:

Fault Codes	**Fault Condition**	**Source of Fault**
1-1-1	No faults	
1-1-2	Fault in control unit	FI control unit
1-1-3	Fault in injector	Fuel injector
1-2-1	Signal missing or faulty to/from pressure sensor	MAP Pressure sensor
1-2-2	Signal missing or faulty to/from air temperature sensor	Air temperature sensor
1-2-3	Signal missing or faulty to/from coolant temperature sensor, possible grounding short	ECT Coolant temperature sensor
1-3-2	Battery voltage too high/low	Check battery and charging system
1-3-3	Throttle switch: idle setting faulty, possible grounding short	TPS Throttle switch
2-1-2	Oxygen sensor signal missing or faulty	Oxygen sensor
2-1-3	Throttle switch: full load setting faulty; possible grounding short	TPS Throttle switch
2-2-1	Oxygen sensor not operating	Oxygen sensor or intake air leak
2-2-2	Fault in fuel injection relay	Fuel injection relay
2-2-3	Signal missing to/from idle valve	IAC Idle air control valve
2-3-1	Self-adjusting oxygen sensor not operating	Intake air or fuel system
2-3-2	Self-adjusting oxygen sensor not operating	Intake air or fuel system
2-3-3	Idle valve closed	IAC Idle air control valve
2-4-1	EGR system malfunction (California cars)	EGR vacuum booster
3-1-1	Signal missing from speedometer	Speedometer signal
3-2-1	Signal missing to/from cold start valve	Radio suppression relay
4-1-3	EGR temperature sensor circuit (California cars)	EGR temperature sensor

OBD-II Scanners and Tools for 960/90 Cars. Here are sources of OBD-II scanners and PC-based scantools for 960 and 90-series cars using OBD-II protocols:

- Freediag: Freediag is a suite of vehicle diagnostic protocols and an OBD II (mostly) compliant Scan Tool, currently for Linux platforms.
- Automotive Electronics Services: Suppliers of a variety of electronics and scan tools, including adapters and software for PDAs and laptops
- OBD Auto Diagnostics: Makers of a simple interface box to read codes on a laptop.
- OBDII Vehicle Scan Tool: Software interface and OBDII manager for Windows
- OBDScan: Interface and software for Windows laptops or Palm PDA.

Other information, buying guides, and links are found at:

- AutoTap: Buying guides and basic information on OBD-II

[Tip] I purchased a $99.00 OBDII code scanner for the '96 and newer 960's from http://www.ghg.net/dharrison/obdscan.html I received a ISO9141-compatible device that connects between the OBDII connector on the car and the serial port on a PC. It arrived today and I installed the software on my laptop (3 diskettes) and took the unit out to my '96 960 wagon. I connected it up to the 960's OBDII port and started the program on my laptop. When I turned on the ignition, the scanner successfully connected to the ECU and they started communicating. At first, it appeared that although it was telling me that the MIL lamp was not on and that I had no trouble codes set, it did not provide a list of parameters that I could monitor in real time... The instructions mentioned that some cars start the OBDII communications with the transmission ECU, and that's what appears to have happened here. There is an on-screen button you can toggle to "Change ECU's". Once I toggled this button, the engine ECU came on-line. I'm very pleased that for $99.00 I now have a tool that can monitor a number of engine parameters, report OBDII trouble codes and reset the MIL lamp.

Fuel Injection and Ignition Diagnostic Procedures in Earlier Bosch LH-Jetronic 2.2, EZK 102/115/117/118 for B280/B200/ B230FT.

§ Using test diode #5280, connect the LED to the test terminal (yellow/red lead, usually by left front wheel well), and the red lead to the positive battery terminal.

§ Turn ignition on, do not start car. LED should be illuminated.

§ Start car.

B23FT (EZ-102K): Rev engine past 3000 RPM (light should turn off) and allow it to idle around 1000 RPM. Watch for flashes.

B200E, B230 E/F/K, B280 E/F (EZ-118K, EZ-117K, EZ-115K): Slowly rev engine past 700 RPM (B280) or 920 RPM (others).
Light should turn off. Drive car (high and low load conditions). Then, quickly rev engine past 2500 RPM (to check the knock
sensors, B280). Make sure to reach full throttle, and to rev past 3150 RPM (B200/B230). Watch for flashes for at least
three minutes.

EZ-102K codes:

1 flash: Maximum timing retardation reached (9.8 degrees)

2 flashes: Low battery voltage

3 flashes: Fault in control unit (knock sensor circuit), replace ICU.

4 flashes: Fault in knock sensor or wiring.

5 flashes: Faulty load signal from fuel injection ECU

EZ-115K codes:

1 flash: Knock occurred.

2 flashes: Faulty signal from temperature sensor

3 flashes: ---

4 flashes: Faulty signal from knock sensors, or ICU knock detection circuit faulty

5 flashes: Faulty signal from #1 cylinder detector (#1 spark plug lead)

EZ-117/118K codes:

1 flash: Maximum timing retardation reached under full throttle acceleration

2 flashes: Temperature sensor fault (B230K only)

3 flashes: Maximum timing retardation reached at idle or > 3150 RPM

4 flashes: Faulty load signal from fuel injection ECU (engine at part load, not idling)

5 flashes: Insufficient advance at idle (B200E/B230E/B230K only)

6 flashes: Insufficient advance (B230K only)

Engine: FI and Ignition Computers

Abbreviations:

AMM Air Mass Meter
ECT Engine Coolant Temperature sensor
ECU Engine Control Unit computer (either fuel injection or ignition)
FI Fuel Injection
FPR Fuel Pressure Regulator
IAC Idle Air Control solenoid valve
TB Throttle Body
TPS Throttle Position Sensor
VSS Vehicle Speed Sensor

Symptoms of Bad LH 2.4 ECU. See also Engine Failure/No Start: Bad ECU

Common symptoms of a failing LH injection module:

- Engine will not run at idle
- Air-fuel mixture is too rich (this can damage catalytic converters)
- No fuel pump operation, but the fuel pump operates when its relay is jumpered between pins 30 and 87/2
- The engine will not rev higher than 3000 RPM
- Engine will not start, spark plugs are dry and the ignition system produces spark.
- Multiple error codes, sometimes randomly generated, despite using known good sensors and components.

Intermittent stalling in 89 760T. The owner of the shop hinted that "late 80s and early 90s 760s have had problems with their computer chips" -- something like $800 plus labor -- OUCH! Has anyone heard of this?] [Response 1:] Yes, very much so...LH 2.4 modules from 1989-1991, maybe 1992 too, have been very troublesome. However, as far as I know, 1989 Turbos still used LH2.2 modules, so I'm not sure that this applies to your car. Also, often when the modules fail, they fail rather radically, such as the car running very rich, or a no-start or cases like that. [Response 2:] I experienced almost identical symptoms for several years. They went away when the ECU on my 760 Turbo had to be replaced because the AC enrichment circuit went south.

Marginal Operation. When mine died it got stuck in diagnostic mode 3, pulsing the injectors every second, which was enough fuel to start the car but not much more. Other cases I've heard of has the adaptive rich code getting set permanently. [Yet Another Opinion:] As a general rule, ECU's don't go half bad, and don't work intermittently: they work fine or they don't work at all. It is wires and connectors that have "off days". [JKordzi]The 561 ECUs have had very high failure rates. Used 951 ECUs (the replacement model) are pretty reasonable now and may be had on EBay or in wreckers' yards for US$50 or so. [Editor] In my case, my 556 ECU vintage 1990 failed in such a way that the car would idle, but any application of throttle to raise rpms above about 1,200 would suddenly cause total injector failure: they would just stop pulsing until the rpms dropped. Changing the ECU solved it.

ECU Diagnosis. First check the fuel injection system and radio suppression relays. Check all the sensor inputs to the ECU at the connector: you can remove the small screw and wire tie on the cover, pull it off, and remove the little "haircomb" plastic piece on the side which exposes all connectors without actually disconnecting the ECU itself. All grounds, power and sensor inputs should be tested at this plug before the ECU is condemned. Is the ECU is getting a signal from the ignition system? How about power from the ignition? Only after a complete diagnosis should you condemn the ECU.

This note is from Car Electronic Service in the UK and applies to: 1988 to 1992 740 and 740 GLE with Bosch Jetronic LH 2.4 fuel injection ECUs part numbers 590/591/594/595. Symptoms...No prior warning, car usually breaks down on road or fails to start when warm through loss of fuel pump relay control. Diagnostic checklist: ACCURATELY Identify fuel pump relay and remove. Now take a small piece of wire to jumper terminals 30 and 87/2 on the relay board (the terminals are identified on the relay module pins). USE CARE. The 2 terminals are the nearest left and middle right pins on the relay board). This +12V jumper should make the car act like the fuel pump relay is ON. If car now starts and runs, take for road test to confirm OK (put on exhaust gas analyser first with catalyst equipped vehicles). IT IS NOT OK to continue to use the car with this fixed jumper feed to fuel pump. If the car runs, then the ECU fuel pump control circuit is bad.

ECU Failure Modes.

Pattern Failure ECUs. [Robert Haire] This info is from pulling and running dozens of ECUs of each number discussed. The bad ones are all LH 2.4 including the 561, with few pink label ECUs surviving. Typically, this is a no start failure. However, I have had two white label 561s that failed recently so they are not a sure thing. I have never had a bad 951 that I can recall. The 16 valve ECUs 928, 571 seem to work fine in these cars too. The LH 2.4 California emission with EGR 556 Volvo original must be atrocious too. Every one I have seen lately is a Fuel injection or Programma rebuild with the old Volvo ECU long dead. The rebuilds seem to be just fine. The only turbo ECU that causes problems is the LH 2.4 563. That one has a steady demand so failure must be fairly common, though not like the non-turbo counterparts as far as I can tell. Possible replacement units are 937 and 967. Other ECU failures may rarely occur but they are much more unusual than those listed above.

ECU Circuit Chip Failure Mode. [Tips from Richard at Elektronik Repair] The main cause of failure in the LH-Jetronic fuel injection ECU is the hybrid circuit. To understand the function of the hybrid, please envision it as a type of interface that converts the 5 Volt signals of the microprocessor to 12 Volts, or 12 Volt signals of the controller to the level lower 5 Volts for the microprocessor. Additional functions such as Lambda regulation, resets and reference voltages are also integrated. The hybrid circuit contains two integrated circuits (ICs) and several discrete components which provide these functions. The ICs are protected by a silicone covering. Over the course of the time, oxygen and water molecules diffuse through the silicone covering and cause oxidation at the chip which eventually leads to a loss in functionality. Unfortunately, the loss of the hybrid circuit functions can lead to the complete loss of controller functionality and thus the engine stops running. When asked how the failure occurred and how it affects the car, nearly 95 % of the time the answer is: "it worked properly when turned off, afterwards the engine would no longer start." Beyond "oxidation" and “turning off your engine"you need to understand these two facts. 1. The age of the controller is the main enemy here, not the actual hours of operation 2. The controller will fail mostly after turning the off the engine. As Murphy’s law dictates, it will fail most often at the place where it will cause you the highest possible inconvenience. If your controller fails, never buy a used or repaired controller that contains an old hybrid chip because then “it will get you again.” The record that one customer holds is three successive failures when purchasing used controllers, each failure came approximately 6 months apart. More information available at info@electronikrepair.com

[Richard Keys] One cause for ECU failure is due to excessively high stray high voltage levels within the engine compartment or by unusual signals being seen by the ECU`s sensor inputs. If this situation occurs, then it is strongly recommended to replace the high voltage system with new genuine parts (i.e spark plug leads, distributor cap, rotor, coil) and the main engine to body and battery grounds are renewed before fitting a replacement engine management ECU.

ECU Fuel Pump Control Circuit Repair. [Tips from Michael Craig] My 940GL with B230F and LH2.4 suffered from a secondary fuel pump relay supply failure, caused by faulty ECU. This problem apparently required a new ECU - VERY expensive. As I am an electronic engineer by profession, I do not believe there is such a thing as ‘beyond repair' -atleast for electronics! After a lot of web searching, I managed to gather a small amount of information about the Bosch ECU. Armed with this and an oscilloscope, I was able to diagnose that the circuit within the ECU that controls the fuel pump relay had failed. Further research led me to believe this was a fairly ‘standard' fault, as there are a couple of companies here in the UK who specialise in this particular fault, however the prices quoted for repair are still very high - in the order of £200. This motivated me to re-design the relay control circuit, the details of which I will share with you!

The pump relay control circuit functions as follows:

- When the ignition is initially switched on, the pump runs for about 1 - 2 seconds, in order to ‘prime' the fuel rail. If the engine is not started within that time, the pump must stop. You should be able to hear the pump running, so you can test this function by listening! If the engine is not started and the ignition left on, the pump will not run again (see next).
- When the engine is started, the EZK ignition unit sends a series of pulses to the ECU, the rate of which is proportional to the engine speed. When these pulses start, so must the pump. This is how the pump control logic knows if the engine is either starting, running or stopped.
- When the engine is stopped, the pulses from the EZK cease and the pump also stops. If the engine stops for any other reason, it must be assumed that the EZK will also stop, therefore so will the pump.

The 555 timer IC is operated as a slightly modified 'missing pulse' detector. Pulses from the EZK are used to hold the timing capacitor (22uF) in a discharged state. Should these pulses cease, the timing capacitor will charge through 390k and the timer output will change state, turning off the relay drive transistor BC140. The LED and 2k2 are a visual indication of the output state for testing purposes, and could be omitted. The 1uF capacitor ensures that the timer runs on power up, which gives the initial ignition on pump run. The transistor BC107 is really just a switch, and the zener 6v8 limits any spikes from the EZK.

It is possible to construct the circuit using stripboard about the size of a matchbox, which will fit inside the ECU, making a really neat repair. None of the components are particularly critical - most any transistors could be used, however the pump relay draws about 20mA. (This pump relay is actually part of a double relay - two relays in one case - often referred to as the 'LH Jetronic' relay). MOST IMPORTANT - Always disconnect the car battery before removing any ECU connectors. These ECU's are not well protected, and spikes will kill them.

ECU Missing Pulse Detector Workaround [Ed Pennings]

I have been able to test the self-built replacement fuel-pump-relay control unit in my Volvo 940 from November 1990. My car has the OEM Bosch LH Jetronic 2.4 part no. 0 280 000 595. The loss of fuel pump relay control is a well known problem of the Jetronic 2.4 with part numbers 0 280 000 59x. This replacement control unit is the size of a match box and can easily be built inside the ECU housing. I found out that I had to change a few components in order for the unit to function properly: pump on after contact on - then fall off after one second - then on again when starting and motor running (= obtaining pulses from the ignition unit) - and fall off when engine stops running while contact on (for example after a car crash). It is basically according to what Michael Craig wrote above but with a few adjustments. The unit is basically a missing pulse detector. My Volvo is running OK now with the fix installed inside the original Jetronic.

[Tip from Steve] Applies to a 1989 240, with similar electronics as a 740 with a failed Bosch 556:
A lot of folks do this because of a failed fuel computer. I am not sure what model you have so I will tell you how I did it for my 89 240DL. Mine has a White fuel pump relay located under the right front kick panel. I installed another relay to switch ground to the connector on the Fuel Pump relay. This ground source normally comes from the crank sensor or the fuel computer and senses that the engine is rotating; hence the fuel pump will run. You must install another relay. Connect a switched 12-volt source to pin 85 on the "New relay" and a good ground to pin 86 and 30. Then connect a wire to provide the ground when the relay receives a power source to pin 87 on the new relay. This wire will need to be connected to 86/2 on the Fuel pump relay. You should be able to test this before you install the relay with a test light or a ground source, just turn the key on and touch the ground source to the 86/2 pin on the Fuel Pump relay...You

should hear the fuel pump humming. Then just install a relay to provide the ground you need.

Repairing Your Own LH 2.2 ECU
[Tip from Vroom] I have a 1988 765 turbo which uses the LH jetronic 2.2 system, ECU # (bosch) 0 280 000 541. I had an idle problem which was very thoroughly traced to the ECU. The following is what worked for me:
We traced pins 10 and 23 to two transistors: one is the middle one of the three on the heat sink, the other stands alone in a black plastic holder directly in front of the first one. Only one was blown. We looked the part numbers up and cross referenced to a Motorola power transistor (Part # 2N6488 (229)) which seemed to fit the bill and installed it. To remove the transistors from the heatsink I drilled out the peened pins (start small 1/32 then up to 1/8) and used 1/8 aluminum pop rivets to reinstall. It has been working flawlessly for a week now. Again this worked FOR ME on this model ECU; I would hate to cause anybody any problems with info that doesn't work for their particular situation. I suggest that you consult with an electronics whiz before trying this.

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561 ECU Workaround: Swap the Relay and Not the ECU. [Tip from Colin] It has been suggested that it may be possible to overcome the failure of the 561 ECU to operate the fuel pump relay by replacing the (white) L-Jet relay with the (green) K-Jet relay. This type of relay senses engine rotation internally instead of using the ECU. The relay fits the same relay base as the (white) L-Jet one but is wired differently. Reading my latest edition of the UK. V.O.C Technical Driver magazine I found an article by Peter Suchy on how to do just this. With the permission of Jack Cluer (the editor) I have reproduced the relevant part below.

"First remove fuse one! Then remove the wires from the fuse/relay unit, with a slim spike pushed down between the housing and connector release the barb then push the connector out, you will need to bend the barb back out so that it locks when you refit the connector. Then put them back as follows making sure they correspond with the numbers on the relay thick blue/ yellow wire to 87b,pink to87, brown to 30. Run a (blue/red) wire from terminal 15 to to fuse 13. (an ignition controlled source) Run a ground (black) wire from the negative bus on the fuse box to 31 Run a (red/white) wire from the single Red/white wire on the tach to terminal 31b. You will now be left with the black/yellow, red and a looped blue/yellow and brown and white wires. Insulate these and tie them neatly away in the loom where they can accessed if needed. Tape the wire from the instrument panel firmly to the loom and make sure that all wires are neatly fitted. This is to prevent the wires pulling out next time you remove the fuse box! Now refit the relay making sure all the connectors are firmly pushed into the relay base and start the engine! The relay is now powered by an ignition pulse from the coil when the engine is turned over." The above is a bit more work than fitting a new ECU but a hell of a lot cheaper and it retains the original safety feature of cutting off the fuel supply if engine rotation ceases.

Buying a Used ECU. [Suggestions:] It now appears that the lifetime of these ECUs is around 14-15 years: beyond that and the hybrid chips are at risk as noted above. When you buy a used unit, take that into consideration. And get at least a thirty-day or no-DOA ("dead on arrival") guarantee when you do buy the used unit. Paying over $150 for a used ECU is not wise; you can buy a rebuilt unit for $400.To locate units and price them, check out http://www.car-part.com for US and Canada yards.

Buying a Remanufactured ECU. Remanufactured computers are available for most cars including Volvo. Several companies specialize in remanufacturing computers. Most are priced around $400 with guarantees ranging from one year to life-of-the-car. See also the FAQ notes in Parts.

- Micro-Tech, in Louisville, Kentucky (800-688-1588). (sold through NAPA). 12 month warranty.
- Standard Motor Products.
- Elektronik Repair.Com in Mesa, AZ. 3 year warranty
- Programa in Boca Raton, FL specializing in Bosch for euro cars: 561-338-8843. 3 year warranty
- Python Injection in Las Vegas, NV 800-959-2865. 12 month warranty.
- Fuel Injection Corporation in Santa Ana, CA 925-371-6551. 18 month warranty
- United Kingdom: ATP Electronics in Cannock, Staffordshire, UK 44 (0)1543 46746. 12 month warranty
- United Kingdom: Car Electronics Services in Southampton, UK 44 23 80777748. 24 month warranty
- Europe, Africa, Scandinavia: ACM Elektronik Repair.Com in Ravenstein, Germany +49 (0) 6297/929462

760T Engine Stops Dead at 60MPH; Bad Power Stage . [Inquiry: driving down the highway at @ 60mph with 1/4 tank of gas in 100 degree temp in well kept 84 760 Turbo; car just dies, engine turns over but will not start] [Response:] When my '84 760 Turbo died for no apparent reason as you describe, it was in the freezing dark, going over Donner Pass. Everything on the car worked except no spark and the engine wouldn't run. It turned out to be the ignition amplifier or "power stage" module, which is mounted on the inner driver's side(LHD) fender well behind the headlight. It's easy to get to and replace. If that turns out to be the culprit, shop around before buying the new part. Volvo dealers charge several hundred $$$ for this thing, but I found one from an independent parts distributor for about $80 - the identical part made by BOSCH with the same part number on it.

Engine: Turbo

Volvo Maintenance FAQ for 7xx/9xx/90 Cars

Version 7.5

Turbo Operation and Maintenance:

Turbo Idle and Shutdown. [Inquiry:] The figure of a minute or two before shutdown was relevant for the older, non water cooled turbos. Yours ('86) should have water cooling, and thus only require a few seconds. Is this so? [Response:] Yes, it is. The reason the two minute cool down period was required is that so called 'first generation' turbos had oil cooling, but no water cooling. The effect of oil cooling is less, and thus these units ran MUCH hotter than later, water cooled turbos - after a long drive they could be glowing red! This is hot. And it can burn the oil. This does not cause a problem while the car is running, because the oil pump keep recirculating the oil around, so it doesn't stay in the turbo long enough to burn (and it has that nice oil cooler next to the main radiator as well). The problem is that as soon as you shut down the engine, the oil pump stops. If the turbo is still spinning, it has no pressurized lubricating oil. The oil that sits in the turbo stays there and can burn and coke. If solid sludge particles form in the turbo bearing (which is an oil bearing), they can score the bearing journals - kind of like your very own grinding machine inside the turbo.

Enter second generation turbo.These units have the same oil cooled bearings, but they also have water cooling - much like an engine has oil bearings and water cooling. The effect on the turbo is two fold: One, it runs much cooler - doesn't glow red or anything (the exhaust manifold might (read: does...), though - but that's a different story). Aside from that, the water keeps recirculating even after the engine is switched off, due to convection (i.e. hot water rises). Hence, the danger to second generation turbos is considerably reduced.

So, one would ask, what is the reason for the few seconds of idle after starting and before switching off? Simple. In the first few seconds after starting (even after the oil warning light is off!) the oil pressure is lower, and fresh oil may not have reached the turbo yet - and if you race the engine, the turbo will spin fast with insufficient oiling of the bearing - not good. Likewise before switching off: when the engine stops the oil pumps stops immediately. The turbo, however, may keep on spinning for a few more seconds if the engine was racing just before being switched off - simply because of inertia. So again the turbo would spin fast with insufficient oiling. This (and the 1st generation problems mentioned before) is the reason behind the different 'turbo pre- and post- oiler' systems.

This is also why a synthetic oil is best for a turbo car (bearing (sorry) in mind the drawbacks of synthetics) - apart from any other qualities they may have, synthetic oils maintain their properties MUCH better in high temperatures - and while a normal engine normally wouldn't have such high temperatures in it, the turbo does.

[Response: David Farrington] Basically your "Idling down" is merely sitting at idle for 30 seconds or a minute before shutting down the car. The turbocharger can literally get red hot during spirited driving. Naturally we don't normally do that, but depending what our drive has been like - 70 miles at 80 on the freeway is not the same as 5 miles at a steady 25 mph. This idle time gives the turbocharger time to cool down a bit, both with some water cooling and more importantly some oil cooling and circulation. One can purchase and install automatic oil timer pump kits that circulate the oil automatically, but good habits are far cheaper.
First word on owning a turbo engine - change the oil & filter! I'm religious, every 3k miles and the turbo seems fine at 190k miles although I'm starting to think of a pre-emptive turbo cartridge replacement.

Gasoline Recommendations for Turbo Engines. See the link to the Fuel and Lubricants file.

[Other related comments:] . I could pick up some pinging on 87 octane when boost was up, thus switched to 89 and things are much quieter. I'll even go to 92 octane when I know I'll be up on the boost gage. [Editor] To avoid pinging and lower performance, use the specified 91 or 92 octane gasoline.

Turbo Maintenance.

Turbo Components. [David Armstrong] See the photo for a depiction of turbo components.

1 incoming air

Turbo Components

from filter
2 compressed air to intercooler
3 vacuum from intake manifold (drives CBV)
4 compressor bypass valve (CBV)
5 hose with compressed air driving wastegate actuator
6 wastegate actuator
7 wastegate actuator rod
8 wastegate shaft
9 oil supply line mount point
10 coolant drawn into turbo from overflow hose split
11 coolant supply line
12 coolant outlet
13 water pump draws coolant here via lower rad hose split

The only things not clearly shown here are where the coolant supply line connects (180 degrees from coolant outlet connection) and oil outlet line (180 degrees from the oil supply line mount point).

Inspecting Turbo Hoses. [Inquiry] I'd like to clean and inspect my turbo hoses. What can I use? [Response: Warren Bain/John Sargent] Use Simple Green and a soft bottle brush to clean the hoses. Inspect them, especially around the bottoms of the clamps, for softness, cracks, and holes. The small coupling hose for the intercooler is vulnerable and the turbo inlet hose from the air cleaner deteriorates at the underside of the hose at the turbo inlet. The next to go is the outside of the rubber elbow at the throttle body. They get soft and then crack.

Removing The Turbo and Inspecting.
[Inquiry:] I'll be ripping the turbo off the exhaust manifold soon. Is there any bench top inspection I can do on the turbo? Any turbo tips while the turbo is off the car? [Suggestions:]You can do a little pm work here. Take the oil return tube and make it spotless. Any blockage from oil gunk has to be removed. Some turbo shops recommend replacing it; their warranty is void if you don't! Do the same with the oil supply line. An automotive machine shop vat is a good way to make sure they're clean, or a good soak in carb cleaner. Check the rotating assembly by spinning it by hand; it should rotate freely. Look for any obvious signs of contact, or any damage by debris. You'll need to look as far up in the housing as you can. If you are really industrious, match mark the housings and remove them to expose the impellers. Word of warning here: stripped and broken bolts are common here. Also check for radial clearance in the bearings by moving the shaft perpendicular to its axis. There will be a fair amount of play, but it should not move more than maybe a sixteenth of an inch at the end of the shaft (this is a very rough estimate, use good judgment or get someone with experience on this to check it for you). Another area to examine is the waste gate section. Cracks radiating outward from the hole are common and considered to be normal. Only if they have really opened up, or if there are other cracks through the housing, should this piece be replaced. Depending on the mileage and your wallet thickness, consider a new water-cooled center section and ease your worries. For around $400 you can put your housings on a new cartridge; or they will do it for you (recommended). A shop I would recommend is Turbo Engineering Consultants in Colorado; friendly, easy to deal with. Phone number available if you're interested.

Also check out http://www.alliedsignal.com:80/turbos/sitemap/index.html for a sitemap and good general information and pictures related to turbo operation and maintenance.

[More on Turbo Wear Inspection.] [Inquiry] I currently have the Turbo off. The Turbo has 100,000 miles and had no problems before taking it from the car. What can I inspect (without tearing the Turbo apart) to see what the condition is of my Garrett Intercooled Turbo unit. Any information is appreciated. [Response: Thomas] Make sure the compressor wheel has a small amount of play (turbo's have full floating bearings) Check for excessive wear on the compressor blades(not likely), Carefully clean out any coke or sludge in the oil galley's, oil return pipe and oil feed pipe. Check the internal horn passages for cracks. I have a 130K on my turbo, I hope I can get more then that out of it. I wish I knew what exactly makes a turbo last the longest. Anyhow just make sure it's all intact.

Coolant Hoses. [Editor:] My brother bought an otherwise pristine 940T. When changing the oil, he noticed swelling in the coolant hoses going to the turbo oil cooler (the small metal can just behind the oil filter.) These hoses are exposed to oil dripping from the filter housing when the filter is changed. If they fail, all the coolant will rapidly drain out and the engine will seize. SO: when you are changing your oil, take a close look at these two short hoses. After about eight years, you may want to change them, along with all the other coolant hoses and clamps, as a preventative maintenance measure. They are unobtrusive but still critical to engine longevity. See the Cooling System file for more information about radiators, hoses, water valves and other components prone to failure in high-temp turbo engine compartments.

Wastegate Arm Lube. [Tip: Jim] We changed a turbocharger today which had failed in a new and interesting way, to me at least. The car is a 1990 740 with the mitsubishi turbo, and only 170,000 km on it. The rod from the wastegate actuator had seized solid on the pivot where it connect to the arm on the wastegate, which prevented the valve from closing completely onto the seat in the housing. The result is a hole burnt into the casting you can put a pen through and absolutly no boost. The hole looked exactly like an exhaust valve that has burnt due to carbon sticking on the seat. I would think the first sign of a seizing pivot would be excessive boost on first hitting the throttle hard, with the boost leveling off as the actuator forced the valve open, possibly followed by low boost on the quick reapplication of power, as the valve would not yet be closed. A touch of antiseize on the pivot once a year should eliminate any trouble. This is one of those failures that could be avoided easily if only a person knows.

Wastegate Cotter Pin Failure. [Tip: Editor] Remove the small cotter pin clip holding the wastegate actuator rod to the wastegate valve stem occasionally and lube it with high-temp nickel-based antiseize. This clip can rust and fail, breaking off at the edges of the holes and leaving a corroded section inside. This latter piece is a bear to remove. If the clip is rusted, replace it. If you need to drill out the old clip remains, remove the oxygen sensor to gain better access from below and use a Dremel tool with a right-hand drill attachment. Be prepared to use up about five or six titanium 1/16 inch bits on this very hard rod. Replace it with a new clip, a stainless cotter pin, or a piece of stainless wire.

Wastegate Circlip Replacement

Coking Due to Poor Lubrication. [Inquiry] Is coking is the biggest contributor to turbo death? [Response: Herman of Cherry Turbos] A great amount of built up crystalized carbon, or"coking", is definitely the reason behind most turbo failures. Next is poor balance, and the rest are blade erosion on the turbine blades, blade strike and exhaust chemical build-up on the turbine blades. The coking occurs in varying degrees at primarily two locations. In the Garretts it usually occurs inside the bearing housing, or center section, and inhibits oil flow to the hot side bushing. In the Mitsubishis it usually occurs behind the heat shield on the turbine side and eventually presses the shield against the back of the blades and machining material of the turbine away rendering it unbalanced or causing it to sieze. The best oils are full synthetics for reducing this problem however the combustion chamber chemicals suspended in older synthetic will release from the oil at very high temps and "coke" as well. Your best bet is frequent changes, synthetic or petroleum based, to ensure that the oil in the crankcase has a fresh additive package at all times. (The additives are what inhibits wear, evaporation, shear, etc.)

How Does Wastegate Operate? [Inquiry:] This is the first turbocharged vehicle I have owned. My question is how can you tell when the wastegate opens and dumps excess exhaust? Does it open right before the boost gauge goes into the red?

Turbo Wastegate Adjustment. [Inquiry:] Before I start out on my own experimenting, maybe someone can get me going in the right direction. Do you lengthen or shorten adjustment rod? How many turns in or out equates to approximately how much boost? I don't want to grenade

the motor just looking for a little more kick.   [Response 1:] Shorten rod. That preloads the spring that diaphragm is working against inside wastegate actuator. If a rod comes out of the block then lengthen it a couple of rounds when you put in new engine... A couple of turns is about all you should do to not have too much stress on head gasket and other drivetrain parts. The best way would be to adjust so that the max boost in a higher gear at 3500 RPM full throttle is not more than 10 psi (70 KPa). [Response: Caveat] The actuator can normally only be adjusted about +3psi. If you try to get more from it the preload on the spring will be so high that the remaining travel can´t open the wastegate properly. [Response: John Sargent] The best wastegate adjustment instructions are in the Factory Service Manual. Without the service manual, crawl under the car and cut the sealed wire the factory installs to detect tampering. Then remove the external snap ring that retains the wastegate actuator rod end on the wastegate shaft. Loosen the jam nut that keeps the rod end locked on the shaft. Adjust the end in or out as you desire. One turn equals 0.4 to 0.6 psi. Factory boost is set to 6.8 to 7.7 psi. It is easy.
{Response:] If you wish to increase boost, I highly recommend that you either use the Volvo "Turbo +" kit which will adjust the boost curve so that you do not get too much boost at low rpm, and give you higher boost overall, or install the Saab APC system (see the directions on the Turbobricks site). Simply increasing the boost with the control rod will increase the tendency to predetonate or ping, and the control system will back off the spark advance negating any gains you might have made. There are also lots of other things that might be going on that can be mis-interpreted by the knock sensor as predetonation with the result that the timing is backed off and you get less than maximum power. It would be wide to check the engine thoroughly to make sure that everything is working properly. Also, be sure to use high octane gas, and if your area adds methanol or MBTE, I recommend use of a fuel additive like AMSOIL PI to keep the fuel system clean and improve the performance of the fuel.

Preventive maintenance: see the notes on Preventive Maintenance above.

CBV and Vacuum Check Valve Operation.

Theory of CBV/BOV Operation. [Notes from Anthony Hyde] There are numerous names for relief valves fitted to turbocharged engines e.g. Compressor Bypass Valve (CBV) / turbo Blow-Off Valve (BOV) / Dump valve / Vent valve / Relief valve. Described below are two main types and the essential difference between them:

- Compressor bypass valve (CBV) In the CBV case, pressurised air is returned to the turbo compressor inlet for reuse. The valve is open under engine vacuum conditions, and closes firmly when positive (boost) pressure is present in the inlet manifold (or plenum chamber). As you change gear a sudden vacuum condition is created and the valve opens again, directing pressurised air back to the turbo inlet. A CBV is used with Bosch K and LH-Jet injection, as being a closed system, any loss of air for which fuel has already been metered by the movement of the airflow sensor plate, will result in an over-rich condition and possible backfire. A CBV is found on many "OEM" original engine manufactured EFI turbo systems.
- Blow-off valve (BOV) / Dump Valve / Vent valve This valve type features an adjustable

spring design (spring in compression) to keep the valve closed under idle, cruise and boost conditions (eg 0.5 bar). Sudden throttle lift-off (eg 0.8 bar) opens the valve to vent the pressurised air directly to atmosphere (and wooshtssh). Not used with Bosch LH-Jet.

A small diameter hose connects between the intake manifold and the relief valve: changing pressure conditions (vacuum or pressure) will exceed the spring sealing pressure, and the valve will open or close accordingly. Vacuum (pressure less than atmospheric) is formed in the cylinder bore/s when a piston decends on the "intake stroke". Vacuum transfers through the opening and closing intake valves back into the intake manifold, and rises when the throttle plate is fully closed. With a valve closed under boost pressure, a sudden throttle lift-off between gear changes creates an instant vacuum inside the intake manifold that pulls the valve open, momentarily venting boost pressure.

Why vent the pressure? - Primary reason is to reduce strain on the compressor turbine wheel due to compressor surge. Between shifts, or sudden throttle lift-off, the turbine is still spinning fast (but slowing) pumping air at the closed throttle plate, as well as placing strain on the intercooler, hoses and fittings. A CBV / BOV keeps air from flowing backwards over the compressor wheel, allowing the turbine to continue spinning freely. When back on the throttle, boost pressure quickly rises again with little lag. A suitable valve location is just before the throttle plate.

Garrett Turbos. [Inquiry:] I was working on my engine last night and I thought I should check the one way valve on the CBV (compressor bleed/bypass valve)for proper operation. I checked the operation of the oneway valve and it was on backwards, meaning boost pressure was being forced into the CBV. I turned the valve around and took it out for a drive. It bleeds now, but it does it almost all the time while in normal aspiration mode.

1. Is the valve destroyed?
2. I noticed I can adjust the valve. Is it worth doing this or should I go buy the Bosch plastic valve and replace it?
3. How should I adjust the valve to get it to only open at max vacuum?
4. One the one-way valve has been opened and vacuum has opened the CBV, how does it close back up? The one-way valve would seal off and not allow air to go back in to re-pressurize the CBV, right? I am having a difficult time understanding how air would re-pressurize the thing.

[Response: Abe Crombie] That check valve should be installed so that it can pull vacuum on the bypass valve. This is so that on deceleration when the manifold vacuum goes up it opens valve and allows the diaphragm to be moved upwards opening the valve and allowing the boost trapped on lifted throttle to in effect re-circulate in outlet plumbing of turbo. The valve would prevent the boost from reaching the diaphragm of bypass valve when installed properly. The check valve allows vacuum to be pulled and the check valve has a controlled bleed in the reverse flow direction to allow the diaphragm to close in a dampened manner. Reverse check valve and see if all is okay. If it is then nothing else needs to be done. If not you will have to replace the bypass valve.

Stuttering Under Load (Garrett Only):

[Tip from R Tilghman] While driving down the highway with cruise control set, the car will just suddenly stutter. When it happens it feels like the car has reset or maybe an air bubble has passed through the fuel system. It was infrequent and spontaneous. It seemed most common when I had the cruise control engaged and the cc would gas hard, let off, and then gas hard again for some reason (uphill, just engaged cc, etc.). In these instances the turbo needle would be up in the yellow, drop to low black, and then return to yellow. I replaced the check valve and it solved the problem. If you are having this problem pull the check valve (little red valve that sits in the middle of a vacuum hose from the intake manifold to the CBV on top of the engine) aand blow through it both ways. You should get major SOLID resistance (but not full stoppage) going both directions. If you feel a sudden "thwap" as you blow that means the diaphragm inside is probably shot. This applies only to Garrett turbos. [John Sargent] The Garrett CBV is actually a Pierberg unit. When the unit fails you get a "stumble" when you let your foot off of the gas pedal unless it is a very slow and easy release. To test the unit use a rubber hose connected to the CBV and suck on the end of the hose. When you have sucked as much air out of the CBV as you can, stick the tip of your tongue in the end of the hose. Wait a minute and see it it holds the vacuum. If it doesn' hold vacuum, it has a bad diaphram and needs replacement.

Mitsubishi Turbo Note. [Inquiry] Does my '89 740 Turbo Wagon with Mitsubishi turbo have this "check valve"? I know it has a "valve" on the turbo (Bypass valve) but I'm assuming that there's also supposed to be a vacuum check valve on the line between that bypass valve and where it connects to the intake manifold? [Response: John Armero] The Mitsubishi turbos on the late 700 cars do not have the "vacuum check valve".

Replacement Diaphragms for CBV. Various turbo rebuilders carry the diaphragm repair kits for reasonable prices. Check Rick Banas at D&W Diesel (r.banas@dwdiesel.com) at 800-824-0151 for Mitsu diaphragms and some Garretts. Mitsu made several types and the year of the car manufacture mattered. Says he sells a lot of them, below retail, but its still pricey.

Turbo Oil Cooler Maintenance.

Oil Cooler Behind Filter

1. *Aluminum Heat Exchanger (Radiator)*. [Tip] My oil cooler by the radiator sprang a leak on my 91 940 turbo. The top and bottom brackets are rusty (unusual) and when I undid the bolts I found that the bottom (aluminium) leg of the replacement cooler disintegrated. The top legs were also starting to show signs of aluminium corrosion!!! This is due (I think) to contact between the alloy and steel brackets and a poor paint finish on the steel brackets. Both sets of brackets are showing 100% rust coverage and both bottom brackets are rusted into holes! So: check them, paint them and introduce something to stop the action between the 2 metals. [Editor] Check all hoses as well.

2. *Coolant Heat Exchanger by Oil Filter*. [Tip] Replace the coolant hoses (see photo to the right) at the first sign of swelling, since they are exposed to oil dripping from the filter above. Use Volvo OEM hoses from the dealer, not aftermarket or old heater hose stock.

Turbo Model Identification. [Inquiry] Which turbo unit do I have: Garrett or Mitsubishi? [Response: Jim McDonald] The most obvious difference between brands is that the Misubishi has a large "hose clamp" holding it into the exhaust manifold. The Garrett has bolts. You'll also notice the Mitsu has the blow-off actuator on the turbo, rather than in-line. [Justus/Josh Sawka:] Look at the markings on the turbo. a Garrett will have a tag in it about 1" x .5" and the Mitsu has the little tri-star Mitsu icon on it. Garrett has the emboldened words "Air Research" wrapping around the fresh air compressor side. [Roguls:] Volvo used a Garrett T25 turbo on 90+ 740s. Garrett T25 also had an integrated cbv, just like the Mitsu. To identify the specific model, there should be a nameplate on the body of the turbo identifying the model number. See also the photo file showing various models. FCPGroton has illustrated diagrams of turbo configurations: FCPGroton.

Troubleshooting:

Excess Crankcase Pressure in B230FT. [Inquiry:] There seems to be excessive crankcase pressure in my engine (B230FT) I've checked the ventilator under the intake manifold, it is not plugged. Is this the only relief the engine gets from the pressure buildup. What is causing this pressure, the only reason that comes to mind is bad rings. From reading postings it seems that a negative pressure is the norm.
[Response:] I have seen plugged oil traps. Make sure that the oil trap isn't plugged by blowing through it with the oil cap off. Hook a hose to the oil trap where the flame trap goes. Any compression loss into the head or crankcase will cause excessive pressure. [Response 2:] Excessive crankcase pressure is often the result of bad/worn piston rings, or worse; broken piston ring lands (ring lands is the part between piston ring cutouts on the piston). The main reason of this fault is detonation/knocking... To diagnose this problem; take a dynamic combustion pressure check.
Turbo Oil Breather Box Notes: See the link for more detailed information. Also see Michael Ponte's excellent description and illustration at http://www.mikeponte.com/volvo/oiltrap.htm

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Turbo Performance Problems: Basic Diagnostics [Symptoms:] 740T experienced a number of problems: occasionally hard to start, with intermittent rough idle and stalling out; frequent stumble under boost once motor was warm; lack of power. On a cold start, it ran flawlessly, but I never run much boost on a cold motor, so I don't know if it would have stumbled under boost when cold. Despite many FI and ignition components being checked or replaced, the problem continued. Everything had been checked out or replaced (fuel pumps, relays, ignition system, ECU, etc).

Various Vacuum or Intake Hose Leaks:

[Response 1:] The problem turned out to be caused by a VACUUM LEAK in a rubber tube under the intake manifold. The tube only leaked when it was hot, and subject to vibration/movement of the motor. My mechanic has been elevated to "saint of motors." The bright side is we now have all new ignition, wires, ECU, fuel pumps, etc. There is a moral here: "Go ahead and get your hands dirty...really dirty." Unless you know the car's history fully, remove every rubber hose and inspect it closely, even if they are hidden below the intake manifold and throttle body (yes Virginia, that may be a very oily area). A minor vacuum leak there seems to have major consequences with the injection system. The way-high boost TB guys have already found that the main boost hoses can give out and cause poor driveability. I am here to tell you that even with stock boost getting to the local grocery store can be risky if the various minor vacuum hoses develop hidden cracks. [Tip from Chris deCourcy-Bower] If you notice low turbo pressure, reduced performance, hissing noise when accelerating, then check for a split or de-laminating hose. Check ALL of them including the short piece where the air leaves the intercooler. If it turns out to be a damaged intercooler you will need to visit the junk yard. They are not cheap. See the discussion in Special Tools about a homemade leak tester for the intake system.

[Response 2:] I had a poor driveability problem with my 87 760t on take off. Turned out to be a vacuum leak on the big hose from the air box to the intercooler.....and a big dent in the pocketbook since the thing is a preform with a couple other hoses molded into it......$130 or so. I just replace all the vacuum hoses every 5 years or so.
[Response 3: John Sargent] The turbo on our third 740T was not putting out enough boost. I used a pressure gauge (installed with a tee fitting under the dash) to verify what the boost gauge was telling me, the level of boost was too low, about 1.0 to 1.5 psi. I checked all of the hoses from the turbo on, but all were okay. The turbo spun well and did not contact the housing, and it was quiet. The car seemed to drive fine, and seat of the pants performance was okay, but less than the other cars which have the Turbo Plus. There was no black smoke to indicate a too rich mixture caused by a leak after the AMM. The wategate was connected, and not seized. The catalytic convertor was not plugged. It didn't make sense, everything to check was fine, but the boost was still too low. Finally I pulled the rubber line that connects the intake manifold to the boost gauge, and blew on it. Well, you have probably guessed that the rubber line had a hole in it where it passes under the intake manifold. The hole would mostly seal itself under vacuum, but would go wide open under pressure. That was the cheapest turbo overhaul I've done! Always be sure of your tests, and don't jump to conclusions. [Ernest Smith] When my turbo stumbled under boost, my mechanic first put the complete intake under pressure. He found a couple of bad gaskets at the BOV valve, and made new ones to fit.

Tips for Checking Intake Hoses. [Randy Starkie] I had one intake hose leak that I couldn't find until I applied 15psi of compressed air on the end of the hose that connects to the turbo. I made a plug of the correct size and added a Schrader (tire) valve for this test. The plug I use is the cap off of a master cylinder that has a schrader valve in it for flushing the brake systems on my cars. Put the plug in the hose after disconnecting it from the turbo and apply the air. Listen for the leak. Splits are hard to find sometimes without simulating boost with compressed air. [Tip] A crack in a hose may only show up under boost. I found a leak in a guy's hose by having him sit in the car with all brakes on full and in drive. I opened up the throttle under the hood till it was making boost. I could then hear a leak in one of the hoses. See Special Tools for a simple pressure tester design.

Noise and Whining:

[Inquiry:] I'm getting a whine that sounds like a vaccum leak which comes and goes with the turbo. When the turbo kicks in the sound increases incrementally with the increase in boost. Cannot find a leak in any lines, any suggestions. Turbo is still performing and no loss in pickup. [Response: John Sargent] My wife's 86 745T made that sound when the small line to the waste gate came off. The other problem was way too much boost. Check the line. If you have the Turbo+ kit, there will be a tee fitting in the line which connects to the Turbo+ solenoid valve mounted at the front of the air filter. [Response: Abe Crombie] You should also look at the bypass valve. It is the valve on the bracket forward of exhaust manifold. It is plumbed into the turbo outlet hose and the turbo inlet hose. There is a gasket between the valve and the bracket that holds it and the bolts are notorious for loosening and letting the gasket go away.

Low Oil Pressure. See Oil Pump: Wear and Replacement for more information.

Turbo Blows Black Smoke; Poor Acceleration; Hesitation. [Inquiry:] While my 740T used to have great pick up with the Turbo engine, now when I push down on the gas pedal, black smoke comes out the exhaust pipe and it feels like the car is dragging or being pulled back and it stops accelerating. One of the hoses between the turbo and engine has oil in it. Any ideas? [More Symptoms:] On acceleration under turbo boost, the car will lose power and may have black smoke coming out of the tailpipe. [Response: David Tidaback]
Background. This problem may not occur every time it accelerates, but will usually be worse on harder acceleration. The car will run just fine under all other conditions. Initial testing of engine and tuning basics will show everything adjusted and functioning just fine - no problems. Cars manufactured in 1990 and later may output a generic fuel mixture fault code such as 113 or 231, but the MIL will usually not be activated. To understand the cause of this strange behavior, it is first necessary to understand how the fuel mixture control system works. The Bosch LH-Jetronic system (LH 2.1 in 1984, LH 2.2 1985-1989, and LH 2.4 in 1990 and later cars) uses a hot-wire mass-airflow sensor to meter intake air. This sensor is positioned in the intake hose of the turbocharger so that air is metered as it is drawn into the turbo. This means that any loss of air after the turbo will not register at the LH-Jetronic control unit. It will still be adjusting injector duration on the basis of information from the mass-airflow sensor, on the inlet side of the turbo.
Test and Fix. On these cars, it is necessary to carefully check for intake air leaks under pressure between the turbo outlet and the engine. Very often, such leaks will be the result of cracked intake boots or stripped hose clamps that will not show any leakage with the usual tests using propane or brake cleaner with the engine running at idle, with vacuum on the intake system. The system must be pressurized to show leakage (see also Randy Starkie's cheapie intake system pressure tester below).. The greater the degree of leakage, the richer the system will go under turbo boost. One additional note regarding this problem: Testing with the greatest care may not show any leaks, or the leaks may be repaired and the problem will be unchanged. Another failure that can give exactly the same malfunction symptoms is a fuel

pressure regulator that sticks shut with pressure on the vacuum line from the intake manifold, increasing the pressure to the injectors to full pump pressure, which is near 100 psi. To determine if the pressure regulator is malfunctioning, monitor fuel pressure under boost. [Another Response:] Check the hoses and fittings to and around the turbo to be sure none are loose or have leaks, including the turbo compressor inlet hose. This can cause poor acceleration or running rich. The breather box on the intake side of the engine which is hard to get at, if clogged can cause the turbo to blow oil through its seals. If the turbo has lots of miles on it you may have a bad turbo which is blowing oil also. Don't drive with the turbo blowing oil as it will clog the cat converter! When the engine is cold you can take the rubber hose off the intake side of the turbo and see if the shaft has excessive play, or is frozen.

Turbo Blows Smoke: Overfill Oil. I have received several messages from Volvo neophytes relating the same or similar stories: "I went to the quickie lube, where they proceeded to overfill my Turbo-engine oil by [1-2-3] quarts. Just after I started up and drove out, thick clouds of blue/black smoke came out the tailpipe. Now my mechanic says I need a new turbo. What gives?"

I am not exactly sure how to diagnose this, but let me throw out a couple of hypotheses for comment:

1. It would appear that anything restricting the turbo oil drain would cause the unit to overfill and blow oil into the exhaust pipe. If the car were seriously overfilled with oil, this may have an effect on crankcase ventilation, probably starting at the oil breather box drain. So overfilling might clog the breather box, interfere with crankcase ventilation, stop the oil drainage from the turbo, cause the turbo to overfill, and allow this extra oil to be forced out past the turbo seals.
2. Similar hypothesis but the unrelieved blowby increases the oil pumped to the turbo and not drained, causing excess oil in the turbo, increasing crankcase pressure, and forcing this oil out the exhaust.

If either of these are correct, then fixing the problem merely means draining the oil, replacing with the correct amount, and cleaning the crankcase breather system. Oil burning should then stop at once. Why would the turbo unit be damaged? If indeed it was damaged at all (another dealer boat payment due?) Thoughts?
[Response: Abe Crombie] The seals used in turbos are a single piston ring type seal and a labytrinth seal system. The labyrinth deal is simply slinger washers in a cavity through which the oil would have to travel against centrifugal force to leak out. If you overfill engine the oil is restricted in draining back to the hole in side of block because the hole is now covered by oil being splashed up into the drain tube. With no easy path to drain the oil out of the piston ring seal area the oil can be passed through both the intake housing seal and the exhaust housing seal. The flame trap/crankcase breather system being plugged has similar results. [Response: Jim Stephenson] I believe this is the answer. My turbo was overfilled and would blow clouds of smoke. The oil was being burped up through the breather box and would run in to the turbo. Under heavy boost it would drag the turbo impeller down and shortly after that a BIG cloud of white smoke would billow out the back. After I changed the oil no more problems. But what a mess!!! [Response: Rob Bareiss] This experience shouldn't result in a damaged turbo. Mechanical parts don't usually fail due to TOO MUCH oil... The turbo might not pump oil very efficiently, and it could conceivably do something strange if a lot of oil hit the vanes as it was spinning at a high speed, but they're pretty tough little units. I could see damage to a catalytic converter resulting from this. [Contrary Opinion: John O] I've rebuilt my original turbo using IPD's

kit and there's a direct oil feed line running line pressure directly into the turbo unit, which then feeds the bearings. The only thing that keeps the oil in there are the seals. I've honestly never seen this happen, but I think it's possible that if too much pressure got to those seals, maybe one blew out, like the exhaust side? [Response: Dick] You may have messed up the O2 sensor at this point which will generally cause lots of black smoke, at least in my experience.

Slow Throttle Response After Turbo Replaced; Diagnosis. [Inquiry:] Told that my turbo was indeed in a sad state, I opted to have it rebuilt, figuring I'd save some cash. BUT, when I got it back I noticed that the car was slower. I couldn't peel out if my life depended on it. I later found that the turbo was set very conservatively at 5.5 psi, apparently, it was sent out of town to be rebuilt, and the wastegate came back set low. The stock is (or so I have read) 7.5 psi, so I had it pumped up to 8.0, and it hasn't helped. The car is still slower than when I sent it in. When I accelerate the turbo spins all the way up past 2000 rpm, like it used to, but doesn't seem to give any boost until about 2500, at least nothing you can feel. If I start at the bottom of a hill from a dead stop and punch it to the floor, I find myself creeping uphill at a measly 10 miles an hour with the turbo spinning like mad at 2000, and suddenly I am squished into my seat at 2500. Does anyone know what could be causing this delay between the spinning up of the turbo and the acceleration boost it provides? [Response 1: Kevin] I was told by a very reliable source (Garrett) that the reason for a slower car with a new turbo is as follows. The old turbo probably had a lot of play, slop in the bearings, enabling it to spin up very fast, had you been running higher than stock boost, say 12psi, you probably would have noticed poor performance at the top end bacause of the slop. The new turbo is nice and tight, and there is not nearly as much slop, therefore it takes longer to reach boost, tatke it on a long fast trip, thats what I did. I was told that a turbos bearings have to "break in" just like any other engine component. On the way there go 65, on the way back you'll be going 120 uphill. [Response 2: Hunter] I had the same problem. My problem started one day when I was coming home and I had boost one second and the next it was gone. It was like driving a GEO! It turned out that the actuator rod cotter pin had fallen out. My wastegate rod was just sitting there. I attached the rod back onto the bolt and put in a new cotter pin. It solved the problem. Just reach under the turbo and feel, or climb under the car and see if the rod has come off. If this is not the case it is your wastegate, or vacuums. Check all vacuums to the wastegate. You can remove the vacuum from the wastegate and plug it temporarily with a screw. Then try driving it, be very careful with boost. It could be the APC module. My problem started one day when I was coming home and I had boost one second and the next it was gone. It was like driving a friggin GEO!

Lack of Turbo Boost. [Problem: Lack of Turbo Boost.] Thanks to Steve, Paul, George, Doug and Robert for giving me the help in troubleshooting my lack of Turbo Boost.

The Turbo itself spins smooth and there is virtually no end or lateral play. The Oil Accumulator that has been on this thing since day one. The tests made with the new boost gauge placed in-line before and then after the throttle plate confirmed the problem and it was seconded by the removing of the plug in the catalytic converter housing. The cat is plugged tighter than a crab's ass. So now I need a new cat and with that new pipes.

[Another comment:] That's exactly how I got my turbo wagon cheap -- the PO had a new turbo installed (lucky me!) and then, 5000 miles later, it wouldn't go into boost. She thought the new turbo was toast and junked the car in frustration. [Another comment:] I am experiencing similar problems with no turbo boost on my 83 240T. When I bought the car, the turbo was leaking oil like a sieve. I replaced it, and boost was a little better, but just a little. All the other usual things were done such as new plugs, wires, filter, vacuum lines, etc. Still barely getting boost. After reading the posts on BrickBoard, I began to suspect the catalytic converter. I removed the test plug and noticed a lot of pressure from the opening. Drove around for about a mile without the plug, and had a little more boost. I then had car checked a reputable independent Volvo garage, and they confirmed that cat was so plugged it almost "broke their gauge".[More diagnostic comments:] Before you get too carried away, note that at steady state - i.e., constant speed on level ground at 3K in second gear, there will be relatively little boost measured at the MANIFOLD. If you are measuring the boost on the high side of the throttle plate, then it is likely that you have a problem. But if you are measuring the MANIFOLD pressure, then try starting at 3K and flooring it. You should see the boost climb to ~8.5psi until you pass 3700 rpm. Then the boost should jump to about 10.5 psi as the IBS valve opens. IF the boost does not climb smartly and jump quickly at 3700 while you have your foot to the floor, then you have either an intake obstruction, turbo going south, stuck/broken waste gate or waste gate controller, or clogged cat.

Remove the plug at the top of the car, just behind the turbo exhaust housing. Try it again. A noticeable difference indicates clogged cat. No difference indicates turbo, waste gate, or intake plumbing obstruction. Remove intake line from front end of turbo. Use your fingers to wiggle turbo shaft and spin it. Should spin freely and smoothly, there should be SOME lateral play, but NO contact by impellers on housing.

Turbo Overboost. [Inquiry:] Today I experienced something strange, the turbo seemed to be overboosting. I was on the freeway and accelerated to pass another car, it felt as though I had gained 50 more HP. I looked at the boost gauge and the needle was past the end of the boost indicator. Worried I would toast something or send parts flying, I kept off the accelerator for the most part. It definitely felt and acted like the turbo was working overtime. The car was parked for about two hours, and did not misbehave again. I have no idea what my boost pressure is running, but my last gas mileage check was at about 21mpg(mixed hwy/city driving). Anyone have any suggestions on what to expect next, where to look, what to do? [Response:] Check to see if the actuator hose is split or broken off. That will not allow the actuator to open the wastegate, causing the overboost.

Turbo Loses Performance under Boost. [Inquiry:] In my 760 with turbo and intercooler, when trying to accelerate quickly or when driving up a large hill I lose performance the more gas I give it and it blows black smoke out the back. The turbo needle is about at 11:00 when this starts and never seems to get past 12:00. I have not been able to get more that 4000 RPM's out of this car at all except maybe in park. [Response:] Find the leak in the pressure side of the turbo. Mine happened to be in the bypass valve...allen screws back out. It could also be a leaky hose or clamp or leak/hole in the intercooler ...somewhere your engine isn't getting all the air being blown into it and your dash gauge is showing it! The AMM thinks 9 lbs of boost is being fed to the engine and gives the ECU/Injectors the fuel...since a lot less than boost is getting to the engine, you blow black smoke/overfuel. Could also be fuel pressure regulator, but unlikely since it idles, apparently. [Woody Sulloway] My engine was cutting out when the turbo was over 50% boost. As the boost increased the car began to surge- almost like a prolonged miss; accelerate, bog momentarily, accelerate, bog momentarily in a rather rapid sequence. It turned out that a rotten AMM-to-turbo inlet hose was collapsing under high vacuum, limiting air flow into the turbo. [HenryC] In my case, the hose from the AMM to the turbo inlet was soft and had a small rip in it. The turbo sucks air in through this hose, so it is in vacuum all the time. As a result, the mixture was lean as well as constrained by air flow.

Diagnosing Intake System Leaks. [Tip from Randy Starkie] If you take a plug of the correct size- the inside diameter of the turbo hose- and install a schrader valve you can use compressed air to check for leaks in the system. I use a master cylinder cap with a schrader tire valve to bleed my brakes using a bicycle pump. Turns out the cap is the correct size for the turbo outlet hose. I use a hose clamp around the outlet hose and turn my regulator on my air compresser down to 15psi. I use that to pressurize the system and the leaks are then apparent. I find leaks I miss with visual inspection.

740T Has Weird Deceleration; Anti-Stall Valve Hose. [Symptoms:] Our '87 740 turbo has recently begun behaving very strange. Acceleration is fine, normal running is fine, but if you lift off the throttle after acceleration (with boost), the car jerks once and a "hiss" can be heard from the engine. [Response: John Binford] '87 7xxT's had an anticompressor stall valve......about a foot beyond the turbo, close to the fan. If the hose to the valve is off, it won't release and you'll get compressor stall and maybe the excess pressure can 'hiss' somewhere. The diaphragm in the valve can also die/hole, in which case it won't release either. Check the valve for proper hose to it and operation.

No-Hot-Restart Problem: Boost Overpressure Switch Failure. [Dan Ridenour] The Boost Overpressure Switch is “normally closed” and is designed to “open” if the turbo-boost pressure exceeds some preset limit. This function is designed to protect the engine from a runaway turbo or a stuck waste-gate. On my 1988 760 Wagon, the boost overpressure switch is mounted in the engine compartment, on the right front strut tower, and is effectively “just above” the turbo. High underhood temperatures can cause this switch to fail and shut the engine down. To confirm switch failure, disconnect the waste-gate controller and wire the waste-gate fully open, effectively disengaging the turbo. Then short the boost overpressure switch. If the car starts while hot and runs without incident, then you've found the source of your hot-restart problem. Don't drive the car this way as you may overboost the engine.

Compressor Bypass Valve Diaphragm. [Inquiry] My Mitsu TD-04 with integrated CBV has a torn CBV diaphragm, but no one carries a replacement. Volvo will sell me a $300 rebuild kit with the CBV included but the parts stores don't have a clue about selling just the diaphragm. The rice shops want to sell me a $200 Blow Off Valve that I don't want. Where can I get a NEW CBV diaphragm? [Responses:]

Mitsu CBV Diaphragm Interface

Replacement Diaphragms for CBV. Various turbo rebuilders carry the diaphragm repair kits for reasonable prices. Check Rick Banas at D&W Diesel (r. banas@dwdiesel.com) for Mitsu diaphragms and some Garretts.

Turbo Has Power Loss and Cherry Manifold: Knock Sensor. [Inquiry:] My 740t intermittently looses power and the exhaust manifold turns bright red. I don't know if the two are related but when the car was in the loss power mode I opened the hood one night to check for arcing wires and I noticed the manifold glowing. [Response: Abe Crombie] Those are the symptoms of a knock sensor problem. The knock sensor may be bad but more likely the connector is the problem. When the ignition control unit detects no input from sensor the timing is retarded which is the safety from excessive spark knock but this does make engine power suffer and the delayed timing sends exhaust gas temp skyward.

Lubrication:

Normal Oil Consumption for Turbo. [Inquiry:] What is the normal oil consumption for a turbo engine? [Response 1:] Based on a highly non-significant sample size of 2: my friend with a 245 Turbo says that he levelled out at one quart per 2,000 miles, and that this rate of consumption remained the same from 80,000 miles until he sold the car at 150,000-plus miles. This is the same rate of consumption as my 744 Turbo with 91,000 miles, so I say that 2,000 miles per quart is healthy for a Turbo motor. [Response 2:] My 87 764T w/187k miles uses zero quarts amsoil synthetic 20W/50 in 10,000 miles, I change the oil and AMSOIL ASF-42 filter every 10,000 miles. My 90 744T w/83k miles uses zero quarts amsoil synthetic 20W/50 in 10,000 miles, I change the oil and AMSOIL ASF-42 filter every 10,000 miles.
I also ran a spectrometric oil analysis comparison on wear metals using dino oil at 3,000 mile change intervals and oil samples with synthetic every 3,000 miles to the 10k oil change interval I have settled on. On my engines, the dino oil accumulated more wear metals, had lower residual alkalinity (total base number or TBN for any lube engineers out there), and increased it's original SAE rating by 5-10 points with regard to the synthetic at 10,000 miles. The only reason I change the synthetic at 10k is that I do get carbon particulates (soot) buildup to .5%, the buildup curve turns the corner at around 10-11k (it runs 0-0.4% for the first 8-10k but then climbs quickly...I chose to dump at .5%----BTW, this stuff is so fine that a micron bypass filter won't clear it out past 15k...I've tried AMSOIL bypass filter and while it clears the oil it won't take out the soot.) I believe the soot/carbon particulate buildup is characteristic of the turbo gas engines, inasmuch as my experience is duplicated on my Saab 900t, both the 84T (RIP) and the current 87 900T. I have no experience with turbo diesel engines, but maybe their soot particulate size is somewhat larger than gas engines.
That's not to say either engine has NOT used oil....but when they do, I have invariably found the

problem to be an oil LEAK, front or rear main or cam cover gasket. Once the 740t leaked at the turbo oil return gasket at the block and also at the oil filter adaptor. Have also had oil leaks at the distributor on the rear of the hear....but all fixed relatively cheaply with Volvo O-rings. Point is these engines are really good on oil control IMHO.....but they are also b!^&hing leakers!
[Response 3:] my '87 740T with 178,000 miles runs on dino oil. Lately the oil consumption has been 1 quart in about 2700 miles. Since I usually change the oil at 3000 miles, I don't bother adding the oil. I have been just changing instead. Can't tell you anything on how much my '88 740T consumes. It has been a leaker since I bought it last spring. The oil return pipe from the turbo leaks at the block. Maybe 1 quart in 400 miles. I can see it leaking and dripping when the engine runs. Just recently cleaned the throttle body and crankcase vent system. Maybe this will help the problem. If not, I will have to repair the leak with a new o-ring. OTOH, with all that oil dripping and blowing under the car while driving, a good part of my undercarriage is coated with oil, it will never rust.
[Response 4:] My (brief) experience has been 0 quart consumption. I run Mobil-1 10W30 on my 1992 944T with about 80k km (50k mi).
[Response 5:] My wife's '91 940 Turbowagon that has 102,000 miles on it goes through a quart of Castrol Synthetic 10W-30 every 2000 miles. This number seems to coincide with what you have stated. The Turbowagon is in mint condition without a single spot of oil leak on the garage floor. I have pulled all the plugs to check their condition and there is no evidence of oil in the combustion chamber. The exhaust pipe is also quite clear without any residue or smell of burned oil. I am just amazed with this 940 Turbowagon and the ride fells like new.
[Response 6:] I change my synthetic oil as close to every 3k as I can. The longest interval was just over 5k. I'm not into the turbo a lot, generally I nail it once a day getting on to the highway. This is an '84 with 160k and it uses no oil worth writing home about. Honest.

See below for more information about oil leaks and consumption in turbo engines.

Oil in the Intercooler. [Inquiry:] When changing my radiator (91 940 137,000 miles and new to me)I noticed black oil in the air hose from the turbo to the intercooler. Is this normal? Or do I have problems? [Response: RandyS] It's normal, don't sweat it! Unless it spewed out a quart, I'd say you are doing OK.

Turbo, Drain Line, and Cooler Oil Leaks. [Inquiry:] 740T leaks oil out the oil filter adapter and turbo return line

Flametrap and Crankcase Pressure:

[Gary DeFrancesco:] Before going too crazy, make sure you have good crank case ventilation. See the extensive discussion of this at Excess Crankcase Pressure and below under Extended Boost and Oil Consumption.

Sources of Leaks:

[Tips from Gary DiFrancesco] Turbo cars do have some common leak points when the age and mileage build up. There are two places I would check right off. First check the oil return pipe going between the turbo center section and the block. Where the pipe goes into the block, the o-ring at this junction can and will break down and oil will blow out here (even with good crank ventilation) and run down the side of the block. The other leak point is from the oil cooler adaptor. You know about the o-ring between the adaptor and the block, but there is another o-ring in the adaptor assembly. One or both of these o-rings will also start to leak eventually.

[Inquiry:] I have a 88 760 Turbo with 226,000KM on it, losing oil. I am going to look at it this weekend and would appreciate any suggestions on what tends to leak most on these engines. I don't really notice any oil onthe driveway from where I park and it doesn't seem to burn oil. . [Response from Michael Jue:] Oil leaks on B230FT can be due to any or all of the following:

- Oil blowby due to worn valve seals OR clogged flametrap housing (no actual flametrap, just the housing - part of the EGR system; located directly beneath #2 & #3 intake runners. A real knuckle buster.)
- Oil leaking (weeping) from oil filler cap - Either bad gasket on cap and/or clogged flametrap housing. The clogged flametrap creates high crankcase pressure forcing oil by the gasket.)
- Oil leakage past turbo bearings - a fairly likely cause at 226k Km; imperceptible in exhaust (absence of blue smoke).
- Rear main seal - not as likely but possible (changed mine twice in 255k miles); check for inordinate build-up of oil on transmission. See below under Extended Boost and Oil Consumption.
- Front engine seals (cam, crank, idler) - pull the top half cam cover and inspect timing belt for oiling; change if any sign of oil contamination and replace the seals at the same time. (Recommend changing them as a complete set with your timing belt change as the belt must come off for replacement of any of the seals anyhow.)
- The old oil filter gasket was left on the oil filter adapter *face* when installing a new oil filter.
- [Christopher Rowat:] One other possibility for oil leaks is the oil filter adapter gasket, a little O ring that seals the oil filter adapter to the block.
- [Dick Riess] The engine oil dipstick tube o-ring, where it mounts into the block, can fail and allow blowby to carry oil past the tube onto the surrounding block.

Oil Cooler Adapter Oil Leak Repair:

[Responses:] There are two oil cooler systems used on turbo units: the earlier radiator-style with pipes from the oil cooler adapter (740s), and the later can style mounted just ahead of the oil filter with no radiator and hoses to the block (940s). The *oil cooler adaptor* has 2 large o-rings (one between the block and adaptor and the other between the adaptor and the oil cooler unit) that compress and get hard with age. They can leak. The o-rings cost about $2.00 each but are a bit of a PITA to replace. You have to remove the whole adaptor. You will need two large sockets: 32mm (preferably 12-point) for the bolt that holds the adaptor to the block, and a deep 29mm or 1-1/8 inch for the nut that holds the thermostat unit to the adaptor unit. There are two ways to accomplish this. (1) You can remove the power steering pump from its mounting bracket. The pump can be left in the car, just remove it from the bracket. This will allow you to move the pump out of the way so that you can get a socket on the big 32mm bolt that holds the adaptor on the engine. Once off, the two parts of the adaptor are separated with the removal of the big nut just below where the oil filter screws on. **If you have the early style oil cooler mounted near the radiator with pipes to the adapter, make sure you mark the adapter parts so that you can reassemble everything in the same orientation.** Replace the two o-rings (using some grease or silicone RTV to hold them in place) and put everything back together. [Lars] When you insert the new O-ring in the groove, try to "reverse-roll" it a bit so it sits in place while mounting. Make sure when you reassemble the cooler that you leave clearance for the turbo oil return pipe right next to it. (2) [Scott] Removing the entire right hand motormount and wheel allows easy access;the job took around 1.5 hours including changing the oil and doing some clean up. I recommend cleaning these areas before attempting this job to keep any dirt out of critical areas. I placed a wood block at the point that the power steering pump mounts to the block and used an old screw jack to lift the engine up enough to remove the entire mount assembly.

Oil Cooler Lines to External Cooler (Early style). [Norm Cook] Note that the cooler lines require 22mm wrench; 7/8" will work but it is .23mm or .009" larger than 22mm. It's useful to have 2 wrenches for this job. I found it easier to thread the fittings into alum filter base and then connect lines. Again, make sure you mark the orientation of all parts prior to disassembly.

Some useful part numbers for various parts in the oil cooler (both early and late style parts noted), thanks to Norm Cook:

- Oil filter aluminum threaded filter base: 1276680 (early)
- Aluminum base to block: 1346618 (both early and late)
- Oil cooler can 3507371 (late)
- Green o-rings 967343- one goes between the cooler adaptor and the right-angle adaptor (early); the other goes between the right-angle adaptor and the engine block (both)
- Copper washer 3531702- goes under the bolt that holds the right-angle adaptor to the block (both)
- (2) black o-rings 925093 (early)
- Black o-ring 3547188 -goes between oil cooler can and adapter (late)
- Aluminum crush washer 957189- placed under the banjo bolt screwed into the block (early)
- (2) Aluminum crush washers 957179- placed under the fittings into which the pipes enter (early)
- Steel washer 824589- placed under the nut that threads down the shaft onto which the filter goes. This washer is re-usable. (early)
- Coolant hoses 9161383 and 9161384- connected between block and oil cooler can (late)

Oil Return Line O-Ring Leak Repair:

Diagnosis. [Various Contributors: John Sargent, Gary DeFrancesco,Paul Seminara, Don Foste, Ryan M, Dick Riess] The leak in the turbo *oil return line* is due to a failed o-ring. The *oil return pipe* in the turbo will start to leak where it enters the block. The return pipe just sits in the block against a rubber gasket/washer and seals through a press fit. .It must be properly centered and seated in the block recess. Make sure that the oil cooler is not preventing this pipe from seating fully. If the cooler is rotated, the pipe will be pushed out. Before doing any repair, get the correct O-ring and fibre gasket for the top end. The proper seal is red; approximate dimensions are 4mm thick, 19mm ID, 25mm OD, to fit the 20mm OD oil tube where the seal slips over.

Sometimes dealer techs will shortcut the turbo return line O-ring installation by using silicone sealant slopped around the return line and the block instead of replacing the seal; this silicone eventually fails.

Before attacking the turbo oil return line leak, check your crank case ventilation. If the ventilation system is not working perfectly, the pressure build up can force oil out the turbo oil return o-ring. Replacing the o-ring may not solve the leak entirely, so fix the ventilation first. Once fixed, you may find the leak is gone or at least greatly reduced.

Repair: Removing the Drain Line. Replacing it can be a real PITA on earlier Garrett-equipped cars. On a Garrett turbo, you may have to loosen the turbo from the manifold (4 nuts) and pull away slightly. This gives a little more play. You may also need to loosen coolant lines and oil line at top to do it completely. Or, remove the oil filter adapter to make room to install the oil return line (good opportunity to change the o-ring between the adapter and the block.) When doing a turbo replacement, bolt the exhaust manifold up loosely, and THEN install the drain tube to engine block and drain tube to turbo lightly. Torque up the manifold and then tighten the turbo drain gasket bolts. Replacing the gasket/O ring with the turbo bolted down tightly can be done but it's a close thing. The bolts on the turbo end, including the wastegate actuator, can be sticky and there is not much room to work. Always use lots of PBlaster and a six point socket on stuck bolts. If you are unsuccessful in removing the two screws/bolts that hold this pipe to the turbo center section, the only other way to replace this o-ring is to remove the exhaust manifold/turbo assembly. With a Mitsu turbo, remove one bolt holding the wastegate valve at the front and the cotter pin holding the wastegate actuator rod, drop the wastegate to one side, and remove the two oil pipe bolts at the turbo.

Once off, clean up the parts.

Repair: Seal Installation. The proper way is to remove the pipe from the turbo center section and replace the old seal at the bottom and the fibre gasket at the top. Put a little grease on the o-ring to help it go back into the block. If the pipe is not inserted into the block properly, it will leak again. The pipe doesn't really sit against a gasket on the block. The O-ring, mounted on the pipe BELOW the ridge, fits INTO a hole in the block (and can get distorted, bent, cut, skewed, screwed, blued, and tattooed) in the process. Be very careful getting it back in with new seal - it is easy to pinch the new seal even after lubing with synthetic grease. I usually keep an extra seal in my tool box in case I pinch one during install. Maneuvering the turbo, pipe, and O-ring into position can be a challenge. If you have problems attaining a good seal, Here are three thoughts:

- The O-ring may have gotten cut during installation. Even a nick can let oil seep out.
- The O-ring might have peeled up over the ridge in the pipe.
- It might not be the correct O-ring -- too thin, so not squeezing into the block.

That tube is only a gravity-fed drain -- there's really no oil pressure there, so there's almost no driving force to push oil out. O-rings get their sealing properties from the "squeeze" against opposing surfaces. In this case, those surfaces are the tube and ID of the hole in the block. You shouldn't need to push it down solid to achieve a seal. Now twist and turn it to get it to back into position. (Probably want to practice this without the o-ring and gasket before actually doing it.) It sets in the block against a square lip, which you can feel with your finger, and it needs to be square and snug against this lip. And after the installation, use an inspection mirror and strong light to check to make sure that it went in properly.

Turbo Oil Return Bolts. [Inquiry:] I removed the turbo oil return tube the other day to replace gasket & seal. Got the parts, went to install them, now it seems the bolts that go into the turbo are too long, they bottom out. [Response: Paul Kane] The bolts in that area LOOK the same - but they ain't. Just a 1 or 2 thread difference can cause a 'bottom out' . You may have swapped 1 or 2 and didn't realize it.

Quick and Cheap Silicone Fix:

If you can't get the pipe out (since some previous grease monkey stripped the socket on one of the cap screws on the turbo end), then you can always seal up the leak like I did. I completely cleaned the area around where the pipe goes into the block. I used a strong degreaser to clean the pipe and the surrounding area. I even used Q-tips soaked in degreaser to get inside where the pipe goes into the block. I then used lacquer thinner to prepare the surface. Once everything was surgically clean, I dried the area with a warm heat gun. I split the new washer so that it could be placed around the pipe. The washer was coated with Permatex Ultra Blue silicone sealant, and some of the sealant was also injected into where the pipe enters the block. The coated washer was then pushed into this space and sealed into place with even more sealant. It is a bit of a patch job, but it is working just fine. No leaks in the year since I did the job and it is cheaper that screwing up the turbo. Before I fixed this leak, I was loosing a quart of oil in less than 500 miles. Since the repair, I am estimating over 5000 miles per quart. Hard to tell for sure since I change oil at 3000 mile intervals. Those are the leaks I am familiar with on the B230FT engines. [Randy Starkie] I cleaned the joint at the oil return line and the block with lacquer thinner, then sealed it with silicone sealant. It has lasted three years with no leaks.

Clean or Replace the Oil Return Line?

[Inquiry] One thing I haven't done to my car is clean the oil supply lines to the turbo. What is the best thing to shove into the lines in order to really clean them well. [Response: Dick Riess] If your turbo is under warranty, the warrantor will insist on a new supply line. Reason: coke can chip off and destroy your bearings in the turbo. I really believe in buying a new supply line. [Response: Hermann of Cherry Turbos] The chemicals, time and elbow grease needed to clean the line out are no guarantee that all the coke inside the line is gone. Because the coke is so brittle, it can crack and release just from a heat cycle. Ultrasound would actually be the only "safe" way to clean the coke out. Buy yourself some peace of mind and order the new line.

Extended Boost and Oil Consumption

[Report from JMars] My 89 745 TIC has had catastrophic oil losses twice. Both times happened when the cruise control caused a downshift from OD and full boost for a time at 4000rpm± on a long mountain upgrade. At neither time did the plugs foul - this is a key since the non fouling of plugs told me that the oil lost did not pass thru the combustion chambers. It is impossible to burn that much oil without fouling the plugs!!! Hence it was not a case of a bad head gasket, valve seals, rings, turbo seals, or anything else that would have put oil thru the combustion chambers. The solution: there is a small hose going from the intake manifold to the plastic fitting in the large breather hose. Apparently it is there to vent the crankcase to the intake manifold when the latter is under vacuum. There is NO PCV valve in the system. Apparently extended boost was transferred through this hose to the crankcase. Oil puddled at the rear of the crankcase with 11 lbs of pressure behind it leaked out the rear seal at higher rpm. So how do you fix this? A check valve in the small manifold hose that lets fumes be sucked into the manifold but prevents pressure to be passed into the crankcase: a simple PCV valve. A check of the PCV valve display at your local AutoZone will will reveal a nice little black&white plastic jobbie (Deutsch # PCV 161 - $3.99) with small barbed inlet/outlet tubes on it that will slip into the suspect hose with no clamps needed. If you pick the wrong one it is no big deal as long as it fits and is positioned the right way. Mine cost $3.99 and was installed in mere minutes by cutting the hose and inserting the PCV valve (white side toward manifold). This solved my oil loss completely and makes sense: . the more you use the turbo the more the crankcase becomes pressurized and the more you blow oil out seals; especially if the seal is completely submerged and cannot vent air. I can see no harm in the addition of this PCV valve - the manifold vacuum still vents the crankcase.

Intake and Exhaust:

Intake Manifold Gasket Leaks. [Inquiry from Joel Eisner:] Rough idle with some lean backfiring but it holds at 900RPM. Diagnosis steps:

- # 4 plug wire when removed does not affect the idle but the others do.
- good spark (swapped plugs and wires)
- plug looks no different than the others (a little black)
- swapped out the fuel injector with another one
- checked compression (approx 140 psi on 1-3, 130 on #4) and oil helps only a bit
- swapped out a different fuel line to the injector

I am about to give up and part the thing out if I can't fix the idle. I would like to keep the car but it is driving me crazy. Clues? [Response: Joel Eisner] I found the problem. I pulled the intake manifold and about an inch of the gasket around the #4 cylinder is missing with obvious signs that it has been gone for a while. That area was black. {Response 2: Warren Bain] The gaskets go quite often on the turbos. Mine went and the idle was very rough. A quick replacement and all was well. It's quite easy. [Tip] The turbo is prone to intake manifold gasket leaks, (so I hear) and mine was no exception. The WD-40 spray test showed much leakage. I used a cheapo gasket (stiff type), put it all back together and voila - NO difference. I tried again with a high quality (rubbery (nitrile?)) gasket and used permatex liquid gasket sealer (although there are various views on sealer use) and voila - BIG improvement at idle. Lesson - use high quality gaskets.

Turbo Hoses: Preventive Maintenance.
Air Intake Hoses. [Tip from Simon Eng] If your car is equipped with a turbo, please inspect the rubber air hose from AMM to turbo. This is the one that is about 3" in diameter and is in the form of an elbow about 12" total length with two small connections on the side. Pay particular attention if your car is over ten years old. Inspect the end that is connected to the turbo inlet. Due to the extreme temperature at this location, the rubber deteriorates and actually melted in my case. It is probably cracked and leaking air into the turbo, leaning the mixture, or even collapsing. Cost is over $100. [Response: Rob Bareiss] Any and all of the air hoses on a Volvo turbo can leak, with two rather unpleasant consequences:
1) The car will run like crap and you may have weird symptoms such as cutting out under boost
2) You're going to have to spend some money
The usual cause is oil attacking the rubber from the inside out. Some of the hoses are REALLY expensive. The large S shaped one is about $180 list price. The one just before the throttle body is $80-$120 depending on which model you've got. The little one right at the intercooler is only $10. The silicone high-temp L-shaped hose at the turbo is over $100.
It's probably a good idea to periodically look inside one of these hoses to see if there is any evidence of oil. If they're wet inside, you've got a turbo leaking oil, AND sooner or later you're going to need to replace these hoses. The only good news in this is that you'd be pleasantly surprised at how well duct tape can seal up one of these, and how long it can last... And it's a LOT less than $180....

Wastegate Hose. The small vacuum line controlling the wastegate on the turbo is exposed to high temperatures and can embrittle. Change this if it feels hard. Not doing so can cause overboost in the turbo when it fails.

Pressure Leak Tester: See Special Tools for a simple intake system pressure leak tester: you can pressurize the intake system and listen for leaks.

Coolant Hoses. [Editor] Turbos run hotter than NA engines, so inspect all your coolant hoses regularly and consider replacing them after eight years or so. These include the radiator, heater, reservoir and turbo oil coolant hoses. Highly recommended: use Volvo OEM hoses from the dealer, not aftermarket or hoses formed from stock coils.

Turbo Hose Sources. [Inquiry:] I'm looking to replace the original turbo hoses. All are either really soft and/or showing signs of interior deterioration. The only problem now is that my dealer's prices are about ten times what I'd expect to pay for these hoses. Does any one know of a cheaper source for such hoses?

OEM Hoses. Try Borton Volvo in Minneapolis or FCP Groton for lower-priced OEM hoses guaranteed to fit your turbo application.

Silicone Hoses. [Tip:] For a source of silicone hoses for turbo intercoolers and other applications, see: http://www.bakerprecision.com/silicone.htm or http://www.hosetechniques.com/ These come in standard sizes (elbows, etc.) and will likely not fit your car without additional fabrication. [Inquiry] I'm thinking of just buying some straight 2" ID silicone hosing from one of the many turbo outfitters for the short hoses that come off the intercooler. However, what should I do about the 90 degree bent hose that comes directly off the turbo outlet? [Response 1: Don Willson] I just bought a set from an independent parts house for my '89 760Ti. The short silicone was $24.25 pn 127-6963 The fresh air hose air filter to turbo input was $127.42 pn 138-9648 The slight "S" outlet turbo to intercooler was $47.12 pn133-6815 Mine were failing, not from turbo heat but from exposure to the radiated heat from the exhaust. I found some aluminum tape with high temp silicone adhesive and wrapped around them to reflect some of the heat.

Exhaust Manifold Gasket & Studs; **Turbo to Manifold Joint**

Exhaust Manifold Parts: Use only the Volvo OEM brand exhaust manifold gaskets, which are of higher quality. Aftermarket brands have been known to quickly fail, especially on turbos. Since you will likely have to remove the oil filter adapter, buy a complete set of OEM parts: exhaust manifold nuts (8), manifold gaskets (4), oil filter adapter-to-block o-ring, oil cooler o-ring, turbo oil return line gasket and o-ring, and (depending on your car configuration) turbo to down pipe nuts and lock washers if any. If your car is non-turbo, then you will not need the filter adapter parts. Note that the Volvo OEM manifold nuts are flanged: the nut has a serrated self-washer that helps secure it against the manifold. Aftermarket nuts may not have this flange, in which case a copper washer may prove useful in keeping the nuts and studs secure. Useful tools: in addition to normal hand tools, jack, etc., some corks to plug the oil cooler lines so you need not drain the system are helpful. Six-point sockets are invaluable for removing stuck nuts. PBlaster is essential, and an acetylene or propane torch with a pencil flame are often helpful on stuck nuts.

Exhaust Gasket and Leaks; Why Repair?
[Tip from John B] As far as the manifold to head leaks...my opinion is fix them soonest. The leaking gases will erode the gasket and make the leak worse. For example, the leak from #1 cylinder exhaust at 3 o'clock eats a hole/slot in the timing cover back and front...ask me how I know this! It sound like the manifold leak issue is concurrent with the dealer fix of the turbo. When you do this, plan on renewing other gaskets, o-rings, hoses etc. that you remove while replacing the manifold gaskets.

Exhaust Manifold Gasket Replacement Procedures. [Tips from Turbobricks, John Sargent, and others] Remove all the manifold nuts and loosen the turbo to down pipe nuts OR loosen the down pipe fixing bolts at the bell housing and transmission, depending on your car. These will be rusted, so use LOTS of penetrating spray for a couple of days before. Use the old trick of first tightening a little, then loosening. Heat often helps. Loosen the two bolts holding the manifold bracing bracket to the side of the block under the manifold. The bracket has one bolt into the manifold, and two into the block. This is hard to find and access. You may have to remove the turbo oil supply and return pipes and the oil filter adapter: if so, use new gaskets and o-rings on re-installation. Loosen the EGR pipe into the back of the manifold, if so equipped: this pulls back about a centimeter, but is invariably rusted. You may also have to release the transmission bracket from the down pipe (and maybe the down pipe at the rear) to gain enough clearance to move the manifold; this too is usually rusted solid. To prevent damage to the radiator, loosen the coolant lines at the radiator using two wrenches. You will have to push or pull the engine toward the driver's side to clear the exhaust manifold studs: use a jack beneath or a puller on the top engine lift at the thermostat. The exhaust manifold gaskets fit into each manifold runner. Needless to say, you should replace all four. If you look closely at the exhaust manifold gaskets you will notice they are not symmetrical. If the exhaust gasket are rotated 180 degrees when installed, they will burn out in a month or two. Watch how the old ones were fitted. Each gasket is stamped "UT" which means "out"; that side faces away from the cylinder head. On reinstallation, use high-temperature nickel-based antiseize to make life easier next time around. Note as well that, if so equipped, you need to replace the engine lifting hook in the correct spot: it fits into a recess in the manifold in place of one of the thick washers. The latter are replaced with the dished side inwards toward the manifold. Re-torque the manifold nuts to 10-20 ft-lbs for B230F/T/D.

Exhaust Manifold Gasket Set

Replacing Manifold Nuts and Studs:
[Inquiry:] My 744ti currently has 184,000k mi. It is leaking a little at the exhaust manifold so it is time to replace the gasket. I have noticed that it looks like it is the original gasket. I am thinking about replacing the studs and the on the head when the gasket is replaced. Is this a good idea or am I wasting my money. I want to do the job right from the beginning. [Response: Rob Bareiss] I always recommend replacing all the exhaust nuts, and to try to save the studs I split the nuts with a chisel. This can save a great deal of aggravation (it's an old VW trick- the studs on VW heads always broke). [Another philosophy from: Onkel Udo] You might want to spray the studs w/a penetrating oil repeatedly for the preceding days. When you reassemble, use nickel-based antiseize compound on the new studs and coat the exposed areas with a silicone spray or a grease of some type. There is nothing more annoying than trying to remove rusted-in-place nuts on exhaust flanges knowing that at least one stud is going to shear off no matter what you do. [Response: Don Foster] If the original studs appear "eroded" (rusted away) and you think you can remove them without snapping even one, then new studs would be a cheap investment. I dearly love my oxy-acetylene torch. Every time I use it, I kiss it. You might also consider replacing the big O-ring in the oil cooler adapter at the same time -- they age, dry out, crack, and start leaking at about the 10-year point with your mileage, and are a B*ITCH to get to -- but with the turbo out, the area's wide open, and access is much easier. [Response: John B] I wouldn't fix the stud problem if it's not a problem. OTOH, if you break one stud in the process, might as well replace them all. Editor: turbo studs differ from non-turbo studs: make sure of your part numbers.

Stud Removal Tips See Exhaust Manifold Nuts, Studs, and Gasket Replacement for complete tips on how to remove broken studs. [Paul Seminara] ! When you have it out soak again in PB Blaster, clean and brass brush it, smear with a good Ni or Cu antiseize for future removal. Under no circumstances should you use an Easy-Out or other stick-in-the-hole and simply twist stud remover.

When you pull out the manifold/turbo, then's the time to replace the turbo/tube and tube/block gasket and O-ring. Even if you don't pull the entire manifold/turbo out to replace the exhaust gasket (best case) the turbo oil tube is a lot easier to reseal with the manifold loosened (and the two bolts holding it onto the turbo removed). How's your 02 sensor? It's easy to get to with the manifold out.

Exhaust Leak at Turbo/Manifold Joint: Nuts, Is there a Gasket?; Tightening Procedures:
[Inquiry] I recently saw some condensation on the top of the turbo/exhaust manifold joint just after startup that quickly evaporated as the engine ran. The joint was dry prior to startup so I imagine condensation was forced up out of the joint. The joint is the one tightened by four nuts/studs. I noted that the #2 and #3 exhaust manifold runners were sooted a little bit and could feel a little bit of gases escaping. It was not uncomfortable for me to hold my fingers over the leak. Questions: 1) Other than the obvious exhaust gases in the engine compartment, is this a don't drive it until you fix it repair?   2) Does this joint typically leak? I think the turbo was replaced by the dealer in May 2000, 6K miles ago.   [Response: Abe Crombie] The turbo (as with almost all turbo applications) uses no gasket between the turbo and manifold. It is a flat machined fit. It is not at all unusual to have some seepage when cold at this location. It might actually improve as rust seals it up. You may want to be sure the turbo-to-flange bolts are secure. That is about all you can do.
[John Sargent] There is no gasket between the manifold and the turbo. Until the 1990 model year, both Garrett and Mitsubushi turbos are bolted to the exhaust manifold with bolts from the engine side of the exhaust manifold (see photo right). For the 1990, and later, model year 700/900s Volvo used nuts to hold the turbo from the front side of the manifold. The later manifold has studs which the nuts screw on to. You will also need new keeper plates which lock the nuts in place. [Notes from JohnB] The problem with checking the bolts that hold the turbo to the exhaust manifold is that they're supposed to be locked in with a lock plate. The bolts on the manifold side are 12 point cap screws angle-torqued using special tool 5411 to 30 Nm or 22 ft-lbs, then the lock plate is pounded over the bolt heads. Checking the bolts is useless...if they move the lock plate is defeated and if they don't it's no indication of proper installation.   If they are loose, then the dealer didn't install the turbo mounting bolts correctly. Generally the exhaust manifold needs to be removed to properly install the turbo mounting bolts and locking plate. A new plate and new bolts should be installed every time since the bolts are torque-to-yield. However, in my experience and in everything I've read, angle tightening isn't that far off from simple torque-wrench, something like 25% variance from specified clamping force vs 35% for torque wrenches. [Inquiry] My turbo to manifold nuts are loose. Is there a gasket in there? How do I tighten them? [Response: Bob] There is no gasket between the turbo and the manifold. If the nuts are loose, don't just tighten them. They will loosen again. Replace them with new locknuts. The Volvo special tool 5411 for these manifold-side nuts is an open end wrench about 6" long with a square drive hole on the other end for a torque wrench which is held at 90 degrees to the wrench. Tighten to 30 Nm (22 ft-lb) in a 1-4-2-3 pattern starting with the top rear as "1" and then going clockwise around the nuts ending at the bottom rear.

Turbo Mounting Studs on Earlier Pre-1990 Manifold

Volvo Special Tool 5411 for Turbo Nuts

Removing the Exhaust Manifold Brace. [John Sargent] Tough time removing the brace above the oil filter? First remove the oil cooler adapter and the coolant tube to the heater for better access.

Torque Reference. Retorque to 10-20 ft lbs (14-27 Nm) for B230F/T.

Broken Turbo Exhaust Stud. [See also the section under Exhaust:Exhaust Manifold Gasket and Studs Replacement for an extensive discussion of techniques.] [Inquiry:] I have an 86 760 Turbo that was rebuilt about 15,000 kM ago. The problem is that one of the exhaust manifold bolts has snapped off and when the turbo is under boost, it whistles. I think it is on number 3 cylinder and of course the bottom bolt. Is this leak going to harm the exhaust valve over time? I was also thinking about the doing the work my self and was wondering if anybody out there has had success with replacing exhaust studs with the head on? I really do not want to pull the head but I think it maybe the easiest way to get the stud out. My biggest fear is breaking off all the studs in the head. The head was rebuild when the engine was rebuilt so I am hoping all the studs have anti seize on. What should I use on the new bolts for anti-seize? If I remove the head do I need new head bolts??? I got the specs on torques for the head but what torque do I torque the exhaust manifold too, I think they recommend only about 30 Ft-Lbs? Is this right?
[Response 1:] Look at the bolts that hold the bypass valve on the pressure side of the turbo. This is the valve on top and in front of the turbo unit with the vac. hose leading to the intake manifold. These bolts can loosen slightly and allow boost pressure to leak. It sounds like a whistle when under boost. When I first heard this on my car, I thought I had a turbo starting to die. Fortunately an honest service manager at my local Volvo deal went straight to the bypass valve and showed me the loose bolts.
[Response 2:] A broken exhaust manifold stud and failed gasket usually make a significant exhaust "putt-putt-putting" sound. I would never describe it as a "whistle". You might have a failed hose or coupling on the high-pressure side of the turbo, and you're hearing air escaping.

Turbo Exhaust Stud Replacement. [See also the section under Exhaust:Exhaust Manifold Gasket and Studs Replacement] [Inquiry:] Is there any reason not to install 3/8" exhaust stud in lieu of the 8 mm that seem to sheer off. Are there higher strength 8mm studs available?
[Response] Stainless studs are an excellent idea for aluminum heads. Try to find a local fastener supplier that offers high-strength metric studs (8mm x 46mm: (std pitch, 1.25mm), 45mm long with approx. 15mm thread on one side (head side), 25mm on the other and 5 mm of no thread.). They are hardened to 10.9 grade. Always use high-temperature nickel-based anti-seize on all studs. Search yellow pages under nuts & bolts.
[Response: Jeff] Open up the manifold holes and the holes in the head. Retap the head for 10m-1.5 size bolts. Use 10mm Allen Head Cap Screws to secure the manifold to the head. You will have to open up the holes in the gaskets as well to make them fit. This is about as bulletproof as you can get. [Paul Seminara] I do question the use of socket head cap screws....I don't know if these are that great of a choice for this application since they are weak at the head.
[John B] Almost any stainless alloy is going to be weaker than a good steel alloy...it's only

advantage is it's supposed to be proof against corrosion. But you're not a marine environment, so I'd go with stock steel studs. Helicoil the heads if you must, but you'll get higher clamping forces with the stock studs.

Exhaust Manifold Cracks and Repairs. See the FAQ file in "Exhaust" for more information. In a word, replace, don't repair.

Cylinder Head Replacement. [Inquiry] If the cylinder head in my turbo engine fails, can I substitute a non-turbo head? [Fitz Fitzgerald] Tthe heads from a Turbo and non-Turbo B230 engine can directly swap, but note the differences first and then you judge if you want to proceed on that route:

1. Valves: Both the turbo and non-turbo heads have Stellite-flashed exhaust valves to resist burning (can not be machined). Also, the valve stems in the turbo valves are hollow and are partially filled with elemental Sodium. The Sodium is solid at room temperature, but once the engine warms up it becomes liquid. The up & down movement of the valves causes the liquid Sodium to be tossed up and down in the hollow valve stem, and helps to conduct heat away from the valve face at a faster rate. While this isn't an absolutely critical requirement to have on a turbo car, it does help to reduce valve face temperature.

2. Camshaft: The camshafts are different in the turbo and non-turbo engines. You'll need to swap them, and then also re-shim the tappet clearances under the camshaft. This requires having a large kit of spare shims (aka "Pucks") of various thicknesses to get the proper clearances under each camshaft lobe. You can rent the tools and shim kit from IPD, and a micrometer and feeler gauge set will also be required.

If this were my vehicle, I would probably just have the head machined flat and re-install it rather than swapping the camshafts to a non-turbo head. I wouldn't hesistate to machine a bit beyond the Volvo minimum thickness specs.

Turbo Rebuild and Replacement:

Turbo Failure Signs . [Inquiry:] Does anyone know what a turbo sounds like when it starts to die? does death usually come slowly, or suddenly. will the car run without it, and if so, for how long? [Response:] Some die slowly, losing output gradually as the engine ages. Others begin to make noise (scraping or rattling), especially under load or when very hot, that may signal that the impeller blades are touching the housing (or have been bent through the introduction of a foreign object), or the bearing is about to go south. Others fail through seal failure, dumping oil out the exhaust. I have been told that turbos can fail without any warning whatsoever, but I would not expect that. Your car should run without the turbo, but you will be driving a car with something like 80-90 horsepower because of the reduced base compression ratio on the turbo cars. In other words, maybe okay to limp to a garage, but no for everyday use unless you are a glutton for punishment. If the car is throwing oil out the exhaust, do not drive it at all. You may be able to clear a little out, once the turbo is rebuilt or replaced, but if you get too much into the exhaust you will be buying that as well.

Turbo Replacement.

Does It Need to Be Replaced?

[Tip from Herman at Cherry Turbos] Before you conclude you need new turbo seals, you need to check the end play in the shaft first. Do the blades touch the sides? If not, you need to address a very common problem in the B230FT and that is excessive crankcase pressure. Get a new oil trap (under the intake man. 2x3x4 black plastic) and clean out all crank vent hoses. You describe classic symptoms for oil hanging up in the turbo because it can't fall back to the oil pan with the crankcase pressure pushing against it. I've talked myself out of dozens of rebuild jobs as a result of dispensing this advice.

Checking Shaft Play and Wear. [Inquiry] What does "checking shaft end play" in my turbo mean? [Response: Adam/Dave] Check both front to back (axial) or sideways (radial) clearance. Axial play should not be noticable (< .008"), but radial play can be a max. of .022", which is definitely noticable. The radial clearance allows for a cushion of oil. Radial clearance may be noticeable but it still should not feel sloppy or have spots where you rotate the turbo and it has different play in different positions. When mine went bad I started to hear a "ching" kinda sound. I took off the intake hose and checked for play and sure enough the compresser blades could be moved into the housing once I rotated it to a particular position. Look out for wear (small chips, rough edges) on the very tips of the compressor blades that give an indication of your air filtration quality over the years, and for rub marks on the alloy turbo housing from scraping outer blade edges.

Removing the Turbo Unit: Tips and Comments

[Tip from Rob Bareiss] Replacement of newer turbos is not bad as the older ones. There are water lines to deal with now, but they don't get in the way much. You might get real lucky and have a Mitsubishi turbo, which will make you happy. They're pretty easy to replace due to the way the studs face. If not, even with the Garretts, its' not as bad as it was. I always recommend replacing all the exhaust nuts, and to try to save the studs I split the nuts with a chisel. This can save a great deal of aggravation (it's an old VW trick- the studs on VW heads always broke). To identify if you've got a Mitsu or not, the Mitsu turbos have a big clamp in the center between the compressor housing and the exhaust-driven outlet housing. It's like a huge hose clamp made of stainless steel. If it's loosened up the two housings can rotate relative to each other (and it'll leak there). If you don't have this clamp it's not a Mitsubishi. A good many replacement turbos are Mitsubishis. Any case, good luck, hope you don't break any studs, and if you do, get ready to pull the head. Don't try to fix exhaust studs in place. [Removal Tip from John Sargent] The Mitusibishi turbos are made to be removed by removing the one bolt and the hinged clamp. No need to pull the manifold. It is the wastegate which remains fastened to the manifold. The

Mitsubishi TD05 turbo used on 87-89 700Ts has the wastegate bolted to the turbo with bolts from the engine side of the exhaust manifold. In order to remove the wastegate, you have to remove the exhaust manifold. The Mitsubishi TD04H used on the 90-93 700Ts and 900Ts has the wastegate mounted to the turbo with nuts on studs which are on the manifold side away from the engine. On this turbo, you can remove the turbo and wastegate assembly without removing the exhaust manifold. Wastegates do crack and sometimes need to be replaced. [Paul Demeo] Removing: Don't sweat the oil return line for now, you can remove the turbo with it attached. (You'll still have to go through the pain when reinstalling, but for now...) Easiest way to remove a Mitsu: There is a pipe-clamp-ish collar between the center section and the exhaust housing, which should come off very easily. Once removed, the turbo is held in place only by virtue of the fact that it's been there a while. A good thump with your hand and it should pop free, allowing you to pull it up and out with the drain hose attached.

Mitsubishi Turbo Disassembly

[More tips] I'm writing now to say that I have completed the turbo replacement on my '84 240. Replacement was purchased from IPD and included everything needed (plus some duplicate gaskets with the watercooling conversion kit). IPD sent instructions, plus I had the Bentley book, and things were relatively straightforward except some hassle getting bolts off and back on in tight places. (It seemed to me I needed to have two hands plus my head/eyes plus a light all in a space that was only big enough for any two of those at a time!) Another hassle was my error in putting the O2 sensor back in before the support bracket (mine's on the bottom); had to take the O2 sensor back out, then do this bracket, which also had spacers between it and the block. I finally figured out I could use masking tape to hold the spacers on the bolts in the bracket while I moved it up into position one-handed and got the bolts started. I've been driving it to work again this week, with no leaks, no smoke, and notably improved power. Should note also that doing it myself saved considerable money; counting new oil pipes (I reluctantly got both, but probably only really needed the "to" pipe) and the IPD costs, I had ~$900 in parts. Local dealer quoted a cost for the job at ~$2100, and one independent shop quoted ~$1400. You'll need the range of basic hand tools, PB Blaster or equivalent if there is one (I used it often, including on exhaust manifold and exhaust flange studs and did not break any of them), and I think a sturdy vice is a must as well to get the manifold and turbo separated, but it was overall not that difficult (at least now that I'm done with it!!) I did have to move the exhaust flange studs to the new turbo, but PB Blaster and the two-nut method worked OK. I at first put the propane torch to the old turbo intending to loosen the studs, but in retrospect it wasn't necessary, once I got the hang of the two-bolt method.
The parts and instructions left me with a pretty good feeling about IPD also (although they apparently just buy the turbo from a different company in Colorado and put it and a watercooling kit together in a bigger box).I don't mean this as an advertisement or a criticism; I'm glad I got

the IPD kit and if an ordinary mortal like me can do this replacement, probably alot of others can too!

Installing a Rebuilt Turbo.
[Tips from Dave Schermbrucker] Just installed my rebuilt turbo (745); thought I'd pass on a couple of hints.

1. Installation should take about 2 hours. You will need to get under the car.

2. Try to install the oil drain line before dropping the turbo/manifold unit into place; it's real pain to connect the flange to the turbo core from below once the unit is in place. I say this because most turbo rebuilders and Haynes says to crank the engine a bit after installing, prior to connecting the oil drain, to make sure oil is running through the unit. Forget it. Just hook it up. If you're worried about oil feed, undo the top supply line adter installation to check that oil is getting through.

3. Alternative to 2: use small studs instead of bolts to connect the oil outlet; that way you're only struggling to mount some nuts on a couple of studs rather than trying to feed the bolts from below in an impossible location. I had to remove the wastegate actuator to get the bolts in; tricky and time-consuming.

4. Use new banjo bolts if you possibly can, since they make it so much easier to snug up the new copper o-washers on the oil and water lines.

5. If you have the oil filter sender assembly (most do) you'll need a 36mm socket.

6. You should remove the lower stud from the turbo exhaust-to-downpipe fitting; otherwise it's impossible to line up the turbo unit. After you locate the unit on the two upper studs, you can simply hand-thread the lower stud, then tighten all three.

7. Torque references: Exhaust manifold nuts are 10-20 ft-lbs (14-27 Nm). Turbo nuts to manifold are 22 ft-lb (30 Nm) but you will have to use a 90 degree extension on the torque wrench for access. Tighten in a 1-4-2-3 pattern starting with the top rear as "1" and then going clockwise around the nuts ending at the bottom rear. Exhaust pipe to turbo is 22 ft-lb (30 Nm). Cat to exhaust pipe is 18 ft-lb (24 Nm)

8. Otherwise it's a total breeze.

Changing Turbo Brands:
[Tips from Fox] I went the route of changing brands from a Mitsubishi to a Garrett. I will say - ask questions of people that have already done it. There's a lot of little things that come up, but if you know in advance, it's not too bad. The biggest thing for me was I didn't realize you had to replace ALL of the oil and water lines - even the ones that look like they'll fit - the fittings are different sizes. Past that, if you can get a junkyard manifold for the brand of turbo you want, it should go pretty smoothly. It took me a week to get mine running again, but that was because I didn't know quite what I needed. Now that I do, it is just a matter of getting everything

beforehand, and then doing the turbo swap, which shouldn't take more than about 6 hours of working time. And FYI, supposedly my turbo (Garrett) was machined to fit a manifold from a Mitsubishi. I will say that it fit on my stock maifold perfectly, but I can't tell if it really was machined. If so they did a hell of a good job. Look into that if you really want to switch brands for some reason. I switched because I got a higher flowing turbo (500+ CFM @ 15psi) for $750. That was the lowest price I found locally, for either brand, and I didn't want to buy a turbo online.

Clean or Replace the Oil Return Line?
[Dick Riess] If your turbo is under warranty, the warrantor will insist on a new supply line. Reason: coke can chip off and destroy your bearings in the turbo. I really believe in buying a new supply line. [Response: Hermann of Cherry Turbos] The chemicals, time and elbow grease needed to clean the line out are no guarantee that all the coke inside the line is gone. Because the coke is so brittle, it can crack and release just from a heat cycle. Ultrasound would actually be the only "safe" way to clean the coke out. Buy yourself some peace of mind and order the new line.

Turbo Rebuilders and Doing It Yourself
Rebuilding Turbo at a Shop. [Inquiry:] The wife's 940 Turbowagon will require a turbocharger replacement in the near future due to oil leak from the turbo itself and the presence of oil in the ductwork into the intake manifold. I found a shop in Rancho Cordova, CA called Volvo & Saab Auto Dismantlers (http://www.volvosaabparts.com). They have a complete turbo replacement for the above car with a 3 month warranty. They are asking for $350.00 and $35.00 deposit for the returned unit. This price looks pretty good in comparision to a new unit from IPD at $1000.00 and approximately $800.00 from Stillman Volvo. [Response 1: Philip Bradley] Your existing turbo can be rebuilt unless the bearings have worn so much that the shaft wobbles and the blades have worn or scraped the sides. The typical rebuild price is around $300. Numerous shops can do this. Check your Yellow Pages. There are also mail order shops that advertise in Turbo and Hi Tech Performance Magazine.

Oil in the intake hoses is not uncommon. In fact, there is a drain plug in the bottom of at least the pre-1992 intercoolers. Oil drips at the turbo could be due to the oil feed or return connections. The gaskets or copper o-rings can be replaced. On the other hand, your bearings could be slowly going. Sometimes changing to a thicker oil helps. The most definitive test is the shaft wobble test. Remove the rubber intake to the turbo, grasp the center of the shaft and try to wobble it side to side. Anything over about 1/16 inch is a sign of wear. The more the wobble, the worse the wear. [Response 2: Gary DeFrancesco] I would agree with Philip. Make sure the turbo is not loosing oil due to dumb leaks. The oil supply and return lines can leak and make a mess. A common leak is where the oil return lines goes into the block. The o-ring here will degrade with age and heat, and leaking can be pretty bad. Sometimes poor crankcase ventilation will cause this o-ring to prematurely fail. So make sure the vent system is working properly. (Do the oil filler cap jiggle test.) A film of oil in the intercooler and associated plumbing is not uncommon. A thick/runny film is too much.

If it is determined your turbo is dying, there are a number of options to consider. I talked with Volvo&Saab Auto Dismantlers last fall when I was looking for a transmission for one of my 740s. The people I talked with seemed knowledgable. The used turbo they are willing to sell you sounds interesting. Do they know how many miles are on the turbo? Don't want to get a high mileage unit and face this problem again in the near future.

Turbo Rebuilders. In the US: There are a few places that do turbo rebuilding. Try D&W Diesel in Auburn, NY. 315.253.2324. Generally speaking, the cost for rebuilding a turbo is around $350. More if an exchange is the better way to go. Sure beats dealer and IPD prices. The catch is, you have to R&R the turbo yourself or work with a cooperative shop. [Response 2: Thomas] Noticing the recent messages of people rebuilding there turbo's. I thought everyone would appreciate some info on an excellent turbo builder out of Golden Colorado. I have dealt with them and also I know that the local Volvo shops use them as there turbo supplier. What you may say is so great about these guys? There turbo builds are inexpensive. I have been quoted $200-350 (roughly) for a cartridge, and $350 to $450 new complete,(don't forget your core) depending on year model and if you want to convert to water cooled.Call them for a quote to get an exact figure. I have found they are about half of what everyone else is and I know they give quality products and are the nicest people! Anyways there names are Turbocharge Engineering Corp, (303)271-3997. Hope this is helpful! [Response 3] Try Turbo City – California.

In the UK: Try Turbo Technics

Rebuilding Turbo Yourself. [Editor] See a complete, illustrated article showing the procedure for a Volvo turbo rebuild (in this case, a Garrett unit) at Import Car Magazine, December, 1999: http://www.import-car.com/ in the archives.

See also http://www.turbocity.com or http://www.dwdiesel.com for repair kits, cartridges and rebuilt turbos. See http://www.turbocharged.com/main.htm for upgrades and service.   Try http://www.majesticturbo.com/
[Tip from Paul Demeo] I recently rebuilt my Mitsu TD04. Piece of cake. If you're able to do a timing belt, you can do this. I bought a bearing and seal rebuild kit for $120 and paid $30 to have the shaft and wheels balanced at www.unitedturbo.com. To balance a turbo they need the shaft and wheels plus the thrust collar. These parts are not in the turbo rebuild kit. If you wanted to buy the complete center section then the shaft, wheels, center casting and internal parts would come all assembled and balanced. Your cost on the exchange center section would be around $395.00. Contact Chet Greenwood at United Turbo Co / Custom Driveshaft, 1757 Route 9, Spofford, NH 03462, 1-800-779-1780

Turbo Plus System. [Inquiry] My mechanic told me my 1991 940 Turbo Sedan has the Turbo +. All I know about Turbo+ is that it was a dealer-installed option, it cost about $800, and that it adds about 20 or so more HP under boost (info from Turbobricks.com). Is the above info correct? If so, how do I identify the components of a Turbo+ system? [Response: George Chow] If you want to positively identify it yourself, look at your airbox. There should be an extra black electronic box on the face of it facing the front of the car. This should be easily seen with just the hood open. You should also see some extra plumbing from the turbo wastegate to a gadget mounted on the airbox. The Turbo+ works by effectively raising the boost level at WOT. The spec for your engine with Turbo+ is about 187hp/205ft-lb. Because it only kicks in at WOT, it's unlikely to affect your city mileage. [JohnB] Turbo+ works on full throttle (switched at throttle body) and above 4000 rpm so you probably wouldn't notice it around town.

Converting a Non-Turbo Car to a Turbo. Dick Riess and Gordon Vos have been among the very few brave and wealthy souls attempting to convert a normally-aspirated non-turbo car to a turbo. See the details at Gordon's website: http://www.maroon.com/iss/745conversion/

Engine: V-6

Abbreviations:

AMM Air Mass Meter
ECT Engine Coolant Temperature sensor
ECU Engine Control Unit computer (either fuel injection or ignition)
FI Fuel Injection
FPR Fuel Pressure Regulator
IAC Idle Air Control solenoid valve
TB Throttle Body
TPS Throttle Position Sensor
VSS Vehicle Speed Sensor

Distributor Cap and Rotor Change. [Tips from Gordon McCracken] To replace the distributor cap and rotor on a B280F you will need:

- 8 mm wrench (open end and "shorty" socket recommended)
- 2.5mm Hex Key

Angle Mirror - useful for viewing bolts.

You will need an 8 mm wrench to remove the distibutor cap shield and the distributor cap - a "shorty" socket wrench will come in handy reaching in between the engine fan blades to remove the distibutor cap. An open end wrench 8 mm (small as possible) is recommended also. There are 3- 8mm bolts that hold the distributor cap and its shield in place. The shield over the cap is actually two piece - the top section section snapping off after depressing tabs. The main section is held in place with the 3 bolts that pass through the shield and also hold the distributor cap in place.

The 2.5mm Hex Key was needed to remove the Rotor. There were three Allen screws holding the rotor in place. Aftermarket (non-Bosch) replacement rotors may not have same type of screws - mine were Phillips. You can reuse the old screws.

PRV-6 Idle Setting Procedure. [Tips from Dan Roth, who archived them from a list] Here's the V6 idle setting procedure that I've been able to find in my archives.

One thing that could be causing your surging idle is a dirty throttle body. This is a real problem, if the TB is plugged so badly that all air regulation at idle goes through the Aux Air. Clean the throttle body, it's easy enough, but DON'T adjust the throttle stop. Just to make it clear DON'T ADJUST THE THROTTLE STOP - not till later. Just clean the TB. Now, you're going to want to balance the airflow to the cylinder banks:

The B28E has three adjustment screws near the throttle housing, the rear one is for the idle speed and about the other two the manuals only ever say: "don't touch". It did need balancing afterwards, so here's what I did:

1. Run engine for 15 minutes so that it warms up.
2. Turn rearmost (idle speed) screw in fully. That closes a passage to the front two (balancing) screws so that turning them at this point won't have any effect.
3. Adjust the throttle stop so that the engine runs at 700 rpm. May be a little rough, but never mind.
4. Turn two front screws in fully.
5. Turn rear screw out four complete turns. Since step 4 resulted in the idle air passages to both banks being closed, this should not change the idle speed at all.
6. Connect rev counter (handheld meter, not the dashboard kind) and note the exact idle speed at this point. Should still be 700rpm.
7. Turn out center screw three complete turns. Note the new idle speed, should be around 1100-1200 revs, but this isn't critical. Just make a note of whatever the number is.
8. Turn center screw back in fully, turn out front screw so that the engine speed increases to the same as measured in step 7. If you can't make it go that far, turn front screw out three complete turns, measure the new idle speed, turn front screw back in completely, then turn out centre screw to match the speed measured previously. The object of this exercise is to find the number of turns for both screws which will result in the same increase in idle speed. For one, that'll be EXACTLY three turns, for the other whatever it takes. Set each screw to the

number of turns you so determine. Idle speed should be at about 1300-1400 rpm afterwards.
9. Finally, use the rear screw to get idle down to 900 rpm. Then check CO level and adjust if necessary. If you're a perfectionist, take the car for a few minutes' drive, then check idle speed and CO again.

V-6 Poor Hot Restart. [Inquiry:Alex] A few weeks ago I made myself an LED diagnostic tool so that I could make use of the diagnostics which come with my model of MV (760 v6) ps if any one is interested to make their own , email me and i will be happy to obligue.

To return to the story, When rigged the LED flashes 6 times (indicating that the sensor which sits on the #1 spark plug lead is not working). Is there any EASY way I can confirm the non operation of this sensor?

Another request. Periodically, the car does not start easily (engine turns for about 20 to 30 seconds)when the engine is hot and the car has been standing for say 30 mins. When it does start there is a faint smell of fuel. I have been advised via brickboard that it could be the flywheel sensor. Here in Aus I have been quoted equiv usd $120 for the part so naturally I am keen to confirm that the flywheel sensor is not working before purchasing a new one. I would appreciate it if someone had a way of confirming the operation of this sensor as well.
[Response: Abe Crombie] The #1 plug wire sensor is polarity sensitive. Make sure the wires on coil are correct, red/white on terminal labeled 1 and blue on the terminal labelled 15. The sensor could be on plug wire reversed if someone changed the wire and slid it on wrong. This wouldn't make it have start problems when hot. The sensor is used to ID the firing order for proper knock sensor use since it has two knock sensors. Pull the vac hose off of the fuel pressure regulator and see if it has any fuel residue in it. Run the engine and then immediately remove the return line off the fuel pressure regulator (soft rubber hose held by clamp) and see if any fuel continues to drip out of regulator. Any loss of residual pressure from system will cause hot, short shutdown starting problems. A dripping leaking fuel injector would do the same. The best way to check this out would be to use a fuel pressure gauge if available. The check valve on fuel pump can also allow fuel pressure loss when shut down.

Valve Lash on V-6. [Inquiry] How much time and effort that is needed in order for me to adjust my valves on my 1990 760 GLE V-6? The valves are becoming slightly noisy.
[Response:] It's pretty straight forward, but on the passenger side of the car you'll have to move the compressor out of the way. If you have the tools and a reclaim machine you

can remove the freon and remove the compressor completely, other wise you have to wire it to the shock tower to hold it out of the way while you work. I've done it in 3 hours at my shop but if you are doing it at home, it may be an all-ay job. Make sure you check the cam lobes carefully; sometimes the cam and rockers may be going bad due to inadequate oil supply. When you adjust them they'll fail much faster. If they appear worn or damaged, youll need to replace the cam and lifters.

Design for an LED Sensor to Diagnose the V-6

[Design by Alex Dermedgoglou]

To make the number 1 cylinder sensor and flywheel sensor you need the following parts:

- 4 meters of single core wire;
- one crocodile clip (for positive terminal);
- one male flat spade connector (for inserting into female connector located close to left hand front strut ;
- one .25w LED (light emitting diode)
- resistor 560 ohms +/- 5% (green, blue, brown, gold bands on a four-band resistor)

Assembly:

1. Cut 4 meter cable into 2 equal length pieces
2. Solder one length of cable to negative connector on LED
3. Attach spade connector to end of cable soldered to negative LED connector
4. Solder resistor to positive LED connector.
5. Solder remaining electrical cable to other resistor leg.
6. Attach crocodile clip to other end of cable connected to resister
7. Cover whole of LED, resistor etc. with insulating tape, leaving gap to see LED flash etc.

To use (see the attached diagram):

1. attach crocodile clip to positive of battery terminal
2. attach spade connector
3. feed LED display through into passenger compartment so that can be observed whilst driving
4. close bonnet and start engine

If there are any problems the LED will flash the following codes

- 1 flash - Engine knock has occurred, activating knock-controlled timing retardation. Can be due to inferior grade fuel, excessive engine temperature, faulty plug, intake system leakage or engine carbonization (due to frequent cold start and idling).

- 2 flashes - Faulty signal from temperature sensor
- 3 flashes - not used
- 4 flashes - Faulty signal from knock sensors or faulty knock detection circuit (internal to control unit).
- 5 flashes - Faulty load signal from fuel system control unit
- 6 flashes - Faulty signal from No 1 cylinder detector

The unit will flash out the code, then there will be a noticeable delay, when it will flash the code again. Some of the codes will only be flashed under load, so if you get no code at idle, take the car for a drive, accelerating etc. The attached drawing shows sensor connection.

Preventive Maintenance for B280 V-6. See the section under "Buying Used" for preventive maintenance tips.

Parts and Tools for B280 PRV-6. See Special T Auto in Forney, TX for parts and tools for the PRV-6 engine.

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Volvo Maintenance FAQ for 7xx/9xx/90 Cars

Version 7.5

Purchasing Used Diesel. [Advice: Steve MacSween] A diesel with a blown head gasket is a large, difficult-to-move paperweight. You cannot negotiate on purchasing a diesel without a thorough inspection by a qualified diesel mechanic. In most areas of North America (except possibly the midwest US) as a general rule that means NOT a Volvo mechanic, from what I have heard. They simply don't know enough about diesels. Go to a VW diesel specialist, or find a heavy truck shop willing to work on diesel cars.

A thorough inspection must include at minimum a compression test, and that is a bare minimum. You should ideally have a cylinder leakdown test (CLT) done as well. Diesels run at around 20:1 compression -- compression loss means they become difficult or impossible to start in cold weather. A compression test or CLT is pointless, with the head gasket blown. If the head gasket is blown, there is an excellent chance the head is warped and will need to be machined before the new gasket is installed.

You will also need to have a mechanic assess if the diesel injection pump is functioning properly. If it isn't, the general cost to rebuild is in the area of $800-1500. Proceed with caution when looking at a used diesel. Only buy a car with a favourable (read: frequent oil changes), documented maintenance history available. Diesel operating principles may seem (relatively speaking) simple. Repairing them is neither simple, nor inexpensive.

Buying a Used 760T Diesel. [Tips from Andreas Buchmueller] The problems with ALL VW Diesels are these: cylinder head cracks and excessive wear of the cylinder lining close to the top position in the cylinder, both due to full throttle cold starts. The engine absolutely MUST be warmed up before use. I bought and sold and repaired lots of VW Diesels in Europe. The rule of thumb is never buy a diesel from someone who lives close to a freeway, since this person will of course enter the freeway with a cold engine. The warmup period HAS to be gauge reading operating temperature plus another 10 minutes before you do any full-throttle work. [Tips from Andre Lam] The other issue is the turbo charger in the 7x0 and 9x0 series diesels, this further added stress to the engine. In their favor, the D24T was an absolute dream to drive on the highway. The engine pulled strongly, and was much more pleasant than a base B23 in a car that size and weight. Off the line with the slush box things were a bit hairy at intersections. The car seemed to wait a second or three for the turbo to spool, then pow... the car started to pull briskly. This car had true turbo lag. Without the turbo... its a dog, with the turbo... very brisk. Noise was very well subdued as well. The engine ran very smoothly. I really liked the car (if only the engine would last). If driven all day long, then the car will last and last. If you drive it shorter distances, be prepared for an early engine death experience. The cold start was an other item that needed to be checked on regularly. If it was not functioning right, it could also contribute significantly to an early death. The "wonderful" change over in Diesel fuel a few years ago was also a real joy as upwards of %25 of all diesel cars on the road had their pump die shortly after the cutover. Since the pump IS the whole fuel system (pump and timing device) it is a complex beast that costs about $700 to have overhauled, re-installed and adjusted. They normally last about 100,000 miles, so that is not bad, but thanks to the fuel, lots of people got "burned." Would I purchase an other diesel car in the USA. No way. For the last decade regular gas was CHEAPER than diesel, and sometimes I could get premium fuel for less than diesel fuel. Mileage was only so-so. My '84 760TD (w/ 4 speed automatic) got about 17 MPG around town and about 28 highway. I can easily beat that with either my mom's 95 850 (4 speed automatic), and definitely better in my '93 850 (5 speed stick). Here in the USA it is also hard to find good diesel mechanics. I took mine to the VW dealer hoping that at least they would have experience ha! They declared the car in perfect health. Two weeks later my engine is toast with below par compression. Rebuilds are possible, but here again a good mechanic shop is hard to come by. In Europe where diesel is sort of reasonably priced, gasoline is 4 times the USA cost, gas stations are much more likely to also have diesel fuel, then my arguments can easily be beaten with simple economics. The NEW direct injection diesel engines from VW in the 850 are supposed to be really excellent. They run quieter (not really a problem in the 7x0/9x0, but certainly so in the 2x0), don't suffer from turbo lag, and get far superior mielage, and don't smoke up the neighborhood when you take off.

Diesel Lubricants and Oil Fill.

Synthetic Highly Recommended. [Warren Erickson] While many people use normal 15W-40 dino oil in their D24 engines, *you might consider a synthetic oil* due to a design flaw leading to low startup oil pressure. I just finished a rebuild on a spare D24T that I intend to use as a backup for my 760. After finishing the rebuild, I did a compression check. I previously screwed a gauge in place of the switch to monitor oil pressure. During the compression procedure I was monitoring the gauge, NO oil pressure. I then decided to bench run this engine. I made it a point to monitor oil pressure. It came up after a delay and was where it should be.

But the delay, and a previous note from a friend that showed no oil pressure for over three minutes if the engine is standing on an incline, pointed out that the D24 has a rather strange oiling system. It has an oil pump with a long suction tube. The pump is mounted in front of #1 main bearing and the oil pickup screen is way down in the sump by #5 main bearing. This suction tube is close to 36" long and has an inside diameter of approx. 3/4". I'm not a mathematician, but it's obvious there's a lot of volume to be filled before the pump ever gets primed. And you'd better have a good pump to pull a suction. To make matters worse there is approx. 6" between the level of the pump and the oil level. That's a considerable suction head for a heavy liquid. Most engines that I have rebuilt have the pump located close to oil level or submerged.

Now when the engine was new and pump clearances were tight, oil delivery was probably was not a problem. After thousands of miles, clearances increase and pickup time increases. Multiply these dry starts by thousands during the engine's life and you get reduced engine life - one of the complaints of this engine - despite its robust construction.

I could never figure out why synthetic oil worked so well on these engines. After all truck drivers were using the likes of Rotella Dino 15W-40, and getting 500,000 miles without a rebuild. Well it all makes sense now: synthetic oil's superior film strength and lower viscosity when cold. It's able to handle dry starts better. Hence, longer engine life in our D24's when using synthetic oil.

Now this does not correct the original problem; it's only a good a work around. Probably the best thing one could do is replace the pump during a rebuild and switch to synthetic. I'm afraid even a new pump will not completely alleviate what is in essence a design flaw and that only using a synthetic will keep your problems at a minimum.

Overfill Crankcase to Maintain Oil Pressure? [Tip from Brandon] I've had issues relating to delayed oil pressure while starting on hills or inclines due to the problem noted above and my fix is to overfill by 1 quart of oil and maintain this level. I know it's safe and I've proven this when I bench ran my engine after the rebuild. The turbo oil return was left open by mistake and the overfill by a quart never ran out onto the bench. There is 21mm of clearance from the bottom of the crankshaft at its lowest point to the level of the oil return hole and peeking in with a flashlight and small mirror shows almost 2 inches of clearance from the crankshaft to the level surface of the oil. To hit the crank with oil you need to overfill by 2 1/4 quarts.

Diesel Information Tips and FAQ. See the Volkswagen Diesel maintenance FAQ site at http://www.bright.net/~vwdiesel/ for good information on the VW diesel (a variant of which is used in

Volvos.)

For an interesting blog on resurrecting an 85 Volvo 740 turbodiesel, see Ross Winberg's work at http://volvoturbodiesel.blogspot.com/ where he has numerous scanned OEM manual pages covering various procedures.

Diesel Fuel. [Andreas Buchmueller] In most countries, winter diesel fuel has anti-gel agents added to prevent wax formation in cold climates. If you are in an area that does NOT have this, then in cold climates VW allows you to mix the diesel with 30% gasoline to prevent the diesel fuel from getting too thick. BE CAREFUL!!! This is an excellent way to reduce the life of your pump.

Diesel Fuel Filter.
Changing the Fuel Filter
[Inquiry] Please advice how to change fuel filter in my 740 diesel (V 2.4 liter 6 - piston engine) and what to buy as replacement. [Response: Gutzy] You can get the fuel filter at a Volvo dealer or major parts supplier (may have to order it) Fram P8043 is just one of the aftermarket fuel filters available. Fuel filter is located just below the injection pump on my 85 740GLE. It's a spin-on filter similar to an oil filter. Fuel is sucked through the filter by the transfer pump built into the injection pump. A trick that I found was to drive the rear wheels up onto a set of ramps to raise the fuel tank higher than the filter to assist in filling the new fuel filter with diesel fuel. There is also a small bleeder screw on the top of the filter housing that can be opened to assist in bleeding air out of the filter, be sure to close the bleeder screw prior to cranking the engine or you will suck air into the injection pump that could cause even bigger problems in starting the car.
[Response: Jim Bowers] Before you start, collect enough filtered fuel in a clean container to fill the new filter. You can do this by opening the fuel return line and then run the engine long enough to get the required fuel. Fill the new filter as full as you can (Note: see Diesel Fuel Injector Cleaner tip below) to reduce the amount of air the injection pump must pass through when you start up. It is important to realize that the injection pump sucks fuel all the way from the tank and any air leak will let the pump suck air instead of fuel. The air bleed screw on the housing top is normally used only to drain water from the bottom of the filter. The filter should have a drain cock on the bottom that allows for this.
On my car, I installed one of those heavy-duty glass-cylinder gas filters in the return line in the filter area. This allowed for diagnostic checks. If you see an abnormal amount of air bubbles you have a leak or the injector pump shaft seal is dying. I once saw a few metal flakes indicating the pump was due for a rebuild. Those pumps were designed for fuel when it had a lot of sulfur in it. With the EPA mandated low sulfur fuels it is important to use an additive in the fuel to make up for the lost lubrication provided by the sulfur.

Diesel Fuel Injector Cleaner. [Tip from Jim Barron] Certain VW experts (Volkswagen built diesel motors for Volvo), including factory service trainers, recommend filling the new fuel filter with non-synthetic ATF rather than fuel oil before installing it. They claim that the ATF is a superb detergent injector cleaner, the motor will start and run quite well on it, and the fuel incoming from the tank quickly dilutes the ATF so that the car is completely drivable by the time it's beginning to warm up. But beware of some synthetic special ATF for Chrysler products, etc: they can be hard on the injection pump because of their viscosity.

Timing Belts. [Andreas Buchmueller] The camshaft in the diesel is belt driven. This is an interference engine and if the belt snaps the piston collides with the valves and you can say "Auf Wiedersehen" to the engine. VW recommends change of the belt every 80.000 Km so, about 50.000 miles. It is easy to change the belt for someone who has some general experience fixing engines. To set the right belt tension is however critical. [Peter LK Milne] The cam and pump belts must be changed at 80,000 miles and every 80,000 miles thereafter. If you have no service information about these two belts after purchasing a used car, then I would have it done straight away as these engines are interference design. If the belt breaks you will almost certainly require at least a new cylinder head and possibly a complete reconditioned engine.

Procedure. [Ross Winberg] It is absolutely essential that you change the timing belt at least every 60,000 miles. If the belt breaks, the valves will collide with the pistons and then you can say good-bye to your engine. The procedure can be found in AllData. I will just give you a few pointers from when I did the job. If the water pump has not been done in a while now is a great time to do it. If the pump is recent, you might want to buy a new water pump o-ring to ensure a good seal.

You must remove the crank pulley to do this job. This is a huge pain. The crank pulley bolt should have been installed with Loc-Tite and torqued to >250 ft./lbs. It was necessary for me to use a chain wrench with a 3' handle and a 3' breaker bar to remove this bolt. YIKES! The other option is to remove the radiator etc. and get in there with an impact. The crank pulley is keyed, but the key is only there for alignment purposes. It has little structural strength, hence the outlandish torque. I torqued mine to 250ft./lbs. and then tightened it some more using the aforementioned 3' breaker bar.

It is of the utmost importance that the crankshaft is spot on TDC. Buy yourself a small mechanic's mirror and use it to site the TDC mark as if the engine were out of the car and you were looking straight down at it. The manual does not show you how to install the camshaft locking tool . You need to remove the rear camshaft sprocket(make sure to lock the injection pump at TDC with the pin) and I found it necessary to remove the last two valve cover studs. There is a slot in the back of the cam that the tool fits into.

Belt tension: I installed mine too tight and it "howled". I kept on loosening it bit by bit until it didn't howl any more. The VW tensioning tool is over $100. Ouch. I can push/deflect mine 45 degrees with one finger-not trying that hard. While doing the belt, it would be prudent to change the tensioner as well. I found it easiest to remove the power steering pump when doing this job. It's only a few easily accessible bolts.

Valve Adjustments and Injectors. [Question:] How often do the valves need to be adjusted on the D24? Should the injectors just be replaced at some point or just run them until they fail? [Answer:] According to the book you are supposed to check the valve clearance every 15k mi (25km.) Injectors should go at least 75kmiles before nozzle rebuild. They don't usually fail catastrophically. Usually you start getting smoke or excessive knocking. adding a bottle of Techron to the tank will often clean out some of the nozzle deposits and cut smoking and knock for a while. Bosch rebuilt injectors are a relatively inexpensive swap.

D24 Diesel Valve Clearance Procedure. [Inquiry:] How do I set the valve clearance on the D24? [Response: Dimitar/Rich]

Tools: You will need removal pliers for shim plates, a set of shim plates, and a valve lifter tool, the same tools and same procedure as for VW or any Audi diesel. [Ross Winberg] Get the Hazet tool 2574, a micrometer, a supply of VW diesel valve shims, and a shim extractor plier. See Special Tools for diagrams.

Cool engine down completely: the clearance specifications are for a cold engine. Remove the rocker cover.
1) Using a 27mm socket, rotate the engine so that the Number 1 (front) cylinder is on TDC or top dead center (at this point both cam lobes for the No. 1 cylinder are pointing diagonally upwards and the mark on bellhousing is aligned to flywheel mark)
2) Measure valve clearance for that cylinder. "Checking" clearance specifications are 0.15mm-0.25mm intake valve, 0.35mm-0.45mm exhaust valve. If clearance is within these limits, then the valve is OK.
3) If too low obtain thinner valve shim plate and exchange the old one with that one. Do the reverse for too high a clearance. The shim plates are inserted "number side down". To adjust any clearances you must turn the engine a further quarter of a revolution from TDC to prevent the valves hitting the pistons.
4) Do this until the "setting" clearance is 0.20 +- 0.05 mm cold for intake and 0.40+-0.05mm for exhaust valves.
5) Rotate crankshaft for next firing cylinder adjustment (1,5,3,6,2,4 order).
6) Repeat procedure
7) Rotate engine twice and check everything again
8) Check clearances every 20,000 miles or so, although an absence of noise indicates clearances are probably within specifications.
9) Replace with new valve cover gasket.

Water Pump. [Inquiry] My water pump is leaking. Since the water pump is driven off of the timing belt, is it a big job to change the pump? [Responses: Mark Stites] The toughest part of replacing that belt will be getting the crank bolt out. If you are doing JUST a belt and pump you can get away without having to check pump timing. It would be nice if you could recheck your pump timing but I can tell you from experience that if all you do is change out the water pump and belt and you are careful not to move ANYTHING you should be alright. However, if you have no experience with timing belts I sure as hell would not start with a D24 just on the simple fact that you could blow the motor up if things are not right. If you do elect to have it done I would put in a new belt, pump, and idler pulley (the water pump is your tensioner in this set up). While you are there you might as well have the rear belt changed and the pump timing checked and adjusted. If you elect not to have the rear belt changed understand that it will not cause the motor to blow up if it breaks but it will leave you on the side of the road. It is best to do them together. [Robert Ludwick] If you've never dealt with timing belts before, the D24 is not for the weak-hearted. Timing one of these things is not overly difficult, but it requires having the proper tools, an above- average level of mechanical skill, and following directions exactly in the factory green manual. Anytime that you fool with the timing belt on a diesel, count on retiming the whole engine (special tools required) You might get lucky and have the new pump be the exact dimensions as the last one and have the timing belt under tension wind up in the same place... but I wouldn't count on it. Often mechanics will try to swap water pumps on these engines and they won't start after completion. If you aren't too far from a t-belt and tensioner change anyway, it might be time to invest in the tools and do it, or find a liberal-minded VW diesel mechanic to do it for you.

Faulty Starting: Troubleshooting.

Glow Plugs. [Tip from George Holmer]. My very well maintained turbo diesel would start up badly in the morning and smoke, the colder outside the more smoke, lots and lots of smoke. I knew all the glowplugs were brand new so I suspected the glow plug relay. I opened it up and lo and behold, there is a copper plate partially split in two with two contacts at the split end. The smaller bit was seriously affected by heat and had severe discolouration. The contact was badly pitted and the copper had bent downward sligthly causing this contact to meet but not the other one, thus rendering the relay useless. In my case, with severe pitting the relay will soon need to be replaced but just cleaning the surfaces with a sandpaper and bending the two split parts of the copper plate and making them level has made my car start up much, much better and there is much less smoke. Since I did this, a number of other diesel owners have confirmed that their relays have suffered similar fates. If your diesel is a hard to start from cold and smokes badly, the glow plugs are often the culprit but do not forget the relay, it's easy to check and fix. [Andreas Buchmueller] I recommend changing ALL the glowplugs every 60.000 miles and keeping an extra glowplug relay and fuse in the car all the time. If one glow plug does not work the car WON'T start in cold conditions. A well-maintained diesel engine HAS to start in less than a second after the second preglowing. [Peter LK Milne] The only things that stop a D24 from firing when cold (ie left outside all night, not in a dry warm garage) are the glow-plugs or the glow plug relay (front of left hand wheelarch above battery). Any poor connection to/from this relay will impair the starting quality as will a couple of glow-plugs gone down.

Changing the Glow Plugs. [Inquiry] My D24T was suffering cold start problems. My local volvo mechanic has changed plugs 1-4, but says that 5/6 require a lot of dismantling to get to and replace. [Response: Peter LK Milne] Basically undoing the busbar nut (loosening but not removing) should enable the correct spanner to be fitted to the body nut. With spanner in place slip a noose of string over the plug insulator. This should stop it falling when fully loosened from the head. It should then be easy to remove the glow plug. It should then be possible to (using spanner and pressure from a finger to fit the new glow plug. No 5 is removed/replaced in a similar way but using the busbar (with loosened top nut) to hold the plug as it is removed.

Transferring the busbar to the new plug will facilitate replacing it. It would, of course be better to test the plug's resistance before attempting to remove it. It should read about 1.3 Ohms if good and will nearly always read quite high when knackered. Obviously a good Ohmmeter is essential. My 5 & 6 are due for replacement which will be done when the Cam and Pump belt are changed which gives a little more room to reach them. [Ross Winberg] Contrary to popular belief, it IS possible to replace all 6 glow plugs without removing the fuel pump. You need to purchase a SHORT (or "stubby") combination wrench to fit the glow plugs, remove the rear timing belt cover and go in through the rear timing belt to get glow plug #6. The hardest part about this job is reattaching the glow plug wire for #6. I needed a deep offset box end wrench (Sears sells them, but I used a Hazet). Clean off the electrical contacts while you are doing this job. I use Wurth Contact OL. Replace any missing insulation on the copper strip with heat shrink tubing. [Response: Robert] I always first remove the buss bar from #4, 5,6, and pull the wire that goes to the temperature sensor on the back of the head and move it out of the way, then # 6 is easily reached with a 12mm angled box end wrench(spanner) turned over (the end of the wrench that would normally be angled up and out, turn it down toward the head. Slip it in from the back of the pump bracket and you'll be able to work # 6 out from the back without too much trouble at all. The flipped- over wrench helps on #5 too The best way to reach this is to lay some padding across the right-side fender and lay on your stomach and access the #5, 6 glow plugs with your left hand.It's really quite easy this way. Trying to reach them from the other side is a nightmare. A good idea to use a touch of anti sieze compound on the threads of the new glow plugs so the'll come out easier next time.

Diesel Glow Plug Fuse

Glow Plug Fuses. [Ross Winberg] Extra fuses are always good to have on hand. You will not find the glow plug fuse in any local auto parts store so all the more reason to have a spare on hand. The glow plug fuse on the D24T is basically a flat strip of metal. It is rated for 80 Amps and available only through Volvo for a cost of less than $3. To replace the fuse you need a 10mm socket to remove two nuts that hold the glow plug relay (located on top of the driver's wheel well) and a phillips screwdriver to replace the fuse. It is good practice to clean all electrical contacts that you disassemble with contact cleaner.

Vacuum Leaks or Fuel Drainback. [Inquiry] I have a problem with my 1990 760TD (D24TIC) in that when the car is cold or hot it starts fine. But after allowing to cool for say 15 minutes it becomes increasing difficult to start the longer it is left to cool, until the point at which the glow plugs come on for the normal period when it starts fine once more. My local Volvo dealer typically wanted to replace all the parts as a means of testing which I was not going to allow. But I have been letting a local diesel specialist look at it and he has checked the obvious things like glow plug relay (was brand new anyway), injectors, glow plugs etc. and now thinks the problem lies with the fuel pump. He believes that the fuel is draining away back to the tank after stopping because of a potential fault in the vacuum side. He has suggested I try & source a new pump and warned me it can be expensive. [Response: Peter Milne] Have you checked that the fuel filter is screwed in properly and that the drain screw on the top of the body is tight with the drain tap at the bottom of the filter tight as well? Apart from that the only other source of drain down is perished rubber hoses on the fuel lines between pump and left hand chassis member where the fuel lines affix, or perished hos connections at the rear hwere they enter the tank. A further reason could be one of the injector pipelines has worked a little loose at pump end or one of the return line rubber hoses between the injectors may have perished or is not as tight as it should be. Sometimes a leak can develop in the body of the pump which can be cured by carefully retightening the bolts holding the pump body together.

Excessive Smoking. [Inquiry] After replacing my turbo and reconditioning the head, the engine still smokes. [Response: Peter LK Milne] Under General Fault tracing in the relevant Green Book the reasons for black exhaust smoke are given as follows:

1. Excessive amount of fuel injected
2. Incorrect injection timing (too far retarded)
3. Dirty air filter, too little air getting in
4. Worn injectors
5. Poor grade or contaminated fuel
6. Blocked exhaust system.

The very first thing I would do to eliminate the most expensive item in the list would be to pour into a full fuel tank some fuel and injector cleaning fluid at the recommended dose. I would take the car for a run of about twenty miles to see what effect that has. Then check whether your cold start fuel enrichment is working correctly or if it has stuck in the cold position. Does your car have Exhaust Gas Recirculation? If so it would be a very good idea to disable it. The only emissions valve I know of is a trap in the rocker box vent to inlet. Your engine should have hydraulic tappets and an extra cam belt tensioner under the camshaft wheel at the front. When you have done the above checks then have the car's fuelling set up from scratch, including the cold start fuelling and idle revs (cold and hot). The important things to get right before this are the cam belt timing and the fuel pump timing. Also put in a new set of glow plugs, I know 5 & 6 are pigs but well worth doing as most garages tend to leave them alone because they are difficult.

Excessive Smoking on Cold Start, Lumpy Idle. [Peter K.L. Milne] The cold start depends on two things. Firstly the glowplugs which are energised via the glow plug relay. This is the black box sitting just behind the battery on the forward face of the wheel arch. There is a set way to test the relay and glow plugs using a test lamp (about 5 Watts is plenty). If these work OK then the fuel cold start device needs to be checked. When cold the fuel lever on top of the fuel pump should be about 4-5mm clear of the slow idle stop (engine side of the pump). If this is not so then check that the attachment (on end of cable from start device) is correctly fitted. Then check that the two small hoses are attached to the cold start device at front of pump. If so and there is no movement of the cable between cold and hot then the thermal bulb inside is duff. If everything works as it should then you may need to recalibrate the pump and reset the stops. This is explained rather nicely in the Green Book for the D24.

Excessive Smoking, Poor Low-End Power: Timing. [Peter KL Milne] Make sure that pump timing is spot on. I had very similar symptoms with a 944 TDI because the pump drive belt had jumped a tooth and retarded the timing so that at low revs there was next to no power, but if you managed to wind her up she would do 90 mph all day long. To quickly check you need to remove the rocker cover and pump drive belt guard. Turn the crankshaft so that the timing mark coincides with the two front camshaft lobes pointing equally upwards (like a wide "V"). The mark on the rear face of the pump drive sprocket should line up with the two marks on the bracket and pump housing. The pump needs to have these three marks line up. Two are set in the mechanical set-up of the pump body and bracket, the third is the mark on the sprocket outer edge, which can be set by the stop pin tool which is inserted through a hole in the pump drive sprocket to lock the pump into it's correct setting - if there is then any discrepancy in the cam to pump timing it will show up with the pin in place to lock the pump setting as you set the camshaft/pump relative timing -done before you use the dial indicator.) I use the Sykes-Pickavant timing tool set with my car and it is pretty foolproof. It consists of the square tool that fits into the camshaft rear sprocket slot and two sets of feeler gauges (as it is a universal kit) and the locking pin

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Replacing Cold Start Device. [Ross Winberg] After I determined that my cam timing and injection pump timing were spot on, it was time to figure out why the car started so horribly cold (lots of white/blue smoke).

Cold Start Device Cutaway

One obvious issue was that the coolant-regulated cold start device was non-functional. It is designed to advance the injection pump timing for cold starts. I called up Bosch and they put me in touch with a dealer that could order the part for me. From the swedishbricks.net FAQ, 1-467-202-302 is the correct part number. It cost me about $50.

To replace the innards of the cold start device you will need a vise, small needle-nose vise-grip, 4mm allen, a hammer and a punch. When you disassemble the device you will quickly notice that it is under a LOT of spring pressure.

The punch is used to get the wax thermostat out of its housing. Here is a picture of my old one cut in half(above). It has a rubber boot that goes around a sliding rod. I have no idea how this thing works, but I like to take things apart.

When you get the thermostat in the front housing(the one with the coolant ports), take the rear housing with all its springs, cable, etc. and compress it in a vise. The cable should come out the back exposing the stainless steel shaft that the cable is crimped into. Put the needle-nose vise-grips on the shaft so that whe you release the vise, the springs stay compressed. Install with the two 5mm allen bolts and then remove the vise-grips.

I recommend soldering the cable end. It will keep the cable from fraying, which mine is doing.

Injector Rebuild. [Inquiry:] I am looking for a source to either rebuild my injectors or to purchase rebuilt ones. Does anyone have a source that offers good prices? [Response: Dimitar] I would suggest you ask at a VW dealer or preferably Bosch. It is the same injector (or nozzle for rebuild) as in VW Golf or any other VW/ Audi diesel car. For D24 T opening pressure should be adjusted to 155 bar. Bosch part no. of the nozzle is 0 sd 293.

Diesel Compression Test. [Inquiry:] I am interested in getting a compression guage to test the compression. Unlike a gas engine I'm quite sure that the guage would have to come with a fitting to thread it into the injector holes since I doubt that you could hold it in place with the high compression pressures of a diesel. [Response: Dimitar] You are correct. For good engine performance it is rather important that all 6 cylinders has close compression results, 6-8 bar difference between any two. When new compression is 33 bar and low end (per manual and Volvo) is 24 bar.

Procedure. [Ross Winberg] Compression testing this motor is quite an ordeal. Before you compression test, adjust your valve clearances. To do the test, you first need to remove the injector lines with a 17mm line wrench, carefully labeling which goes where. Second, you need a deep-well 27mm socket with thin walls. I also found it necessary to use a serpentine belt tool (picture at right) to remove injector #5. The extremely low profile of the 1/2" drive part of the tool (at upper left in the picture) allowed me to squeeze between the injector and the injection pump. I recommend the Sears Craftsman as it was the least expensive tool I found. Be sure to blow out all of the sand/dirt/etc. from around the injectors as you remove them. Once I had the injectors out, I removed the heat shields with a large screw. I threaded the screw into the hole in the heat shield and used a slide hammer to pull out the shield.

Serpentine Belt Tool

I found it very difficult to find a diesel compression gauge (onethat reads up to 500 psi) at local auto parts stores. You also need the adaptor for injector hole (see pic at right) This adaptor is the same as the VW one.

Diesel Injector Adapter for Compression Test

My compression readings (with bad cam timing) were 400 psi for cylinders 1-4 and 360 psi for cylinders 5 and 6. This matches the general consensus that cylinders 5 and 6 can become starved of oil under certain conditions.

Turbo Diesel Vacuum Pump Noise. [Inquiry:] Anybody out there know how to cure a knocking vacuum pump? It's like a noisy tappet but comes and goes without any pattern: seems to be at engine speed, tap tap, but is much more easily heard at idle.. I have renewed the rod between the camshaft and the pump without success. [Response: Peter KL Milne] A new vacuum pump is needed, although you may be able to fix it with a repair kit. The pump will set you back around £170. It can be sourced from G,S & F or Eurocarparts in the UK and is made by Pierburg. The pump comes complete with a matched pushrod which must be changed with the pump. [Response] We used to overhaul the vacuum pump with a kit from Volvo. Occasionally, the big internal spring breaks, which can cause the noise you're describing. You could try a new or rebuilt/junkyard pump from somewhere, if you don't want to overhaul yours. Keep in mind that VW originally built that engine and a pump may be available through a VW parts outlet. [Response] A new pump is around US$550 and an overhaul kit comes to $350. Also finding one in a junkyard is nigh impossible. VW outlets have similar prices.

Turbo Diesel Cylinder Head Removal and Recondition. [Inquiry] Any tips about replacing the head gasket and reconditioning the cylinder head? [Peter K.L. Milnes] Purchase the OEM manual for your engine and follow the instructions carefully. In the front of the manual you will see the special tools that are required. I would personally use all the special tools they specify as they are designed to make the job foolproof. Remember this is a Volkswagen diesel engine, so it needs a bit more care with procedures than a Volvo petrol engine. However, if you follow the steps as in the manual you should have no problems. Just read the section for the job you intend to do thoroughly before you start the job and make sure that the appropriate special tool is there to help you. [Rich] Having removed and refitted several cylinder heads from the D24 engine I can tell you that it is definitely not a job for the DIYer. Specialist Volvo tools are needed to carry out the job properly. If the head does have to come off then you ought to also renew the water pump o-ring, change the timing and injection pump drive belts and injector heat shields too. Of course, the injection pump will need to be retimed too and this also needs the proper tools to get this accurate. Specialist tools are also needed to reset the valve timing as the camshaft pulley is a taper fit onto the end of the shaft without any keyways.

Loose Prechambers. [Inquiry] I have two loose pre-chambers in my D24T cylinder head, removed for reconditioning. They don't appear to be damaged, push back in snugly, still have their locaters, and fit flush with the head surface. How snugly are these chambers supposed to fit? I'm concerned they might work loose in operation. [Tim Hicks/Robert Ludwick] I removed mine to clean them prior to machining. All of mine would not stay in afterwards. I used a Loctite adhesive to keep them in: clean the joining surfaces with anaerobic activator or acetone; let dry for awhile; then seat them with red Loctite . They will not fall out after the head is installed as they are held in place by the headbolts. [Robert Ludwick]

Injection Pump Seal Replacement. [Inquiry] My D24 injection pump front seal is leaking. How can I replace it? [Robert Ludwick/James Souther] Don't waste your money on installing a used pump; you'd most likely just be buying a rebuildable core...which is what you already have. It's not too horribly difficult to remove the pump or replace the seal, but there are a few tools you will need. If you don't already have the special pump gear puller, the easiest thing to do is remove the pump bracket to block mounting bolts (the bolts directly between the pump and the bracket and the one below that holds the dipstick tube). Soak the bolts with good penetrating oill for a couple of days before starting in case the last gorilla to work on it overtightened things)

First remove the belt guard, turn engine to top dead center #1: there should be a mark on the pump gear and the small hole in the gear will line up with the hole in the pump bracket. Take a permanent marker and mark EXACTLY where the pump lines up with the bracket. Feel the existing belt tension so you can get it close on reinstallation. Remove the injector lines (You need at least a 17mm flare nut wrench and a 17m flare nut crows foot wrench comes in REAL handy; the latter about $20 from SnapOn Tools). Then loosen the pump bracket, remove the belt, remove #6 glow plug wire, pull the pump bracket bolts all the way and wrangle the pump out with the bracket.

Now take the whole assembly to a diesel injection shop and pay them to pop the gear off. For a few bucks more, have them replace the shaft seal (or buy the seal and replace it yourself: not hard, but you know the shop will get it right and you don't want to do this job twice)

Reinstallation is the opposite. Two tips:

- When you put the pump back on, loosen the pump fuel input line and gently pressurize the return line to the tank to prime everything. This saves the battery and starter when you fire it up.
- Be sure you are at true TDC if you have to start over because there are two marks on flywheel. I do a mandatory engine turnover with a wrench on the crankshaft pulley a couple of complete turns to know I had everything timed right. If it is not timed correctly, then this manual turnover will allow you to feel a valve hitting the piston rather than crushing one with the starter).
- Do not fully tighten the injector line nuts until you see diesel pulsing out without bubbles when you try to restart the engine. As you tighten the bled ones, it will start to run and then tighten them all.

If you marked things carefully then HOPEFULLY you will get it close enough to run, but if not, you'll need to buy a timing gauge.

Can I Replace My Non-Turbo Injector Pump With One from a TurboDiesel? No: a turbo pump has different parts inside it, uses atmospheric compensation, and is matched to different injectors.

Oil Pump Gasket Replacement. [Tips from Dimitar Vlahov] I will try to give a list of neccessary work to change oil pump gasket on VW/Volvo diesel so that can be compared with gas cousin.
First remove: valve cover, electric harness big connector on firewall, front timing belt cover, front timing belt, rear timing belt, injection pump turn away in bracket, PS pump, A/C compressor and complete cooler and fan system. Anti freeze must be poured down as to change front timing belt it is neccessary to move (and open) water pump- water pump tensions timing belt-. Then, left and right engine mounts are going off in order to pull engine out of bay for about 20-30 cm up. That is needed because to reach oil pump pipe bolts oil sump must be off (and that is not possible with engine in place). Then alternator and fan goes out, together with crankcase dumper which is 2 piece part (and 400Nm or around 350lbs-ft torqued). When engine is almost bare enough only then you can first unbolt carefully oil sump followed by oil feeding pipe inside. Only after all of that oil pump can be taken from crankshaft and crankcase, remove paper gasket and inspect everything.
In process it is necessary to use some special tools and it is GOOD to have factory green manual at least.
Assembly is obvious following the manual (it is easy to say but not so easy to not forget some part or assembly timing).
After everything is back on then you must do proper engine timing of front and rear timing belts, injection pump, cold start device. There is no marks on crankcase or crank dampener but there

is alignment point on flywheel. Also there is no any marks on timing belts. When doing timing belts there also must be redone initial injection pump timing.
I think that on D24 it is very complicated to work for everyone who is accustomed to the Bxxx series Volvo engine. It is completely different way of thinking from bottom to top of engine. And prices for engine work seem to be higher then for any other diesel engine around here. And yes, you can drive gas Volvo with slight engine defect but diesel Volvo will not forgive any lack of precise and in time service procedure. It is susceptible to bolt overtension in alu head, to head gasket at full temperature in summer, to cold winter starting, to oil supply system, to cold start device. But if everything is in original specification it has almost flat torque and is vibration free. It is only 82 hp but still you can pull trailer with 1.500kg (3.300 lbs) effortlessly.

Starter

Failure. The starter may not be the problem; check the wiring harness first.

Removal. [Peter Milne] Starter removal is best done from underneath with the car on a ramp with the exhaust downpipe and clamp removed. [Inquiry] I'm having trouble getting the starter out of my D24T. I have the two bolts out and seems to be loose, but won't come out. What am I missing here? [Response] Loosen the cable, then wiggle and twist; it fits the hole rather snugly. [Brandon] Diesel starter is an easy affair: two bolts plus electrical connections and then wrestle it out. I believe the bolt head is 3/4" compatible so you can use a standard socket. [Noel DeSouza] Don't expect to take those nuts off the 2 bolts that stick out from the back of the starter: I have 2 starters and both had nuts stuck onto the bolt. Use the correct size wrench and you will find that the bolt (which is as long as the starter) will unthread from the other end and the entire bolt will come out.

Starter Rebuild. Hitachi made the diesel starter rated at 2.1Kw which used ball and roller bearings and did not require a support snout on the end making it easier to change. After 1985 all 760 diesels were "supposed" to have the Hitachi starter and all the ones I've seen had them. It's a snappy little motor but doesn't tolerate long crank times. It's also a bit more efficient than the old Bosch motor that used bushings and tape wrapped coils. Hitachi is a sealed encapsulated part. The picture shown on many online ordering websites is NOT the Hitachi gear reduction starter, it's a generic Bosch for the B2x gasoline motors. The Hitachi has a defined offset look to it along with big mounting ears and lots of space between the motor and solenoid itself into which you can fit a finger. Problems you might encounter with getting the wrong diesel starter: bolt length issues. I don't remember if they were different lengths but in any event the bolt is an M12X1.75. The battery positive cable lug end may need to be enlarged slightly with a reamer to fit the larger lug on the motor. This ONLY applies if you have the older-style Bosch motor and not the Hitachi gear reduction unit.

Starter Motor Brushes. If you are tempted to resolder the motor brushes, do it at your own risk: a lot of current passes the junction and causing heat sufficient to soften the solder. The proper repair is to spot weld the flyleads to the copper bus bar using phospher-bronze based silver solder.

Solenoid. [Noel DeSouza] To repair the solenoid, you will need a soldering iron to remove the contact plate, clean and reinstall it. My biggest challenge was removing the 2 flat-head screws that hold the solenoid to the starter - you need a very good 3/8 or 1/2 flat-head screwdriver with a perfect tip to pull those 2 suckers out as they are really tight, and using anything less than a good screwdriver tip will mess up their heads and result in them being permanently stuck in there. I replaced them with 2 socket head screws.

Diesel Parts. [Parts Source Tip from Kevin Rhodes] Try the VW suppliers - Rapid Parts and Wolfsports are two good ones - it's just a VW 4 with two more cylinders. Used in VW trucks in Europe. Most parts are interchangable - there are just more of them. The specs are pretty much the same too. My roommate had a 740TD, always bought from Rapid Parts for FAR less than the Volvo dealer.

See Fuel Additive and Lubricant Reference Information for information on lubricants.

Maintenance:

"Service Engine" Light Reset in Various Models. See the discussion in Electrical-Instruments for information about re-setting the "service engine" lamp, which is an engine oil change timer.

Oil Filter Recommendations. [Editor/Kane Leung] Universal and near-unanimous opinion on Brickboard, Swedishbricks, UK Volvo Club, et al is that one should use either the Volvo OEM or the identical Mann oil filters for all Volvo engines. These are of exceptional quality, have large filter media and full nitrile antidrainback valves, are very inexpensive (Mann W-917 filters for B230 engines come as low as US$3 each), and are readily available. So there is no need to use another brand unless you are in a pinch. For links to oil filter information, see the [FAQ file].

Oil Filter Change. Changing the filter on 7xx series Volvos can be a challenge and I've never seen any way to do it that does not make a mess. As to hints - make sure you use a "low profile" filter. The generic Fram filter (the PH8A) is way too tall, you can get it in, but getting it out is a pain. The Volvo / Mann filter (or one of comparable size) is the one to use. As to the wrench (I use a band type wrench - where the metal band goes around the filter body) - I tried drawing a picture in my service manual to remind myself how it fits, but I end up "re-inventing the wheel" each time. I've just resigned myself to fitting the wrench and moving the filter only a 1/2 inch at a time until it gets loose enough to remove by hand. Thankfully, you can move the wrench more as you refit the filter. [Editor:] The wrench to use on turbos is the large curved pliers with gripping teeth that fit around the filter.

Tips for Mess-Free Filter Changes:

- [Yeti Man] Put a rag over the motor mount. Place a plastic bread bag (long bag with NO air holes in it) over the filter after 'cracking' it to the point where it's hand tight. Scrunch the bag over the filter, against the block, let the filter drop into the bag. Obviously not good on a Hot engine, but doable on a warm one.
- [Greg Sievert] Wrap an old sock (best to have a white, cotton sports sock) around the filter. The sock absorbs a good portion of the oil that drips out. Also, remove the filter as fast as possible and tip it upright immediately. Obviously if you tip it bottoms-up, the oil in the filter (nearly a quart) will spill on everything.
- [Bob] I use a piece of stiff plastic cut to fit under the motor mount and filter. When you remove the filter, the oil runs down my plastic "Bucket Buddie" and in to the drain pan. Still get a small amount on the motor mount bracket but this is quickly cleaned off with brake cleaner.
- [Editor] I use a large piece of aluminum foil to direct and hold the oil so it does not soak my motor mounts. DON'T allow this to contact any electrical terminals, for obvious reasons.
- [Ivan] Using a nail or similar sharp object, punch a hole in the filter while it is still on the car. On vertically mounted ones, straight through the middle, on horizontally mounted ones, just bellow the top (remember there is oil inside). With drain plug and oil filler cap already off there is enough pull to completely drain the filter free of oil. It works like a charm.

Oil Viscosity Recommendations for Volvo.

Volvo Oil Recommendations and Warranty Requirements. [Technical Service Bulletin 174901201 and Service Maintenance Bulletin SMB-17-4, Dec 90, updated by SMB 22-3 of Feb 1995 and July 1998] This TSB has a discussion of the dangers of using oils with too heavy a viscosity grade. "Volvo's recommended oil viscosity in most climates is 10W-30" (with 5W-30 acceptable in colder climates.) "*The maximum acceptable viscosity, which is reserved for extreme duty only, is 15W-40.* Extreme engine duty is defined as driving conditions that tend to raise oil temperature excessively, such as sustained mountain driving, trailer hauling, etc. An exception to the above restriction could be high mileage engines (above 100k miles) operating in hot climates. These engines may require a heavier viscosity oil to maintain oil pressure and reduce oil consumption. Oils with viscosities heavier than 15W-40 are not approved by Volvo." They then discuss the ills attending use of heavier-than-approved viscosities (which include poor fuel economy, poor cold start lube, poor engine cooling, etc.). "Synthetic Oils are HIGHLY RECOMMENDED for vehicles operating in temperature extremes (very cold or very hot climates), continuous mountain driving, trailer pulling, and for turbocharged engines." The July 1998 SMB lists the the most recent oils by brand and viscosity that are acceptable for Volvo new car failures warranty claims; they include Agip Super and Turbo, Amsoil, Castro GTX and Syntec, Exxon (Superflo synthetic or blend only), Mobil 1, Pennzoil Performax Synthetic, Quaker State (Super Blend, 4x4, High Performance, Synthetic), Texaco Havoline and Synthetic, Valvoline All Climate, Durablend, and Synthetic. Synthetics and most blends are approved for both 5W-30 and 10W-30; nonsynthetics only for 10W-30. Dealers are "highly encouraged" to use the oils listed. Using oils not approved by Volvo may result in new car lubrication/engine warranty repairs being denied.

Comments. [Tom] My brother and I have made a pasttime of studying engine oil. We respectfully disagree Tim's recommendation of 20W-50. The 30 point gap between the weight and the film strength is too much. The additive package necessary to make up the difference is being asked to do quite a herculean task. We would recommend using a 15W-40 for a heavier weight oil. The 15W-40's have been so extensively developed, that for heavy duty applications such as over the road diesels no mineral based oils come close. Mobil Delvac 1300 is a readily accessible choice and the 'badge' oil of Detroit Diesel; Shell Rotella T is another. A good choice for fall and spring is a high quality 10W-30. 10W-30's are technically acceptable down to 10 Fahrenheit. In the winter you can trust a quality 5W-30. Department store Pennzoil has done well in past tests. We disagree with Consumer Reports conclusions on their NYC taxi tests. Running a taxi is a lot of stop and go with perhaps a lot of rapid acceleration, but the engine is always warm. It's cold starts that are hardest on engines and oil. Granted they tried; they had to design something they could control. Well, that's just two oil fanatics' opinion.
[Editor's Note:] Volvo concurs; see Technical Service Bulletins 22-3, Feb 95: Oil viscosity grades 10W-30 and 5W-30 are recommended brand-by-brand (and include the usual Pennzoil, Quaker State, Castrol, Texaco and Valvoline brands.) The use of 15W-40 "should be limited to engines in extreme duty."

Diesel Engine Recommendations. Diesel engine owners should use the CG-4 oil listed in their owners' manual. See Warren Erickson's recommendation about using synthetic oil in D24s due to a poor starting oil pressure and the following note recommending overfill due to poor oil pickup tube location.

Changing to Synthetic Oil. [Query] I had an oil change done and switched to Amsoil 10W-30 synthetic yesterday. I asked the service guy at least twice whether to replace the oil filter after 1000 miles. He said that it wasn't necessary. Whats going on ? [Response: Mr. Lube] The synthetic will clean a great deal of gunk out, which will plug the filter quickly. I have seen it happen at my oil change shop over and over and over. I tell people to bring the car back after a month to change the filter only. It can and will cause some damage. I do not think it is a matter of preference or choice really. Rather, the $4.00 filter will become plugged with the switch, and it is left to the wise to follow past experience and advice from the ample evidence. Get it changed, and you will be surprised how dirty the filter will be.

Oil Drain Bolt.

Don't Strip It!. [Tip] When reinstalling the oil drain bolt, don't mash down on the wrench and don't use too long a wrench or a breaker bar to install it. I hold my ratchet midway down the handle when re-torquing so I don't overtorque the bolt. Install it with the copper sealing washer. It goes without saying that you loosen it counterclockwise; tighten clockwise. Fast lube shops are notorious for over-torquing these bolts.

Size. [Tip from Roger Huggins] The Bentley book for B230 recommends a 1" socket and a torque setting of 60 Nm (44 ft-lb).

Caution. [Dick Riess] The IPD magnetic drain plug has very few threads compared to the OEM plug and consequently the torque is on only about three rounds of threads. Hence, it is easier to strip the pan threads when replacing it. Be careful!

Leaks. [Tip from John Sargent] My car will leak from the oil drain plug even if it is very tight with a new copper gasket. I use an o-ring at the base of threads on the oil drain plug. It does not leak. If you use an o-ring is too large it won't work. You need one which will sit down in the tapered area leading to the threads in the pan. Ideally you would find a washer that would keep the o-ring from pushing out from under the edge of the drain plug hex.

Stripped Plug Threads. While you can find repair kits for stripped plug threads, you are best advised to replace the oil pan. [Dick Riess] To retap the threads, try a 3/4 inch tap with 19 pitch threads. [Jeff Pierce] For a short-term fix, wrap a band of aluminum foil around the bolt (in the opposite direction as the threads, but not extending up beyond the end of the threads) and tighten the bolt to "good and snug" (that's a technical value that's achieved by tightening until just before you think the threads are gonna give way). Then when you're ready to fix it right, get an oversized bolt -- not a self tapping one --and a tap and retap the threads. Self tapping bolts are essentially screws. They're made to "self tap" once -- not a good idea for this application. After you've changed your oil a few times, the "threads" will be gone, and then you'll just have new stripped threads in a bigger hole.

Troubleshooting and Tips:

Oil Leak Diagnostics
Major Culprits:
[Summary of article by Boe Kalinoski, Import Car Magazine, April 2001] The first step in discovering the source of any oil leak is to try to clean the areas where dirt, grime and oil are present (I've found that steam cleaning is best). In our shop, we use a fluorescent/black light along with a special dye. Simply add it to the engine or transmission and run the vehicle while the fluorescent light is warmed up. Most of the time, the leak instantly appears in the form of a bright glow. Or use foot powder: dust it near the leak and the oil will show up later, allowing you to pinpoint the source. Leaks in Volvo B230 engines can occur when the crankcase flame trap ventilation becomes restricted. It consists of a small, black plastic tube located under the rear of the intake manifold that is cleaned at normal service intervals. To help identify the source of the leak, see the chart in Garage Floor Mechanics.

Potential Oil Leaks:

- Any of the three front three seals located behind the timing belt — cam seal, idler shaft seal and front crankshaft seal, can fail and should be changed with the timing belt at the 100,000-mile service interval.
- Distributor shaft seal or O-ring
- Oil cap seal or the valve cover gasket (both easily fixed): this oil can leak onto the manifold, vaporize, and disappear. You can lose large quantities through a bad seal.
- Rear main crank seal, but make sure this isn't caused by leaks from above at the distributor or valve cover gasket.
- Oil filter mounting oil rings, between the oil filter housing and the block and the fitler housing and the cooler connections. This is awkward to get to on the turbos, but a reasonably simple repair and the problem is obvious by inspection on a lift. You can also have an oil leak from the oil return line if the cooler has rotated around so as to keep the return line from seating.
- Valve cover nuts: Re-torque the valve cover nuts to 9 ft-lb (12.5Nm) in order to prevent oil seepage per Volvo TSB Jun 88.
- Oil breather box plastic canister that is bolted to the engine block above the starter can crack and deteriorate with heat.
- Oil pressure sensor - another common problem. Right side of block, toward the front,

  below #1 exhaust port.
- [Tip from Bob] PCV (flame trap) elbow going to the oil/vapor separator. If you haven't personally cleaned it, chances are it's plugged. It's a plastic elbow with a little nipple on the outside...it's generally in the 1/2" hose from the compressor outlet tube to the intercooler that goes across the cam cover and down to the vapor separator. There's a smallish vacuum hose from the intake manifold that goes to this elbow. Also check the vacuum line and nipple at the intake manifold for plugging. If this system is plugged you won't get positive crankcase ventilation...oil life is radically reduced and crankcase pressure is generally relieved through the cam seals if not the engine main seals.
- Transmission leaks caused by a worn-out tailshaft bushing that leads to excessive play on the shaft and a leaking seal that spews ATF all around the tail section. Deterioration of the rubber transmission mount will result.

- The power steering rack and rubber hoses can cause small, disturbing leaks.
- Steering rack seals leaking internally; check the boots for the presence of fluid.
- Steering rack input shaft spool valve seals. At this point, you should replace the rack assembly, as steering assist will be lost if the power steering pump runs out of fluid, resulting in pump failure.
- [Very Rare, per Dick Riess] Engine oil dipstick tube o-ring. This o-ring can petrify over time. The tube is a light friction fit into the block and loss of the ring can cause blow-by.
- Oil Pan Gasket: see FAQ notes.

Major Oil Leak: Diagnostic Steps.
[Query] Returning from a 500 mile drive the rear gate on my 745 looked as if it had been sprayed with oil. Didn't think too much of it, thought I may have driven through something. 1 Week later after another 500 mile trip the engine smells hot. I check the oil. The end of the dipstick has baked on oil. It takes 3 quarts to fill. Another 300 mile trip at 85 mph and no oil is lost. The oil light comes on at start up then goes out so I assume it works. The engine temp has stayed in the normal range though. I am frightened. [Response: L.K. Tucker] You have a major, probably crankcase pressure caused, oil leak. At this point there will be so much oil blown around that the location will be impossible to find. Go to a pressure wash and clean the engine and under carriage. This will not be a hard diagnosis since the most likely point is the rear main seal although front seal total blow out is possible. [Response: Steve Seekins] You certainly need to figure out where it is leaking out. FIrst thing to check is the PCV system to make sure you do not have any clogged hoses/fittings. Be sure to check the nipple in the intake manifold to see if it is blocked and pull the hoses off and check for clogging or restriction by crusty coating inside - replace any that seem hard and brittle. Check the crankcase vapor separator box - black plastic unit bolted to block underneath intake manifold #3 & #4 runners - if the port appears crudded up, replace the unit. Put the car on a rack and inspect the underside with a bright light to locate sources of leaks - places to check are front end (crank, camshaft, and intermediate shaft seals), oil pressure sender unit (look for leakage from the unit itself), oil filter assembly (turbo?), rear of head around distributor, bottom of bell housing (rear main seal). If you can't tell where it is coming from due to overall oil and dirt all over the engine, get it cleaned, then start checking regularly for signs of fresh oil.

Using a UV dye and lamp to find leaks

Use of UV Dye to Diagnose Oil Leaks:

Using a bottle of compatible ultraviolet dye and an ultraviolet lamp is a highly effective way of tracing oil or fluid leaks. Dye can be purchased from NAPA in small one ounce bottles for about US$3. Dyes are made for motor oil, a/t fluid, coolant, and R12 or R134. Place the dye in the system, run the engine, and use the UV lamp to locate the leak, which will fluoresce in bright blue when you are wearing a pair of "UV-enhancing" yellow glasses from JCWhitney ($4). Various firms sell UV lamps specifically for leak detection. Clean the dye off with Simple Green and a hose.

Flickering Oil Pressure Light. [Symptom:] Oil lamp flickers.

Potential Diagnoses:

- Are you sure you are using the correct oil viscosity? (5W-30 minimum unless synthetic.)
- Failing oil pressure sensor. Test the oil pressure with a gauge.
- The insulation on the wire from the sensor has degenerated from heat over the years. I had the wire replaced for about $85.00 and it has been fine ever since. This is a major problem on pre-1988 cars with rotting wiring harnesses.
- One of the o-rings on the oil pickup tube on the pump has slipped, causing the oil pressure problem.
- Oil pressure bypass spring has fatigued, requiring a new oil pump.
- Signs of pump wear. Oil pumps don't fail at once they just slowly wear out. As the gears wear the oil pressure drops so slowly that we don't notice it. Meanwhile the bearings are getting less and less oil and their wear accelerates.

Oil Pressure Test Port (Circled in Blue)

Testing Oil Pressure:

[John Sargent] To install a gauge to test oil pressure, use the front oil galley port (circled in blue in the photo) which is just ahead of the oil pressure switch on the block, and faces the front of the engine. It is 6mm internal hex, and the block threads are 1/4 inch NPT.

[R Haire] The oil pressure sending unit threads for the B230 are 14 mm/1.50 thread.

Oil Delivery Tube O-Ring Modification.

B230 [John Sargent] The oil delivery tube connects the oil pump outlet to the inlet for the oil galleys in the block. Occasionally the o-rings sealing the oil delivery tube at the pump will slide out of place, reducing oil pressure. [See the photo: the seal is bulging out on the left.] Oil delivery tube seal failure is a known problem, but I can't give you any figures. If you don't get the tube seated all the way in the block and oil pump cavities you will probably experience the failure. It is possible that some tubes are manufactured with a smaller ridge on them than others. Those tubes would be likely to have the seal slip up and over the ridge. When you reinstall the tube, carefully drive it into place with a mallet, using a wood block as a cushion against the delivery tube. Make sure it fits: some are looser than others. Watch carefully and make sure it is fully seated.

Replacing the Seals. [John Sargent] The B230 oil delivery tube is a pipe that goes from the oil pump to the engine. To replace the seals, access the oil pump as noted below. Then pull the pipe after you remove the two bolts securing the oil pump

Solving the Problem. To solve this I modified an extra oil delivery tube by building up a ridge of JB Weld, a high (read slow setting) strength epoxy that bonds well to metal,.on both ends of the pipe. I did this by using an old oil pump for a casting mold. I use a Q Tip to put a light coat of wheel bearing grease in the cavity which the oil delivery tube fits into. I mixed up the JB Weld and coated the ridge and about 1/4 inch of the delivery tube above the ridge with the epoxy. Then I inserted it into the oil pump housing and let it set up overnight. The next morning I twisted the oil delivery tube out of the housing and went through the same process with the other end of the tube. I used a fine mill file to smooth the epoxy at the ridge where the square cross section o-ring fits. The ridge now has a square shoulder and the o-ring cannot be pushed over it with high oil pressure. The tips of the oil delivery tube are unchanged, but the tube at the ridge and past is now a precision fit in the respective bores in the block and oil pump. The modified tube is shown to the right. The seals cannot get pushed past the improved lip on the tube. Hot oil pressure is now 42 psi at idle. Hot running oil pressure is 65 psi.

Oil Delivery Tube Modification

B6304. See Below for more information on the o-rings and tube for B6304 engines.

End of Oil Delivery Tube Showing Epoxy Ridge

Oil Pump: Wear and Replacement.

Rebuild or Replace? [Tip from Engine

Builder Magazine, Jan 04] No engine builder in their right mind is going to risk a failure by reusing a worn pump in a rebuilt engine, so most simply replace the pump. According to Melling Engine Parts, a major supplier of oil pumps and repair kits, most engine builders today replace pumps rather than rebuild them because installing a new pump is quicker, easier and less risky....Another item that should always be replaced (but often isn’t) is the pickup tube and screen. Pickups are difficult to clean and can hide debris that may damage a new pump or the the engine.... The pump should also be filled with oil when it is mounted on the block to prime it and reduce the risk of a dry start. Do not use grease or assembly lube here... Feeding pressurized oil into the main oil gallery through the oil pressure sending unit fitting will route oil to all the critical areas inside the engine and eliminate the risk of scuffing the bearings when it is first started.

[Tip from Dick Riess] Paul Despres posted a note on in-the-car oil pump replacement in a 200 series. This stimulated me to try a 700 and 900 series.

Problems: Cold idle 1.5 bar
Hot Idle: less than .5 bar
Cold at 2000 rpm, 2 bar +
Hot at 2000 rpm l.5 bar
Not good and below spec.
Engine approx 130K. This is a turbo running Mobil l.

OEM Pump Replacement Procedure. [There is in addition to the following instructions a separate FAQ file describing disassembly of the bottom of the engine.] Note that replacement oil pan gaskets come in 2 flavors, a complete 1-piece gasket, and a 3-piece gasket that's used when you can't fully remove the oil pan from the vehicle.

Followed the Volvo manual and changed out pump in approx 6 hours after fabricating a jig to hold the engine up slightly. Built out of 2x6 yellow pine, a couple of chain repair links and a 1/4 inch hook eye.
Instructions:
Take off license plate and bracket so you don't make new holes in your body. Place car on jacks. Locate them on box frame just before the box slopes and becomes small, not on the frame crossmember. Take off belly pan. Unbolt sway bar at frame only. Undo steering shaft at U joints and slip upward. Remove negative cable from battery. Remove intake hose (turbo) from intercooler to intake manifold. Loosen power steering reservoir. Clip tie holding hose to motor mount. Under engine, remove nuts and bolt from bottom of passenger (LHD) side motor mount. Remove entire motor mount series of bolts and nuts, 6 total. Snug up and lift slightly on engine jig. I used a nut to tighten and lift the hook eye connected to the lift hook on the thermostat housing. Unbolt the frame, 4 bolts. It will drop slightly. Undo bolts and remove the reinforcement plate between engine and bellhousing. Remove motor mount from the driver side. No need to remove actual rubber from metal portions. Unbolt oil pan, drop and rotate nose toward the driver side (this is why you remove the motor mount). Remove oil pump, replace with new one and new rubber O rings on feeder pipe. Lube rings with oil or Vaseline to help with reassembly. Carefully reassemble pump to block aligning pump driving shaft with driving shaft from engine.

Clean pan and gasket leftovers.   You can also replace your rod bearings if you want. I did on one of the cars---less than an extra $30 using a standard size. Reassemble.

Results:
Cold idle: 4 bars
Cold 2000 rpm: 4.5-5 bars
Hot idle: 3.5-4 bars
Hot 2000 rpm: 4.5 bars

As Paul experienced, both engines (B230FT) are much quieter re: piston slap. I used a Febi Bilstein HD pump in both. Cost approx $120 without rod bearings and approx $150 with bearings.   This is not a bad job to do and may prevent some major blowups on engines which are good, but have a failing oil pump. So far I have a series of 5 oil pumps which I have replaced either rebuilding an engine or as this and all show the same wear pattern. Mileage usually in the 125-150K. All turbos. Believe they are wear items.

Oil Pump Replacement Without Dropping Crossmember? [Isaac/Kenny] Undo bottom bolts on both engine mounts, raise the engine slightly, then completely remove the driver side mount. Then jack the engine as high as it'll go (watch that you do not smash the distributor cap against the firewall).. Undo all the bolts on the pan (after draining) and drop the pan. At this point the pan will still be impossible to pull out, but you don't have to. You can get at the two oil pump bolts with a 13mm (approx) wrench. Once the bolts are out (watch out for washers) pull the pump out, and be sure to fish out the O ring seal in the block if it didn't come out with the oil pump output tube. There should also be a seal between the output tube and the pump itself, in case it fell in the pan and you didn't see it, you'll know to retrieve it. To install the new pump, feel around where the drive shaft of the pump meets the drive on the block, and feel what direction it's pointing. Line up the notch in the drive of the pump with that so it's close when you raise the pump up into there. Lube the new seals on the new pump, dump oil in the pump to prime it (it will not prime itself), and put it inside the engine with the output tube attached, lining the tube up in the block at the same time as you raise the pump into place. With one hand holding the pump, put the bolt (the one without the tube guide thing) into place. Then do the other one and you're done. Raise pan, bolt into place, and reverse the rest. If you have trouble getting the pump back in, it'll take 3 hours. If not, 2 hours. And make sure you have oil pressure before driving off.

Oil Relief Spring Failure. [Editor's Note] Dick swapped the pumps because after dropping the pan, a $100 pump replacement did not seem to be a big expense and would certainly eliminate any uncertainty. If you remove your pump, note that clearance between oil pump gear teeth should be between 0.15-0.35mm, and axial clearance between the end of the gear and a straightedge across the face between 0.02 -0.12mm. The relief valve spring, which is highly suspect in low oil pressure conditions, should compress from 39.2mm to 26.25mm under a load of 46-54 N (10-12lbs) and to 21.0mm under a load of 62-78 N (13.6-17.2 lbs.) Unfortunately, the spring is no longer available separate from the pump. Also, make sure the drive shaft cog teeth are intact and not fractured. IPD sells a reinforcing ring for this drive and if you have the pump out of the engine it is worth installing. Use new delivery tube seals on reinstallation.

Oil Drain Valves. Oil drain valves are available for Volvos from Fumoto Engineering of America, 12328 Northup Way, Bellevue Washington 98005. Phone is 206-869-7771, fax is 206-869--2558. The part number for four-cylinder engines is T-204; V-6 engines (1976-1982) use part number F-108. I've heard there might be a clearance problem with 850s because the drain nut isn't on the bottom, but can't say for sure. It's operated from below, but requires only pushing a lever out of the spring-loaded locking position, then rotating 90 degrees. It doesn't create a clearance problem, and can not open by mistake. I used a copper washer on mine rather than the washer supplied, and it has never leaked. I've used these for more than 25 car-years and they are really great. No stripped drain bolts, no bashed knuckles, no mess, no wrenching, less time...

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960 B6304 Oil Pressure Problem: O-Ring Problems. [Query:] i have a 95 960 with 114k miles with an unusual oil pressure problem that my repair shop nor I can solve. I'm hoping someone out their may know of this problem, know of someone that knows of this problem or can direct me to someone who can help me. I've owned this car for 6 months with absolutely no problems except a noisy ps pump. Suddenly the oil light went on and i then heard the valves complaining of no oil pressure. After flushing the engine, replacing the filter, oil pump and associated tubes, pickups and valves, it still has the problem. From a cold start the engine will idle for hours, including running the rpms up, and the oil light stays off and there is oil pressure. Then a short trip down the road produces the light and valve noise. After a short cool down everything is ok. Sometimes the light goes on right from cold start up. [More Symptoms] My 98 V90 runs as smoothly as one could wish except for an occasional valve tap. It seems to occur after a long drive. I can hear it while the car is idling. I can shut the ignition off and restart it immediately and the tap is gone.[Response: Abe Crombie] The o-ring on the oil pump suction tube in the oil pan has been pulled inward allowing air to enter. While the pan is off the two o-rings at the pan-to-block joint need to be replaced also.

See the FAQ file: B6304 Oil Pickup Tube Repair for more information.

Engine Mounts:

How To Inspect Mounts. The mounts should keep the front of the engine oil pan off the rubber bumper on the frame cross member. There should be a gap of 3/8 to 1/2 inch there. The fan should also be centered in the shroud. If not, your mounts need replacing.

Changing Engine Mounts on 740/940

Buy the Correct Mounts.

Note that earlier 740s came with solid mounts shown at the right, especially on turbos and manual transmission cars. Later cars have the hydraulic mounts pictured below. Buy the correct mount.

Solid Engine Mount

Raising the Engine:

[Tip: Bill Aileo] Some folks carefully jack up the engine from below the short distance necessary (after making sure at least one side of the old ones is not connected. I prefer to use a 2x6 cut to fit snuggly over the engine compartment on top of the strut mounting area. [See Dick Riess' lift design in Special Tools.] The 2x6 is positioned like a joist and a hole for a piece of threaded rod is drilled near the center to line up with the lifting hook on the front of the engine. Put a piece of threaded rod about 12-18" long in place through the hole. Figure out a way to attached one end of the rod to the lifting hook and slip a large washer and nut on the other end. Then simply tighten the nut to raise the engine. Replacing the mounts is then easy.

[Another Tip:] Instead of raising the engine by using a board between the jack and oil pan , I cut an angle at the end of a 2x6 and raised the engine at the front of the oil pan. The angled part of the 2x6 was pressed against the oil pan bolts at the front of the engine, the other end was square against the floor jack. I didn't want to risk damaging the oil pan. I also had to use a small hydraulic jack to help the engine raise straight. It worked fine and with new mounts my brick is running smoother now than it has in 10 years.

Hydraulic Engine Mount

How to Change the Mounts:

[Procedures from Christopher Ascoli/Joshua Block] Using the jack and wood block method should be sufficient for lifting the engine to remove the mounts. I did this procedure just a month ago and it worked just fine. My mounts were the hydraulic mounts. As for tips, I have only two. First and foremost, make sure you buy VOLVO or comparable HYDRAULIC mounts. Second, I remember not being able to reach all of the bolts from above which tie down the mounting bracket (that the motor mount sits on) to the car's frame. Chilton's made it sound like all you had to do was unbolt the top and bottom of the mount and yank it out. If you haven't done this before, you must:

Before you jack up the engine, unscrew the top bolt on each motor mount. I also removed the bracket with each mount due to clearance. The bottom nut on right side mount by the turbo was completely inaccessible with the bracket attached to the crossarm. I took the left bracket off because of clearance. If the mounts are OEM the nuts are on rather tight.

Driver's side

1. Remove the top nut on the mount. If this is seized (as it often is), use a u-joint, a few extensions, a big breaker bar, and a six-point socket to get your hands and knuckles up above the engine and then pull on it. It will come off, as long as you haven't rounded the corners from letting your wrench slip off the nut. In bad cases, unbolt the mount bracket from the block and from the crossmember to remove the assembly, mount it in a vise and get the breaker bar or air wrench on it.
2. Raise the engine (the bracket that sits on the mount does not have to be raised all the way so it clears the top of the bolt; you will remove the entire lower bracket with the mount so you have some play)
3. I think you can get to 2 of the 3 bolts of the bracket that the mount sits on, the last you'll have to get at from underneath the car
4. Once all 3 bolts have been removed, lift the mount out with the bottom bracket still attached and you'll have access to the bottom nut that connects the mount to the bottom bracket.
5. If you find that there still isn't enough room to remove the mount, you can remove the engine top mount bracket (or remove 2 of the 3 bolts and swing it out of the way) and then extract the mount.
6. Attach the new mount to the bracket using anti-seize compound on the bolts. Install the bracket and bolt it in.
7. Let the engine down making sure it sits on the mount correctly. DO NOT ATTACH THE TOP NUT UNTIL YOU HAVE BOTH MOUNTS INSTALLED!

Passenger side

1. Same as the driver's except you don't want to mess with the upper bracket. It connects WAY too many things to be screwing around with it. I didn't have touch the top bracket at all. This side was definitely easier. If you're struggling with access to the passenger side, removing the pre-heater hose and the heater assembly from the manifold makes things so much easier (at least, on a n/a car). You may have to reach 2 out of the 3 bolts from underneath on this side. The job is not technologically challenging, but depending on when the mounts were last changed, you could be in for some blood and sweat. Just be careful not to strip the lower bracket bolts when removing (for obvious reasons), and some anti-seize compound on them when they go back in could make the next mount change a lot easier on you or the following owner. Good luck!
2. Put the top nuts on both mounts. Make sure everything is tightly attached.

Other Ideas to Help the Work:

[Tip from Don Foster] When I do mounts, I offset the jack to favor the right side, and do the right mount. Then offset it to favor the left side, and do the left mount. In this way you avoid tugging on a good mount as you lift the motor. As you lower the engine onto the new mounts, you may need to "persuade" the stud into the bracket. Because of its angle, it doesn't naturally engage with the hole.
[Tip from David Steffy] You don't say whether you have a turbo. Our '88 is, so the left mount was easy and the right was a very tight spot. I took the brackets off with the mount in both cases, but didn't really need to for the left mount--just take off the upper nut and jack away. On the right one, I had to move the oil lines to get access to the bolts. Messy on my old gunky engine, a bit slow, but not a bad job overall. Without the turbo it's probably a lot better.
[Accessing the Mounting Nuts: Dick Riess] In my experience it is necessary to take off the belly pan to get at those front nuts on the drivers side. You also will have better access to the bolts, but a universal joint on your socket will help. I have had to attack from the front of the mount by the power steering rack and also from the rear. On the pass side, for me it helps to take off the oil filter to get at things and you may as well take off top and bottom mount brackets. Believe one of the bottom is bolted through the crossmember and you have to unbold from under the car. Jacking up your engine a little at a time helps access. When reassembling, tighten the mount to the bottom bracket, but leave the top loose so you can move it around for alignment to the block.

Preventive Maintenance Tips:

[Tip from Ed Kucinski] Just a reminder, when changing oil, keep the oil off the rubber motor mounts. Especially when changing the oil filter, some tends to get down there. Wipe it clean. Its the oil that deteriorates the rubber and speeds failure.

Changing Engine Mounts on 960/90 Series Vehicles. [Procedure by Walt Posluszny]

-Lift vehicle and set on jack stands.
-Remove the belly pan
NOTE : The motor mount actually consists of two pieces, the rubberized mount itself and the metal bracket it is attached to. However, it is removed and installed as a single unit.

Passenger side *(straightforward and fairly easy):*

Removal:
FROM THE TOP:
-Remove top nut (15mm)
-Remove rear most nut on the bracket (13mm)
FROM THE BOTTOM:
-Remove front inboard nut (13mm) on the bracket with a box or open end wrench.
-Remove bottom mounted bolt from the bottom of the bracket thru the chassis. This bolt is 12mm for some reason, and you will need to move the steering arm boot to get a socket on this bolt from below the bracket/chassis.
-Once all three nuts and the one bolt is out, carefully jack up the engine and chock tthe engine with wood blocks for safety (you don’t want the engine to come down on your hand when you’re taking out or putting in the mount).
-The mount will now come out to the front.
-Remove the mount from the bracket by removing the one nut at the bottom of the mount (15mm IIRC)

Installation:
-Install new mount on old bracket
-REVERSE above removal procedure torquing the top (15mm) bolt to 37 ft./lbs. (there were no specs to be found for the other nuts/bolts).

Driver’s side *(a bit more challenging)*

The procedure for removing the Driver’s side is the same as the Passengers’ side except for the following:

Removal:

I couldn’t even see the mount from above so I decided to remove the following items to make the R&R even possible.
FROM THE TOP
-I removed the aluminized cardboard hot air tube from the air box to the manifold. This facilitated now seeing the top bolt (15mm). I was able to use a very long extension to get to it from the top now.
-To get the above hot air tube out I actually removed the top of the air box to make life a little easier and to give me more room to maneuver.
FROM THE BOTTOM
-I was unable to get a socket on the rear bracket nut (13mm). The metal power steering line was in the way. So from under the vehicle, from behind the front tire I reached in and kept bending the

tube rearwards until there was enough clearance to get a 13mm socket on the nut from above. Once I accomplished this, I was able to get the nut off from above with a long extension and a wobble socket or you can use a universal joint because you can't get to it at the perfect 90 degree angle.
-You have to also remove the oil filter. This will make it easier to get the inboard 13mm nut off the bracket, and give you room to pull the mount out from the front. Also don't forget to remove that 12mm bolt from below the bracket /chassis.
You should now have all the nuts/bolts off, the engine safely jacked up and chocked, and the motor mount out from the front.

Installation:
-Install new mount on old bracket
-REVERSE the above removal procedure.
Note : You can get the aluminized cardboard hot air tube back on the manifold from underneath the car from behind the front wheel. You can get your hand in there easily and install the tube and then go back on top and install the other end on the air box. You can also put the same oil filter back on if you recently changed the oil. I only lost about a cup of oil during this procedure.

Spark Plugs:

Removing Spark Plugs.

B2XX Series Engines and General Notes. The spark plug socket used to install plugs is sized 13/16 inch. A swiveling u-joint and three inch extension is also needed. [Inquiry:] One plug is stuck and cannot be removed. How do I get it out? [Response: Steve McChesney] Penetrating oil. [Brickboard penetrating oil preferences: PB Blaster, Kroil, Liquid Wrench, in order of effectiveness.] Soak the area, and run the engine. Let the engine cool off, and soak it again before you go to bed at night. Do this again and again and again. 30 or 40 times over the next few weeks would not be excessive. No need to have the stuff dripping all over, just use a little bit at a time. It's likely that the temperature cycling and vibration of the engine, with gradual penetration of the oil, will loosen the corrosion of the threads. The stuff is magic, but only if you have plenty of faith and patience. [Response: Don Foster] I recently changed plugs on daughter's VW. One plug was dead tight, and when it finally broke free I was sure the aluminum threads were coming with it. Kroil didn't help. I first ran the engine for 15-20 minutes to get it good 'n hot -- aluminum expands at twice the rate of iron. The resistant plug backed right out without damaging the aluminum. [Response: HTH] Soak liberally with KROIL, PB Blaster, or your favorite serious penetrant (don't even think about Liquid Wrench). Start engine, run about 3-5 minutes. CAREFULLY check the temp by putting your hand on the exhaust manifold to feel the heat. You want to stop the engine just as the head is warming up. Hopefully, if you get it just right, the head will have warmed up but the plug will not be at normal operating temp and the hole will be a little bigger than the plug. At least that's what I theorized and it worked for me.

If the plug was cross-threaded, you have a different problem entirely. See Spark Plug Hole Re-Threading. The head will need repair. Typically this mandates removal, but I have had good luck with high mileage cars by going ahead and using an impact wrench, starting off at a low ait pressure, and working upward as necessary. Again, liberal penetrating oil is a help. If you are commited, the ceramic insulator can be broken off the plug for better access. Once the plug is out, setting the offending cylinder piston to BDC and filling the cylinder with a foamy shaving cream will catch all the chips made when you helicoil -- or possibly only re-tap if the threads are not too bad. Crank the piston back to TDC slowly with a good shop vacuum covering the spark plug hole.

If you crack the insulator during removal, use some compressed air to blow out any ceramic chips so they do not fall into the cylinder after the plug comes out.

Check the specs, Volvo says about 9 ft-lbs on the six and 18-ft-lbs on the four cyclinder engine. (700 series).

[Response: Paul Grimshaw] I suspect that jammed spark plugs would be a much more rare event if folks used a bit of anti-seize compound [see Spark Plug Installation below], started the plugs by hand (socket & extension but no ratchet handle), and used a torque wrench to tighten the plugs to specification.Strangely enough though, factory torque recommendations are based on a dry fit (ie. no lubricant or anti-seize)??!*! (See below for torque recommendations.)Should one use some type of lube on the thread, try backing off a couple of pound-feet of torque to avoid stressing the thread in the cylinder head.

Analyzing Spark Plugs for Combustion Conditions. [Erling Brox] To "read" a spark plug's appearance, see the NGK website: http://www.ngksparkplugs.com/techinfo/ and look in the spark plug FAQ section for photos of various pluts.

B6304 Series Engines. To remove the covers for the plugs, you will need a T-30 Torx for the cover screws, 10mm for the coil retainer screws, and a 5/8" plug socket. Remember the coils fire sequentially so don't mix up the wires.

Spark Plug Hole Re-Threading. Heads with dirty or damaged spark plug threads can be cleaned up with a thread chaser readily available at auto supply stores. Smear grease on the chaser. Carefully thread the chaser in and out of the head. The chaser will clean the threads and the grease will capture any metal bits or carbon in the vertical grooves. [Inquiry:] I finally changed plugs in my aluminum-head B230F to find that my number two plug was somehow cross-threaded by a previous mechanic (the plug was tough to remove, and the new plug tough to install.) Using a plug hole thread chaser did not solve the problem. Any solutions? [Response:] The best repair is to use a product called Time-Sert. This is an insert that can be installed without removing the head and also is a quality, permanent repair. Check with one of your local foreign repair facilities, they most likely will have heard of the product and can turn you onto where to get it. You will also have to have the kit of tools to install the sleeve. Kit consists of drill bit to presize the hole, a countersink flycutter, step tap to create the threads for the sleeve and a roll tap to install the sleeve. The cost of the kit may exceed the justification to repair just 4 holes, so you might just have someone do them for you. [Tip from Bob Dietz] Time-Serts are by far the best choice for thread repair. It's second oversize with respect to a heli-coil, a solid insert and has proved to be very reliable in the several I've installed over the years. They don't leak and don't come out. [Rob Bareiss] A company called KD Tools sells a tap and insert kit you can use in the car. You should not need to remove the head. You will want to coat the tap with grease so it picks up its own chips as it cuts. The inserts look like little top hats- the "brim" is the stop when threading the insert in. They aren't like Helicoils, which are wound wire- these are machined solid inserts. Really good permanent job when complete. The tap is shaped jsut like a bolt- you drive it with a 13/16 socket. It's quite low-profile and should be able to be repaired with the head on the engine. Starting the tap at the proper angle is important of course, but it should be quite possible to repair this without major surgery. [Editor:] IPD sells a re-threading kit with the KD tool and thread inserts from Loctite.

Hints for Sparkplug Hole Re-threading. [Tips from Larry:] Here are a couple of things to watch out for:

1. When you tap in the new threads, you'll want to catch as many of the metal shavings as possible by completely packing the tap with grease. Scrape the shavings off the tap several times and re-pack with grease each time.
2. Blow out the cylinder with compressed air. If you don't have a compressor, buy a can of "dust off" from a photography store--it's used to blow dust off of negatives. It's important to have #4 at the top of it's compression stroke--both valves will be closed, so you're less likely to get metal shavings into the intake or exhaust manifold.
3. Clean the new threads VERY THOROUGHLY with carb cleaner (toluene) and starting fluid (ether). The carb cleaner will dissolve the grease and the starting fluid will wash away the carb cleaner and evaporate completely. If the threads aren't clean, the cement for the heli-coil insert won't adhere.

Spark Plug Installation. Tips and Cautions from spark plug and car manufacturers.
Installation
[From ACDelco]   Use the following four steps to properly install AC Spark Plugs:

1. Make sure that cylinder head threads and spark plug threads are clean (figure 14). If necessary, use a Thread Chaser and Seat Cleaning Tool.
2. Make sure that the spark plug gasket seat is clean, then thread the gasket to fit flush against the gasket seat. Tapered seat spark plugs do not require gaskets.
3. Use an AC Gap Guide to make sure new spark plugs have the correct gap setting.

   Gap: Volvo B230F/T and B234: 0.028"-0.032" or 0.7-0.8mm
   Volvo B280: 0.024"-0.028" or 0.6-0.7mm

4. Screw the spark plugs finger-tight into the cylinder head. One easy way to prevent cross-threading is to insert the plug and first rotate it backwards (counterclockwise) with your fingers until you feel the thread drop in (it feels like a "click" or a bump on the threads), then rotate forward to engage the threads. Use a torque wrench to tighten spark plugs following manufacturer's recommendations. It is most important that spark plugs be seated properly for correct heat dissipation properties. Seat the spark plug too firmly and the shell could be stretched, allowing combustion blowby to pass through the plug. It will be difficult to remove a spark plug in this condition from the engine. Seat the spark plug too loosely and it will overheat.

   Torque Settings (use a torque wrench!):

   - B230F/T and B234 4-Cylinder Engines: 18 +/-3 ft-lb or 25+/-5 Nm "unlubricated" torque per manual
   - Volvo B280 V-6 Engine: 9 +/-1.5 ft-lb or 12 +/- 2Nm "unlubricated" torque
   - B62XX/6304 Six-Cylinder Inline Engine: 18 ft-lb or 25 Nm "unlubricated" torque

5. Coat the inside of the plug wire boots with silicone dielectric paste to prevent them from adhering to the plug. Make sure the plug cap is tightly screwed down, then push the wire boot on until it "clicks". The wire installation sequence is the same as the firing order.

Tightening, Torque and Anti-Seize Compounds:
[From AC Delco] Do not use any type of anti-seize compound on spark plug threads. Doing this will decrease the amount of friction between the threads. The result of the lowered friction is that when the spark plug is torqued to the proper specification, the spark plug is turned too far into the cylinder head. This increases the likelihood of pulling or stripping the threads in the cylinder head. Over-tightening of a spark plug can cause stretching of the spark plug shell and could allow blowby to pass through the gasket seal between the shell and insulator. Over-tightening also results in extremely difficult removal.
[From NGK] Torque is one of the most critical aspects of spark plug installation. Torque directly affects the spark plugs' ability to transfer heat out of the combustion chamber. A spark plug that is under-torqued will not be fully seated on the cylinder head, hence heat transfer will be slowed. This will tend to elevate combustion chamber temperatures to unsafe levels, and pre-ignition and detonation will usually follow. Serious engine damage is not far behind. An over-torqued spark plug can suffer from severe stress to the Metal Shell which in turn can distort the spark plug's inner gas seals or even cause a hairline fracture to the spark plug's insulator... in either case, heat transfer can again be slowed and the above mentioned conditions can occur. The spark plug holes must always be cleaned prior to installation, otherwise you may be torquing against dirt or debris and the spark plug may actually end up under-torqued, even though your torque wrench says otherwise. Of course, you should only install spark plugs in a cool engine, because metal expands when it’s hot and installation may prove difficult. [From Denso] If threads are lubricated, the torque value should be reduced by approximately 1/2

to avoid over-tightening.
[Tip from Underhood Service Magazine] One vehicle manufacturer warns against using antiseize because antiseize acts like a lubricant and may allow the plugs to be overtightened, which can damage the threads. If you do use antiseize on the threads, their advice is to reduce the tightening torque on the plugs 40%.
[Tip from Autolite] We do not recommend the use of any anti seize products for installing spark plugs. Antiseize compounds are typically composed of metallic, electrically conductive ingredients. If antiseize compounds come in contact with the core nose of the plugs, it can lead to a misfire condition.   Antiseize compounds can also have a torque multiplying effect when installing plugs. This can lead to thread distortion and thread galling resulting in cylinder head damage. Autolite spark plugs are nickel plated to resist the effects of corrosion and seizing. However, plug seizure is aggravated further when steel plugs are installed into aluminum cylinder heads for a long period of time.   You may want to consider the periodic inspection of the plugs to reduce the likelihood of plug seizure during extended plug service intervals.

If You Do Not Have A Torque Wrench At Hand:

Always use a torque wrench to install spark plugs. However, if you do not have one at hand, you can use the following technique as a rough approximation [courtesy Denso]:

- First install sparkplug finger tight
- Then tighten another one-half turn using a wrench and spark plug socket

1. First intall plug finger tight

2. Then tighten 1/2 turn. Better to use torque wrench.

Caution on Spark Plug Number Four. [Tip from Rob Bareiss] I can't tell you how many people have screwed up the #4 plug. It seems to be difficult for some people to grasp the concept that since the plug came out at an angle, it needs to go back in at an angle. Too many of these have been crossthreaded.

Cylinder Head and Valves:

Top Dead Center. How do I locate "top dead center (TDC)" on my B230 engine? [John Sullivan] Some tips on locating engine position:

- When the notch/slot in the crank washer is aligned with the vertical mark on the block, the #1 piston is at TDC
- When the cam gear's mark is aligned with the mark on the timing belt back cover (about 11 o'clock), both valves for the #1 cylinder are fully closed, and...
- When the intermediate shaft gear's mark is aligned with the mark on the timing belt back cover (about 3 o'clock), the distributor's rotor is pointed at the #1 cylinder ignition wire contact in the distributor cap--and that rotor is also aligned with the mark on the distributor's base.

Intake and Exhaust Manifold Gasket Replacement.

Exhaust Manifold Gaskets. See the FAQ section for instructions on diagnosing and replacing exhaust manifold gaskets and safely removing the manifold nuts.

Intake Manifold Gasket.

B23X Engines. Clean off the area around the gasket as best you can. Remove all the manifold bolts and pull it back enough to replace the gasket. There will also be a couple of air tubes that have to be loosened or removed, but you'll see what is necessary as you pull the manifold away from the head. It needs only about an inch and a quarter of movement to clear the studs.You may also want to disconnect the throttle and transmission cables at the pulley wheel (write down how they are routed) so you don't bend them. The surfaces should be clean and the old gasket was installed dry, so you do not normally need to scrape the area. Do not use any sealer or RTV. Retorque to 15 ft-lbs (20 Nm) for a B230 F/T, B234 or B6304 engine; to 7-11 ft lbs (10-15 Nm) for a B280F.

B6304 Engines. [Doug Young] To my amazement replacing my 960's intake manifold gasket wasn't as difficult as I had expected! I removed all the air intake tubing to the throttle body, then the throttle linkage assemblies along with the fuel rail and injectors. You may want to spray some non-silicone-based lubricant around the rubber couplings for the intake plenum and manifold so they'll slip out easier when loosened. At first I was concerned about the metal clamps that secure these rubber couplings. I decided that replacing them with plastic tie-straps would work just as well. You will need a universal jointl for your ratchet to get to some of the bolts. Be very careful removing them because those bolts love to fall and disappear into the bowels of hell. I grabbed hold of the plenum then pulled and wiggled it away from the manifold.When I pulled the manifold off, I found the intake gasket broken in about 10 separate pieces. The new gasket was around $16. I put everything back together and erased all stored codes. Turned the key and it made the sweetest sound without any stumble at all.

Vacuum Leak Diagnosis. See the FAQ section on diagnosing vacuum leaks in the intake system.

Headgasket Failure: Diagnostics .
Basics of Headgasket Failure:
[Tip from Import Car Magazine, Oct 2001, Gary Goms] When diagnosing a leaking head gasket, it’s important to remember that bi-metal engines with cast-iron blocks and aluminum cylinder heads will eventually wear out the head gasket due to the different expansion coefficients of cast iron and aluminum. Each time the engine goes through a warm-up cycle, the aluminum head slips a few thousandths of an inch across the head gasket. Although current head gasket technology drastically reduces gasket wear, head gasket replacement is still the most common major engine repair. [Tip from Motor Service Magazine, Feb 2002, Greg McConiga] Two major causes of head gasket failure are overheating and detonation. Don't forget to check for the root cause of the failure, especially if it's a car with a history of problems. Cooling fan and water pump operation, radiator cap, thermostat, radiator flow, engine timing and EGR function are just a few of the things you need to check.

Diagnosis of Headgasket Problems:
Symptoms of a blown head gasket include a continually increasing consumption of coolant, a milky accumulation found under the engine oil cap after extended engine runs at operating temperature, a very obvious thickening or sludging of the crankcase oil, gas bubbles exiting through the radiator cap,or inexplicable oil consumption. There are several diagnoses that can be done on the car that will nearly pinpoint the trouble spot and tell you if it is indeed a head gasket or something else.

1. The first test that should be completed is a coolant system pressure test   Test your system for leaks with 12 psi (85 kPa) for 1984-86 cars and 22 psi for 1987+ cars with B2XX engines. It should not show any noticeable pressure loss within 3 minutes.
2. The second is a block test, also known as a combustion leak test, performed on the coolant in the radiator/expansion reservoir to determine if you have exhaust gases in your cooling system. A combustion test kit can be found on the web or at your local NAPA,Snap-On, or auto parts store. The part number is NAPA 700-1006 ($50) or Snap-On GDCT16 "Combustion Leak Tester ". The homemade version is in Special Tools. Exhaust gases in your cooling system can suggest a head gasket leak, a cracked block, or a warped head, etc. To do the test, add the blue detector fluid to the block-tester plastic

container according to the directions, and place it onto the coolant reservoir. The squeeze bulb is squeezed repeatedly (Some block testers, have a tube that connects to a vacuum line instead of a squeeze bulb). Squeezing the bulb will draw air from the reservoir through the test fluid. Block tester fluid is normally blue. Exhaust gases in the cooling system will change the color of the fluid to yellow, indicating a combustion leak. If the fluid remains blue, exhaust gases were not present during the test. The vehicle should be started and at operating temperature before performing the test.

3. The third, usually performed after a "failing" exhaust gas test, is a leak down test of each of the cylinders. This is similar in nature to a compression test but this actually will measure close to the exact location of compression leakage in the cylinder.
4. A fourth test is a chemical analysis of the engine oil. Often, what might be construed to be a head gasket leak of engine oil could actually be seepage past a bad valve guide/piston ring, etc. In this scenario, a test of the motor oil will usually reveal inordinate amounts of combustion by product in the oil. Then again, if any of these are bad, the head gasket's gonna be removed anyhow.

Note: the above four tests are generally not shadetree mechanic things performed as the cost of the one time use equipment can be prohibitive. Well equipped shops can handle these types of tests. Sometimes it's worth it just to have a pro shop diagnose the problem, even if you are planning to do the r&r yourself.

Temp Gauge Acts Oddly: Leaking Headgasket? [Inquiry:] When I first get going, the temperature gauge will get into the middle, and stay there for few minutes. Next, it will rapidly shoot for the “red” zone. It will do this in seconds. The moment the red zone is touched, the gauge falls just as fast to the middle, where it will stay for duration of the trip. Next day, same situation. Should I be concerned, and replace the thermostat ? [Response: Robert S.] You may have an air pocket during startup due to leaking head gasket or antifreeze leak (or combustion gases accumulating around the thermostat.) Try flushing cooling system to get junk out. Pressure test your cooling system to eliminate the possibility of the blown head gasket. When you first start your car leaking head gasket will introduce gas into the head cooling space. It will replace fluid from the area. The thermostat is closed so the gas has no place to go. The gas acts like an insulator so it will delay heat transfer to the thermostat. But other parts of the engine covered with the fluid blanket will heat the water up to the boiling point. Finally engine is hot enough to cause thermostat to open and let the gas go into the radiator. After the gas goes the overheated water and that's what causes your needle to rise on the gauge. Further operation is normal because thermostat is open and the gas goes to expansion tank as soon as it gets into the system. You need to repair the leak as soon as possible if that's the cause or you will end up with warped head due to spot overheating. [Response 2: Art] I might add a note to suggest you squeeze the radiator hose early in the warm up cycle. If it is a bad exhaust leak it will have pressure long before the engine is warm.

Headgasket Replacement Tips: B230 Series.

Which Gasket Kit To Buy? [Tip from Rob Bareiss] For the B230F engine, your best bet is the ScanTech head gasket set from FCP Groton for around $30. This compares favorably with Volvo's own $120+ head gasket set. But replace the head gasket in the kit with a FelPro or Victor Reinz-brand head gasket from any local parts shop because of its high quality. I STRONGLY recommend getting the proper M8 copper washer-face exhaust manifold nuts from Volvo or a specialty parts shop. Use nickel-based Anti-Seize on those studs, too.

Basic Procedure for Headgasket Replacement. See the Headgasket Replacement file for a description of this procedure.

Procedural Tips and Ideas. [Mark Stites] Basic time estimates to repair are: B230F: 8 hours; B230FT: 10 hours; B234F (16 valve):12 hours. Plan on additional time to send the head to a machine shop for refurbishing. [Chris Herbst] The head gasket repair job itself is NOT very hard. Drench the exhaust manifold nuts with PB Blaster penetrating oil. Get it at Wal Mart in the auto section, if you don't already have it. Squirt them for a week or so every day, before pulling the head. Clean the threads if necessary. If you believe them to be a disaster waiting to happen, then consider pulling the head WITH the exhaust manifold attached, and taking them off of the head when you have more control on the angle. Also if you break any you can fix them with the thing on a workbench rather than messing with drills in the engine bay. The intake manifold and associated things come right off easily if you have 1/4 inch drive 10, 12 & 13mm sockets. Disconnect any sensors necessary. If you are motivated, find a GOOD (ask shops who THEY use) machine shop and have the valves adjusted and the valve guides & seals changed if necessary. This will make for good performance when you're done. Usually around $250 for all machine services and adjustments. If you have to do machine work, take the sensors out of the head while it's being worked on. Make sure you have a good torque wrench for setting the head bolts. Clean it FASTIDIOUSLY before you mate the surfaces. Then put the new gasket in. IT is really an easy job to accomplish quickly, but the details depend on you. The only remaining thing is to line up the timing belt again (or also a good time to replace it if motivated). [Rhys] Stuff oily rags into the cylinders and wadded up bits of paper towel into all the other holes in the block deck. Scrape the block surface with a sharp carbon scraper held at a shallow angle, using a vacuum cleaner to pick up debris. Wipe with lacquer thinner to reveal any missed spots. Leave the pistons alone, but it you must clean them, do it very carefully, and hold a running shop vac in the other hand. You do not want to introduce particles to the piston/cylinder wall area. Roll the engine over several times, oiling the bores, and wiping until they produce no further bits of carbon. Take the cylinder head to a machine shop and have them skim it to clean it up. Not only do you not have to worry about scraping and gouging the head to get the gasket off, the surface is now flat. [Bram Smits] A paint scraper (with the sharp points rounded off - you definitely don't want to gouge the mating surface) or a dedicated gasket scraper tool will get you started. Then finish the job off with razor blades. I just did so, and with some work it'll clean up the block really well. Wipe both surfaces with a cloth soaked in lacquer thinner to remove remaining gasket and debris. [Bram Smits] Don't get any crud in the holes; stuff them with something you know you'll be able to retrieve, or just work carefully and direct the scrapings away from the holes as you go. Don't forget to clean out the bolt holes. Bolt torque specs are for oiled bolts; use plenty of oil or assembly grease when reassembling the head, and (you probably know this, but I'm surprised by how many people don't) the gaskets go on DRY! The torque specs for B230F/T are: first torque all in correct sequence to 15 ft-lbs, then torque all in sequence to 45 ft-lb, then all in sequence another 90 degrees. [Chris W/Tom F.] Some tips from my recent headgasket replacement:

- One of the biggest time savers is a bunch of re-sealable plastic bags into which to throw all the hardware (nuts, bolts, etc.) along with a piece of paper noting whence they came.
- Pull the front RF wheel and get the car on jackstands in the front. Your back will thank you, and you'll need to spend a lot of time under the car.
- Be careful breaking loose the head bolts. Mine were very seized up and broke free with a SNAP. Use a six-point impact socket to remove these bolts.
- The toughest part about removing the exhaust manifold was figuring out how to do it. This is what worked for me: (a) remove the three 13mm nuts from the manifold to downpipe flange (right behind the exhaust manifold) using six point sockets/wrenches, else you will round off a nut. (b) then unbolt the catalytic converter (three nuts). And (c) remove two exhaust pipe fastening points (one to the bellhousing, the other just in front of the cat). This allows you to slide the pipe out of the way. The manifold will still be attached to the block, with a T bracket just below the manifold. (d) Remove the oil filter to gain better access to this attaching nut (which faces the bottom of the car). Use some extension and socket combinations to remove this T bracket from the block and move the manifold away from the cylinder head. When reinstalling the manifold to the reconditioned head, first install the T-bracket onto the manifold, then as you slide the manifold toward the head, bolt it back to the block.
- Use liberal amounts of high-temperature nickel-based antiseize on all fasteners.

Tips from Victor Reinz Inc and Corteco:

- Never use a Scotchbrite abrasive pad to whiz off old gasket residue from a head or block. Abrasives can leave low spots on the surface that will prevent the head gasket from sealing. Use a gasket-removing compound and a scraper or soft wire brush on the block and a plastic scraper on the aluminum head.
- If the surface finish on an aluminum engine head and cast iron block is too rough and digs into the gasket too deeply, it can literally tear the gasket apart over time. That’s why surface finish is so

important. For bimetal engines with composition gaskets, the recommended surface finish is 20 to 50 RA.

- Inspect all head bolts to make sure they are in perfect condition with clean, undamaged threads. Dirty or damaged threads can give false torque readings as well as decrease a bolt's clamping force by as much as 50%! Bolt threads should be wire brushed, then inspected. Replace any that are nicked, deformed or worn. Bolts should also be measured or compared to one another to check for stretch. Any bolt that's visibly longer than its companions should be replaced.
- Run a bottoming tap down each bolt hole in the block. The tops of the holes should be chamfered so the uppermost threads won't pull above the deck surface when the bolts are tightened. Clean all holes to remove any debris.
- If the head has been resurfaced, check bolt lengths to make sure they don't bottom out in blind holes. Make sure bolt lengths are correct for each hole location (some holes require longer or shorter bolts than others). Bolts should also be measured or compared to one another to check for stretch. Any bolt that's visibly longer than its companions should be replaced.
- While the head is off the engine, check the flatness of both the head and block. Use a high-quality machinist's straight edge and feeler gauges to check all critical areas – especially those between the cylinders.
- Lubricate bolt threads as well as the underside of the bolt head with 30 weight engine oil (not assembly lube or grease) when the engine is assembled. If the bolt shares a colant passage, use thread sealant. Use a calibrated torque wrench and carefully follow the tightening sequence in stages using a smooth, continuous pull.

B23X Head Bolt Removal and Re-installation.

Bolt Removal. [Inquiry]I tried removing the first head bolt in the star pattern order shown in my manual. I stopped because I was putting lots of torque on the bolt and it wouldn't budge. I didn't want to break it off. What should I do? [Response: John Sargent] You must use lots of force. I use either a 6 point 1/2" drive socket or a 6 point 3/8" drive impact socket to remove and intall the headbolts. If you don't have a 14mm six point socket, get one before you return to your project. You will break even a Snap-On 6 point 3/8" drive socket on this job. Don't use a 3/8" drive socket unless it is a black impact socket. See also Mechanical Tips.

Broken Headbolt? [Don Foster] If the broken bolt is under the surface, the block has to go to a machine shop for drilling and retapping. If 1/2" or so is sticking out of the block, you should be able to get a stud remover on it. Or you can try Vise-grips, but they usually chew things up. Use PB Blaster or Kroil, soak it several times a day for a week or more. (WD-40 and Liquid Wrench are totally worthless except as tar solvents.)

Bolt Re-Installation. [Tips from Engine Builder Magazine, Jan 02]

1. *Use New Bolts*. As fasteners are tightened in the engine, they stretch. Because of the elastic properties of steel, the fastener wants to return to its original length (tension). Load on the gasket surface is created by the elasticity of the fastener and this desire to return to the original length. Fastener threads deteriorate with use and also can become damaged by handling and cleaning, negatively affecting the ability of the fastener to deliver the desired load on the gasket. There's also the potential for fasteners to fatigue, to work-harden and to become at least partially yielded during normal engine operation. All of these potential problems are reasons to replace fasteners during the engine rebuild. Engine builders need to give very serious consideration to replacing head bolts when they rebuild an engine. [While Volvo recommends not reusing headbolts more than five times, it's still a good idea to replace them. If you do reuse them, measure each bolt to make sure none has stretched.] Head bolts used against aluminum often have a hardened washer to help distribute the load. Make sure the rounded or chamfered side of the washer is facing up. Tip: don't use cheap aftermarket bolts; buy the Volvo OEM

quality fasteners.

2. *Thread Hole Quality.* Often neglected, but equally important as the fastener, is the condition of the threaded hole the fastener screws into. Thread chasers (different from taps: they do not remove much metal) should be employed to chase every head bolt hole. Clean out any coolant and oil in the thread recesses. In the traditional method of tightening fasteners, using a torque wrench and tightening to a specified point, thread friction accounts for about 45 percent of the tightening effort applied to the fastener. Rough threads in the block can increase that percentage, robbing effort that would have, under normal conditions, been used to stretch the fastener and load the gasket. [Randy Starkie] I have always power wire-brushed the bolts. I also always use solvent/degreaser in the headbolt holes. I have also used some lightweight wire brushes used in rifle or shotgun cleaning in conjunction with the solvent. I then surround the bolt hole with a rag and use compressed air to blow out the degreaser. I spray more degreaser in and blow it out again. Recently I made a cleaning device using an old headbolt with four flutes cut in it with a die grinder which I use before the degreaser and air routine. [Underhood Service Magazine, Jul 2004] Resurfacing a cylinder head decreases its overall height, so be sure to check bolt lengths to make sure they won't bottom out in blind holes. If a bolt bottoms out, it will apply little or no clamping force on the head, which may allow the gasket to leak. If a head has been milled and one or more head bolts may be dangerously close to bottoming out, the problem can be corrected by either using hardened steel washers under the bolts to raise them up, or by using a thicker head gasket.

   Fluted Headbolt Used as Thread Chaser

3. *Thread Lubricant.* The standard lubricant for threaded fasteners is 30-weight motor oil. Both the threads and underside of the head of the bolt should be lubricated because these are the two major friction sources. There are, however, a couple of exceptions to this general rule. One is for fasteners that screw into contact with the water jacket. Their threads should be coated with a thread sealer rather than 30-weight oil. Another case is when the fastener comes with lubricant or sealant pre-applied. The use of so called "super lubricants" (molybdenum-based assembly lubes, graphite, Teflon-based products and even beeswax can all be used to lubricate bolt threads and heads)can actually be detrimental, reducing the friction so much that the fastener is inadvertently yielded in the normal tightening process. The logic in this is if the bolt is stretched the desired amount using 30-weight oil as a lubricant, then using a lubricant that reduces friction more than 30-weight oil will result in more stretch at the same torque. This could potentially cause a fastener or a gasket failure. So use only 30-weight oil as the lubricant. For bolts threaded into blind holes, lightly lubricate the threads and underside.
4. *Washers.* If any were installed, make sure they are positioned right side up (usually with their rounded or chamfered side up) and that there is no debris or burrs under the washers.
5. *Tool Accuracy.* Your stakes are very high when you rely on tightening tools. A torque wrench that is off by 10 percent can be the difference between success and failure. Torque wrenches are still used for lots of conventional tightening jobs, and they need to be checked and calibrated. The "old fashioned" deflection beam style torque wrenches are the least expensive wrenches but also the most accurate in terms of holding calibration. Unfortunately, they are also the hardest to read because of the pointer and scale on the handle. Dial torque wrenches are easier to read, but are more expensive and apt to be damaged if dropped. Adjustable torque wrenches that can be preset to "click" or slip when a certain torque value is reached are the easiest to use, but are expensive and need to be recalibrated on a regular basis (every 100 engines or six months, depending on usage).Use an angle indicator on the end of the wrench when the specification calls for angle tightening.
6. *Proper technique* when using a torque wrench: use socket extensions to clear obstructions so that you can swing the wrench through the entire arc in one continuous motion right to the appropriate torque value. If you need to reposition the wrench handle to clear an obstruction, do so in such a way that the last movement to the correct torque value will be continuous and not jerky.
7. *Follow the Manufacturer's Specs Closely.*
   1. **B230F.** Tighten the oiled B230F four cylinder head bolts in stages (see your shop manual for the specific tightening pattern, bolt by bolt):
      1. 20 Nm, or 15 ft-lbs

2. 60 Nm, or 45 ft-lb
3. Angle tighten another 90 degrees using a "Torque to Angle" indicator on the wrench or some other angle indicator

2. **B234F.** Tighten the oiled B230F four cylinder 16 valve head bolts in stages (see your shop manual for the specific tightening pattern, bolt by bolt):
    1. 20 Nm, or 15 ft-lbs
    2. 41 Nm, or 30 ft-lb
    3. Angle tighten another 115 degrees using a "Torque to Angle" indicator on the wrench or some other angle indicator
3. **B6304**. Tighten the oiled B6304 six-cylinder head bolts in stages (see your shop manual for the specific tightening pattern, bolt by bolt):
    1. 20 Nm, or 15 ft-lbs
    2. 60 Nm, or 45 ft-lb
    3. Angle tighten another 130 degrees using a "Torque to Angle" indicator on the wrench or some other angle indicator.

If a bolt is not coming up to normal torque or is not holding a reading, it means trouble. Either the bolt is stretching or the threads are pulling out of the block.

Headgasket Replacement Tips: B6304 Series.

[Tips from Patrick McGinnis/Tom Irwin] This job is not for the faint of heart or mechanically dysfunctional!! You should have the OEM green service manuals. You will need a 6 point 14 mm 1/2 " drive long socket, power bar and long cheater pipe! Those head bolts are on there! You need as well a good set of Torx allen wrenches, PB Blaster, light, mirror, electronic torque wrench, and patience.You will also need a way to align the camshafts when you re-install without the benefit of the Volvo special tools. I used the Corteco head gasket set & new bolts. You need all new head bolts! You will also need to buy the gasket for the coolant pipe from Volvo along with the special gasket goo for between the cam cover and head.

- FOLLOW THE MANUAL INSTRUCTIONS & PUT THE GOO ON THE CAM COVER DURING RE-ASSEMBLY. Why? You fill up the oil passages and holes in the head if you don't which means you will be taking it all apart again. Ask me how I know!
- Align the camshaft timing marks & then put match marks on the gears & camshafts BEFORE you remove the gears or take off the cam cover. I use a small cold chisel that leaves a mark in the middle of the cam gear and cam.
- You must remove the cams.
- Number the lifters by cylinder & valve location before removing them from the head.
- You should also try to borrow a head bolt angle installation guage. You need to turn the bolts 130 degrees after the final torque spec and you can't do it in 1 motion. TRUST ME! The gauge is essential to getting it right, you have no idea how much futzing is required to get the socket on the bolts, pull, re-adjust, pull, etc, you need some sort or angle indicator. Your back will hurt the next day. Extreme patience is needed to install the top of the cylinder head after all your head bolts have been torqued.
- [Tom Irwin] The cam-locks are real nice to have. But the cam carrier squeeze tools (a pair of them) are a must-have in my book! Your only option is to sequentially torque each of the 48 cam carrier bolts, a tiny bit at a time. And those threads are so frigging fragile that I stripped 8 of them last time before I ever got near the torque value. Blow one of them and your engine will be puking oil very soon. The cam carrier press tools thread into the #2 and 5 spark plug holes. They have a thread starting knob to seat in the spark plug holes and then there are steel wings you turn to achieve the squeeze. You really must use these. there is no non-dealer option that I am aware of. I have heard of desperate individuals making their own crude copies, without the bearing plates.
- Bolt the thermostat housing to the head BEFORE mating it to the block. Access is very tight after it is installed.

- There is a whole buch of stuff bolted to the back of the head with about 2" of clearance to the firewall.
- The "ungodly, unreachable" bolt on the bottom of the intake manifold is best addressed with an "S" shaped or "obstruction" type 13mm wrench. Hold it palm up and wedge your hand between the harness and other crap next to the manifold while sliding the wrench to the left, finding the bolt, getting a grip, and loosening it 1/4 turn or so. Repeat as needed. Swear a bit. [Tom Irwin] Aafter my 5th time it is not too bad. If you can handle some slight contortions, you can do it. The key is to pull the hot air exchanger completely out and get a hand up in front of the rack and pinion.

Suggested Engine Removal. I suggest that you remove the engine and transmission as one unit. To take the engine and tranny out requires less than 2 hours. To remove the head in the car requires scraped knuckles and lots of expletives plus many more hours and more headaches. I will not do this job ever while the engine is in the car!

Removal of Cylinder Head. [Inquiry] I am trying to get the top half of the B6304 cylinder head off. I've removed the 46 bolts, the cam position sensor, the screw in the back on the connector bracket which is threaded into the top cyl head section, and the cover on the intake cam is loose. I think that all that is holding that top half down is the chemical gasket. The Volvo manual say to "CAREFULLY" tap upwards (with a copper mallet) on the top section & the camshafts to push it up. There aren't a lot of places to tap upwards. I am reluctant to try to chisel/pry the two halves apart for fear of damaging the sealing. [Response: DanR] The first time I did this I had tremendous reservations with using a mallet. The Volvo green book I have came with "new update" stickers where the direction to hammer with a mallet was covered up and the new direction was to order the Volvo special tool which not only holds down the top to put in the bolts but also pulls it off and breaks that seal. I think too many mechanics were breaking the hammer points. I proceeded without the tool and used a soft mallet and a screw driver at the two or three spots where there is a little tab hanging over the outer edge of the head cover. These tabs have the guide pins in them. The glue is strong, but using a flat blade screw driver in those spots did the trick. Do not use any thing to pry on a sealing surface: these are machined to a very tight tolerance; a few scrapes and things will be leaking later.

Compression Test Procedures. [Tips from Motor Age Magazine, Apr 2002, by Glenn Hunt, adapted to Volvo B2XX]

When Should the Compression Be Checked?

By performing a compression test, internal engine malfunctions, such as bad valves, piston rings or excessive carbon buildup, can be detected before they cause irreparable damage. It benefits the owner to be aware of these problems so they can make an informed decision whether to invest in repairs or sell the vehicle.

How is the Engine Compression Checked?

The compression should be checked in any instance when an engine is running roughly or is lacking power. Engine compression on a gasoline engine can be tested in two ways. One method of testing involves the use of an electronic engine analyzer. But for the do-it-yourselfers, the easiest method is the manual compression test using a manual, handheld compression gauge. A screw-in gauge is generally more accurate than the gauge with the rubber seal.

- Run the engine until it is hot. A cold engine will not test correctly.
- Disable the ignition coil by disconnecting connection 1, ground, at the coil.
- Remove spark plugs for all cylinders being tested.
- Crank the engine continually for at least five to 10 full revolutions to obtain an accurate reading on the compression tester. The starter must be operating normally at around 4-5 revolutions per second or 250-300 rpm.

- Hold the throttle to full open position to ensure the engine gets adequate air intake.
- Insert the compression tester into one cylinder spark plug hole at a time. Specified minimum value for B2XX engines is 0.9 MPa (128 psi)]
- If all cylinder readings are within the Volvo B2XX specification [0.2 MPa or 28 psi] of each other, no further testing is required and compression is considered optimal.
- If any of them vary by more than this value, a problem may exist in one or more cylinders. Specialized testing equipment may be required to fully diagnose the problem.
- Spark plug re-tightening torque is 25 +/- 5Nm or 18 +/- 4 ft-lb.

What if the Compression is Too Low or Too High?

Consecutive low compression in all cylinders could mean that the problem of fuel washed cylinders exists. This means that the engine has had too much fuel introduced into it and all of the oil has been washed off the cylinder walls. The oil creates a sealing effect between the piston and ring assemblies and the cylinder walls of the engine block. Without this thin layer of oil, the engine compression would be allowed to escape into the crankcase. This is common with an engine that has a 'flooding' problem.

If the engine seems to run normally but is weak and puffs a small amount of bluish smoke, it could be an indicator of worn piston rings and cylinder walls. In either of these events, use a small oil can and squirt a little oil into each cylinder, then repeat the compression test. If the compression dramatically increases then you have found the problem(s). If the compression readings do not change, then it would indicate a timing problem between the camshaft(s) and the crankshaft of the engine. The timing chain or belt would need to be checked for proper timing.

If you find the compression reading is very low or zero in one cylinder, it is highly probable that internal engine damage exists such as:

- There is a 'blown' or weak sealing surface at the head to block mounting area, which basically means a bad head gasket (likeliest condition).
- A valve could be stuck or leaking.
- If the compression is low or zero on two adjacent cylinders, it might indicate excessive camshaft excessive wear or a broken camshaft (not likely with Volvos).
- The piston could have a broken connecting rod or a hole in it.
- There could be a broken valve spring or a bent push rod.

When the compression is found to be too high in one or more cylinders, this would be an indication of excessive carbon buildup in the engine. It can only be corrected by performing a chemical de-carbonizing process on the engine or by removing the cylinder head(s) and physically removing the carbon that is attached to the cylinder portion of the head(s) and the tops of the pistons.

Combustion Chamber Deposit Removal. For *Chemical Removal Techniques*, see the FAQ link. *Water Techniques.* [Tip] My check engine light came on while at the Blue Ridge Parkway, so I take it to my friends shop and they determine the it's the O2 sensor, they run a further test which shows it's voltage regularly dropping well below the minimum, but this still doesn't prove anything. They reset the light and it stays out. But then, he takes a jar of water and using a section of vacuum hose connected to the vacuum port for the cruise control he quickly dips the hose in the water repeatedly while reving the engine, not very high, producing plenty of steam and a really small deposit of black on the ground under the exhaust pipe. Here is the technique:

- Engine should be fully warmed up.
- Connect an 18" vacuum hose from a vacuum port between the throttle and the manifold. I used the small vacuum nipple on the manifold where the flame trap connects to the inboard side of the intake manifold. I

just pulled the small hose from the manifold and left it disconnected: reconnect when done.

- Take a jar (normal size mayo or spaghetti sauce jar) filled with water (this would be just under 3 cups)
- One hand holding throttle open so engine remains in the 3 to 4 thousand rpm range.
- Dipping hose in water over and over approximately once a second for about 1/2 (0.5) second or less, less often if engine slows significantly, engine will run rough so use throttle to maintain engine speed until all the water is gone which will take only a couple of minutes more or less.
- Repeat with the 16 oz can of Seafoam Carbon Cleaner or GM Top End Cleaner. NOT recommended: carburetor cleaner or Berryman's Chemtool.
- Let the engine stall before you run out of cleaner and let it sit for 15 minutes. Then restart and finish with the Seafoam.
- Remain alert and focused and just don't let the hose stay in the water/fluid for much more than half a second at a time and you should be safe. You know you are feeding in too much fluid if the engine speed drops significantly even though you are trying to maintain it with the throttle.
- Take the car out for a vigorous run at high rpms.

His technique was to dip the hose (with no orifice) in the liquid (only when the engine is running at a mid rev range) only for a second at the most, but over and over again not letting the engine slow significantly, using up all the fluid. Next using exact same method with an injector cleaner, Sea Foam Carbon Cleaner (SF16, UPC#: 1881200001) (or GM Top End Cleaner), this time producing plenty of smoke, both black and blue. She survived I thought to my self. Did not expect any difference in the car but I was wrong. This made a car that felt great feel much better, pulls stronger, revs smoother, louder exhaust.

Other Ideas. See the Notes in the Engine:Performance Section for more ideas and tips.

Burnt Valves in 740GLE Head with Hydraulic Lifters. [Problem Diagnosis by James Rothe] At about 90k miles, my 740 GLE started a recurring burnt valve problem. Three times (!) did I have valve(s) replaced before we found out what the problem was. I should add that throughout my ownership of the car it has burned oil -- slowly, so that you could not see blue smoke -- but as much as one quart per 1000 miles.   The previous owner reports the same. The dealer said that was "within normal limits."

What we finally found out was that early B234 engines, with their "hydraulic valve lifters", had an infrequent manufacturing defect in which the holes for the valve guides were made ever-so-slightly oval. The problem, as it was reported to me, is that the hole in the head itself, into which the guides are pressed, was oval. It's an infrequent defect that reportedly occurs in both 740 and 850 heads with hydraulic lifters. That's a very different situation from having defective valve guides or seals.This is not exactly a perfect fit for a circular valve guide, so it allowed a small amount of oil to seep onto the valve. The speculation is that this burned onto the valve, caking up the valve with carbon deposits, and prevented the valve from properly seating. Without proper contact with the cylinder head, the valve could not transfer its heat to the head and it burned.

My mechanic, a family friend who works as a mechanic at a Volvo dealership very nearby Volvo's North American headquarters in Rockleigh NJ, found out that Volvo is aware of this problem in the 89 740 GLE and in other Volvo engines with hydraulic lifters, like the 850 series, but that "the problem is not statistically significant enough to justify a [costly] recall campaign." Or so says Volvo Customer Relations.

We didn't find out about this manufacturing defect until after two top-end rebuilds, by which time the car had over 120,000 miles on it. Needless to say, Volvo declined my request for "goodwill" service. Part of their argument was that "this problem usually shows up within the first 10,000 miles." My response was "perhaps, but if it's been going through oil for all of it's life, and that condition stops after the valve guide hole is corrected, doesn't it make sense that this oil control problem at the valve guide would adversely affect the valve, just like your 'statistically insignificant' manufacturing defect is known to do?" I also added that I was the first owner to do extensive hi-speed highway mileage with the car. The previous owner may have never got the head as hot as I do every day. "It didn't matter."

They finally put it to rest by saying that it may have been damaged or improperly serviced during one of the previous head rebuilds. I can't say for sure that it wasn't, but I'll stand by my mechanic's abilities. He's been a Master Mechanic for Porsche/Audi/VWs for years, and has a similar history with Bricks. I can't say I blame them for declining to service my car, but they did at least acknowledge that there is a problem with the heads in the hydraulic lifter engines.

For those of you who have experienced similar burnt valve problems to be able to check the valve guide holes in the cylinder heads. A fix can be implemented, if the "oval shaped guide hole" is suspected, by overboring the hole and installing oversize guides.

Cylinder Head Valve Train Oil Holes. I decided to clean the "basin" in the valve cover compartment; there are four compartments and two holes (finger size) per compartment. Inside these little basins & holes, the oil had hardened and coked up, I had to scrape it out with a dental-probe type tool. At first I was amazed, but then I realized that these little basins never drain. Every time you shut off the engine, the heat from the exhaust (which is right under it) comes up and does a little more cooking of what's there. I used a syringe to suck out the oil. I couldn't get everything out because there is a lot of dirt - almost solid particles that my syringe couldn't suck in, so I used a shop vacuum to finish cleaning it. I attached a small plastic hose to the end of the vacuum tube and wrapped it with a duct tape and it worked perfectly.

Valve Cover Gasket Fit on B230. [Inquiry] My replacement valve cover gasket came: it is flat and appears to be too wide. [Response] The gasket fits over the semicircular cam bearing covers at each end. Once you wrap the ends over these covers, it suddenly becomes the correct width! To make sure you avoid oil leaks, use a little Hypalon or RTV sealant on the gasket at each corner of the bearing caps.

Valve Adjustment on B230 Series. [Tips from John Kupiec]
Frequency of Valve Adjustment. [Inquiry] How often should the valves be adjusted on a B-230F non turbo and should they be adjusted hot or cold? [Response: JohnB] They should be CHECKED every 60K or so and adjusted as necessary. I've used synthetic oil on both B230FT engines and haven't had to have either one of them adjusted in 150K on one and 50K on the other. So check valve clearance yourself with engine hot when you have to do a cam cover gasket replacement (which works out to about every 3-4 years and 30-40K on my cars or when I do a timing chain/seals replacement, whichever comes first) and adjust as necessary. Changing shims is trivial with the IPD rental kit. [Response: Paul Seminara] I have found that Volvo valve adjustments don't "drift" much. Unless there is a serious wear issue, and after a good "initial" adjustment, some cars have gone over 100K miles and the valve adjustment is still in spec. [Response] You are correct in thinking that B230FT engines rarely need valve adjustment. Valve adjustment on B230 engines is done via shims. It is easily within your ability to check the valve lash on your engine. All you need is a feeler gauge, a replacement valve cover gasket (about $20 or so), some BF pliers and the procedure.

Useful Tools. [Tip from C. McGrew] I used the j-hook levering valve spring compressor from ipd, and a pen magnet and pick to get the shims out. The ipd rental for the shims and compressor is the best bet. If you do not have the tools, see the FAQ Section.

Valve Clearance Adjustment Procedure. Summary of valve lash check procedure on B230 engine appears below. While Volvo says the procedure can be performed when the engine is hot, I am in agreement with the late Jon Muir (How to Keep Your VW Alive...) who wrote that the only way to get a correct reading on valve lash is to check the engine when it is stone cold.

1. Remove spark plugs. Remove valve cover.
2. Use LARGE pliers (e.g, Channel Lock makes a great set for this) to turn the engine clockwide. The grab point for the pliers is the outside surface of the mount for the cooling fan on the end of the water pump.

3. Timing order is 1-3-4-2. Number 1 is at the front of the car, number 4 is back by the firewall.
4. Turn engine until TDC indicator on timing gauge (down near the crankshaft pulley) is around zero degrees. Number 1 is at TDC when mark on crank pulley is at zero on timing gauge AND cam lobes for number 1 point out and slightly upward in opposite directions. Think perky ;-) and you'll get the idea.
5. As you are checking clearances write them down on a large piece of cardoard on which you have made eight circles, one for each valve.
6. With number 1 at TDC, use the feeler gauge to probe the gap between the cam lobe and the lifter. Volvo says the valve lash should be between .3 and .4 mm when the engine is cold. If a feeler gauge setting of .4 won't go, and one of .3 will go easily, the valve lash is within spec. If your feeler gauge doesn't have .3 and .4 mm, use what you have, and interpolate accordingly.
7. Turn engine 180 degrees so that the cam lobes from number three are perky and pointing in opposite directions. Repeat step 5 for Number 3.
8. Repeat steps 5 and 6 for cylinders 2 and 4, taking note of any readings that are out of spec. If they are out of spec, use the feeler gauge to determine the actual gap.
9. Reseal valve cover, using new gasket.
10. If one or more of the valves is out of spec, you will need shims. Some dealers and independent shops will sell individual shims. Find a shop a give them your readings, and they should be able to give you the correct shim. You will need a shim removal tool. KD sells one for about $30. Or, you could have the shop replace the shim. If you do not have the tools, see the FAQ Section.
11. You may wish to re-tighten the valve cover nuts after a few days. I find that doing so helps stop any leaks. Torque on the valve cover nuts is not that high: 9 lb-ft should do it.

Notes on Use of Feeler Gauge:
[Tips from David Hunter] There is a picture in Bentleys of a guy trying to shove a very bent feeler guage under the cam lobe. This is not good because you cannot really "feel" for the correct clearance. I remove the feelers from the tool, array the .015 to .018 feelers in order on the radiator top so they are handy. I insert the feelers under the cam by turning them so they can slide under the cam flat. Hard to explain but you will know what i mean when you try it. The correct size will slide free without having to mess around with a bent up feeler that wants to stick and bind.

Valve Cover Gasket. [Chris Herbst] For a killer valve cover gasket seal, clean the mating surfaces with carb cleaner or brake parts cleaner, put a little bit of RTV sealant on the valve cover gasket and the end bearing caps before you set the valve cover down, and fasten it evenly. It'll almost NEVER leak oil if you do that. Make sure not to use gasket maker. I have made that mistake before, and it ruins your day if you have to pull the valve cover later on. [Steve L] The new gasket looks like it's 2 inches wider than the head and couldn't possibly fit. The extra width is needed to run up over the front and rear cam bearing/seal assemblies. The cover forces it to the required shape. One tip: use just a touch of silicone sealent in the inside corners next to the cam bearings and it will never leak and don't over tighten the acorn nuts on the new gasket.

Valve Cover Nut Re-torque: Re-torque the valve cover nuts to 9 ft-lb (12.5Nm) in order to prevent oil seepage per Volvo TSB Jun 88.

Valve Adjustment Technique if No Shim Kit At Hand. [Great Tip from Jim Bowers] I assume the technique is the same as on my former diesel. Shims of different thickness set between the cam lobe and the top of a tappet on the top of the valve stem & spring assembly and adjust the clearance. Its important not to go too long as the valve seats usually wear faster and reduce the clearance which will lead to burnt valves! A shop assortment is very expensive at several $100!
Here is the technique I used. First buy the valve depressor tool and the shim pliers from your Volvo dealer. Then take off the valve cover and measure and record the clearance between the cam lobe and the shim, (assuming you know how to properly set the cam for this) Then using the tools, take out each shim in turn and read or measure its thickness and put it back, also record these values. Now put the valve cover back on using the old gasket for the few days you will need to get the new shims. Use the data recorded to determine the new

shim value needed at each valve. (Always err on the loose side or more clearance if you must err!) Compare the new determined shim numbers to those available from other valve positions and allocate your existing shims to as many locations as possible. The missing values are the ones you need to order from your Volvo dealer along with a new cover gasket. Once the new shims arrive, go back to the car and move the existing shims to their new locations, install the new shims in the proper spots and save the leftovers for some other time. The next time you can probably guess which shims are likely to be needed and order them before starting the project. Good luck. I got a lot of satisfaction in doing the job and saved the cost of the tools the first time. If you have no tools, see the FAQ section.

Valve Adjustment Tool. [Inquiry] Anyone know where I can purchase a tool to depress valve springs so I can change shims? I know one is available from Volvo but is expensive for infrequent use. [Response: Jim McDonald] Mine is made by:

S.P. TOOLS/SCHLEY PRODUCTS INC.
5350 EAST HUNTER AVE.
ANAHEIM HILLS, CA 92807
TEL: (714) 693-7666
FAX: (714) 693-8558
P/N 81350

It's a lot cheaper and simpler than the Volvo tool.

How To Adjust Valves If You Do Not Have the Tools. [Tip] I did mine when I was replacing the timing belt at about 120k miles.

- I measured all the clearances with a feeler gauge
- Then I removed the timing belt and unbolted the cam
- Then flipped out the disks that needed to be replaced with some sharp object (paperclip?l)
- Measured the disks I removed with a vernier caliper to see if I could re-use any of them in another spot.
- Ran down to the Volvo dealer and picked up the disks I needed. Take a calculator because you likely measured them in inches and he sells them in mm.
- Put everything back just as I found it. Lubricate the cam bearing shells, tappets, and the cams. Install the cam with the guide pin for the timing gear facing up. Lubricate the caps and Install them and the nuts, starting with the rear cap and first just tightening the nuts lightly to position the cam. End with the center bearing cap. Then crank the cam down evenly with carefully torqued nuts on the cam bearing caps (20Nm or 14 ft-lb).
- The result will be corrrectly adjusted valve clearances.

  No special tools other than a torque wrench.

Valve Stem Tip Rubber Cushions. [Tips from Dick Riess/John Sargent/David Hunter] The B21/23 and B200/230 series of engines are overhead cam with solid cam followers. Valve adjustment is made by changing shims held in the valve depressor. The valve depressor looks like an inverted straight sided bucket, and the shim snaps into the shallow (up) end. Under each valve depressor there is a little rubber cushion which serves to take the "click" out of the actuation of the valve. This little rubber cushion is called either a "husher" or "valve absorber" depending on who your are talking to. These hushers snap into the valve keeper. The rubber looses its elasticity over time and heat, and you get noticeable valve noise.

Worn vs New Valve Husher

Valve Husher in Place on Valve Stem

The husher is a rubber flange shaped device that sits on and around the top of the valve stem which keeps the stem and lifter from clattering against each other. The actual valve stem seal is located on intake vales and is on the guide and under the spring---more difficult to reach. If you start to hear some valve noise in your car and it is high mileage, you might want to seriously think about replacing these little rubber hushers. They are inexpensive and do not change your valve clearance. Your engine will be quieter too. To change, first remove the cam. If all you are doing is replacing the little hushers, just remove the valve adjustment discs and keep track of which valve they go to. Be sure to clean out the buckets which slip over the valve and remove all the husher pieces before reassembling and installing new hushers. Your clearance will not change, but measure if you like. You are only inserting a rubber shock absorber not modifying the cam or lifter. However, if you have new hushers installed it makes it tough to feel properly with a feeler gauge, although they will compress down after a few minutes of hot operation and the valve clearance will revert to normal. I complete the valve clearance process before I install the new hushers. Do not overtighten the cam bearings -- 14 lbs only. You might use some Hylomar sealant between the front cam bearing caps to eliminate oil seepage.

Hylomar HPF Sealant on Bearing Caps

Valve Adjustment on 95 960? [Inquiry:] Seems to be some valve clatter in my 960 wagon. It has 50 k on it. Do these engines need valve adjustments? [Response: Zippy] No, hydraulic lifters as used in Volvos are not adjustable. You might be hearing some lifter noise as the lifters pump up with oil. I wouldn't worry about it as long as it goes away once the engine warms up.

Cam Replacement. [Tips from Dick Riess] A cam can be easily pulled in an hour, but reassembly takes me a lot longer, probably an extra 2 hours. I like to make sure everything is clean and checked prior to assembly. Tips: Attack as if you are changing a cam belt, even better, when you are changing the belt. That way you can renew all 3 front seals and the tensioner, if required. Remove distributor, cap and rotor first. Remove valve cover. There are 10- 13 mm nuts that hold the cam down. Release each bolt approx. 2-3 turns and keep doing this till they are all loose. Make sure you record the order in which the bearing caps are removed: they are different and need to be replaced in the same order. The cam should gradually lift the cam caps as the nuts are released. Now is the time to clean and check the rubber stem tip seals under the lifter. The lifters are like an upside down can and come out easily. Pick out the old stem tip seals, install new. Clean inside of lifters.

Lubricate the bearing shells with assembly lube. Reassemble. You do need to put the cam back in as you removed it. A few turns at a time until snug. Torque using a torque wrench to 14 lbs, that is only fourteen!! Check valve clearance. If you did not change the cam, the clearance should be unchanged. Replacing the cam you will probably have to change a few shims. When replacing the cam on my NA recently, I only needed to replace 3 shims and they were close. [Chris Herbst] When you replace the cam and pull the buckets out of the head, it's a good idea to smear the buckets and insides of their bores with engine assembly grease. The cam bearings should get a coating of that as well. Ditto for the cam lobes. I always plop a little bit of fresh oil into the valve stem too, since cleaning the stuff often deposits dirt where it might not ordinarily get to. For a killer valve cover gasket seal, clean the mating surfaces with carb cleaner or brake parts cleaner, put a little bit of RTV sealant on the valve cover gasket and the end bearing caps before you set the valve cover down, and fasten it evenly. It'll almost NEVER leak oil if you do that. Make sure not to use gasket maker. I have made that mistake before, and it ruins your day if you have to pull the valve cover later on. [Editor] According to the manual, after laying the cam (with the guide pin for the timing gear "up")and bearing caps in place, you first tighten the rear nuts very lightly, then all except the middle nuts. Then install the middle nuts and tighten lightly. Then torque them all to 20Nm (14 ft-lbs).

Block, Crank and Pistons:

Failure of Harmonic Balancer.
1. Operation and Construction of Harmonic Dampener. [Tip from Tim] The front pulley on the crankshaft is made up of three parts. The inner part is bolted to the crankshaft. The center part is a rubber ring. The outer part is the one with the timing marks and pulley cuts for the belts. These are all attached when it is new.

When this part fails, the rubber part becomes dry, the two metal parts are then able to "slip" around this rubber part. The timing marks are able to "walk" around the inner member. This does not affect the timing, as the inner part is keyed onto the crankshaft. Problem arises if you start to time the motor. The normal marks are then chasing each other around the crank and make no sense at all.

Crankshaft Harmonic Dampener Pulley

You can hear a squeeling from the pulley. There can be a vibration from this part at times, cold start etc. If the timing is not changed, you can wait for the part to fail to the point that the belts to AC/PS and alternator all stop doing their thing. Another approach is to just replace the part at the time you are already doing the timing belt, seals, water pump and tensioner/idler. I know it costs more, but are you in it for the long run or short run? [Tip from Don Willson] Paint a stripe from hub to rim on the balancer and look for displacement.

2. Symptom: Crankshaft Pulley Shakes. [Inquiry:] I've got a '85 760 Turbo with a B230 engine and I've been noticing a rattling noise in the front of the engine. Upon closer inspection, I saw that the crankshaft pulley seemed to be vibrating somewhat and shaking intermittently while idling, in comparison to the other pulleys such as the water pump and alternator. It appeared that the rattling noise is linked to the vibration of the pulley. However with higher RPMs, the rattling seems to go away. Currently I can grab the crankshaft pulley with the car off and slide forward and back on the crankshaft with my hand. There is about 5 mm of play in direction of the shaft forward and back just applying hand pressure and with all the belts fully tightened, much worse with the belts off. The metal portion doesn't move at all, its just the pulley that’s moving. This results in its shaking during idle. The center bolt is still there and tight so I guess it is the damper unless anyone else has a suggestion. Or am I looking at the possibility of excessive crankshaft endplay and faulty main bearings (the car does have over 120K miles)? Or could it be just the pulley itself? [Response 1: Burton] It's probably the pulley. It is a wear item, and I have replaced a few on my cars. It's made by GM, and it has a rubber damping sleeve that comes loose or otherwise goes bad. Usually it just allows the pulley to spin on the shaft, making the timing marks inaccurate. I've located the part $155 at the dealer (part num: 9135194) [Response 2: Don Foster] Is the center bolt still there, still tight? Is the pulley actually sliding on the crank, or has the pulley started to separate -- and you're pulling the pulley apart? If the pulley is loose from the crank and spinning, then it's likely the key is beat. The pulley will probably need to be removed for repair (or maybe replacement) and to replace a battered key. However, it sounds like you (and others) have it pegged -- unfortunately, to a new front damper.

3. Symptom: Timing Marks Drift. When the harmonic balancer fails, the timing marks drift. The harmonic balancers on both my 745T and 765T have a hard rubber cushion between the hub and the outer grooved ring. Over time, this cushion will deteriorate -- the rubber will dry out and crack, and will separate from the metal sections, leading to a condition where the outer grooved ring will spin independently from the hub. Once this occurs, it will have to be replaced -- for obvious reasons. I had to do so shortly after buying my 765T. And from what I've learned since, this is a relatively common repair on Volvos with 100k+ miles on the odometer. Thus, it's a good idea that one inspects the harmonic balancer for signs of deterioration when the time comes for that 2nd timing belt change.

4. Replacement Tip [from Zippy] Regarding overtightening of the harmonic balancer bolt, as a Volvo Master Tech for 10 years, in all of that time I have seen one (1) ruined crank and balancer due to improper tightening. As for using an air wrench on the front crank bolt, that is the hard way to do it, the simple holding tool Volvo has (PN 9995284 @ around $35.00 for those interested in making the investment) is a much easier way to do it. Most harmonic balancer failures are due to the rubber giving up, allowing the outer part of the balancer to spin on the inner. The only fix is to replace the balancer. It is a common repair on Volvos with ten years on the engine, regardless of miles. [Editor] Note that Scantech and some Volvo harmonic balancers must have the holes filed out to fit the 5284 tool. The casting is ridged, causing the tool to shift under torque. File square. Note as well that the Volvo balancer has usually been found to be of much higher quality and with better ease of installation. This is one part you may want to buy OEM.

5. Wear in Notch of Crankshaft. [Inquiry] I recently replaced the front seals and timing belt on my 740 with 208,000 and noticed that the timing belt gear had grooved the crankshaft quite a bit and there was some wobble in the gear. Since there has never been a loose pulley bolt or anything done incorrectly, this must be normal wear. Has anyone found a good repair for this? [Reply: John Sargent] I experienced the same damage to front end of the crankshaft of a 1987 B230FT. The harmonic balancer had not been tightened adequately, and the looseness resulted in wear of the crankshaft tip where the harmonic balancer seats. I measured the amount of wear and cut some shim stock of the proper thickness to fit between the crankshaft tip and the harmonic balance, and carefully formed it to fit. That was the end of the problem.

Failure of Lower Timing Sprocket. [Kuba] If any of you has sheared the pulley key on the crank timing sprocket (the small one), here's what I did to get it fixed. The key got sheared off by the crank pulley. The pulley started rotating against the sprocket because the crank bolt came loose. The bolt came loose because some #$%@!& mechanic didn't bother torquing it to specs. See the preceding section for information about wear in the notch at the end of the crankshaft.

1. File the old key away. Make sure to leave a couple of thousands of an inch worth of material still protruding, so that you can easily see the boundaries of the old key.
2. With a caliper, mark the center of the old key. You do it by measuring with and length of the old key, and marking in the half.
3. Use a center punch. Don't miss this step. If you don't have a center punch, get one. It is used to make a guiding "pit" so that the drill won't slip when you start drilling.
4. Drill a 1/16" hole in the spot you've marked. Make it about 1/4" deep, no more.
5. Re-drill the hole to 2/16" and then to 3/16".

6. Get a hammer, super-glue, and a 3/16" drill bit you want to make a tad shorter.
7. With the caliper, measure how deep is your hole (dimension A), how deep is the groove in the crank pulley (B).
8. Add A+B=C, cut off C length off the shank end of the 3/16" drill bit.
9. Put super glue into the hole and on the C-long shank of the 3/16" drill bit, hammer the shank into the hole as far as it will go.
10. Leave the glue to set (15 minutes).
11. File the shank (your new key) with a fine file so that it will fit into the groove in the crank pulley. You need to shave off just a couple of thousandths of an inch (a hundredth of a millimeter or so). Make it a loose interference fit, if you will.
12. When your key gets sheared, your front timing belt locator plate will be damaged, just get a new one. It costs about $5 at the dealer, IIRC. The front locator plate is a "washer" that goes between the timing belt sprocket and the crank pulley.

Piston Slap and Engine Noise. [Inquiry] I have noticed on my 940 Turbo when the motor's cold it makes this sound almost like hydraulic valves tapping but it comes from the bottom of the motor. Is this piston slap? [Response: Don Foster] Could be. Piston slap occurs because the piston rocks slightly in the bore. What you hear is a "tapping" sound, somewhat like tapping the engine block with a 2x4. But as the aluminum piston warms it expands (twice as much as the iron block), and it expands to fit the bore. As a result, piston slap usually diminishes after several minutes as the engine reaches operating temperature.. In my '91 740 (225k miles) the slap is pronounced (and irritating) when cold but completely gone at running temp. Piston slap is sensitive to throttle position. That is, if you give it a bit more gas, the slap increases. Needless to say, when wife drives out in the morning I can hear the piston slap for about 20 miles. In my opinion, piston slap sounds somewhat deeper than a loose lifter but not as deep or strong as a worn wrist pin or rod bearing. I'd characterize it as hammering the block with a chunk of oak. Valve clatter and injector noise, on the other hand, are both independant of throttle and don't change as the engine warms up. Valve clatter is a distinctly lighter tapping sound, and injector noise is a high frequency clicking or ticking sound. [John Sargent] I will concur with Mr. Foster. Volvo introduced a longer piston about 1993 or 1994 model years along with piston oil cooling. Piston slap was no longer a problem. When I rebuilt the 1987 B230FT in the wife's 1986 745T, the machine shop supplied the new longer skirt pistons. The car has zero piston slap noise. It helps to have the pistons perfectly fitted to the bores, but the longer piston skirts help too.

Connecting Rod Bearing, Oil Pump, and Oil Pan Gasket Replacement. See the FAQ file for more details.

Block Freeze Plugs. [Tips] Corroded and leaking freeze plugs should be replaced. Size is 40mm. If you have one bad, some of the others may be eaten up also. Might be to your advantage to replace as many as possible. Not a fun job with engine in the car, especially when you cannot see half of them. [Tips from Michel Goudeseune] Be careful when removing them that you do not damage the flanges or drill too deep a hole into the block or the cylinder wall. Remove intake or exhaust manifold for better access. Drill a hole in the center of the plug. Using a slide hammer mounted in the hole, pull the freeze plug off. Do not use a punch and hammer: you risk damaging the flange. For information about installing an engine block heater in one of the freeze plug holes, see the FAQ section.

Other:

Oil Pan Gasket Replacement. [Inquiry] My oil pan is leaking oil: how can I change the gasket? [Fitz Fitzgerald] Try tightening the pan bolts first. I've had great success in fixing leaky oil pans and transmissions just by tightening the pan bolts. I personally use a bit of RTV gasket sealer on the pan bolts (oil pan, transmission pan, and valve cover gasket) to keep them from slowly backing out due to heat and vibration. LockTite is too strong to be used here, but RTV works perfectly. Cleaning your flame trap and breather box are also advised since it will lower the crankcase pressure and decrease the oil's "desire" to escape under pressure. If you still need to change the pan gasket, see the FAQ link.

Accessory Mounting Bushings. [John Sargent] To replace your accessory mounting bushings, you can use OEM rubber or harder polyurethane that does not compress over time. The power steering pump doesn't use them, but you will need four for the A/C compressor and three for the alternator. Total of seven. [Editor] The IPD poly bushings are of superb quality; others have failed rapidly from poor materials.

Alternator: See the FAQ notes

Air Conditioning Compressor: Remove the splash pan. De-tension the belt. From beneath the car, remove the mounting bolts. Replace the four bushings and reassemble. The lower rear bushing can be almost impossible to remove due to pipes off the back of the compressor and you might ignore it. Belt tension is 1/4 inch deflection under moderate finger pressure.

Accessory Pulley Removal. [Editor] To remove the pulleys on power accessories when installing replacements units:

Alternator. Use an air or electric impact gun to remove the center bolt, then slide the pulley off. Many auto stores (e.g., Autozone) will do this for you when buying a replacement alternator. Pounding is not good because you are likely to bend the pulley.

Power Steering Pump. This pulley is a press fit onto the shaft and is very, very tight. Pounding or trying to use a gear puller will almost certainly bend the thin sheetmetal pulley. Either have a shop or the store do this, or buy a special power steering pulley removal kit at an auto parts store (~US$10-$50) which has adapters to pull the pulley off the shaft without bending it. Harbor Freight has a cheap kit; Lisle Tools makes a high quality version.

Air Intake Box Latch Repair. [Tips from Kerry] I finally repaired my air box after the last OEM latch broke off. The repair worked great! (I just couldn't bring myself to use a huge wire tie). I used 4 latches. I should have ordered 5 or 6. The parts I used were ordered from McMaster

Carr. They have an excellent on-line catalog. I used: 2-7/16" long x 7/8" wide, 1-5/8" reach-Stainless Steel Draw Latch (catalog number 1889A22. Costs about $4 each) I used 5/32 inch aluminum rivets with 1/4 inch reach rivets with a backing of glue or a drilled piece of metal strapping to mount them. You will have to cut a little plastic away to properly position them. The clearance is fine once the air box is installed. I recommend this repair to anyone who has a bunch of busted latches. [Another Approach from Dave] Go to Home Depot and buy a small piece of galvanized steel plate (get it thin...easy to bend). Get some self tapping screws with philips heads about 1/2" to 3/4" long. Cut strips about 2 1/2" long...thin enough to fit through the thinnest part of the latch clip (the clip must be able able to rotate easily). Fold the strips around where the clip normally would fit into the box "ear" (which has broken off so you can no longer mount the clips..right?) Be sure to leave a round "chamber" for the clip to move, and rotate. Now use a punch to start a hole about 1/4" below round chamber, drill for screw. With the airbox removed and the top in place...position the clamp where it will clamp the upper box in the right spot. Then mark both outline and where you will actually drive the screw through the plastic. I found that the screw needs to go slightly upwards so that it was snug in the corner of the plastic lip. Cut another piece of metal about 1/2" by 1/2"...and round off the sharp corners! This will become your inside backing plate... you will want to punch a small hole for the screw to bite into after it goes through the plastic airbox...the "backer" should be flush or below the airbox edge. If you want to put a washer on the screw make sure that it is small enough not to interfere with the clamp. Clip or cut off any excess screw length that will get in the way of the filter (using lineman's pliers, hacksaw, boltcutter, Dremel). Replace all of the missing/or soon to be and you should now be able to clamp the sides and the top of the airbox with the original Volvo spring clamps.. [Response by Philip Baugh]. I just tried for an hour to put a latch on mine. I got a latch from Lowes that looks like the one recommended in the FAQ. But it did not work so I just screwed four long sheet metal screws into the edges. It is tight and will unscrew easier than those tricky latches anyway.

McMaster-Carr Replacement Draw Latch

For instructions on replacing the air intake thermostat located in the bottom of the air box on non-turbo cars, see the FAQ section.

Splash Shield Repair. [Problem: Cracked belly pan; they get brittle and crack pretty easily at sub-zero temp. here in Ottawa. Repair or replace?] I have had great success heat welding cracks in these things. I just refurbished the one off my '84. I used a butane pocket torch and an old metal putty knife to buffer the flame, heating the crack slowly and using the hot blade to puddle and draw the plastic to the crack line. I also tried a regular propane torch on real low, that also works. It's quite easy, no great skill required. Do it outside though; it smells a bit like real hot wax. The repair is as strong as original, if you do it from both sides. I was missing a couple of corners and actually welded a couple of pieces in from an old very cheap black plastic garbage pail, must have been the same stuff, as it melted similarly, and was compatible. Don't know what it is, but it has a low melting temp. and flows before it ignites. [Tip from JoeB:] I cut pieces of galvanized sheet metal into the appropriate shapes, and pop-riveted them into place. Then I drilled holes. The repair is holding well! [Tip from Bob Cavenaugh] My solution to failing and falling splash pans has been a steel bar, 0.125 inch by 1.0 inch by 32 inches, bought at 36 inches from ACE Hardware. Drilled oversize holes for the three bolts along the rear of the pan. Then fender washers on the front corners. The two side ones don't add much anyway. [Editor] I use 1-1/4 inch fender washers, cut to fit, and "Goop" urethane adhesive to reinforce the holes. Lay a heavy bead of adhesive inside the bends at the sides, especially around the area of the rear corner holes, which tend to crack.

Replacement Engine Splash Shield. [Tip:] A mechanic friend showed me a new heavy duty variety he began stocking a few years ago. It is much heavier gauge plastic than the original. Sorry, I don't remember what they go for... The mechanic friend's name is Carl Drennen and he is located in Ravenna, Ohio. SE of Cleveland and E of Akron 330-297-1297 I gave him a ring and he tells me they are sourced from RaMac in Nevada and SAVE in California. Note: Both these suppliers do NOT sell to the general public. They list as a belly pan speed fit heavy duty.
They are vacu-formed and have a reinforcing rib in them... Both the 700 series and 200 series lists from $74.68 to $78.04 Carl sells them for $50.00 and shipping costs... Shipping UPS would probably be around $5 for most places in the continental U.S.

[Editor:] When you install a new splash shield, reinforce the holes with glued fender washers (see Repair above) and lay a bead of urethane adhesive such as "Goop" along the side corners to distribute stresses, especially at the rear corner holes.

Bellhousing Bolt Removal. [Inquiry] How do you remove the top bellhousing bolts, which have little access?
[Response: Dick Riess] I used two long sections of extensions, one with a wobble joint, while dropping the tail end of the tranny and got at them very easily.   I believe the secret is to allow the engine and tranny to drop down after removing the tranny crossmember so that you can visualize them from a distance. See the FAQ section on transmission removal for more information.

Flywheel Position on Re-installation. [Inquiry:] I didn't mark the position when I removed the flywheel to replace rear main oil seal. How do I replace it? [Response: Abe Crombie] Turn the engine to #1 TDC (timing marks in line on crank pulley to pointer on timing belt cover), then install the flywheel so that the two rivet-like pins that are on flywheel inboard of ring gear about 1+ inch are on the exhaust side of block roughly at 2 o'clock and 3:30 while the engine is at TDC. You might find that at this position you will see a faintly stamped arrow pointing at the crank sensor. Not all flywheels had this arrow for the first couple of years, so you might not find it on yours. One bolt hole in either direction puts them way out of this orientation. The spot on edge of flywheel where the holed surface is interrupted will be mostly lined up with starter when it is correct.
[Response: Dick Riess] The flywheel orientation must be correct on newer engines using crank position sensors or you will get a no start/erratic spark timing problem. The crank sensor reads special cutouts in the flywheel to determine crankshaft positioning. On these newer engines using the crank position sensor, the flex

plate TDC is with the flex plate arrow to the top of the engine, not the 'long tooth' on the sensor part of the flex plate. I suggest the following:

Find TDC for cylinder one, however you want to do it. I took off the top one half of the timing belt cover and noted the cam at TDC and crank at TDC.

1. Mark the arrow on the flex plate so you can see it. It is marked on the side toward the engine, which really doesn't help.
2. Place the flex plate so the arrow is pointing to the top of engine, where the crank position sensor is located. The 'long tooth' should be at 270 degrees,or 90 degrees down from the top of the engine.

Drive Plate Position at Starter

Checking Correct Position After Installation. [John Sargent] The LH 2.4 RPM sensor gets its signal from a slotted wheel riveted to the drive plate. For LH2.4 engines there are 58 slots with room for 60 slots, there being two hole voids. To check the ring gear installation for proper timing, remove the starter and position the engine on TDC for number one cylinder. There are 58 holes on the timing ring, with a void of two holes (room for 60 holes, total). The void will be at the bottom of the starter opening if the ring gear is installed properly.

Drive Plate Position at Starter Opening

Parts Caution. [Duane Hoberg] Make sure you buy the correct flywheel from a Volvo savvy parts supplier. One caveat of multiple application parts (auto and manual trans flywheel with multiple bolt holes for differently-mounted pressure plate or torque converter bolt positions and crank position magnet or stud on flywheel) is that you may install the pressure plate or torque converter in the wrong holes. Or buy the wrong part altogether.

Torque on Reinstallation. Retorque flywheel bolts to 50 ft-lbs. For a counterhold to secure the flywheel, install a very strong C clamp through the starter hole in the block, squeezing on the front and back of the flywheel.

Engine Mounted in Support Stand. [Qeury:] Ok, so its a basic question but I would like hear from those who have placed their B21/23/230 in an engine stand. Whats the best way to go about this? Can the threaded engine/bellhousing holes support the weight of the engine? What about the aluminum reinforcing bracket at the bottom? [Response 1: Dick Riess] I use an engine stand with 4 arms, two attatching at the top two holes where the bellhousing mounts to the block and the bottom two at the lower end of the block. One goes to a starter bolt hole and the other opposite side. Have to use nut-bolt combos on the bottom two. This works nicely for me rebuilding all but the clutch. You can do a complete engine with no problem re weight and balance. [Response: John Laughlin] I usually put one starter bolt through the upper starter bolt hole and attach a nut to that, then attach two bolts to the top bolt holes on the block, and one to one of the right (passenger) side bolt holes on the block. I've supported two B23's that way and they both stayed in position.

Engine Paint. [Inquiry] Anyone know a source for Volvo red engine enamel? Response: Vin Razo] Tempo Volvo Red, #TEM 020472, is an exact match. It is a quality marine engine paint, and you might find it a local marine supply store. If not you can order it from the shipstore.com. [Response: George Downs] I've been using Rustoleum's red spray can paint over Rustoleum Rusty metal primer with good results. Similar Chevrolet Engine Red paint is a little too orange for my taste. The Rustoleum seems to resist engine heat fine (not on the exhaust).

B234 Seals: Counterhold Tool	

Abbreviations:

AMM	Air Mass Meter
ECT	Engine Coolant Temperature sensor
ECU	Engine Control Unit computer (either fuel injection or ignition)
FI	Fuel Injection
FPR	Fuel Pressure Regulator
IAC	Idle Air Control solenoid valve
TB	Throttle Body
TPS	Throttle Position Sensor
VSS	Vehicle Speed Sensor

Accessory Belt Tightening and Maintenance.

Belt Diagnosis. [Problem: Squeeling belts; how to set tension?] You can easily isolate the problem. Take a spray bottle of water filled with water. With the engine on fast idle, spray a stream at each belt separately. The world will all of a sudden get real nice and quiet when you've hit the problem belt(s). If that doesn't alter the noise then you can look elsewhere (like bearings in the water pump, alternator, power steering, etc.). Tightening the belts will normally eliminate the squealing, but you don't want to overtighten lest you shorten the life of the water pump and/or alternator shaft bearings. (PS. While you're in there with the bottle, shoot the base of each injector with water. If the engine stumbles at all then that's a sign that the injector seals need replacing.
[Editor's Note: see http://www.dayco.com for a discussion on the various kinds of belt noise and causes.] The spec calls for a 1/4" max deflection (see below for tension specs) at the mid-point of the longest span, but a heavy thumb can often get 1/4" even with the belt overtightened. I prefer to run my belts not too taut because of this and consequently a tendency for belt squeal is the price I pay. You can eliminate this by keeping the belts in top shape:

- replace at the first sign of fatigue (fraying, hardening, cracking)
- de-glaze the belts and pulleys (with sandpaper and/or emery cloth)
- check that all pulleys are aligned. Any belt deflection will only hasten belt wear, glazing and squealing. If they are misaligned, suspect your rubber mounting bushings.
- power steering pump pulley misalignment is usually due to a worn steering pump bracket.

B23X Drive Belt Change. [Tips from Ed/Bruce/JTCharger/Jay Simkin and others] Drive belts are changed by loosening the fixing nuts and the 10mm adjuster bolt, pivoting the accessory toward the crankshaft, and changing the belt. Use a little PBlaster dripped (not sprayed) onto these bolts to ease in removal and avoid rounding them off. If they are corroded (and they frequently are), use six-point sockets. Reinstall using a little antiseize. It is easiest to replace all three belts as a group.

- The outer air conditioning compressor belt requires two fixing nuts on the two curved mounting arms (one in front and one in back) to be loosened. Use a flashight to see them. These can be done from above, or below with the car on ramps and the plastic belly pan removed for easy access. The rear bolt can be difficult to reach: it is right in the middle of everything. Don't confuse it with the inboard mounting bolt near the engine block. Loosening the 10mm adjuster bolt and the bottom pivot bolt (easiest from below) then allows the unit to swing up after loosening the tensioner bolt (anti-clockwise to loosen).
- The middle alternator requires two nuts to be loosened (not removed) other than the adjusting tensioner bolt. One is at the back of the long top fixing bolt; the other is at the bottom in front. The tensioner bolt is beneath on the side. Turn the tensioner screw counter-clockwise to move the unit toward the engine and loosen the belt. You should check the three rubber alternator bushings when you replace this belt. They can be pressed out and replaced by hand.
- The inner power steering pump belt requires that you loosen the 13mm lock nut at the front of the power steering pump bracket (just above the pulley) and loosen the tensioner bolt (anti-clockwise to loosen). You may also need to loosen the nut and bolt through the bottom of the pump (best reached from below). To get enough slack to remove the belt, remove the bolt that tightens the pump against the adjustment bracket. WIth this bolt present, the pump will not move freely through the entire adjustment range. You will need to replace the bolt after you put the new belt on. If the pulley is misaligned, see the Steering section for information about the pump bracket.
- In the case of the compressor and power steering pulleys, you may need to lever the belt over the edge of the pulley to install it.

Belt Tension. [Tips: Steve Ringlee/Jay Simkin] When you adjust the belt tension, take a look at how the adjuster mechanism works before you go at it. Loosen the 13mm or 12mm lock nuts on the belt side of the mechanism (two in the case of the compressor). This unlocks the alternator or compressor and allows you to adjust tension with the long 10mm bolt parallel to the belt. This latter bolt is only used to position the alternator. Once you have set belt tension (3/16 to 5/16 inch or 5-10mm deflection) with the long bolt, lock the position with the 12 or 13mm bolt and back off a turn on the positioning bolt to unload it. Don't forget to lock the main nut/bolt or your belt tension will eventually fracture the adjusting bolt. [Paul Spasske] The Krikit 1 belt tension tool (available at NAPA online, part number NBHKR1, US$10) is useful to test belt tension. Contitech recommends the following drive belt tension settings for Volvo B2XX engines:

Krikit Belt Tool for 15-70 kg tension range

- Narrow 11.9 mm belt used for alternator, power steering, and some air conditioning applications: *New:* 40kg; *Used:* 25-30 kg after 50,000km in service
- Wide 13 mm belt used for later (>1992) air conditioning applications: *New:* 55 kg; *Used:* 40-45 kg after 50,000km in service

960 Serpentine Belt.

Changing the Belt. [Jim Bowers] Use a 3/4" square adapter in the tensioner hole to remove tension on the belt. Take off the old belt noting the routing and install a new one. Let go of the tensioner and you are done. There is a revised belt that is longer and uses a new routing. The new routing as the belt leaves the crank going CCW is: A/C to Alternator, back down and around the idler, up around the power steering punp, down past the tensioner to the crank.

Checking the Belt. [John Shatzer] Just a cautionary note to check your serpentine belt for inside edge fraying. Apparently when you begin to accrue higher mileage (in exess of 100K), the tensioner begins to sag, it will cause rubbing along the inside edge (toward the engine) of the belt surface. Replacement of the tensioner is called for. We've heard about at least one (rare) instance of a broken serpentine finding it's way into the timing belt housing, and the rest, as they say, is history. *Belt Noise.* [Dave Stevens] The usual source of screeching is the serpentine belt travelling through misaligned pulleys caused by worn (crushed) rubber accessory mounting bushings. Bushings are readily available and relatively cheap, even from Volvo. Poly bushings are also available.

Alternator Belt Slips and Doesn't Charge. [Inquiry:] My alternator belt is squeaking and the alternator is not charging properly. [Response: Don Willson] Check the harmonic balancer for the cause of squeeking. Paint a stripe from the hub to the rim. Run the car until you hear the squeek. Look at the stripe, if it is displaced replace the harmonic balancer. The rubber insert loosens and slips after a time.

B230 Series Engines:

Do I Have an Interference Engine? [Editor] An "interference" engine is one in which the tops of the pistons and the valves may collide if the timing belt breaks or is misaligned. If you have an interference engine, you MUST change your timing belt on schedule or else you risk very expensive damage. You must also pay closer attention to the condition of the tensioners, pulley bolts, and front seals: anything that can cause the belt to fail prematurely must be repaired quickly. Not all Volvo engines are non-interference. [Colin Shepherd/Peter Milnes]

"Interference" Engines:

- B200 series (including E, F, G, FT, GT)
- B230E (high-compression B230 sold outside of North America)
- B204 series (including E, F, FT, GT)
- B234 series (including F, G)
- All B5XXX five-cylinder inline engines and 6XXX six-cylinder engines

The B230 series is non-interference with the exception of the B230E.

Timing Belt, Seals, Tensioner, Balancer Preventive Maintenance in B23/B230 Series. [From RPR: illustration copyright and used by permission]

Four-cylinder engines 1976 and later all drive the camshaft(s) and intermediate shaft with a toothed timing belt. This part is replaced during normal maintenance every 45,000 or 50,000 miles, depending on your year and model. See the owner's manual. It is highly advisable to change the seals on cam, intermediate and crank shafts when changing the belt at 90,000 miles or more. Additionally, at 135,000 or more miles, consider replacing the timing belt tensioner, since its bearing will not last much longer. Always carefully inspect the crankshaft sprocket for cracks along the keyway that locks it to the crank. If your front seals (or any engine seals) are leaking, or you find your dipstick pushed up after running the engine, check your flame trap! For 960 B6300 series engines, see 960 Timing Belt Change below. [Motor Magazine, Jul 2004] One belt manufacturer estimates that 50% of newly replaced timing belt failures are the result of nonreplacement of faulty tensioners and/or idler pulleys. So the best thing to do is to install all the components at the same time.

Timing Belt and Seals

Belt Change: Mileage, Time or Condition Indictators? [Inquiry] Other than mileage is there a way to tell when it is time to change a timing belt? Does the belt show a particular wear pattern? Car in question is a 93 965 with 110k miles. Belt has 7K miles and there a very fine crack in the rubber on the inside of the belt next to one tooth. Crack goes across the whole belt width.
[Response: Chris Herbst] If there's a crack across the whole belt on *any* tooth, it's time for a replacement. Occasionally I've seen where the belt is joined, it will have a similar crack across the entire width (on the inside of the belt). You can sort of see the mark if you look at it carefully. But I'd be suspicious of the belt anyway with a crack in it. If it breaks that tooth, it will break more also.   In the interest of potential expense vs. preventative expense, I'd get it replaced

Belt Tensioner/Idler Replacement. [Editor] Replace your B230 belt tensioner at 150k miles. See below for tips on replacement of B6304 tensioners and idler pulleys when changing the timing belt. These are critically important to your engine.

Harmonic Balancer Condition Indicator? These generally last 150k miles. This two-piece pulley has a rubber isolator between halves; it fails right there. To monitor its condition, paint a white stripe across the two pulley halves so you can detect any differential rotation.

Changing Timing Belt: Procedures for B23/B230 Series Engines.

For B23, B230F, B230FD and FT (incl EGR) Engines. See Michael Ponte's excellent website at http://www.mikeponte.com/volvo/timing.htm, a complete illustrated guide to changing the timing belt in B23/230 engines.

1. Remove engine cooling fan (fan and fan shroud, clips for preheater hose), lower splash pan, drive belts and upper timing belt cover. It helps to have the front of the car on ramps or jack stands. Label the drive belts so you can reinstall them correctly.
2. Cover the radiator fins with cardboard to keep from damaging them with tools.
3. Unbolt and remove the camshaft drivebelt cover. (On B230 engines, just remove the top half of the cover.) If this is stuck, remove the water pump pulley cover (four 10mm bolts) for better access.
4. Line up engine: Use crankshaft center bolt (24mm) to turn engine, bringing the engine to TDC, No 1 firing. This is indicated when the mark on the camshaft sprocket is in line with the mark on the camshaft cover or the drivebelt backplate. At the same time the marks on the crankshaft sprocket guide plate and the oil seal housing will be in line. IMPORTANT! Do not turn crankshaft or camshaft with timing belt removed.
5. Secure Crank. Use special tool 5284 to hold when removing crankshaft pulley with a 24mm socket. Remove tensioner 15mm nut and washer. Attach tool 5284 to tension stud. Use tensioner nut (no washer) to hold tool 5284. See the notes in Engine-Mechanical regarding inability to insert the 5284 tool tangs in certain aftermarket harmonic balancers. If you have no tool 5284, then you can see the notes in Crankshaft Bolt for tips on how to secure the crank.
6. Loosen the crankshaft bolt counterclockwise using a 24mm socket and the remove vibration damper assembly. Remove the lower timing belt cover.
7. Remove Timing Belt: Loosen tensioner nut approx. 1 turn. Pull belt to compress tensioner spring. Tighten tensioner nut. Secure spring tensioner by inserting a drill bit or nail through hole in tensioner bolt (photos).
8. Check Tensioner: Check tensioner roller bearing. Check tensioner roller. If roller surface is damaged, roller as well as timing belt must be replaced. Make sure the tensioner is seated correctly back in the block and not hanging at an angle.
9. Check Crankshaft Pulley/Harmonic Balancer. If your car has high miles, the rubber can deteriorate. Now is the time to change this if it is needed. Install the drivebelt lower cover and the crankshaft pulley. Make sure that the dowel (guide pin) on the sprocket engages with the hole in the pulley. Tighten the pulley bolt to the specified torque which is 44 ft-lb (60 Nm) PLUS an additional 1/6 turn, or 60 degrees.
10. Check that engine is correctly lined up: IMPORTANT! Do not turn crankshaft or camshaft with timing belt removed.
11. Do not contaminate the drivebelt with oil, nor kink it or fold it sharply.
12. Install Timing Belt: First place timing belt on crankshaft sprocket and then on intermediate shaft sprocket. Two lines on timing belt should fit toward crankshaft

marks. Make sure the guide washers are oriented correctly on the lower timing gear on the crankshaft.

13. Stretch timing belt on tension side and fit timing belt on camshaft sprocket and tensioner roller. Make sure timing belt is correctly installed and sprocket marks line up with marks on engine.
14. Tension timing belt: Release the belt tensioner by loosening the nut or pulling out the nail. Tap the tensioner flange with a hammer to ensure it is seated in its mounting holes. Tighten the tensioner nut. Loosen tensioner nut approx. 1 turn to let it tension timing belt. Then tighten tensioner nut again to 37 ft-lbs.
15. If this is your first belt change, use Whiteout or white paint to highlight the timing belt marks on the inner timing belt cover and make the next change easier..
16. Clean and install timing belt lower cover. Install crankshaft pulley vibration damper. Make sure that the dowel (guide pin) on the sprocket engages with the hole in the pulley. [Editor: See Timing Belt Tips to help ensure the damper pin is engaged.] Use special tool 5248 to hold. [Editor's Note: See Bolt, Two Caveats first.] Use special tool 5284 or secure the flywheel and tighten the pulley bolt to the specified torque which is 44 ft-lb (60 Nm) PLUS an additional 1/6 turn, or 60 degrees.
17. Clean and install upper timing belt cover.
18. Install: clips for preheater hose, fan, fan shroud and drive belts. Check that ignition timing is correct.
19. Run Engine Run engine until it reaches normal operating temperature while checking operation. Then stop engine.
20. Readjust timing belt tension. Remove rubber plug from cover. Release belt tensioner nut approx. 1 turn to let tensioner spring stretch timing belt. Rotate engine clockwise at least one half turn to top dead center (TDC) using crankshaft bolt in order to properly position the tensioner. Retighten nut to 37 ft-lb (50 Nm) and install rubber plug in cover. If a new belt has been installed, repeat this re-tensioning after approximately 600 miles (1000 km).

3. Plate and Pulley Tensioner Re-Assembly. [Inquiry:] I got the crank pulley on my 91 740 off finally, retimed the sprockets and the crank is on TDC. I now need to reassemble everything. The first question I have is which guide plate goes in first. There are two: one has a u- shape hole on the edge, and the other has two holes on the edge, a rectangular shape hole, and an additional small notch on the opposite side. Which plate goes in first?
[Response: Don Foster] You'll notice that the washers or "guide plates", as you call them, are flared or beveled or dished or bell-shaped -- pick your descriptive term. They must be oriented so the flare is away from the belt like this "**)B(**". Otherwise the sharp edge will quickly abrade the belt.
First, slide one "plate" over the crank. I think the plate with a notch fits over the woodruff key. Be sure the "dish" is toward the engine. Then fit the crank sprocket, again over the key. Then install the timing belt, taking all the previously-mentioned precautions to align timing marks on belt, sprockets, and block. Release the tensioner to hold the belt against the sprockets.
Install the outer "guide plate", nearest you (this one dies not need to fit over the key), assuring the "dish" is outward (toward you) so it won't cut the belt. It has no orientation, other than dished-out. (And the inner plate has a keyway simply so it'll fit over the key -- it doesn't otherwise need

to be "timed".) Install the lower cover.
Install the front crank pulley (vibration damper). Because the top belt cover is still off, you can insert the crank tool over the tensioner stud to hold the pulley while you tighten and torque the center bolt. NOTE: It is this that holds the inner parts tightly in place. The front pulley bears against the timing sprocket and two "plates", squeezing them against the crankshaft. It's a big sandwich.

4. *Tensioner Reassembly*. [Tip from Chris Herbst] If the tensioner is poorly seated, your belt can migrate off the tilted pulley. You might THINK it's seated properly, but the little peg that sets it into the head can bind and cause the tensioner to become crooked JUST enough to get the belt running off of the pulley. So... with the tensioner nut slightly loose, hammer lightly but firmly on the flange on the tensioner, that holds the peg that seats into the head. Got it? Pound the tensioner's peg into the bore in the head where it lives. THERE. Now it's seated properly. Tighten the nut slowly, and pop the tensioner a few more times as you go. This is common. If you can't solve the problem this way, take off the tensioner, grease the hole in the head (after cleaning it out with a pick or some such thing) and slide everything back together. [Tony Hoffman] Use a socket and ratchet to turn the engine just slightly before tightening the tensioner bolt. Just a slight bit because the belt will start to walk off the tensioner. I've notice this helps a lot in 'setting' everything. Tighten tensioner and use the socket and ratchet to turn the crank at least one full revolution. Line the crank up to the zero timing mark, take the bolt out and take off the lower cover just to eyeball that the intermediate gear is lined up properly along with the cam gear. Now you can feel secure that all is well. Because of the way the tensioner works, I have had problems where it would pull in such a way that the cam gear would be off a tooth after releasing the tensioner. So it's worth the extra 2 minutes to feel good that all is OK. Drive the car for about ten miles then unplug the grommet on the upper timing cover and loosen the tensioner about 1 full turn. Then retighten. This will take out any additional stretching from the new belt. [See below about adjusting the belt after 500 miles].

4. *Tips and Ideas*. See the sections below on Bolt Removal, establishing Top Dead Center, Pulley Removal, various Timing Belt Installation Tips, and Adjusting the Belt After Installation.

Changing Timing Belt: Bolt Removal in B23/B230.
Bolt Size. [Don Foster] A 24 mm socket fits the crankshaft pulley bolt on my '86 245 and my '91 740 (both B230 engines). A 1/2" drive Craftsman socket would probably be perfect. On the B230, don't forget that an impact wrench is NOT a good idea because of the risk of snapping the crank. You'll need some way of holding the crank or pulley so you can use a breaker bar. The bolt loosens counterclockwise. See Special Tools for some homemade tool ideas useful for crankshaft immobilization.

Advice. [Editor] Of the techniques listed below, only one is guaranteed to remove and install the crankshaft pulley without potential damage to your engine: using tool 5284. Now that IPD sells this for a reasonable price, you might consider obtaining it and doing the job correctly. Other techniques work, but read the caveats and cautions very carefully so that you don't turn a simple job into an engine replacement.

Securing the Crankshaft While Removing the Center Bolt.

Method 1: Tool 5284 [Added Notes] When the time came to replace my timing belt the first time, I tried every manner of removal for my crankshaft bolt. Nothing would budge that thing. Out of desperation, I sent off for the special tool 5284 which turned out to be a godsend. In order to break the bolt free, I had to literally jump and down on my 15 inch long wrench (I weigh 180 lbs.) multiple times. I bought the car new, so it came from the factory way over torqued. Despite the upfront cost, the tool was a worthwhile purchase and I would recommend it for anyone contemplating keeping their brick for a long time. At the time, it cost me $45 US from an out of state dealer who discounts 20% for out of state purchases. The tool for holding the B230 crankshaft pulley to loosen/tighten the center bolt is called "Counterhold: for vibration damper" Part # 999 5284-8

Counterhold-Special Tool 5284

Method 2: Strap Wrench on the Pulley. [Another technique:] Had same difficulty when changing belts on both 745 & 245, after much aggravation, bought a large (12", I believe, made by RIGID) plumbers' strap wrench at professional plumbers supply. This enabled me to hold pulley without damaging it so that I could remove it to change belt. [But: SEE BELOW for a Warning.] For really tight ones, it helps to have a cooperative assistant to hold strap wrench. [Another technique for tightening:] For the camshaft and intermediate shaft pulleys, what I did was wrap the old timing belt around the pulley as padding, grip the padded wheel with my largest channel-lock pliers, (a big pipe wrench would also do) and torque the bolt to 37 ft/lbs. [Another technique but SEE BELOW for a Warning:] here's a great way of loosening the crank bolt regardless if you have a stick or auto. All you need is a socket wrench and some blocks. Put the socket over the crank bolt and support the wrench with some blocks/bricks (on the driver's side of the crank). The blocks go under the head and handle of the wrench so that it (wrench) sits parallel to the ground. Disconnect your coil wire and give the starter a turn (about half a second). As the engine cranks over, the bolt will loosen itself against the wrench which is stationary against the blocks. I've done this about five times now and never fails. The harder part is actually removing the pulley!

> ***Caveat:re: Harmonic Balancer Failure*** While the "strap around the crank pulley" method will work just fine on the 84 B23, I'd be very careful doing this to the later B230. The 84 B23 has a solid metal crank pulley that should have no problems with this method but, all B230's (that's 85 and newer) use a two piece crank pulley. Not two piece like the B23's pulley, two piece like a common harmonic balancer. In fact that's what it is, a center pulley section with a rubber strip sandwiched between it and an outer pulley section. The early B230's had some problems with the outer pulley section "moving" because the rubber was not holding it tight enough. This causes no problems until you try to set the timing etc. Remember where the timing mark is? That's right, on the outer section of the crank pulley, (harmonic balancer).

Holding the outer section of B230 crank pulley to loosen/tighten the center bolt would tend to promote movement of the outer pulley section. The early B230's moved on their own without help, think of the movement possibilities with help! That being said, I wouldn't recommend holding the outer section of a B230 crank pulley to either loosen or tighten the center pulley bolt. If you plan on keeping your car and will be changing the timing belt yourself, buy a tool from Volvo they're not that much. As a heads up to everyone, if you find the timing mark "way off" when checking the ignition timing of a B230 (it usually way retarded). Make sure the pulley is OK first, before doing anything drastic. OK, OK you're right, buying a new B230 crank pulley is pretty drastic too, they don't come cheap. I've changed more than a couple pulleys, not only because you can't check the timing properly. It's because once the outer pulley section has moved you can be certain it's loose. Once it's loose, how long before it flies off completely! Will it happen at 70 MPH in traffic! Thankfully I've only seen this happen once or twice and no major damage was done but you do loose all the belts etc. and a tow truck is in your future.

[***Caveat re: Timing Pulley Failure*** [Tip from Tom Irwin:] Here one problem to watch out for... B230 lower timing pulleys have a little 'nib' extrusion that does the work of a keyway/shaft. It is a cast part and it is delicate. In the old days we used to fix a large socket and breaker bar over the pulley bolt, wedge it against something solid and whap the starter over to break loose the bolt... DON'T DO IT! That little key/nib will break off or weaken so it breaks later and ALL your accessory drives (alt/ps/ac/etc) stops spinning. Oh yah! that little chunk o'metal is special order and about a hundred bucks!   Any bolt removal technique that relies on "whapping the starter", jamming the ring gear, or using an air wrench on the center bolt, may cause this key to break off. Get the right tool (Volvo 5284) and restrain the pulley

Method 3: Jamming the Ring Gear. [Another technique:] **[Warning: NOT for LH2.4 cars or any car with a crankshaft sensor]** The inexpensive alternative (actually free using standard tools): After jacking up the car, remove the flywheel inspection plate (4 bolts) [Note: don't really know if this works for manual trans cars but I know it works on any of the AT cars with this inspection plate...AW trannys, not sure about ZF] Place a sizable screwdriver into the ring gear tooth closest to the bellhousing plate. With the other hand, use your ratchet/breaker bar with the appropriate socket on the pulley slowly and lock the screwdriver against the bellhousing as the engine and ring gear turns. Now, simply apply the necessary torque to break the bolt. [See below for a better variation on this flywheel technique but remember the caution above regarding breaking the cast key in the crank.]

To tighten/torque the bolt on re-assembly, switch the screwdriver over to the other side of the bellhousing and repeat except in the opposite direction.

Caveat: Sensor Ring Damage. Don't even *THINK* about attempting this ring gear technique above if you car has a Crankshaft Position sensor. This applies to all cars with LH 2.4 or greater. On these cars, what you have access to through the inspection plate on the bell housing is a thin sheetmetal metal ring with little square windows evenly spaced around the 360 dg with two windows missing at TDC and

TDC + 180dg (or is it TDC - 90dg and TDC + 90dg? can't remember.) Either way, these little windows look like the perfect place to put a square shank screwdriver, but the sheetmetal ring is very weak and if you bend it even the slightest there's a good chance your fuel injection system will get highly confused. I believe that if the ring is even 1mm out of round, the pickup may miss one or more windows.

Another Flywheel Clamping Technique from Barret Flake: A similar alternative to the one requiring the removal of the flywheel inspection plate: Remove or back out most of the length of the bolts (4) holding the flywheel inspection plate. Take the flat head screwdriver bit from your cordless screwdriver, I think they all are 1/4" hex drive, and slide it between the inspection plate and the bell housing with the flat head pushed in between the gear teeth. Now tighten the bolts to effectively clamp the screwdrive bit between the bell housing and the inspection plate. With this set up you don't have to worry about holding the screwdriver in the teeth while trying to simultaneously loosen the big bolt. Also, you don't have to switch the screwdriver from one side of the housing to the other when you retighten the crank bolt. Worked like a charm for me. (93 940 B230FT/AW automatic)

Method 4: Large Breaker Bar on the Bolt. [Yet Another Bolt Removal Technique from Chris Mullet] Remove the splash shield. After all drive belts are removed, take the short wide one (from A/C) and hang it on the crank pulley only, so that it dangles down below the car. Slide about a 4 foot long board, under the air dam, through the hanging belt, and lodge the end under the cross member or oil pan. (I used a 2x6 with a belt I knew I was going to throw away. You could probably round the edges of the board, use a pipe, or just be a little careful if you are worried about hurting the belt.) With one foot, push down on the front end of the board in front of the bumper, until you just start to compress the motor mounts. I don’t think it will take much weight as you have quite a mechanical advantage. While holding down on the board, take your breaker bar and solid hammer and knock the bolt loose.
You can use the same method to retorque the bolt.
Now, some people will say you run the risk of spinning the center part of the pulley inside the damped outer section. I guess that’s a possibility, but by pulling down firmly on the outer pulley, versus just holding it stationary with some other strap type holder, you increase the friction between the two....don’t you?

Method 5: Rope Trick in Cylinder. [Another Bolt Removal Tip from Don Foster: The Rope Trick] Use nylon rope to jam the piston at TDC while you turn the crank pulley bolt. Be careful how you do this: you can damage the valves.

- Be absolutely certain you're at cylinder #1 TDC between the compression and power strokes. This way the valves will be closed. You can tell this by feeling compression pressure, using your finger, in the spark plug hole.
- Turn the crankshaft clockwise (facing the engine) about 1/4 to 1/3 turn. Stuff in about 2-3' of 1/4" soft rope — nylon or cotton clothesline should work.
- Turn the crank counter clockwise as to unscrew the pulley bolt. The rope compresses and jams the piston. Using a breaker bar, loosen and remove the bolt.
- To reassemble, use the same approach except stage the crankshaft about 1/4 to 1/3 turn counter clockwise from #1 TDC. Stuff in the rope. Turn the crank clockwise to compress

the rope and jam the piston. Tighten and torque the center bolt following the "torque and turn" procedure.
- Remove the rope, install the plug.

Pulley Removal. [Tip from Pete Fluitman] Once you get the bolt off, the pulley will just come off with a little persuasion. Don't get violent with it though. Usually as I'm facing it and it is stubborn put a pry bar on the left f the pully between it and the engine block, and on the right gently tap, preferably with a hide hammer. Once it moves you can just wriggle it off. Or use a puller. Now is the time to inspect the condition of the harmonic balancer rubber and make sure it is intact.
[Chris Herbst] Take a rubber mallet or a light hammer and tap the perimeter of the pulley, going around the edge as you tap. Sometimes you can hit on it a few times in one spot, and a few times directly across from that spot. Repeat a few times but don't smash the thing unnecessarily. Eventually you should be able to just pull it off. You'll see it start to move around a little bit, and that's the high sign. Sometimes you have to wiggle it back and forth a little bit as it goes.

Pulley Installation: Tightening with a Belt. [Tip from Carl Buxbaum] After replacing my timing belt, in order to tighten the crankshaft pulley bolt to 60N/M, I wrapped one of the old drivebelts around the innermost groove of the pulley, and notched a couple of teeth of the belt over the top of the water pump, where there are a couple of ridges that helped hold it there. While grasping the belt with my left hand I was able to tighten the bolt to spec with my right without too much difficulty. [Editor] Note that Scantech and some Volvo harmonic balancers must have the holes filed out to fit the 5284 tool. The casting is ridged, causing the tool to shift under torque. File square.

B230F Crank Bolt Torque on Re-installation. [Abe Crombie] Torque this bolt to 60N-m (45 ft-lb) plus an additional 60 degrees (1/6 turn).

Timing Belt Tips in B23/B230.

Save Your Radiator. [Steve Cole] Cover the engine side of the radiator with cardboard to prevent damaging the fins. I thought of doing this at the begining of the project, but decided to be careful instead. After I hit the radiator fins twice with a wrench I put some cardboard there.

Aftermarket Belts? I am going to be replacing the timing belt and front engine seals, on a 91, 740, non-turbo, sedan, B230F engine. I have a few questions: Does anyone besides Kent-Moore make any of the Volvo Special Service Tools? Are aftermarket timing belts and seals okay on quality from somewhere like PepBoys? Will I need a Vibration Damper (Harmonic Balancer) puller for the Crankshaft?
[Response 1: Phil] Pep Boys is not known for good belts...at least the ones I've tried. You're better off getting a name brand belt. Both TRW and Goodyear brands both have the markings on them and I'm sure other name brands do also.[Response: Zee] Contitech is an aftermarket belt that my shop has used for decades. I liked the fact it had lines on it marking the positions of the timing gears. Great help on the install. (you will only see the lines for the two top gears,

though, as the crankshaft marks are well out of sight at the 7 o'clock position. [Rob Bareiss] Don't buy the wrong timing belt. Cars to 1993 had a 50k belt with square teeth; 1994-95 cars with FD engines use a 100k belt with rounded teeth.

Removing the A/C Compressor Belt. [Tips from Justin Seiferth] This can be tough. Loosen the 12mm holding bolt and the unscrew the 10mm tensioner bolt till there's a 1/4" of slack or so. If you still can't remove the belt, try unscrewing the 13mm mounting bolt just below the A/C compressor, this should give you enough slack. When putting the belt back on, make sure this mounting bolt is retightened. Put the A/C compressor belt onto the bottom of the crankshaft pulley and use the crankshaft bolt to turn the engine and inch the belt back on. It's a tight fit.

If you have a two piece *timing belt cover*, you can't remove the bottom half until you've taken off the crankshaft pulley. Be sure to put this cover back on after you've changed the belt and before you reinstall the pulley!

Lower Timing Gear Washer Installation [Gary DiFrancesco] This is one of those goofs that not everyone wants to fess up to, but sharing it could save someone a lot of grief. Several weeks ago, I replaced the timing belt in my '88 745T. The job seemed to go normally. A few weeks later I noticed what sounded like a worn bearing squawking away in the area of the tensioning pulley. I did not change the pulley when doing the belt since it seemed to be in good shape, and running smooth. When I removed the timing belt cover to replace the pulley, I found the compartment full of black fuzz. It was apparent the source of the fuzz was near the crank, and evidence of abrasion was visible on the outside edge of the timing belt.
To make a long story short, I reassembled the lower timing belt gear (on the crank) incorrectly. The outside washer for the timing belt gear was put on the shaft backwards. The subtle flare of this washer was pointing in and was rubbing the edge of the timing belt. I lost about 1/16" of the width of the timing belt in less than 400 miles. This error is an easy one to make: the washers can be installed both ways. The lesson here is obvious; double check your work before covering everything up. It might just save you some grief. [Genaro Lopez] Install the metal washers like this: **) belt (** The dished sides go away from the belt.

Locating Top Dead Center. [Inquiry] How do I find TDC on my B230F when changing the timing belt? [Response: Don Foster] Pull plug #1 and stick your finger in the hole. Turn the front pulley with a socket wrench until you see the timing mark (front of timing belt cover and on front pulley) coming up on 0 degrees. If you feel no pressure in cylinder #1, then it's TDC but on the exhaust/intake stroke.
Continue turning the front pulley until you feel pressure on your finger as you approach 0 degrees. At 0 degrees, you're at TDC for #1.
Remember that as you replace the belt, you should "fine tune" setting the crank and cam at their alignment marks (the I-shaft isn't important on a 700, but it's good practice to do it).

Timing Belt Marks [Tips from Ross Gunn] The OEM belt has some printed lines that you position at the timing marks on the three pulleys, but other than that not much difference. You still have to find the timing marks and it can be a nuisance trying to position the belt on the marks on the pulleys. If you have factory belt with alignment stripes on it, use a piece of chalk to extend the alignment marks onto the front of your new belt. This will make installation just a little easier.

[Editor] Once you find them, use "White Out" or white paint to mark them for future use. [Chris Herbst] The camshaft pulley dot lines up with the dimple on the inner timing cover. The intermediate shaft pulley lines up on the dimple on the inner cover. The crankshaft pulley's dot lines up with the extruded line in the block. It isn't exactly at 12:00. Once they all line up, if the white marks line up too, that's great. But as long as the PULLEYS line up, that is the important issue. I have a white paint pen that I dot the marks on the engine, and on the pulleys with. It makes alignment a 100% easy job.

Timing Belt Marks

The belt may be a bit small to get on easily- get an assistant to use a pipe wrench to compress the tensioner just a little.

[Timing Marks Tip from Mike] The crank timing mark is on the thin metal washer you removed after you removed the pulley. It is keyed. I determine which tooth on the crank gear it lines up with and then line that gear tooth or valley up with the casting mark on the motor behind the rear washer. Be sure to position the washer with the flanged side facing out or it will tear up your new timing belt.

[More from Ross Gunn] With the aftermarket belt, if there are no printed marks, just ensure the timing marks on the pulleys are lined up with the marks on the engine and you will be fine. The tricky one is the intermediate shaft. You will have to either look through the rad core with a light held between the rad and the block or hold a mirror directly in front of the timing mark and at 45 degrees so that you can look down from the top to see that the pulley mark and the mark on the plate behind are lined up. Or stick a small screwdriver into the slot and line up with the dot on the pulley to see if the pulley and alignment dot are aligned correctly. [Smitty] Count the number of belt teeth between timing marks on the cam-to-intermediate gear, and intermediate gear-to-crank gear... BEFORE you pull the old belt off. It's a reassuring check before firing up.

It helps if you line up the cam pulley mark before removing the old belt and then be careful not to let the intermediate shaft pulley move when installing the new one. The mark on the plate behind the int shaft can be hard to find - try to locate it after lining up the cam pulley marks and before removing the old belt. It would be wise to locate the crank pulley mark and corresponding mark on the block at the same time. [Chris Herbst:] Are you absolutely positive that the intermediate shaft didn't slip when you were putting it back together? That mark is really hard to see. I usually have to line it up with a punch pin in the pulley groove before sliding the belt on. [R.Haire] On the timing belt, once it is installed, make sure the cam mark is dead on (easy to see), the intermediate shaft is set so the distributor rotor is pointing dead center at the tic mark on the distributor lip (subtle but very informative, no one ever mentions this trick) and the crank guide slot is exactly on the relief mark on the block at TDC on the crank. This last one can take time to find and appreciate.

I suggest removing the old belt with a sharp knife to avoid disturbing the position of any pulleys. Before removing the old belt, compress the spring on the tensioner and insert an appropriate pin in the hole in the rod inside the spring to retain it in the compressed position. Remove the pin after the new belt is installed. [Don Foster] You know, of course, to first squeeze the tensioner back and lock the nut to hold it. Once the belt's in place release the lock nut so the tensioner presses against the belt. Tap it lightly -- this takes up the slack -- and lock the tensioner nut (37 lb.-ft).

Holding the tensioner back

[Tip from Steve Seekins] Rotate crank so that mark is about 9:00. Then put on belt - double marks straddle the crank mark (notch on outer plate). - be sure to get it right. Then put belt on intermediate shaft sprocket - line up mark and clip with a medium binder clip or one of those plastic woodworking spring clips. Do the same for the cam sprocket - you may need to use a wrench to turn the cam so the mark lines up with index mark on the belt - if the marks will not line up, you likely have the belt backwards - all three will only line up one way. Do not worry about rotating components individually - this is a non-interference engine. Before you remove the clips, double check to make sure that the crank mark is lined up with belt marks. Release the tension roller, rotate crank 2X clockwise with wrench and tighten tension roller. Replace covers, pulley, belts, fan and you are finished. After a couple of hundred miles, remove rubber plug in timing cover, loosen tension roller and rotate crank CW 2X again and tighten. Don't touch it again for 50k miles.

Indexing the Timing Belt Markings. [Tip from Randy] Lets assume the belt that is currently on there is correct. All you want to do is replace it with a new belt- you want all the orientations to remain the same. Mark the current belt in some permanent way in relation to the gear. If the timing marks on the gears match up with an individual cog on the belt that will be perfect- if they don't you might have to make your own marks on the gear (fingernail polish comes to mind). The point is once you have the belt indexed to the gear arrangement you can easily remove it and you could put it right back on and be confident of getting it correct because you have the index marks on both the belt and the gears. So all you have to do is take the indexed belt off and carefully transfer your index marks on the old belt to the new one. Do this very carefully and be sure you match cog for cog as you move around the belt and mark the new belt exactly like the old one. BE CAREFUL to double-check the markings before going back to put it on. You might want to mark the front of the belt for reference in relation to the front of new belt. Some belts are already marked when new, but I always mark my own. [Response 2: Paul Kane] The intermediate shaft is no longer important. I use white-out (correction fluid) to mark stuff. The Cam mark is at 12:00, the notch on the belt guide on the crank is at about 10:30 and IS the cast mark on the block. BTW the notch in the center pulley aligns with the pointer on the lower cover.

Do I Wrap the Belt First Over the Crank or Cam Pulley? [Don Foster] My preference is bottom-end up -- replacing a timing belt, I mean. The trick is, first, lining up the three pulleys to the timing marks (timing the I-shaft isn't important on a 740, but it's still good practice). Then start at the bottom by fitting the marked tooth into the gear at the timing mark, and wrapping the belt upwards. (I confess that I use small Vise-grips to loosely clamp the belt to the crank pulley.) Wrap the belt around the intermediate-shaft pulley, around the cam pulley (observing alignment of the belt mark with the pulley timing mark) and slide it around the tensioner pulley.

Replacing the Harmonic Balancer. [Inquiry] How do I ensure that the keyway in the harmonic balancer engages the key on the crank sprocket? My crank:balancer fit is tight and the engagement is not obvious.[Responses: Tom F/Don Foster] I had always had to fight to get off the Harmonic Balancer due to a build up of rust and crud. After I remove the HB, usually after a hundred hits with a chunk of wood a little twisting, and lots of PB Blaster, I'd clean the shaft and the hole of the HB with emery paper or fine steel wool. The pulley normally fits snug but loose enough so that you can slide it and turn it on the crank by hand to engage the keyway. After you THOROUGHLY clean any residue from the crank, lubricate mating surfaces with engine oil and reassemble. Then when you put the pulley on the crank and rotate it as you push it in, it goes "clunk" and seats inward as the key engages the keyway. The looser fit allows you to get the confirmed "clunk" confirming that it has engaged correctly. The next time the HB has to be pulled, it should be easier which is the primary purpose of the oil lubricant along with corrosion control. If after doing this it is still too tight, It's possible that one of the surfaces or edges became "dinged" and a microscopic ridge is causing inteference, hence tightness. Inspect for this.

Poor Performance After a Belt Change: Did I Screw Up? [Comment] I replaced the timing belt on my 740 the other day. The car starts fine, and revs up fine in neutral. However, acceleration is sluggish. When I went to drive away initial acceleration was poor. Once I got the car up to about 2000 rpm acceleration seemed a bit better. Any thoughts? [Responses: Tom] Sounds like you are a tooth off. (I've done it many times!) First remove or pry back the upper T- belt cover to take a peek: the cam marks and the lower exterior timing marks should be enough to determine if you are off a tooth on the cam timing. If that's OK, then pull the lower cover and make sure the pulley on the crank sprocket is mounted correctly.

Timing Belt Tensioner and Belt Adjustment After Installation.

Replace the Tensioner? [Don Foster] A new tensioner every 150k is the prevailing wisdom as I understand it. No need for a new spring -- reuse the existing spring. You'll note a small hole in the shaft inside the spring. Compress the spring with old tensioner and slide a nail through the hole. Remove the tensioner and install the new one. Then pinch up with a big pair of Channelocks and remove the nail. And at 225k miles, start thinking about the three front seals and water pump -- perfect time to do all that stuff. [Inquiry:] Whilst removing the tensioner, it flew apart. How do I reassemble it? [Nigel Sheerwater] Tensioner consists of.....a bar with a big hole one end..pin hole the other. .....a spring...a bearing with a plate on the back and a big hole in the middle and a smaller hole at right angles. Assemble as follows. Put spring on bar. Slide the small hole in the bearing plate on top of the bar to compress the spring....tricky so you will have to work out how to compress spring. Once compressed put a nail through small hole to hold it all together. Torque to 50 Nm (37 ft-lb).

Adjusting the Tensioner After Installing a New Belt. [Stoney] I just got email from 2 dealer techs I know, with 18 and 20 years experience between them both are top VISTA techs and they said that the belt should be adjusted after 5-600 miles due to the fact that a new belt will stretch some in the first 1000 miles and they have seen a few "jump the cam gear"... [Response 2: Don Foster] The tensioner has a spring in it which forces the idler against the belt to a predefined tension. But then, when you tighten the nut on the tensioner, you lock its position. The instant the belt stretches one hair, the tension is relaxed (because the tensioner's position is fixed, it can't move inward to maintain the force). The tensioner, in this configuration, compensates for (adjusts for) the increased length from stretching -- to prevent it from jumping a tooth. It DOES NOT maintain a constant force on the belt. It's assumed a new belt will "relax" a bit during when first used, so you must loosen the nut, allowing the spring to again reposition the idler. This "consumes" the extra length from stretching -- but then you tighten the nut again, locking the idler's position. Ideally, there will be virtually NO tension on the belt, but also virtually NO "slop" in the belt. Hence, after about 500 miles, more or less, remove the rubber plug from the timing belt cover, loosen the tensioner locknut, rock the crank slightly clockwise about 1/8 turn (this makes sure that belt has tension on the drive side between cam and crank gears), and tighten and retorque the locknut. [Editor] Make sure you lock that tensioner nut to prevent the tensioner from loosening and destroying the new belt. Torque to 50 Nm (37 ft-lb).

B6300 Series Engines:

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960 Flame Trap in B6300 Engines. [Inquiry] Can anyone tell me where on the 6304 engine the flame trap is located, and how one goes about servicing it? Last year I replaced the rear engine seal, and I notice there is sometimes a faint smell of blow-by. [Response: Tom Irwin] The flame trap is in the rear of the air intake runner, which is the big air hose between the Throttle Body and Air Mass Meter. The housing is made of 2 separate plastic pieces. One should be clamped in the air intake hose. The other is clamped in the flame trap hose. One plastic piece fits inside the other with a snap and a click. It is released with a firm twist, 1/8th of a turn CCW, and withdraw it from the air runner leaving the clamp on. Beware, this part is probably brittle and old. It may break. Personally, I have never seen a clogged one on a 960. If you have blowby, you need to check at various idle speeds, with the hose opened. If there is way excessive crank blow by... STOP.   Get a leakdown test done and brace yourself for a big tearful goodbye to that car. If your oil consumption is increasing, then watch out. See the 960-90 Series Information section for more information.

B6304 Flame Trap

Plugged Oil Breather Boxes. [Rob Bareiss] Anecdotal evidence from S80 6-cylinder engines indicates that the oil breather box on six-cylinder inlines plugs up solid rather easily and increases oil consumption. If your car is using oil and the flame trap is oil-soaked, consider replacing the plastic oil breather box. To remove this box, remove the two fixing bolts, then remove the alternator to access the box. On reinstallation, grease the two rubber ring couplers to push the breather box back in. The hoses are awkward but do-able.

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960 Timing Belt Change in B6300 Series Engines.

960 Timing Belt Maintenance Intervals [Editor's Note] **This is an interference engine and you MUST rigorously maintain the timing belt and all associated parts!** [Inquiry:] I've heard that the timing belt for the 960 series has to be changed more frequently than stated in the owner's manual. I was wondering if anyone was advised to replace the tensioner as well and if there was a bulletin from Volvo recommending changing the tensioner at 100,000 miles.   [Response:] Follow closely the recommended intervals. The '92 timing belt should have been changed at 20k miles and again at 40k miles. At that time a modification should have been done under warranty. This extends belt life another 10k miles, so the next belt change should be done at 70k miles then every 30k after that. This is only for the 1992 cars!
[Details from Abe Crombie:] The 92's had an interval of 20K. Volvo developed a damper assembly that fits onto exhaust cam that was retrofitted to 92's (if it was being taken to a dealer AND the technical service bulletin was performed) and was factory-fitted to 93's that allowed the 21mm wide belt to last 30K due to less cyclic loading on belt. You can see the damper if is installed by looking through the holes in the cam gear on exhaust cam. The damper will make seeing the aluminum head through these holes difficult, especially if you compare to the intake cam pulley which is the same part but will have no damper fitted. The 94's have a revised damper and some belt driven pulleys revised and a 23mm wide belt is used (belt is different length than 21mm belt) to give a 50K interval. The 95-98 engines got a complete re-do of the belt drive and use a 28mm belt to give a 70K interval.

960 Timing Belt Tensioner/Idler Pulley Change Intervals. **Caution!** [Tips from Randy/Debbie/Lance] The timing belt replacement interval is a well-known critical maintenance item with the various interference motors. What is sometimes overlooked by the home mechanic is the equally important set of parts on which the belt rides: tensioner, tensioner pulley, idler pulley, and water pump. Our 960 threw a fairly new timing belt when the belt tensioner that holds the belt tipped (due to wear/age) allowing the belt to slip off...dead car. We have since learned that the manual calls only for inspecting the arms when the belt is changed. The bearing races can wear and fail suddenly. [Tale from Vic Lind] I heard a strange squeal coming from the engine in my '98 V90. I found the timing belt had worn through the front cover. Upon removing the cover I found the tensioner bearing had failed. **More and more reports are appearing at Brickboard about failure of tensioner/idler/pulleys in low mileage 960/90 cars. We recommend replacing the timing belt tensioner, its pulley, and idler pulleys as a standard maintenance item at each timing belt change. Check or replace your water pump at the same time.** [Rafael Riverol] Change with new Volvo or OEM parts the tensioner bearing and everything else connected with the timing belt that could be even remotely suspect, either with every belt change if at 70K miles. I do not want to risk a broken timing belt!. This is much cheaper than an engine rebuild. [Randy] Another item to check is the water pump: in my case, the entire shaft assembly of my pump had shifted in the cast body and the vanes were rubbing on the casting, ready to fail. The obvious lesson is that the failure of any of the above-named parts (pulleys, idlers, water pump) is the same as a belt failure. Not changing them on a regular basis is a bet against the top end of your engine.

960 Timing Belt Tensioner Lubrication. [Volvo Cars NA] Lubrication and checking for free play of the tensioner pulley bushing is required on 92-93 960 cars with B6304 engines and recommended on 94-96 cars. *To Lubricate the Bushing:*

- Remove lever mounting screw, tensioner pulley, and sleeve behind screwLubricate surfaces of bushing, screw, and sleeve with grease Reinstall sleeve, pulley and screw.Torque for screw: 29 +/- 5 ft-lbs (39 +/- 5 Nm) Torque for pulley lever: 30 ft-lb = 40 NmTorque for idler pulley: 18 ft-lb = 25 Nm
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To Reinstall the Washer on the Timing Belt Tensioner:

- Place NEW washer on piston stem of belt tensioner. Make sure that the correct *countersunk* side of the washer *faces up*
- Check that the washer centers on piston stem and tensioner case.

960 B6304 Timing Belt Change. [Tip from Larry Borella] Recently there was an exchange posted concering replacement of 960 timing belts. I did mine Saturday. All things considered, it was easier than replacing the belts on my 740. Here are a few hints if you are inclined to do this

yourself.
Start by removing the electric fan. Take out the two screws and then pull the wiring loom connectors from the shroud. Then you can just put the fan on top of the overflow reservoir/ac dryer and you don't have to take the battery out etc.
Remove the accessory belt (I use a 3/4 in adapter on my 1/2 drive breaker bar). Take off front cover. I changed the plugs at the same time; leaving the plugs out makes it is easier to turn the crankshaft pulley to align the timing marks on the cam pulleys. I used a 1-1/4 socket to turn the crank. The notch on the crankshaft pulley is hard to find. You have to look straight down; its on the back side hub of the pulley. The matching mark is on the back of the plastic timing belt cover (which is not removed). Be sure to mark the slots for the bolts and then mark the gear to the cam. If you don't you will have three choices for each gear as to the correct position. Get them all lined up, then remove the top bolt from the belt tensioner. Then back out the bottom bolt about 1/4 to 1/2 inch (see below for tool tips). Then you can twist the tensioner which will pop the plunger from its position. Then you can take it off and remove the belt (there is a metal guard held on by two bolt behind the crankshaft pulley that must be removed from under the car). [Tip from Robert Reagan] When I changed the belt, I ignored the reference marks and made my own marks with solvent-based Whiteout or white paint on the cam gears, the crank pulley and the existing belt. I made sure the replacement belt was positioned exactly like the one that came off, and everything went smoothly Put the new belt on. The manual says start at the crankshaft pulley then work up and around in a counter clockwise direction. You have to compress the tensioner before installation. I put it in a vise (the vise has to open about 6 inches to hold the tensioner. If you were hard pressed, I think you could do this in a large c-clamp. The resistance on the tensioner is significant. I found that turning the vise about a 1/4 turn then waiting about 3 to 4 minutes before the next turn worked well. When you get it compressed, there is a keeper hole (make sure you line up the hole before you compress the tensioner) into which you must insert a pin to hold it in the compressed position. I used a 1/16 inch drill bit. Then you put the tensioner back on. I found that putting the top bolt in first worked best. You can push the bottom of the tensioner to get the bottom bold lined up. If you do it the other way, you have try to pull the tensioner (working from the passenger side of the car).
Now you rotate the engine two revolutions and check the alignment. Guess what. Mine didn't line up as well as I would have liked. The cam pulleys were fine but the crankshaft pulley was slightly "advanced" (maybe 5 degrees). I did it all again.
Same result. I took it off and did it a third time making doubly sure I had all the belt lugs where they should be.
Same result. I spun the engine with the starter (with the plugs still out). All seemed well. I bolted her up, put in the Bosch +4's, started the car and went for a test drive. Runs fine.
Two notes of caution. If you leave the plugs out for anything, put the ignition coil cover back on. Those openings look just like a funnel designed to put a dropped screw/nut into the cylinder. Second, don't leave plugs in too long between changes. If they seize up and break off when you try to remove them (as I have heard happens fairly regularly), you got real problems. I put penetrating oil around mine before I removed them and even so, they were uncomfortably tight with only 50 k on the car. *More 960 Timing Belt Instructions* [Procedure from Larry Jacobson] This has play by play instructions about the 960 timing belt. Today was the day to attack the timing belt on my 1996 965. I've changed lots of timing belts on lots of cars, but this was the first time I dug into the 2.9 ltr Volvo. Apparently there are no worthwhile aftermarket manuals for this car. I am grateful to an herein unnamed (for his own protection) list member for snailmailing me a copy of the appropriate section on a genuine honest-to-goodness, bona fide and sanctified

Volvo shop manual. The bottom line was it took me 2.5 hours. It is not as difficult as the belt on the 2.3 ltr 4 cyl engine. No special tools are required. I'm sure I could do it again in 1.5 hours now that I know how. The following are my observations. If you are going to do this job plan to change the oil and filter at the same time, inspect the front brake pads, change the serpentine accessories belt, and if you suspect the integrity of your water pump ... do that too. You can't get back to the water pump without first taking out the timing belt. Before starting you will need common mechanics tools, ratchets, a variety of extensions, a big vice or a 6 inch C clamp, and probably a big pipe wrench. A dental mirror would be handy and some very good lighting. There are some things that are difficult to see. *Parts:* Timing belt is Volvo part 271876. Serpentine belt is Volvo part 9146106. It is stamped Made in USA Dayco. You can probably find it cheaper in a parts store under the Dayco brand name. *Procedure:*
1) Jack up the front end of the car and suspend it on jack stands. Probably best to remove the front wheels. Check the brake pads while you are there. You are going to need enough room to get underneath to work. 2) Remove the belly pan that covers the oil filter. You might want to change the oil and filter now. 3) You're going to need two pins that will be used to hold things in place. Locate them now before you need them. a) Take a 16 penny common nail and cut it to 1 inch so that you have the head plus one inch. It will be used to hold the serpentine/accessory belt tensioner in place while you take off the belt. b) Locate a 3 penny common nail. It will be used to hold the timing belt tensioner in place while you reinstall it. Don't cut the 3 penny nail. 4) There is no need to remove the electric fan. 5) Draw a picture of how the serpentine belt is routed. If you don't know how it came off it is going to be real difficult to get it right when you try to put the new one back on. Now remove the serpentine belt tensioner. There is a tapered square hole that will fit 3/4 inch, 1/2 inch, and 3/8 in square drive. However you'll need a very short extension to fit deep enough into that hole. I couldn't find the right size so I just took a large pipe wrench and moved the tensioner. Line up the holes and slip the cut off 16 penny nail to hold it in place. Remove the two 12 mm bolts that hold the tensioner in place and remove the tensioner. [Tip from D. Morgan] The lower 12mm bolt on the tensioner has been a PITA to break loose and tighten up, due to being recessed and behind the balancer. To remove this, try a Sears offset 12 point, combination 12&14mm wrench (part# 44361). Now remove the serpentine belt. 6) Remove the timing belt cover. It is held on by only one 12 mm bolt. 7) Crawl under the car and locate the shiny metal 'vibration damper guard'. It's held on my two 10 mm bolts. Unscrew those bolt and remove the shiny cover to expose the crankshaft gear and the lower end of the timing belt. 8) There is no need to remove the vibration damper. If you turn it slowly using the small bolts you can turn the engine to line up the timing marks. Turn it clockwise while looking at the front of the engine. The cam timing marks are obvious. The crank timing mark is not obvious. I used some of my daughter's silver nail polish to mark the crank's relationship to the block and the timing marks on the two cams. I also marked the existing timing belt so that if worst came to worst I could count the cogs between the various timing marks. [Tip from Bobby C] If you can't find the marks but the engine is already properly timed, line up TDC exactly on the crank, then (with the old belt still in place and tensioned) make your own marks (either punch marks or filed lines) on the sprockets themselves opposite something obvious (like the top edge of the head or cam carrier) for future use or if the timing slipped while installing the new belt. It's also not a bad idea to count the teeth between the crank sprocket mark to the marks on the other sprockets you made(with the old belt in place), then using "White Out" typing correction fluid, paint the ends of the new timing belt teeth at the corresponding tooth counts with a white dot. Then, it's a simple matter of making sure the painted teeth are installed opposite the marked sprocket marks. Remember that as soon as you

rotate the engine once, those paint marks are no longer relevant. 9) Tensioner efficiency: Before you take off the tensioner and the timing belt, take a moment to notice the tension on the belt between the exhaust cam and the water pump. It seems to move about 1/4 inch with about 10 lbs lateral pressure. This is purely a guess based on what I thought it felt like. 10) Remove the tensioner by a) slacking the two 12 mm bolts, b) removing the upper bolt, c) rotating the tensioner clockwise a little, d) removing the bottom bolt and lifting out the tensioner. [Tip from Vic Lind] If you are trying to remove the tensioner pulley, it is held on with a Torx T-45 bolt but using a shallow hole. If you cannot get this off, try applying penetrating oil to the bolt then use a pipe wrench on the outer washer. This will move and in turn move the stuck bolt. 11) Remove the timing belt by first removing the two 10 mm bolts that hold the plastic housing on the top of the shroud at the top on the engine. No need to actually remove this top shroud. With the bolts out it can be moved enough to get the belt out. Remove the belt off the cams. Then get under the car and very carefully work the belt off the crankshaft gear. ...remembering how you got it off because it's like a Chinese puzzle to get the new belt back on. 12) Take a good look at the tensioner assembly. It is an hydraulic affair and it should not be leaking oil. If it is leaking you need to replace it. That tensioner fails the belt will jump cogs and the motor will be destroyed. 13) Compress the plunger back into the tensioner. First remove the white nylon positioning ring. Line up the three little holes so you can place the keeper through them to allow you to reinstall the tensioner. A vice would work well to compress the tensioner. My vice was not large enough so I used a 6 inch C clamp. Compress the plunger a quarter turn at a time allowing it to 'rest' between twists. When the plunger is all the way flush with the housing push a 3 penny common nail into the hole with the head of the nail facing out so you can pull the nail out when the tensioner has been reinstalled. Place the nylon guide washer back on the tensioner. A new one probably came with the new timing belt. See notes and diagram above about correct orientation. 14) Inspect all the idlers for smooth operation. Inspect the water pump for leaks. This is the time to change the water pump if it isn't in good shape. 15) Install the new belt. I found it was easiest to snake the belt down to the crankshaft gear before trying to place it on any of the other gears or idlers. Crawl under the car with a good light to work the belt on to the crankshaft gear without crimping it in any way. Once it's on the crankshaft gear, then put it on the intake cam and remove all the slack between crank and intake cam gear. Then do exhaust cam and then water pump and finally the idlers where the tensioner goes. You want all the slack at the tensioner idlers. 16) Install the tensioner. Tougher than it first looks. There's not much room between the tensioner and the fan for fat fingers. Locate the top bolt first and get it started. Then do the bottom one. Make sure the tensioner seats itself flush on the front on the engine and torque it down. Volvo says 18 ft pounds (25 Nm). I couldn't get a torque wrench in there. Regardless, that's not a lot of torque. 17) Critical point: carefully inspect all your timing marks. Is there slack anywhere except around the tensioner? Is the belt fully seated on each gear? If everything's OK, take some pliers and pull out the 3 penny nail that has been holding in the plunger on the tensioner. It comes out fairly easy. The tensioner will ease itself back into position and will take up all the slack on the tensioner side of the engine. Inspect by feeling the tension between the exhaust cam and the water pump. Does it feel about as it did before you took the belt off. Are the timing marks still where they are supposed to be? 18) Crawl underneath to make sure the belt is seated on the crankshaft gear. If it is in place, reinstall the vibration damper guard. Reinstall the splashguard that covers the oil filter. 19) Reinstall the two 10 mm bolts that hold the top of the cam belt shroud on the top of the engine. 20) Volvo recommends you make the crank turn two complete revolutions to make sure all the timing marks are still in place. That's more difficult than it sounds. I skipped that step and crossed my fingers. 21) Reinstall the timing belt cover. 22) Install the Serpentine/Accessories belt tensioner. While you are doing that snake the new belt around the accessories and locate the tensioner and bolt it down. Be very careful to be sure the serpentine belt is seated in the middle of all the pulleys on its route. When you are sure it is correctly positioned turn the tensioner just a little and remove the cut off 16 penny nail that you installed at the beginning of this operation, allowing the tensioner to take up all the slack in the belt. 23) Carefully inspect the engine bay for tools and stuff. 24) Voila! You have successfully changed the timing belt and the serpentine belt. *B6300 Timing Marks on Pulleys.* [Jim Bowers] The marks on the pulleys, (2 cam & crank) look like lines made by a cold chisel being stamped against the face. They will "identify" a belt tooth and you follow it across the pulley to the rear where the corresponding reference mark is located. The corresponding mark for the cams is on the front of the top rear part of the plastic belt cover, that is left in place attached to the cam covers. They are approximately at the top and look like a molded in place arrow. Be aware that at least one member of the board found the cam marks not matching because someone in the past had reinstalled the pulleys wrong, (marks not matched), when they were using the cam alignment tool. (The cam pulleys can be installed in multiple positions and the clamp bolt holes are also slotted. Never remove a cam pulley with out careful marking/scribing their location on the cam unless you have access to the cam and crank alignment tools.) I can't remember exactly what the corresponding mark is on the engine casting for the crank but it is on the top adjacent to the pulley. You'll need good light but it will be obvious. [Tip from Robert Reagan] When I changed the belt, I ignored the reference marks and made my own marks with solvent-based Whiteout or white paint on the cam gears, the crank pulley and the existing belt. I made sure the replacement belt was positioned exactly like the one that came off, and everything went smoothly. [Mark Stites] Take some "white out" or any other kind of white touch up paint and put two stripes per cam gear. I stripe two different teeth at the top and then eyeball two stripes on the front timing cover, which has the timing scale and notches cut into it that bolts down to the cylinder head. When putting it back together I counted the teeth between the whiteout marks on the old belt and marked the new one so it went on in the same position.

B6300 Engine Pulley Timing Marks Not Aligned Correctly. [Inquiry] I saw your posting on the internet about changing the timing belt, and wonder if you could help me with a question. I changed the belt on my '94 960 and put the new belt on just like the old one came off. The car ran just fine, so I should have left it alone. However, I noticed that the timing marks on the two camshafts did not align as the service manual showed that they should. The intake mark was four teeth off, and the exhaust was one tooth off. So I changed them to what the book showed, but the car ran ragged. I changed them back, but got confused somewhere along the line. Now I can't get them aligned at all, and the engine won't rotate all the way because of the valve/piston interference (I didn't crank it, just turned the motor gently with a socket wrench, so I haven't damaged the internals of the engine). The service manual says to align the marks on the camshafts with the indicators on the cover plate, and to align the mark on the crank pulley with the oil pump housing. I've studied the crank pulley and can't find a mark anywhere on it for reference. Do you know how to determine the correct position of the crank shaft when aligning the timing belt?
[Response: Jim Bowers] Sounds like someone has replaced seals, had the pulleys off and didn't take the trouble to put them back on with the marks lined up. Now the only way to get them set properly is to use the Volvo alignment tools. There is one that holds the cam shafts and one that holds the crank. The camshaft tool is about $300 and the crankshaft is about $60 from your

friendly Volvo parts dealer if he can get them in a reasonable time. I suggest you take the car to the dealer and ask him to set the timing and be sure to tell them to make sure they line up the marks so you won't have this problem next time.

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960 Serpentine Belt Installation. [Inquiry:] My son's 960 needs a new serpentine belt and I planned to install it. Has anyone had this experience and how difficult is it? [Response: Bruce] It is not difficult to install. You can remove the three top screws holding the electrical fan into the top of the radiator. Pick the fan assembly up and place it along side the exhaust manifold. This gives more room when replacing the belt. Take a good look or write down how the belt travels around all of the pulleys first. You will need a 3/4" or a 3/8" wrench to move the belt tensioner. Depends on the year of the car. The tensioner has a 3/8" hole for a 3/8" ratchet to be inserted and move the tensioner assembly as to release the belt tension. There will be a small hole to insert a 1/8" or 3/16" cotter pin in to hold the tensioner in the released position. Remember how the old belt is routed. It can be installed in different configurations but only one will be correct and fit properly. Remove the old belt and install the new belt. Release the tensioner and you are all done. [Response 2: J. Charger] a smart guy could "unload" the spring loaded tensioner with a very large set of channel lock pliers, then change the belt, with out special tools. on the other hand, the adapter tool needed is probably less than $10, from Volvo, to adapt a 1/2" drive ratchet to the tensioner.

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960 Rear Cam Seal Repair. See 960 Rear Cam Seal Repair**.**

B234 Series Engines:

B234 Timing Belt Replacement Procedures. See Dave Stevens' excellent supplement describing and illustrating the B234 belt and tensioner change procedures.

B234 Timing Belt Cautionary Tales. [Editor] **If you have a B234 16-valve interference engine, you MUST maintain the entire timing end of the engine rigorously. This means new timing and balance belts and a new oil pump bolt every 50k miles, and replacement timing belt covers, new tensioner, and shaft seals on a regular schedule.** See Buying a Used GLE with B234F for more details, along with the notes below. If you don't do this, you will join the ranks of ex-B234 owners whose valve trains self-destructed from belt failure.

Parts. Note that some engines have manual belt tensioners and some hydraulic tensioners. These cars use different length belts (the latter is longer), so don't buy the incorrect length.

B234 Timing Belt: New Oil Pump Bolt Needed. [Tip from Abe Crombie] When replacing the timing or balance belts, replace the bolt on the oil pump pulley. These have been known to break and the belt comes off and you bend valves. It doesn't happen until you replace belt and the stress of new tight belt can pop the head off the bolt and then it's bad news. [Confirmation from Paul Bente] When replacing the timing belt at the recommended 50,000 mile intervals on B234F motors (16-valve interference head), I highly recommend that the oil pump pulley (driven by the toothed timing belt) be removed, the pulley carefully checked for cracks and defects, the bolt replaced with a new one from Volvo, and torqued carefully to specifications. If you must use a non-Volvo bolt, be absolutely sure it is of the proper grade from a reliable source. If your motor has over 100,000 miles I urge you to check it now and not wait. If you wonder why, read the sad story below. Acquired my 91 940GLE from my brother-in-law at 137,000 miles. It had documented service by the Volvo dealer at all recommended intervals. After driving across country, the scheduled 150,000 timing belt replacement and other maintenance was done at 148,200 by a Volvo factory trained (presently independent) mechanic. Within 1,000 miles the engine failed. Symptoms were instant, complete loss of power, and check engine light on. Fortunately it happened at low speed on a two lane road next to a wide shoulder. If it had happened on the #1 lane of a crowded freeway at 70 mph, I hope I'd still be around to appreciate Volvo unibody integrity. Teardown of the engine showed the bolt holding the oil pump pulley failed, pulley jumped off the shaft, engine lost timing, valves crashed into pistons -what a mess. Microscopic (40X)
examination of the bolt showed classic tensile failure at the bolt head with no evidence of defects or inclusions in the bolt. Conclusion: bolt was probably overtorqued during assembly. I also observed that the cast iron oil pump pulley was also cracked starting at the stress concentration point on the inside
diameter and progressing 2/3 of the way to one of the holes in the pulley. The crack was partially rusted, indicating slow propagation. This was not a cause of the bolt failure, but I estimate the pulley would have failed within another 50K miles. Since other B234F motors of similar vintage may also have been similarly overtorqued in assembly I strongly sugggest you check yours out now. Don't wait for it to fail.

B234 Seals: Counterhold Tool. [Inquiry:] I am trying to find out where to obtain a balance shaft pulley counter hold tool (5362). I recently replaced the balance shaft seals but they are still leaking. I am afraid to try it again without the proper tool. [Response: Rob Abel] I got mine at the Volvo dealer, and wouldn't do the job without it. One DIY timing belt and it's paid for.

Vacuum Leaks. See tips in the Fuel Injection FAQ file. For vacuum hose replacement, see the section Vacuum Hose Replacement

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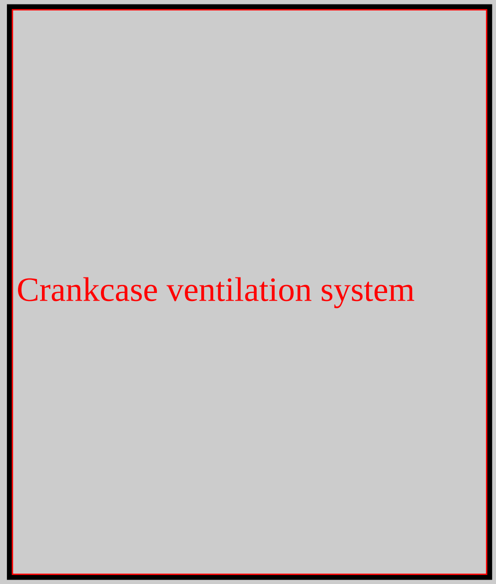
Flame Traps:

Crankcase Ventilation: A Treatise. [Don Foster]

Operation. A normal byproduct of a normal engine operation is "blow-by", or a slight leakage of combustion gases by the piston rings and into the crankcase. It is very desirable to release this pressure. Years ago it was simply vented into the atmosphere. Later, it was vented into the intake system through the air filter. More recently, it is forcibly removed using engine vacuum and certain controls. This system burns the vapors, reducing the environmental problems.
On the Volvo B21/23/230 engines, this is accomplished with the contraption we call the "flame trap" or guard,but the system also includes a flame arrestor, the oil separator, some hoses, and a fitting on the intake manifold.



Excess pressure can force oil past seals. Excess pressure can damage seals and gaskets. Excess pressure gunks up engines. Excess pressure vents into the atmosphere, which is not good for the environment. On the 240 with the B230, excess pressure can pop the plug outta the back of the cylinder head (happened to my daughter and she won't let me forget it). Crankcase vacuum is directed through the "flame trap" system. During normal driving, engine vacuum is from the intake manifold (upstream of the throttle), through the top of the flame trap, through the flame arrestor, through the oil separator (a.k.a. "breather box") and to the crankcase. During idle, when there's insufficient vacuum, additional vacuum comes through a small hose attached to the flame trap and to a small fitting in the center of the intake manifold.
Components. The flame trap consists of a lower hose (which sits directly on the oil separator), the upper hose (which has a large and a small fitting for vacuum hoses), and the flame arrestor. The gases in the crankcase are highly combustible, so it's very important to prevent igniting them with a backfire. (If you did, you'd be replacing all your engine seals and gaskets, or maybe your car.) The flame arrestor will absorb the thermal energy from a backfire and quench a flame front. (Note -- this is a very old technique, used during the last century in coalmines when the miners had acetylene lanterns.) So it blocks flames but passes gas.
Oil Separator. The oil separator is bolted to the block and is a single molded plastic unit. I don't know how to take one apart, although I've successfully cleaned out several of them. They're cheap enough that you might buy a new one without a second mortgage. The function of the separator is to allow the oil vapor and droplets some time and space to coalesce into larger drops and flow back to the sump. The separator has two openings into the block -- one for vapors to rise through, and one for the oil return. The oil return opening has a hose that MUST remain in place -- don't dislodge it, or you'll be pulling the pan.
Flame Trap. The flame trap is located (buried is more truthful) under the intake manifold between headers 3 and 4. It sits directly on the oil separator. Cleaning the system includes cleaning or replacing the top and bottom hoses, the brass or plastic arrestor, the y-shaped fitting in the plastic holder, the large hose to the intake manifold, the small hose, and the small fittings on the intake manifold. And the oil separator. Use carburetor cleaner as a cleaning solvent. The small hose and small fitting (in the manifold) are famous for plugging. Clean the fitting by running a paper clip or pipe cleaner through it, then replace the hose. Inspect the arrestor (old style=brass, new style=plastic) to confirm the passages are clean and free. If not, either wash or replace -- they're only a buck, or so. Buy a handful. Volvo sells a "kit" which includes the top 'n

bottom molded hoses and the arrestor. It's worth the few dollars.
Diagnostics. A coupla quick checks....... With the engine idling, pull the small hose off the flame trap and feel for vacuum -- it should be there. Pull the trap off the oil separator and observe (or feel) the separator to confirm that crankcase vapors are streaming up. [Randy Starkie] Remove the hose from the box and attach a length of 3/8 or 1/2" hose. Remove the oil filler cap and blow into the hose. Do you feel resistance? Could be a restricted oil breather box.
Do the "jiggle test" -- with the engine idling, loosen the cap but leave it in place. If it sits there quietly then there's enough vacuum to hold the cap. But if it jiggles and bounces, you have insufficient vacuum (and maybe too much pressure). *[Editor's Note: This test is reliable only with the earlier metal cap, not the later plastic cap.]* It's conceivable that a partially blocked system might provide slight vacuum, requiring only a little finger pressure to hold the cap down. If so, I'd start thinking about some preventive maintenance.
For the technically-inclined....... I built an adapter and measured the crankcase vacuum at idle. All four of my registered Volvos ('82 245 with 335k; '82 245 turbo with 130k; '85 245 with 235k; and '91 740 with 180k) measured from 1.75 to 2.25" of water, vacuum. *Throttle Body*. While cleaning your flame trap, you might as well clean the throttle body and its vacuum nipples too. See the Discussion in Engine Performance.

Vacuum Leaks. If you suspect vacuum leaks in the intake system, see the FAQ section for diagnostic notes.

Flame Trap Components, Found between Intake Manifold Runners 3 and 4

Flame Trap & Crankcase Ventilation Questions.
Basic Crankcase Ventilation Maintenance: [Response: Don Foster]

> -Perform the "jiggle" test *if you have the earlier style metal oil fill cap* to see if you have enough crankcase vacuum. (See below.) If it fails this test, go on to step two. If you have a plastic oil cap, then the "jiggle test" is not relevent.
> -Remove the flame trap housing -- it's the rubber "cup" into which the hard plastic gizmo fits (containing the flame arrestor sits). Clean it, and inspect the three connections to be sure they're clean and unplugged. The three openings are the bottom one, the large top one, and the small top one.

- Inspect the large top hose to be sure it's clear. Inspect the small top hose -- it plugs into a fitting in the center top inner part of the intake manifold. Often this hose is plugged solid. It's easier to simply replace the line.

- Inspect the small Y-fitting in the manifold where this line connects -- sometimes it's plugged, and must be reamed out. A little carb cleaner helps dissolve the varnish. You can replace this for about $4, not a bad idea since it can become brittle.

Flame Trap Y-Fitting

-The lower part of the flame trap -- the "cup", as I called it -- sits on the "breather box" (again, I don't know the official Volvo name), This box is bolted to the side of the block, and is easier to unbolt and remove than it appears.
-Remove the box, being careful to NOT pull on the hose inside the block -- the box connects to this hose. The hose is clipped into position in the sump, and you should avoid disturbing this. The box can be replaced, or it can be washed out. The function of the box is to provide a space for oil mist and droplets to coalesce into large drops and return to the sump. When reinstalling, check the gasket (O-ring?) -- it may need to be replaced.

Does my Turbo have a "flame trap"? [John Sargent/Editor] While the turbo engine does not have the plastic flame arrestor insert, it has all the other hoses, fittings, and breather box that can clog up. You still have to inspect and clean as necessary.

[Inquiry:] How much suction should I expect with the vent system working properly? Should the oil cap suck down hard, or is a slight jiggle with what appears as an overall suction enough?
[Response 1:] In order for the 'jiggle' test to work, the filler cap needs to have a good gasket. These gaskets only last a year or so on the turbos, then they get hard and brittle. Even with some crankcase vacuum, the engine vibration will make them jiggle. Replace the rubber gasket and try the test again - let us know the results.
[Response 2:] Even without the 'flame trap', the positive crankcase ventilation system can become clogged with hard deposits. The hoses themselves can become restricted, or various ports and orifices can become clogged or the oil vapor separator on the side of the block can become clogged. Often, the hoses, when clogged and old just need to be replaced. (BTW - running the engine with synthetic oil will help prevent clogging of the PCV system because the synthetic oil has a much higher vapor point so that you do not get as much oil vapor condensing and hardening in the system. And what vapor does exist does not coke as easily to form the hard deposits.) The 'jiggle test' is to loosen but do not remove the oil filler cap while the engine is running. If there is negative pressure in the crankcase, it will be sucked down to the valve cover and will sit still. If there is positive pressure in the crankcase, the cap will dance or 'jiggle' on top of the valve cover as the pressure escapes. *[Editor: But NOT for the later style plastic filler caps]*
[Response 3:] I just purchased a 87 745 turbo that was blowing oil from the oil fill cap on the valve cover. I took a rather heavy handed approach. I bought a can of Gunk motor flush. I warmed the motor, turned the motor off and then poured the motor flush down the large hose leading to the flame trap. Initially, the motor flush would not move through the flame trap. Within a few min. it was running through the hose and into the flame trap as fast as I could pour it. I then blew through the hose with compressed air, started the motor and let it idle a few min. Then drained the oil and changed the oil filter. Just to make sure all of the motor flush was out,

I again blew through the flame trap with compressed air. I plan to drive the car about 1,000 miles and replace the oil and filter again. I know this is probably sacrilege to some but I think this is the fix. The motor is no longer blowing oil out the breather. [Response 4: Don Foster] I had luck with carb cleaner, a coat hanger, and compressed air. I sprayed the cleaner in and let it soak 45 minutes before blasting the crud through with compressed air. I followed with a quart of Gunk Motor Flush (I think it's only kerosene or diesel fuel). Then I drove the car 25 miles and changed the oil. In my opinion, if you tried to pour anything down there while the engine's idling, you'd end up wearing most of it. The only reason I didn't remove the oil separator is because on an '82, with K-jet, the separator's buried. It would have been a two-day job to remove and clean it. On the B230 engine, it's a half-hour job to do it correctly.

[Tip from Ralph Haber] This may seem obvious, but can be easily overlooked. During a recent oil change and flame trap replacement, I decided to check for vacuum at the FT fitting. There wasn't any. Closer inspection revealed that the hose and intake manifold nipple were completely sealed off by a 10 year accumulation of dried oil/carbon and other yuk. No vacuum was present at the flame trap fitting. Replacing the hose and drilling out the nipple gunk corrected the problem. This was on a B230F engine in a 89 744GL with 189K on it. This is real easy to check and can be rectified with a minimum of effort. Untreated, it may allow unwanted pressure to accumulate in the crankcase leading to oil leaks and blown seals. [Related Tip from Steve Roop] The intake manifold vacuum fitting (small) going to the flame trap was hopelessly clogged. After struggling with trying to clear the blockage and wanting to get to bed in this century, I found that a 3/32 drill bit, turned slowly, would clean out the nipple perfectly (of course I removed the fitting from the intake manifold first!). Anyway, it really speeds up the cleaning process and I now pass the jiggle test again. [Tip from Mike W.] If the manifold fitting is plugged, the hose between it and the flame trap surely is also, and should be replaced.

[Inquiry:] Why not just leave out the flame trap? [Response: Editor] The flame trap prevents any engine backfires from reaching blowby gases in the crankcase, which would otherwise cause catastrophic results. It is an important part of the engine and must be left in place. Since cleaning it is not hard, there is no reason to remove it.

[Inquiry: Stuck Flame Trap] In the Volvo dealership where I worked as a tech for quit a long time, what we did to get the flame trap out was take your screw gun and shoot a small screw partially into the center hole in the lil bugger. This gives you a handle to pull it out with and makes it very easy to change. Otherwise you'll screw around all day trying to get it out.

Crankcase Pressure Gauge and Tester. [Tips from Don Foster] To measure crankcase conditions, I built a vacuum gauge to quantitatively measure the actual vacuum. I started with a modified oil cap, shown below. It's an older style metal cap into which I soldered a brass barb fitting, available at any hardware store. One could use a plastic cap with the same fitting, glued with Goop or a similar adhesive.

Oil cap modification for vacuum test

The gauge is a Magnehelic gauge, by Dwyer, which measures very low pressures. It can be hooked to measure either a pressure or a vacuum -- it's a differential gauge. These gauges are often on eBay for a few bucks. All my cars tend to run around 1"-2" of water vacuum, so a gauge that measures 5" of H2O max works fine.   Below you can see the gauge (mounted in a metal box) measuring crankcase vacuum on my '86.

Dwyer Magnehelic Vacuum Gauge

Excess Crankcase Pressure. [Inquiry:] My Volvo has recently developed a case of extreme crankcase pressure. I noted on more than one occasion that the oil dip-stick had been blown up from the tube, spraying oil throughout the engine compartment. I replaced the original flame-trap element with the newer factory plastic resin type, cleaned the manifold orfices, changed the oil and filter and checked the results. Once again, the oil dip-stick was blown up, and another oil-bath was applied to the engine compartment. The only way I can make he dipstick remain in place is to use an elastic cord holding the stick to the manifold. I am obviously missing something here... How else can I relieve this pressure? [Response 1:Don Foster] On your engine, the major components of the crankcase ventilation system needing attention are:

The large hose from intake manifold to top of flame trap assembly.
The flame trap housing.
The flame arrestor, now white plastic (formerly brass).
The large lower hose from flame trap to top of "breather box".
"Breather box"
Small hose from flame trap assembly to fitting in intake manifold.
Fitting mentioned above.

Each of these items should be inspected, cleaned, or replaced. Volvo sells a replacement flame trap kit that may be more useful than trying to recover a badly varnished (and hardened)

housing. The small vacuum hose, and the manifold fitting, are notorious for becoming plugged. The hose you replace for $0.25. The fitting can be reamed out with a piece of wire and carb cleaner.
The breather box has been mentioned several times -- it can be removed carefully, washed out, and reinstalled. (Be careful to NOT tug on the hose inside the block that meets this hose.) If these are all fine and you have vacuum at the two vacuum lines, then you might have a serious engine problem, such as a bad ring. This is very rare with that engine. [Randy Starkie] Remove the hose from the oil breather box and attach a length of 3/8 or 1/2" hose. Remove the oil filler cap and blow into the hose. Do you feel resistance? Could be a restricted box.
[Simple Fix to Another Problem from Randy] I had the same problem with a 1990 740 GL. All of the plumbing was open and clean and yet at high RPM'S the dipstick would blow out and the engine bay would be bathed in oil. I even went so far as to rig a pressure gauge to try to measure excessive pressure that didn't seem to exist. After talking to a Volvo mechanic and explaining all the things I had done he suggested I replace the rubber O-ring on the dipstick. That was the fix for me and 40,000 miles later it hasn't done it again.
Turbo Oil Breather Box Notes: [Editor's Note: See Michael Ponte's excellent tips and illustrations on oil breather box maintenance at http://www.mikeponte.com/volvo/oiltrap.htm

Turbo PTC Nipple Clogging. If your 90+ turbo PTC nipple clogs, it can lead to crankcase overpressure and cap/seal leaks.

Excess Crankcase Pressure? Dipstick O-Ring Fails. [Comment from Randy:] I had what I thought was an excessive pressure problem in my 90 740 with the b230f. Had the same problem with the dipstick blowing out and bathing the engine compartment in oil. The flametrap and all the plumbing was not restricted. I even went to far as to hook up a pressure gauge to the crankcase! Findings?? There wasn't the tremendous pressure I expected to find. Solution?? Replaced the O-ring on the dipstick- problem solved. It is worth the investment in a new O-ring to check it out.

Oil Breather Box Beneath Flame Trap. [Inquiry:] My crankcase pressure is still high, even after cleaning the flame trap. How do I clean the breather box?
Function of Oil Separator or Breather Box:
[Motor Magazine, Bob Savasta, July 2001] One of the often overlooked components of the PCV system on the B230 engine is a little black plastic box called an oil separator, which is hung on the left side just below the intake manifold. As the name implies, this three-port gizmo grabs oil and blowby gases from the crankcase, internally separates the liquid oil from the gases, then routes the oil back to the crankcase while the "purified gases" get routed upstream to the intake to be burned. A clogged separator can exhibit the exact symptoms of a sludged-up flame trap.
Diagnostic Notes:
[Motor Magazine, Bob Savasta, July 2001] The oil breather box (the black box under the flame trap) function is to provide a low-velocity space for fine oil mist and droplets to collect (or coalesce) into larger drops that can flow back into the crankcase. Yes, it can get clogged, and

can be removed and replaced. It can also be removed, cleaned, and reinstalled. Diagnosing a plugged separator is a piece of cake. [Randy Starkie] Remove the top hose from the box and attach a length of 3/8 or 1/2" hose. Remove the oil filler cap and blow into the hose. Do you feel resistance? Could be a restricted box. A few observations: 1. Most people haven't had luck cleaning the separator; if it's loaded with sludge, simply replace it. 2. Volvo doesn't include the oil separator in its maintenance program because it's usually not a problem, unless oil change intervals are extended way beyond the norm. 3. Replace the oil separator before going after the rear main seal leak. In many cases, the immediate drop in crankcase pressure will be sufficient to seal up the leak on its own. *Removal Tips.* [Kevin] Access is a little tight, so a set of 1/4 inch drive metric sockets/handles and a selection of extensions is going to be a big help. If you have a portable shop light, hang it in the back of the engine compartment behind the inlet manifold. A little illumination makes this a lot easier. The removal and re-installation should take about 2 hours or so in total, plus whatever time you may take cleaning the breather box, EGR, etc. Overall this is not a very difficult procedure, and with a little patience most weekend mechanics should be able to get through it without too much cursing. Buy a replacement o-ring (it is listed as 34mm IDx3mm) for the box, since the existing ring is sure to be hardened.

B230 Series Engines and General Notes: *Cleaning Oil Breather Box by Removal:*
[Editor's Note: See http://www.mikeponte.com/volvo/oiltrap.htm [Alternate Procedure from Chris Herbst] When I want to remove the breather box, I take the intake manifold off of the head and pull it back to the strut tower. That makes EVERYTHING accessible. It's also a good time to replace the heater hoses as long as you're down there. The oil trap is easily accessible from that position, and if you pop out the airbox (non turbo left side, a few grommets) it makes a great platform to stand and work. Sounds bizarre, but it's really simple when you do it a few times. [Procedure from Kevin & Jay Simkin]

1. Disconnect Idle Air Control Solenoid (IAC) hose and PCV breather hose from main air intake hose immediately upstream of throttle body. IAC hose is the one on the left and breather hose on the right relative to the throttle body. Loosen the hose clamps that hold the air intake hose at the Air Mass Meter (next to air cleaner box) and at the throttle body. Clamps have a 7mm hex head screw that also has a screwdriver slot. Pull the hose off the AMM and the throttle body and put to one side. Remove the flame trap/nipple and the short hose below the flametrap that connects to the top of the breather box. Located between the 3rd and 4th legs of the inlet manifold. If there is not enough room for finger access, the end of the hose may be gripped gently with needle-nosed pliers. Be careful not to press so hard on the plier handles, that you cut into the hose! Pull gently, and the hose will come free.Disconnect the IAC electrical connector (push on the spring clip on the back side of the connector and pull the connectors apart). Remove two 10mm hex bolts attaching the IAC to its bracket underneath the inlet manifold. Disconnect the IAC outlet hose where it connects to the manifold header. The IAC hose is the one located directly below the flame trap vacuum hose. Another 7mm hex-head screw on the clamp. Pull the hose off the nipple. To speed hose removal, slide a short length of 1/4" rope(not twine or wire) around the hose. Gripping the rope on both sides of the hose - do not make a slip not - pull gently on the hose to remove it from the manifold nipple.Remove the IAC, with the hoses still attached, threading the discharge hose down the back of the manifold. Now is a good time to clean the IAC. When you re-install the discharge hose, route it to the right side (passenger cabin side) of the fuel injection harness.*If your car is so*

equipped, the EGR valve is now “exposed”, behind and to the right of where the IAC was. It is connected to the inlet manifold via a steel tube that connects to the side of the valve. There is another steel tube connected to the end of the valve, that runs around the back of the block, to the exhaust manifold. Remove it and the EGR valve bracket on top of the base of the breather box Remove the two 12mm hex bolts that attach the breather box to the block. These can be removed with a box wrench or a socket and there is now plenty of space under the manifold to get at them directly. There is a bracket supporting a wiring harness clip in front of the block at this location. Remove two 10mm hex bolts attaching the bracket to the wiring clip. One is front and center relative to the breather box, the other is to the right of the breather box. Pry the bracket away from the wiring clip and it will pop off. Now is the time to wipe dirt away from the area surrounding the box. Use brake cleaner spray and a rag or brush and remove as much as you can so that when the box is removed, you don't push dirt down into the crankcase through the opening.Lift the breather box up away from the block. Rotate it forward slightly when it raised ½ inch or so, so that it clears the heater hose (this is connected to the block slightly above the breather box) and it will come free and can be maneuvered out easily. **Caution: there is a hose inside the block into which is fitted a 3/4 inch long lip on the bottom of the box. This hose goes back down to the sump, and is held in place with clips. When removing the box, be careful to NOT disturb or yank this hose: gently pull the lip out of the hose.** There's an O-ring where the box fits against the block -remove this carefully as it may be brittle.Cleaning the box. Use a solvent or degreaser that won't attack plastic, such as Gunk Motor Flush, citrus-based solvent, non-chlorinated brake cleaner. [Paul Seminara:] Soak it in Naptha thinner for a day. Follow with a soak and scrub with Simple Green (straight), hot water rinse and dry. [John Sargent/Randy Starkie] Air will flow quite freely through a clean oil trap. If you want to clean it up instead of buying a new one, try probing inside with a piece of wire to break up the deposits. I have found that a lot of deposit build up occurs around the top opening. An initial reaming out by hand with a 5/16 or 1/8" drill bit will remove a lot of the crud. There are no check valves inside the oil trap, just a baffle or two. Carefully clean the bottom surface and o-ring groove with rag and cleaner. Install new O-ring (which will be green and fit nicely). Smear some general purpose grease on the o-ring to hold it in place while re-installing the box. Before beginning to re-install parts, clean up the exposed surface on the block where the breather box sits. This area is usually something of a dirt trap. Be careful not to knock any crud into the openings into the crankcase. Also, while you are doing this, take care not to disturb the oil return hose (front opening). Carefully wipe around the larger opening, and then (even more carefully) around the smaller opening that has the oil return hose inside it. Then spray a little throttle-body cleaner onto a clean rag and wipe the surfaces again. This is the sealing surface for the breather box o-ring, so it is important not to leave any dirt.

2. The rest of the re-installation process is (as they say) a reverse of the removal process. Apply a little dielectric grease to the contacts of the IAC solenoid and EGR before re-connecting them.

If Your Car Has an EGR (Exhaust Gas Recirculation) Valve. [Kevin] You will have to remove the EGR valve to gain access to the breather box. *Cleaning Oil Breather box In Situ:*
[Response 2:] Try running some Gunk Motor Flush (a kerosene solvent/detergent used just before an oil change) down into the breather box through the flame trap tube. It may dislodge any crud inside the box and free up the drain into the crankcase. Just make sure you change the oil immediately after you do this.
[Response: Mark] If you want to unclog the oil trap without removing it, try this. During the oil change, with the plug out and the pan drained, place a funnel in the hose nipple coming out of the oil trap and dump a quart of cheap motor flush down the funnel. It should go right through and drain right out into the pan. If it drains sloooowly, pour some carb cleaner to break up the globs and follow with the rest of the motor flush. The nipple diameter is small. I place a length of hose over the nipple and place the funnel in the hose. Make sure the hose fits the nipple snugly. Use a zip tie to reduce the diameter by tightening it until the hose snugs.
[Response: Ivan] On my '86 B230FT, changing all the clogged PCV hoses did not affect the vacuum at the fill cap, but changing the oil trap sure did. The old oil trap weighed about twice as much as the new, and was visibly full of crud. Changing it was pretty easy, even without removing the intake manifold, but do be sure to buy the O-ring that goes with it, and some liquid gasket. The results are well worth the $37: the turbo is no longer blowing oil past its seals (I think), the car idles a little more smoothly, and the oil fill cap stays happily in place at idle.
Replacing Breather Box with Improved Version:
[Tip from John Sargent] Volvo re-designed the oil trap sometime between the 1987 and 1990 model years of the B230 series engines. The improved oil trap is about twice as tall as the earlier model, and I think it must do a much better job. At least you have twice as much volume to plug up! It is more difficult to remove and replace with the intake manifold in place, but I just did one in a half hour. The new oil trap is Volvo part number 1389430. It can be identified by the flange on the upper end to slide a tinnerman nut onto for securing the engine wiring harness. If I had to buy one, I would buy the improved version in spite of the greater difficulty in removing and replacing. Don't forget to get the new (shorter) S tube with it, and a new o-ring for sealing between the oil trap and the block.

B234 Engines: The B234 breather box is different than that for an 8 valve. While it uses one o-ring, like the 8v, you must pull the intake manifold off to clear the long pan drain pipe when removing the box. This is not very hard: you only have to loosen the lower manifold nuts a few turns, not remove them. The intake stud holes are open on the bottom so you can then lift it off. Makes it easy to put back also. Have new gasket ready.

B6304 Engines: [John Roberson] Disconnect your battery negative. You will need to get a 3/4 adaptor for your socket wrench to take the pressure off your serpintine belt tensioner. With the tension off the belt tensioner, take a small nail and insert it in the hole to fix the tensioner. Now remove the two bolts holding the tensioner from its holding brackets. With the belt and tensioner out of the way, remove the bolts holding your power steering pump and move the pump out of your way your right out of the way, fixing it with a cord to hold it. Next remove your alternator bolts from their brackets and disconnect the two wires from the alternator well. Remove two plates affixed to the block. Remove two 10mm bolts on each side of the oil breather box. Pry off hoses using a blunt screwdriver and inspect them for plugging or deposits. Remove the box. Clean the box and make sure the drain into the sump is clear. Replace everything, using Vaseline as a lubricant to help things go back together.

B6304 Seal Replacement Notes. [Inquiry] The new seals I bought for my breather box look nothing like the old ones. [Response: Walt Poluszny] The new green doughnut goes on the side against the block with the flat side of the doughnut facing the PCV box. The old bottom/right seal against the block was indeed a tube with two hose clamps. The new "upgraded" part (P/N 8653339) is rubber with a metal fill sleeve. The 'flanged' end of the tube goes toward the PCV box. I used RTV as a lubricant and a sealer on the 'O' ring and tube on the advice of a Volvo mechanic.

Oil Seals and Leaks:

Finding Engine Oil Leaks. See also the section at Oil Leak Diagnostics. Auto supply stores (larger ones such as NAPA) sell an ~$5 1-2 oz. bottle of oil leak dye. Clean/wipe existing oil from engine etc., add to engine oil, run for 50-100 miles and inspect for leaks with a black light while wearing UV-enhanicng glasses from JCWhitney or your local supplier. The "dye" fluoresces brightly when exposed to black light. Buy a fluorescent black light from Tracerline at Autozone.

[Look for leaks at:] Regarding oil leaks on 89 744T: Prime places to look are cam cover, distributor O-rings, turbocharger return line (at turbo and the O ring into the engine) and, like Letterman's top 10, Number 1: Oil Filter mounting O ring(s).
[Editor's Note:] It helps to have a clean engine when you are looking for leaks. See below for tips on cleaning your engine.

Cleaning Your Engine. [Editor's Note:] It helps to have a clean engine when you are looking for leaks. Cover the distributor with plastic wrap. Put a piece of well-chewed chewing gum on top of the little vent hole on your brake fluid reservoir. Use Simple Green or a water-based degreaser on stubborn spots, then use the "tire cleaner/degreaser" setting at your local self-carwash to cover the engine with cleaner. Try not to spray into the alternator, ABS unit or distributor. Let it soak for a while, scrubbing with a brush where necessary. Use the low-pressure wash to remove the deposits. Do this at least once per year and you will find it much easier to both work on the engine and diagnose problems.

Replacing Oil Seals. *Seal Removal Tools:* [What have you used to pull the old seals out and press the new ones in?] It's pretty straightforward as long as you have all the timing marks lined up. Just keep that little detail in mind for re-installing the belt. As far as removing the seals go, I have a little tool in my tool cab that I don't know the origin of that slightly resembles a dental probe. It's a straight, ice pick looking thing with a 90 deg bend at the working end. I simply reach back behind the edge of the seals, work my way around and pry 'em out...being careful not to nick any of the sealing surfaces. [Other Techniques to Remove Seals] Use a small screwdriver to pry out the seal. [Bruce Feinberg] Try a "seal puller". The one I used is made by KD Tools. (The rack at the front of many parts stores full of strange and seldom used tools is probably KD.) The tool I'm referring to looks like a hammer that got flattened, but with a hook on each side of the head. Slip the hook under the lip of the seal and roll the tool. Its out...with no damage. *Preparation/Mounting Plate Gasket:* If you're doing the crank-seal and "balance" shaft seal, get the gasket for the front bearing mounting plate in which hese are both mounted, as it makes things much easier if you have this on hand if/when those seals fail to come out in one piece. Much easier to just remove the plate, and push them out from the backside. Then install the seals in the seal cover and remount it with a fresh paper gasket. You get to set them where you want and observe the spring is in place. *Removal Tips:* [Inquiry] How does the lower front crank gear come off? [Randy Starkie] Once you remove the harmonic balancer you just pull the gear off. Remember to replace the pieces on each side of the gear when you reassemble and be sure that the cog on the back of the gear is engaged properly with the slot in the crankshaft. [A cautionary tale] I just did a 120K mile service on our '90 745 (B230F). I did the oil seals (and water pump--how's that for anal!) as long as I was doing the timing belt. Two things about that. First, a good impact wrench makes the crankshaft pulley nut a breeze, even with an automatic trans. The crankshaft barely moves, even with nothing holding it in place. Now the bad news. I think I may have slightly scratched the camshaft in pulling the seal. There is oil on the water pump coming from the vicinity of the top, front of the head, on the order of a drop or two per minute. To be sure I didn't screw it up, I redid both valve cover gasket and camshaft seal the next day (cursing all the way). I felt a slight scratch on the shaft with a q-tip the second time, and buffed the cam with fine emery paper and 1200 grit finishing paper. Anyway, it still seems to leak. [R. Haire] Be careful not to rip the oil pan gasket where the lower bearing housing bottom rests or sticks, or the job will become much larger. *Seal Installation Tools: OEM Tools.*

[Technical Tip from Volvo TSB 21121 Oct 93] New Volvo OEM seal designs are now used for camshaft and intermediate shafts starting in Oct 93. The seals (p/n 6842273-2) are more compact and use a special version of the seal installation tool p/n 9995025 (see photos right and note the lips on the tools). Lubricate the seal and press it onto the shaft using the tool. To ensure that it sits correctly, it must be pressed in for at least 30 seconds. If pressed for a shorter period, it may creep back out. Remove the tool carefully to avoid damage to the seal lip or spring. See the Procedural Tips below; if you do not have the special tools, the homemade solutions noted will work with these OEM cam and crank seals to keep their lips from rolling over. Aftermarket seals are different. *Homemade Tools.* [Response: Rob Abel] That "special tool" is just a socket-like contraption that fits over the crank, then has a bolt which threads to the crank - purpose to evenly, slowly and gently press in crank seal. You can do the same thing with homemade tubing, pvc, pipe, or whatever has the proper diameter and two square ends. On the crankshaft, the tube should fit over the crank, but not be so large as to be larger than the crank seal. Ideally, the outside diameter should be just smaller than outer diameter of crank seal, and inside diameter just larger than ODof crankshaft.

Load the spring into the lips of the seal with some grease so it won't fall out, lube the lips of the seal, start it in by hand evenly, then gently tap it into place using the "seal installer" you've found/made/stolen/borrowed or whatever, and a wooden block. The cam and auxiliary shaft are the same diameter, same seal, so you only need 2 installers, one for cam and aux., and one for crank seal. Just be patient and go slowly, and you'll get them in right. [Another tip:] I bought a PVC coupling that was close to the same size. I used the crankshaft bolt and a piece of flat iron to press it in. Went in squarely. [Another: John B.] Use a seal pusher you can make out of copper tubing or pvc tubing...use a rubber mallet on the pusher to tap the new seals in. *Lubricating the Seal Prior to Installation:* [Fix:] did you lube the sealing lips of the oil seal with engine oil prior to installation? I've learned the hard way; it doesn't take long to maim a dry seal. [Fix:] [See also Cam Seal Replacement] Make sure you put sealant on the sides of the front bearing cap, and on top of the gasket in the same places, also put sealant under the cap on the head mating surface between the bearing and the seal. If the leak is indeed through the seal, you could try moving it in or out a little or get a new seal with two "lips" (no idea what it's called...).I always do exactly as all the books say not to, I remove the front bearing cap and take the old seal out, then I apply oil to the outside of the new one to avoid squeezing it and put it in. Then I apply sealant on the bearing cap, just in front of the bearing surface, and put it back. Torque the bearing cap to 14 ft-lb. [Another response:] Two common problems installing seals are rolling over the seal lip, and failing to pre-lube the lip and crank surface. I hope you considered both of these. *Location of New Seal:* [Inquiry:] I'm still at a loss as to how deep to press in the main seal - should it be flush with the housing or jammed all the way in? [Response : Rob Abel] See if you can get a good look at the surface of the crankshaft which was in contact with the lips of the old seal. Sometimes, grit gets in there and causes ridges to wear in the crankshaft. Because of this, many will seat their seals a bit deeper, to offset the lips of the seal from the more abrasive surface of the scratched crankshaft. The idea is to seat the seal so it contacts the crankshaft at a smooth point. Doesn't really matter whether it's flush or all the way in. I would put it just inside of flush if you can, but it depends on the cranks surface.

[Another:] If you install the seal about 1/16"-1/8" further in than the old seal, the lip will have a fresh surface on the crank. [Tip from Washington Volvo Club] Care is required when installing front oil seals—DON'T push in too far. DON'T get it more than 1/16 to 1/8 in. past flush.

Pressing in the New Seal: Installation is NOT the reverse of removal. I used my hands to gently but forcefully press the seals in place. Worked for me... at least they're still holding after 10k miles. [Response: Paul Grimshaw] There is a special Volvo Tool (PN 9995025-5) that is used to press the oil seal into place. Is the tool necessary? Well, the seal is fairly fragile, with an inner spiral spring that can be easily bent. The seal costs almost as much as the press tool, so I'll let you decide the cost/benefit. As for tool necessity to install the seal, if you are careful it can be done without the press.

Some prefer to use RTV sealer, grease, or other sealing compound on the outside diamater of the seal, others don't. If you do use a sealer, use brake cleaner to clean up all surfaces first.

Procedural Tips: More on Engine Seal Installation. [Inquiry:] I'm doing my timing belt and want to replace the seals. I can't bend, push, force or cajole the new cam and idler seals in place. I've tried everything I can think of. Are there any tricks? The old ones were orange reddish, the new are black and seem slightly larger. [Response: Alan C.] Just my 2 cents worth having just gone through this, twice for the intermediate shaft seal. It leaked after installation. When I checked it with a mirror before the second replacement I saw that the lip had rolled out on the bottom causing the leak. Use a mirror and flashlight to be sure the lip is not rolled out. Volvo told me to put white grease in the area that contacts the shaft but nothing on the outside of the seal. They also told me that they redesigned the seals, that is why the new ones are black. Make sure there are no pieces of the old seal in the recess as it would make it hard to press in the new one. I found it helpful to gently slide the seal over the shaft while rotating it to be sure the lip does not roll over. Find/make a press tool from pvc pipe/coupling and use the pulley bolt to press in the seal. Take your time and check the progress to make sure it is going in straight and do not seat it too far in. I do not think it is a good idea to pound in the seal as this might cause the spring on the inside to pop out. Hope this helps. [Response: Don Foster] Last time I did a cam seal I pulled the valve cover and removed the front bearing cap, which also retains the seal. Be careful of the valve cover gasket. The I-shaft seal, as I recall, pried out easily, and the new one pressed in -- a tad firmly (which is comforting). Don't forget to clean everything thoroughly, and lube the seal lip and shaft surfaces before you install the seal. Also, examine carefully to be certain you haven't "rolled" the seal lip during installation -- easy to do, easy to miss. [Editor] The newer OEM grey Viton seals are tougher to install without rolling the lip. Modelling it after the end of the Volvo tool, I made a semi-circular piece of thin plastic sheet, heat-formed in the same diameter as the shaft, to carefully insert between the new seal lip and the shaft after installation. This gently pushes any rolled seal lips back and ensures a correct installation. [Response: Henry Cordova] When my seals leaked after installation, I traced the problem to forgetting to clean the sealing surface on the camshaft before replacing the seal.   I was used to Japanese engines which have a positive stop on the seal to ensure it always goes in the same depth. The Volvo seals don't have this stop, so I put it in just a little off from where the old one was. The old location was smooth due to the presence of the old seal. The new location had some build up which ruined the seal in no time. I pulled it apart, cleaned the camshaft with fine emory cloth and replaced the seal. No more leak. [Response: Kerry Schutt] Be sure to clean the seating surfaces on the engine real well where the seals go. Most of my time doing the job was spent cleaning those areas. I used small cotton rags and lacquer thinner and kept rubbing until it was all shiney metal. I didn't want any leaks after I was done. [Response: Alan Carlo] So now I gently turn the seal onto the shaft when assembling to prevent this. Then check the installation with a mirror and flashlight, all around. Be sure to pre-lube the seal surface where it contacts the shaft before assembly. A Volvo tech told me to use white lithium grease to fill the small recess of the shaft contact area. Also do not hammer the seal in as the jolts can dislodge the spring causing a leak. [Response: Dick Riess] Volvo even went so far as to advise a wait of 20 minutes to make certain they were in ok as they can flip the seal lip. I use some Vaseline on my seal lips and use an old seal backwards to tap on to insert new seal. Don't drive new seal all the way in either. Would clean the crank surface with some of that 3M Scotchbrite of or a strip of fine emory papers like they use to polish cranks. [Editor's note: use the less abrasive Scotchbrite blue]. [Response: Ivan K] To prevent the seal spring from getting out of position during installation, pack the area around it with grease. [Response:] When punting the cam oil seal, I always put a bit of red RTV/Permatex on these seals between the cylinder head and bearing cap for insurance... [Editor's Note: See Cam Seal Replacement] Also use sealant on the valve cover gasket, where it has a sharp bend around the front bearing cap. *If You Are a 240 Owner Reading This:* The only thing you have to worry about that most 700/900 owners don't is maintaining the correct intermediate shaft timing, because the distributor is driven off the intermediate shaft on the 240 versus the back end of the camshaft for most 700/900s. *Crank Seal Leaks After Installation*.

[Problem:] I could kick myself! I just checked my front main crank seal I replaced a week ago! After running the car for a short bit, I noticed leakage at the bottom of the crank housing! Ahhhhgg! I know when I put the seal in it was flush to the housing and felt even all the way around! I have heard you should seat them deeper when replacing one - but it looked good and I did not have the proper seal tool to do the job, plus I afraid to seat it to deep and get a leak that way. I used a giant 3/4 socket to seat it in the past. But this time I didn't have it around! I bet I didn't seat it far enough or messed up the spring! [Suggestions:] If it leaks after installation, you probably flipped your seal lip; I have done it more than once. [More:] Something I did on mine when I replaced it was coat it thoroughly with petroleum jelly. I had been warned that the seal can be messed up by installing it "dry". Also, are you sure it's straight? If it is cocked at an angle, it will leak. Also, You may have popped out the spring! If you pounded the seal the spring can pop out. Check it! If you didn't buy an original seal, check the rotation mark. They make seals for both rotation directions. [Eventual solution:] Spring had popped out. [Jon Scheetz] : If you are looking for an oil leak that appears to be a shaft seal on the front of the engine, be sure to check the security of the bolts holding the metal crank seal carrier cover on the lower front of the engine block. On my 1995 940, I had replaced all the shaft seals when I renewed the timing belt only to have the leak return almost immediately. When I went back in and checked the front cover bolts, a couple were barely finger tight. I did not trust a gasket that had leaked to seal again by simply tightening the bolts. So I carefully removed the front cover, cleaned the block and renewed the gasket. The routing of the engine wiring complicates removing the front cover but it can be done: loosen/remove all the wiring attachments and wiggle. The bottom of the front cover also mates with the oil pan. I cleaned the pan gasket surface with solvent and applied a sealant before replacing the front cover. This fixed my leaks. I now recheck these bolts when ever I'm in to do the timing belt but have not had a recurrence.

Front Cam Seal Replacement. *Tools:*[Tip from Zippy] The latest seal installer for the cam and intermediate shaft seals is nylon and steel (Volvo special tool 9995025) and I don't see how anyone can successfully install the Volvo Viton seals without it. Some replace the seals at every 50,000 service, we do it every 100,000 or sooner if required. (which it rarely is). [Editor] This device is a thin sleeve just large than the diameter of the shaft that pushes out the lips of the seal and seats them against the shaft. You can simulate its results by following the "procedural tips" above. *Procedures:*[Inquiry:] I have identified an oil leak on my 740 as a blown front cam seal and I'm preparing to replace it. Any tips I might benefit from? [Response 1: Don Foster] Very often, the cam seal is the first to leak when you have excessive crankcase pressure -- so it's good you're going after that, too. It's good you're replacing the seal -- excess oil can leak onto the water pump and cause the top "mushroom" seal to leak -- then you'll have more headaches. For crankcase pressure, remember to check and clean the small vacuum line from the flame trap to the intake manifold. Replacing the cam seal is straightforward. You will need a new seal and a timing cover gasket. I first highlighted all the timing marks with white crayon. I then set the engine to TDC. I stuffed a rag into the opening of the bottom cover to prevent losing nuts, sockets, etc. down there. Then the tensioner was pulled back, and I used a small clamp to lock the belt to the intermediate shaft pulley (on a 240, that's important -- on a 740, not important -- but still, you want the belt to stay in position). I also stuffed something down the passenger's side of the belt to prevent it from disengaging from the crank pulley. Remove the bolt holding the sprocket on, using a rubber strap wrench to hold the sprocket while loosening and tightening this bolt. The seal is held in by the first bearing cap, and I prefer to replace it by removing cam bearing cap #1. Of course, this means pulling the valve cover -- so be prepared with a new gasket. The cam seal then lifts out with two fingers. Yes, the replacement seal MUST be prelubed with motor oil, as well as the cam surface. The bolts on the cam gear are torqued to [Tip from Bill Gantt: I found that if you set the belt in place on crank & auxiliary shaft & use a small spring type clamp to hold them in place it helps until you release the tension pulley.] Once the seal was replaced and the cam pulley reinstalled (see torque values below), I looped the timing belt back over the pulley, carefully observing the timing marks. I reset the belt tensioner. Worked great. [Response: Ozzie] You should probably just spend the extra money and replace all three front seals while you have the timing belt off. The only trick I found to replacing the seals was to use a can opener, the triangle tipped kind, to get the seal out...When you put the new ones in cover them in oil and make sure you buy them from a Volvo dealer...I got the wrong crankshaft seal, and lost oil. I had to take everything back off and put the right one in...it took me 2.5 hours to replace all the seals, timing belt, and belts. *Pulley Removal:*[Don Foster] Grabbing onto or jamming the pulley should allow you to loosen the bolt. An impact wrench works wonders. [Editor's Note: Better to use a Volvo tool called a cam sprocket "counterhold" to secure this sprocket. See below under Damaged Cam Gear While Changing Seal.] If you have the special tool for holding the crank pulley, it will also fit the configuration of the cam and I-shaft pullies so you can hold them. I've also used an old timing belt around the sprocket and then grabbed it with a big mutha pair of water pump pliers. The old belt cushions the sprocket teeth, preventing damage. Tighten the cam 'n intermediate shaft pulley bolts to 37 lb-ft of torque. Same for the tensioner nut. [R. Haire] A good rubber strap wrench opposed by a breaker bar should do it. You might see some mention of pliers locking the cam, in a green manual as I recall. Lock on a non-contact part. These tend to be over-tightened, according to the recommended torque for the pulley bolt. [John Sargent] If you insert a screwdriver through one of the sprocket holes in the cam or intermediate gears you can keep the sprocket from turning by pushing the screwdriver tip hard against one of the protrusions under the sprocket. Then use a socket to remove the bolt. *Don't Damage the Cam Gear While Changing Seal.* [Problem:] While removing the camshaft sprocket (for a seal replacement) I put

several small nicks in its teeth. I used a chain vise-grip with grippy rubber stuff in-between the sprocket and the chain. The chain cut through the rubber, hence the nicked sprocket. [Diagnosis:] Why why why did you do that (sorry)? I always used to use a 17mm box wrench, tap the end with a hammer, and depend on the timing belt to hold the gear still. This slowly turns the motor over, but no problem, just move the wrench again. Or, you can use regular vise-grips to grab the non-rubbing part of the camshaft through cloth. You can try to find a used sprocket at a wrecking yard.
[Response 2: Paul Grimshaw] To remove the cam gear (to install the seal on the camshaft), you will need another special tool called a counter-hold. In addition, the timing belt tensioner makes refitting difficult [while the timing belt is in place.] The last thing that you would want to do is wedge the cam gear back onto the cam as you run the risk of damaging the flange.
[Response 2: Zippy] Slack off the tensioner. *Re-Torquing the Cam Gear After Changing the Seal:*

[Tip from Tom Francis] It is very important to correctly re-torque the cam and intermediate pulleys on reinstallation (see this report of a broken index pin to understand why). Torque these bolts to 50 Nm (36 ft-lbs). Use some thread lock to ensure they do not vibrate loose.

Leaking Rear Seal and Replacement Tips. [Inquiry:] I had my Volvo to the dealer today. They told me that there is a slight leak in the rear main oil seal and that it would cost between $700 and $1000 to fix. I only plan on having the car another year or so. Is it really necessary to have this fixed? I never noticed any oil leak and I'm not losing more than .2 qt oil between oil changes (3000 miles.) Is it okay just to keep an eye on the oil level and then fix if absolutely needed? *Diagnostics: Check Flame Trap Function.* Note: for information on B6304 engine rear main seal replacement, see the FAQ file.
[Response: Gene Stevens] Before replacing the rear seal, have you made absolutely sure that the crankcase vent system isn't plugged? The N/A engine uses a flame trap (which doesn't belong on the Turbo, but that doesn't stop some guys from installing one anyway) and when it gets blocked causes excessive crankcase pressure, pushing oil out wherever it wants to go. I've heard of new replacements seals being pushed out of the bore from the same pressure that caused the old one to leak. Curing the pressure may slow or stop the leak.
[Response: Ted] If the seal is seeping keep close tabs on it. Make sure that the flame trap is clear and working properly. If the seal is leaking because of wear this will not be a factor, but if it is leaking because of crankcase pressure the excess pressure can actually push the seal right out of the back of the engine, creating a large leak. *Seal Choices:* [Matt L./Rolyak] There are two rear seals available: one is 10mm thick (red: silicone) and the other (grey or brown: Viton) is 7mm. The more expensive Viton will last much longer than the silicone rubber material.The 10mm is stock and the 7mm is replacement. Why? Because the original 10mm seal wore a tiny groove in the crankshaft after thousands of miles of driving. For best results, the new seal should rub against the crankshaft in a new place (after you have cleaned the crankshaft with crocus cloth or fine steel wool). You could also accomplish the same thing by driving the 10mm seal into the seal housing slightly more than the old one was. [Editor] Volvo grey Viton seal p/n 6842160 is well worth the slight extra cost. When you get the seal, it comes on a round plastic carrier. Cut off the inner protrusion (the lip pointing toward the center of the circle) with a coping saw and an X-Acto knife, then use the carrier as the seal lip seating tool. It will fit perfectly over

the 92mm crankshaft. Insert this after the seal is installed to make sure the lips are not curled under, since the Viton seal is much tighter than the silicone seal. Works like a champ. [John Sargent] If you purchase a universal aftermarket kit, it may come with both the later lipped rubber seal and a replacement for the earlier felt seal (soft white sponge like ring about 3/16" thick) on B23 engines. DON'T install both as some have mistakenly done. *Engine Rear Main Oil Seal Replacement Tips* [Tips: John Sargent] The reason it is so expensive to replace the rear main seal is that the transmission must be removed to access the rear of the crankshaft. See the FAQ section on transmission replacement for more tips. To fix it yourself, you pull the transmission and clutch/pressure plate assembly or the respective auto transmission parts. The rear main seal is pressed into a seal housing. You remove this and press in a new seal. Then you reinstall the seal housing with a new gasket. The seal and gasket are less than $20. When you reinstall the seal over the crankshaft flange, you have to be sure that you don't push one edge of the seal lip over. [Response: Randy] I'm assuming you have a transmission jack. I purchased an inexpensive one from Harbor Freight because several people here at the BrickBoard advised me NOT to try to use a floor jack. It was good advice. It really takes some shaking and push/pulling to remove and install the transmission. My experience is with the 240 but you'll have the same type of situation with the 740. On the 240's it is a very tight fit between the transmission and the sheetmetal in the area of the starter.
While you have it out it is a good time to replace the front seal on the transmission (readily accessable once removed) as well as the rear seal and output shaft bushing if the bushing hasn't been replaced yet (you'll need the gasket between the transmission and the rear housing if you replace the bushing). There are various other seals on the transmission that can be replaced at this time- look for fluid leaks.
The transmission cooling lines may not come off as you plan (rust and corrosion) and you may need to cut those lines to remove the transmission. You can use a high quality hose and clamps to save the cost of purchasing new lines.
Clean up the crankshaft with carb cleaner of something similiar to remove any build up before installing the new mainseal. I packed the back of mine with grease and liberally greased the crankshaft. Don't try to start it straight on when installing on the crank or you might cause the lip of the seal to push out and the spring might come out of place. It would be a bummer to have a brand new rear seal not do its job because the spring was dislodged. [Tips from Chris] Last weekend I replaced (at home with no help) the rear main engine oil seal in my wife's B230F auto. This board has been a great help to me over the time we've been Volvo owners. Here's some of the things I learned during the job. (These are random notes, not a step by step........)

1. It's a common problem (leaking rear main). any local independent volvo shop will be well-versed in doing the job. In NE florida the price for the job is about $350 (it's a big job, really, so think long and hard about tackling this one yourself. About halfway through my project I was wishing that I had had the shop do it. 4-6 hours of labor time in a shop).
2. *Tools.* You need the tools and a good space to work.

- 4 jackstands, a good floor jack, and a transmission jack. Don't neglect to make the work area safe because you will be under the car for a while horsing on the tranny to get it in and out. The regular full assortment of hand tools, including a ratchet set with 12mm and up and an18 mm socket. Prybar & hammer Brake cleaner (for the plate and clutch faces) Long extensions for the bell housing Air wrench Volvo clutch alignment tool(for manual transmissions) Torque wrench

- Volvo flywheel lock. You can also hold the crankshaft with a breaker bar and socket on the bolt that holds the harmonic balancer on the front of the crank, or use the 5284 crankhold tool. This will let you loosen the flex plate bolts without the crank turning.

3. The parts you need are not too expensive. the new oil seal at NAPA was about $20 (I found them cheaper at our local discount chain but they would have to be ordered) and so I paid the $20. While you're under there with the tranny fluid drained, replace the fluid and the the filter and the pan gasket (another $15 kit). I also replaced the front seal of the tranny (pump seal) while I had it out. It was not leaking, that I could tell, but it, like the engine oil seal is a bear to get to and so I did the tranny seal too while I was in there. All together, I think I spent $50 on parts and fluid. Not sure if the $350 at the shop included the parts or not. Also, make sure you know what model tranny you have before you go to the parts store. Ours has a plate riveted on the side of the tranny on the drivers side I bought tranny pump seals for both types and used the one that fit. It can be (was in my case) a messy job. Even after draining the pan and the cooling lines, etc etc the tranny dripped oil all over me and the floor the whole time I was under there. next time I'll be prepared with a short length of fuel hose to cap the two nipples after I remove the lines that run up to the radiator. My book talks about the "option" of removing the exhaust. I took it off and had lots more room to work. I also completely removed the lines at the tranny and at the radiator. not hard to do these 2 things and gives you lots more room. The two top bolts that secure the tranny to the back of the engine block and the top starter bolt are bears to get to. 18 mm. I had to drop the tranny crossmember at the rear of the tranny/engine assembly down so that the angle would allow me access to those bolts. Really tough: required a couple of long extensions to get the ratchet back far enough to have room to use it. Support the engine with a jack stand or transmission jack. After you get the tranny out, MARK THE FLEXPLATE ORIENTATION so you can reinstall it correctly. When you finally get access to the back of the crank where the seal (and the leak is), you will need a small hook tool (or similar) to get the old seal out of its housing. The seal sits in a housing that you can take off if you need to (make sure your engine oil seal comes with the gasket for this housing). I was able to get the old seal out without taking off the housing. [Randy Starkie] The large rear main seals are easy to remove with a screwdriver, as long as you don't scratch the surface of the crank that comes in contact with the rear main seal. Insert the screwdriver so that the exposed back surface of the crankshaft (the part that comes in contact with the flexplate)is the prying point. Get the end of the screw driver up into the old seal and pry it out. Double check the surface of the crank before inserting the new seal. I usually go over mine with light abrasive cloth and check visually and with your finger for sharp edges. Lacquer thinner is helpful in removing buildup and stray abrasive material before installation of the seal. Grease the inside of the seal (but not the metal outside ring) and the crank with white lithium grease. Be careful not to get the edge of the lip hung up on the crankend when getting the new seal started. Get it started and then push the seal against the started edge to get the room you need to get it started all the way around. Once the seal is on the surface of the crank ALL THE WAY AROUND you you tap it into place evenly by working your way around the seal with your striking tool. A 3/8 or 1/2 socket extension allows you to direct the contact on the seal once it is started into place. [Chris] Don't push it in too far so that it slips out the back side of the housing. If that happens, remove the housing and do it right again, using a new housing gasket on reinstallation. Most oil seals that I've dealt with had lips in the

housings that stop you from pushing it too far and make it square to the centerline of the crank. Not on Volvos. (I did the same dumb thing on the front frank seal of a friend's 240). Also, the end of the crank will have some baked on oil and crud on it except for the thin shiny ring where the old seal was riding on it. I recommend that you clean that stuff off (carefully, so as not to nick the crank) maybe with some super fine sandpaper or fine Scotchbrite or similar (?). Make sure that the seal is facing the right way when you put it in. Call me paranoid, but when I replace a seal I always wipe the outside of it with a thin coat of indian head gasket shellack to keep it from weeping around the housing. the book recommends grease for the same purpose. Regardless, ALWAYS coat the lip of the seal (the part that rides on the crank) with some grease to keep it from burning on the crank right after you start it up. [Don Foster] Install your new seal flush or about 1/16"-1/8" deeper. If you see very little wear on the crank, then you can install it at normal depth, i. e., flush. [Tip] To keep the seal carrier bolts from backing out and ruining your starter, use Loctite threadlock when reinstalling these bolts. That's not a bad idea for the flywheel bolts as well.If you are installing the Viton gray seal, see the notes above regarding using the seal shipping carrier to make sure the lips are correctly placed. Getting the tranny mated back to the engine was hard for me. I could get it up to about an inch and no further: much pain here. Finally figured out that the torque converter was not fully seated back into the transmission. The shaft has two slots into which the torque converter must engage in order to engage the cogs driving the oil pump inside the transmission. If the face of the torque converter (the face that bolts to the flywheel/flex plate) is flush with the edge of the bell housing, it's not in far enough. you have to slide it out then turn it a bit and then try to shove it back into the tranny shaft. Took me a while to do this. Place direct, even pressure on the torque converter until you feel it drop. When it's right, the face of the converter should be set back inside the bell housing about an inch or so from the edge of the bellhousing that mates to the block. You may have to turn the tranny face up and rotate the torque converter until it engages and drops an inch. *This is important*, since if you manage to install it with the converter out of place, your transmission pump will not engage. I recommend that you get the tranny completely flush with the engine before attempting to put the flywheel bolts in. I make those the last thing I do when replacing a tranny as they're one of the first things I take out when removing it. [Jerry Andersch] When the torque converter is properly seated it should sit 1/2" below the bell housing flange. If it's flush with it, it's not seated all the way. With the tranny slightly angled up (bell housing higher than the tail) work the TC back and forth until it seats, sliding down 1/2" of so below the bell housing flange. When installing the tranny make sure the BH is slightly higher as you move the box into place, so the TC does not slide forward and out of place. Bolting the autobox into place with the TC not properly seated can damage the transmission. Putting everything else back on and back together is pretty straightforward (heard that before, huh?). During the pull-down I put all the bolts into a single can. Mistake! Many of the fasteners used are the same diameter but slightly different lengths: keep them seperate as you take it apart and you won't have to switch bolts around when they bottom out in the wrong holes during the reassembly.

4. After all this work and my reassembly, mine seemed to continue to leak for a day or so after I put in the new seal. I was sick about it during the time it was leaking. It stopped, though after a bit of driving and has been tight ever since. Looking back, I'm not sure if the oil that I saw on the driveway was really leaking past the new seal while it was getting introduced to the crank OR if it was just some residue oil from before the replacement.

It's a big job, not for the faint of heart. I do almost all my own work but I'm not sure I'd do this one again. Might pony up the $350 next time and let somebody else do it. I'm slow, and I had problems along the way so it took me probably 12 hours total. Having done it once, I think I could do it in 6-8 hours now. I hope this helps, or at least entertains, someone.

[Notes from Paul DePres] Nice write-up Chris. Allow me an addendum.
Stubby box wrenches come in handy for getting the top tranny to engine bolts. The 30" socket extension is necessary for torqueing the bolts, but the stubbies work well for getting them loose and started back in. I removed the ATF lines at the tranny only, and did not have the problems with leaking fluid everywhere. If you plan on removing the seal carrier from the outset, and are not planning on replacing the tranny input seal, then you can leave the exhaust alone; you don't need as much room.
My new Volvo seal still leaks a little bit after several months. I don't know what I did wrong. I used emery cloth to clean the periphery of the crank prior to replacing the seal housing with the new seal. I was very careful, but will probably get a second chance this fall.

Fuel System: Pumps, Relays

Abbreviations:

AMM	Air Mass Meter
ECT	Engine Coolant Temperature sensor
ECU	Engine Control Unit computer (either fuel injection or ignition)

FI	Fuel Injection
FPR	Fuel Pressure Regulator
IAC	Idle Air Control solenoid valve
TB	Throttle Body
TPS	Throttle Position Sensor
VSS	Vehicle Speed Sensor

Filter:

Fuel Filter Replacement. [Inquiry:] The time has come for the fuel filter to be replaced. Rather than pay the dealer an arm and a leg, I'd like to replace it myself. How do I do this?

Replacement Procedure: [Response 1: John B/Tom Irwin/Neos/Philip] Here's how to do it safely:

- Pull the fuel pump fuse while engine is running, engine stops with no fuel pressure left in line.
  - (alternative 1: pull the fuses for the fuel pumps and crank the engine.
  - (alternative 2: attach a vacuum pump to the FPR vacuum fitting and apply vacuum.)
- Shut off the engine and remove the key from the ignition.
- Raise the car (740) high enough, so that you have the best of angles (and room to work) to hold all in proper position.
- The filter and pump sit in a subframe or cradle under the driver's side of the car, mid-ship, held up by three 10mm bolts. The pump is held in place with a cushioned band clamp, one 10mm bolt, that can only be accessed with the tray lowered. The filter itself has two different sized fittings of 22mm and 27mm: each end uses a different size. Do not use an adjustable wrench: buy the proper size open-end box wrenches (Sears). The sizes of the banjo bolts are 18mm (mates into the 22mm or 7/8 inch filter side) and 19mm or 3/4 inch (mates into the 27mm or 1-1/16 inch filter side). These are easily accessed with a ratcheting socket.
- If you are doing this alone, loosen the carriage that holds the filter by ONLY REMOVING THE OUTSIDE NUT that holds it up, then bend the carriage down to work on the filter. The manuals say to take ALL of the nuts loose and drop the whole thing; loosening just one nut makes the job much easier and faster. Unplug the main fuel pump electric connections, disconnect the fuel tank line (plug this one) and disconnect the line to the engine.
- There should be wrench flats on the filter body to counterhold with a wrench as you use another to bust the banjo bolts free. While removing the lines, I almost broke the short line at the front of the filter that goes to the pump. It is real easy to start it bending to the point of having a kink if not careful.
- Instead of removing the filter from the bracket and then trying to disconnect the lines, now I try to leave the filter in place as much as possible, although I find that I do need to loosen the bolts to the cage a little to get my wrenches in there. After the lines are off, I

loosen and push out the filter. When I put it back on, it is difficult to get the right angle of the rubber line around the cage unless it is one of the last things tightened.
- Once free of fuel lines, loosen the clamp around the middle and swap it out.
- Replace fuel filter and banjo gaskets. The new filter will come with 4 copper crush washers, two for each compression fitting -- note the location of the old ones as you remove the fittings. The BEST (most successful) way to reinstall the fuel lines is with an impact wrench, while gripping the filter body with a free hand. Just "BRrraaapp!" until it feels right. Using hand wrenches, you stand a good chance of twisting the lines under load, potentially causing a leak failure. Use a backup wrench. And be EXTREMELY careful.
- Cinch the clamp. Bend the cradle back up and tighten the bolts.
- Check for leaks when you are done and it is running.

Gasoline Spillage. [Tips from Patrick] Make SURE the negative cable on the batt is disconnected! (have your radio code available.) Be EXTREMELY careful as a significant volume of fuel may come out. Be ready to catch all the gas in the filter and the line between the filter and the engine. Some gas drips out of the main pump with the filter removed, but it won't be much as long as you keep the pump and tray assembly elevated as you replace the filter. If you remove all the carrier bolts, have an old box or something ready to support the weight of the tray -- don't let the tray hang by the fuel lines! An oil pan has more than enough volume to do this job. One last word of caution ... don't smoke when doing this job.

Copper Washers. Whenever you change the fuel filter, make sure you have four new copper washers. The filter should come with them, or you can buy them from the dealer. Wagner Brake sells them as brake fitting copper washers, numbers F17 and F10775, at auto stores. There is a copper washer on each side of both banjo fittings. They really aren't designed to be re-used (the old ones work-harden and won't crush enough to make a seal) and four new washers should have come with your new filter. If they didn't, try annealing the old ones. First, dress both surfaces with a flat file, or fine sandpaper on a flat surface to remove ridges left from the banjo fittings. Second, heat the washers to bright cherry red with a propane torch and let cool. This step anneals the copper. Third, clean again with a file or fine sandpaper. When reinstalling, don't get crud or rust-proofing material stuck between the copper washer and the fitting (this crud usually isn't visible after installation).

Fuel Pump Feed Line

Worst Case: Bolts Stuck; Fuel Line Breaks. [Tip from Fisher] If you find that while working under the car, you absolutely cannot remove the corroded fuel filter bolts, you can remove the lines to the engine and to the tank which is easily done. You can then disconnect the fuel pump wires and the whole cradle, pump and lines will come right out. Now with the filter off the car, remove the lines at the filter. [Editor] If you break the small connecting fuel feed line, get another one from an online retailer (e.g., FCPGroton) for around $30.

Airbag Deployment While Changing Fuel Filter. [Tip from Abe Crombie] There is a Volvo SB out on precautions when changing fuel filters. The SRS Airbag system is powered anytime the key is in position I or II. If you are listening to radio while changing fuel filter and you are using air impact tools there are real risks of deploying airbag as you re-install the fuel pump/fuel filter bracket. The hammering of air impact tool on bolts securing this bracket which is very near crash sensor location in floor pan on inside of car, can cause a deployment. This sounds like someone found out about this the hard and expensive way. The bulletin only mentions 700/900 series but the 240 crash sensor is not too far away from the same location. LEAVE KEY OFF WHEN CHANGING FUEL FILTER!! If you need tunes get your rhythm somewhere else besides the car radio. [Comment: S. Ringlee] By extension, then, if I use impact tools on such things as suspension bolts or anything else likely to jolt the body while the ignition is on, the same result may occur. $2500 lesson (bags, sensors, seat belts, glass, speakers, heaven knows what else.) Your advice is great: listen to a boom box and NOT the car radio while banging on the car. Thanks for the tip.

Fuel Injection Relay:

Fuel Pump and FI Relay Diagnostic Tests. Here is a procedure to test the operation of the fuel injection relay and the operation of both fuel pumps. The 3 main things to check in the fuel circuit are the fuel pump relay, and the 2 fuel pumps.

1. *Fuel Injection Relay Test*. There are 2 relays inside the fuel injection/pump relay. One of them should turn ON when the ignition is turned on (without turning over the engine), and the other relay (which actually turns the fuel pumps) should come ON when the engine turns over/runs. You can check the 1st relay by putting your fingers on the relay module and turning the ignition on and off repeatedly. You should feel the relay click on every time. If it doesn't, that relay isn't working. And you'll find the car doesn't start if the relay did not come on. [Tips from Bob Dietz] Locate the main fuel injection relay, pop the cover and operate the contacts with your finger to operate the fuel pump when the key is on. If the pump operates then the problem is in the spark side of the equation. If the pump does not operate then replace the relay. If the pump then operates on its own when the key is switched to start, the problem is solved. If not, leave the new relay in place and check for current at the pump. If current exists, replace the pump. If the pump is defective, you'll want to replace the relay anyway because of an internal diode across the contact points that protects the fuel injection computer. High current loads from a failing main pump will cause extreme arcing across the point contacts on shut down and damage the diode protection circuit.

2. *Fuel Pump Diagnostic Tests*. On the 740, the fuse-box + relay box can be pulled out a little to facilitate inserting/removing relay modules. So pull it out as much as the wires will allow. Pull out the fuel injection/pump relay module. Now take a small piece of wire to jumper terminals 30 and 87/2 on the relay board (the terminals are identified on the relay module pins. The 2 terminals are the nearest left and middle right pins on the relay board). This should make the car act like the fuel pump relay is ON. Note: be careful that you insert the jumper ONLY in these pins, else you will damage the ECU.

Now turn the ignition ON (without turning the engine). You should hear a whirring sound right from where you are. That will be the main fuel pump. Now go to the gas tank and unscrew the cap. Put you ear to the hole and you should hear a smaller whirring sound. Or, listen with a piece of heater hose to the tank pump through the gas filler with car running. Should hear a humming. That will be the in-tank pump. If you hear both noises, the fuel pumps should be OK.

To check the pumps individually, you can pull out the in-tank fuel pump fuse after you do the above test, and repeat the test. You should not hear any whirring at the tank, but you should be able to hear the main pump. [Bruce Young] For cars using fuse 11 to power the in-tank pump or Regina main pump (NB: Regina and post-1994 cars have only one pump), you can test fuel pumps individually. Improvise a jumper wire with a flat male terminal on each end. Disconnect the fuel line at the injector rail and route it into a safe container with a helper watching. To run or test the *In-Tank Pump*, remove fuse 1 and in-tank pump fuse 11 and apply battery voltage from the fuse 1 terminal *closest* to you to the Fuse 11 terminal that is *farthest* away from you, i.e., toward the engine. BE CAREFUL that you do not ground this jumper. The in-tank pump should push a good flow of fuel through the unpowered main pump all the way to the injector rail. To run/test the *Main Pump*, jumper voltage from F1 to the other F11 terminal—the *closest one*.

CAVEAT: The main fuel pump is not designed to be run without the in-tank pump "on", so get the second part of this test over quickly. You should not need to keep it running in this condition for more than a few seconds to complete this part anyway.

Symptoms of Bad Pump Relay. [Symptoms:] 89 740 died & started 10 min. later. My '89 740 did the EXACT same thing for a while. When it acted up it did have spark. It seemed to be related to getting hot. It would die in motion, or when hot, it would also refuse to restart 'til it rested for 10 min. As far as driving it, not much you can do, just be prepared to pull over and give it a rest for 10 min. When it acts up, as the key is turned "ON", listen, the fuel pump should normally be heard to come on for about 1.5 sec. If it's not coming on, I'd bet on the relay. [Diagnosis:] After replacing the fuel pump relay ($38 at dealer), it's been 100% fine. [Editor's Note: See the note on "Headlamp Circuits/Relay Won't Function" in the Electrical: Lighting section for more relay information.]

Fuel Pumps:

Fuel Pump Noise. Fuel Pump Noise. [Inquiry:] My car is running perfectly but whenever the fuel-gauge drops to around 25%, noises coming out unexpectedly, but after refuelling the noise will suddenly disappear. Does anyone could tell me what's wrong with my car? [Response 1: Michael Pardee] Sounds like the hose on the in-tank fuel pump has a hole in it. That is very common, and if the hole gets much worse, it will not be able to run below 1/4 tank at all.

Fortunately, it's an easy fix. [Response 2: Peter James] I would agree with that and/or the intank pump has failed and you are now stressing the main pump, which in turn can lead to premature failure of the main pump.
[Response 3:] Are you sure it's the in-tank pump, not the main pump down by the rear wheel arch that is making the noise? Most commonly this pump makes this noise not because it is failing, but because the in tank pump is not supplying the fuel to it for some reason. It won't do it any good to operate in this condition, and when the main pump fails, you're stuck at the roadside. The most common causes of in tank pump woes are not failure of the pump itself, but two other possibilities:

- The little sock filter on the in tank pump intake is blocked with debris
- The pipe from the in tank pump has split.

Both require the pump removed from the tank to rectify unfortunately.

[Tip from Jeff] If you turn the ignition on to KPII ("on" but not started), the fuel pump should turn on then off after a short time as pressure increases. If the secondary, high pressure fuel pump runs continuously then the appropriate pressure is not building up. Check the fuel pressure regulator and the primary in-tank low pressure pump for faults.

Replace Rubber Bushings. [Tip] I replaced the three fuel pump cradle rubber bushings (Volvo p/n 1255018-2) three weeks ago and today I realized that I wasn't hearing the fuel pump anymore. Replacing all the rubber bushings in many places in the car has made a huge difference in the way it drives and handles.

Fuel Pre-Pump Problems & Diagnoses. *Note: 94/95 940 and all 960 cars lack a pre-pump; they have one main in-tank pump instead.* [From RPR ; illustration copyright and used by permission:] 7xx/9xx Volvos (except later 940s) are fitted with a fuel pump inside the fuel tank. This pre-pump, also called a primary or feed pump, moves the fuel out of the fuel tank to the main fuel pump under the driver's seat. This prevents fuel starvation problems that may occur when the tank is less than half full. If the main pump has failed, the car will not run. If the pre-pump is inoperative or if the junction hose has failed, you'll have fuel starvation symptoms.

These may include hard starting, inexplicable poor idle, louder than normal main fuel pump noise and a loss of power under load. To check the operation of the pre-pump without removing it from the tank, locate the pre-pump fuse. Remove this fuse with the car idling. You should be able to detect increased noise from the main pump and decreased vibration of the fuel tank itself.

Fuel Pickup and In-Tank Pump

Diagnosis of pre-pump: Are there any short cuts to check to see if the in tank pump fuel pump is working? I opened the gas cap and did not hear any noise.] You should really be able to hear a "buzzing" sound in the fuel tank if the in-tank pump is running. Sometimes a length of heater hose inserted in the filler neck and placed against your ear will help isolate the sound. Try it with the fuse in place and removed and listen for a change in the sound. You might also find another Volvo owner who might let you probe their filler neck with your length of hose and listen to their in-tank pump . Assuming their in-tank pump is working you would be able to determine the sound you are listening for. If you do take it out of the tank:

> Replace the short segment of rubber hose with a new section of fuel hose.
> Replace the "sock" that is on the end of the pickup tube (about $15 from Volvo)
> DO NOT bench test the in-tank pump. When the pump is removed from the tank arcing will occur when powered up and can result in a fire due to the gasoline vapors present. Certainly don't remove the pump from the fuel level in the tank and give it a quick bump on the starter to check out its function- that can result in one hell of a fire (and explosion). The pumps are designed to run submerged in gasoline.

Symptoms of worn fuel pre-pump: My experience with a worn fuel pre-pump is that it will cause the engine to miss and lose power under conditions of high flow (high throttle and high rpm). The problem grew worse very gradually (over 10's of 1000's of kms). It certainly wasn't going to leave me stranded anywhere. [Another example:] My wife drives an '83 760, which I have maintained as needed. Recently, the car started to vapor-lock in warmer weather, and/or when the fuel level dropped to around a 1/4 tank or lower. Oddly enough, when I refill the tank, the problem seems to go away. [Test Tip:] As far as a definitive test goes, I guess it would be necessary to set up a pressure gauge and flow meter as well as a valve in the circuit that would allow a specified volume to flow while reading pressure, but see the above fuse and noise procedure for an alternative. [Editor] Hard starting and poor idle have been traced to a bad pre-pump, if other symptoms are also present such as main pump noise.

[Car Stalls During Turn: Fuel Prepump Failing.] [Inquiry:] I bought a used '87 760t. It ran fine when I first got it but after a few months it started stalling when making a left turn. Not every time, but its worse (more likely to stall) if I'm decelerating, in fact I can usually avoid the stall if I slow down before the turn and then give it some gas during the turn. When it does stall it almost always starts right back up no problem. [Response: MikeW] The stalling during turns is usually indicative of a problem with the in-tank fuel pump. Does it happen when you have a full tank of gas, or only when your down around 1/3 tank or less? Anyway, it sounds like your in-tank pump may be bad, or the rubber hose connecting it with the metal line running out of the tank may have deteriorated, or the filter sock on the bottom of the in-tank pump is plugged.

Changing Fuel Pre-Pump: [Parts note from Editor] If you change the pre-pump, have your parts guy supply two compatible nuts for the electrical connections (threads differ) and the OEM outlet hose. [Erik Smith] Before changing the pump, make sure that the fuel pump ground connection is not the problem: if the connection to the body is not intact, the symptom will mimic that of a failed pre-pump. [John Sargent] There is a metal panel (about 6" X 6") under the carpet in the trunk, left of center, in front of the cargo/third seat compartment. Remove that panel. You will see the top of the fuel pre-pump/sending unit assembly. It is retained by a large plastic nut. Take the hoses off, remove the plastic nut, free the electrical wiring from any clamps and loosen both the connection in the trunk and the grommet through which the wiring passes. Mark the orientation of the round plate so you can reassemble it correctly. The fuel pump assembly can be manipulated through the hole. It is very easy to reverse the wires that attach directly to the pump, so make sure you locate "+ and -" on the pump and install the wires with correct polarity. When reassembling, don't overtorque the plastic nut and strip the threads. Access Tips: there is a black ground wire that needs to be either disconnected or cut and re-spliced. To remove the panel covering the fuel sender in the wagon, push the rear seats forward, pull back the front floor panel, remove the three nuts holding the panel in place, and pull the panel up and forward to remove. It is secured by adhesive or Velcro and two clips that clear once it is pulled forward.

Bosch Fuel Tank Pre-Pump

Pre-pump Outlet Hose. Don't let those guys charge you $200.00 for working on your pre-pump! Most likely the small piece of rubber fuel line between the in-tank electric pre-pump and the metal output tube has eroded and needs replacing. This is not a difficult job but requires getting under the car to detach the pre-pump output line from the main fuel pump inlet hose. Then the rest of the pre-pump removal can be done from inside the trunk. The hose is about two inches long in the sedan (Volvo has a nice OEM bellows hose for this application) and about nine inches long in the wagon (standard 5/16 inch fuel hose will work, but you are better off buying the OEM hose from a dealer since it is an exact fit.)

Fuel Tank Line Clamp Recommendations. [Inquiry:] Which clamps work best on fuel lines inside tanks? What's their projected life span ? [Response: Jim McDonald] Breeze Liner all-stainless clamps: about 250 years; somewhat less in plain steel. Buy Breeze Liner clamps from a truck dealer.

Fuel Sender and In-Tank Pump Replacement. [Tips from Dave Stevens and David Schermbrucker]

Fuel sender unit removal and replacement (see below for later Bosch and Regina one-pump systems) See also the FAQ .pdf file describing the OEM procedure with diagrams, courtesy Volvo Car Corporation, copyright; all rights reserved. Note: some browsers will not directly open a pdf plugin. Right-click to "save as" and save the file, then open it directly in Adobe Reader).

[Note: See *Removing Rear Floor Panels for Access to Fuel Tank and Pre-Pump* for instructions on wagon fuel tank hatch access.]

If the tank is brim full you will need to siphon some gas out. Ideally the tank should be 3/4 full or less. If the rear of the car is securely up on jacks or ramps then this is less of a problem.

First disconnect the hose coupling under the rear axle housing -it will be half-seized so apply penetrating oil, give it some time, use a proper flare wrench on the brass collar and an open end wrench as a counterhold to avoid twisting the metal line, work it back and forth with more penetrating oil once you get it started. Inspect the lines; you may need to replace the rubber hoses. NOTE: Volvo uses non-standard 1/2 inch pipes; most auto parts stores only carry up to 3/8 inch injector hose. Before you cut those lines have replacements ready. This applies to the rubber lines running to the main pump and from the fuel filter as well.

Then disconnect all the other clamped hoses on the sender housing: one is a vent hose from the fuel door supply tube; one is the feed hose to the fuel pump; one is the return hose. The clamps will usually be badly corroded. Be careful with the electrical connector on the sending housing: treat that connection as if it were made of gold because if it breaks, then you lose ground contact with the base of the sending unit and you might as well throw it away. Disconnect the electrical connector in the left trunk well, cut the plastic ties, and feed it out of the chassis. Push the wires through the body into the axle area by pushing the rubber grommet out of the sheet metal. If you can't fit the plastic connector holder through the chassis hole, just record the wire colors and their locations in the plastic holder you just disconnected. Separate the plastic connector from the wires by inserting a jeweler's screwdriver into the slots inside, depressing the locking tang between the U-shaped side tangs on each wire (look into the back of the connector with a flashlight), then pulling the wire and metal connector out of the plastic holder. Undo the plastic knurled sender lock collar -you can tap around the lugs at an angle using a piece of wood to start the process. Now you're ready to perform the sender extraction.

Twist and pull the unit straight out until it is free of the collar. Now pull all the fuel hoses and wires out of the trunk opening. Once you get the rubber collar free there is no need to force anything. Now, starting from the six o-clock position turn the unit clockwise to about the ten o-clock position, tipping it up as you pull it out. Note the position of the filter sock (if it's missing you've knocked it off and will have to fish it out of the bottom of the tank). Check the filter sock for damage or dirt -replace as needed. The rubber neck seal usually needs to be replaced: buy a new one before you start the job.

Replace the pre-pump. That's the easiest part of the whole job.

Now is the time to remove rust from the sender top, treat with Metal Ready deruster, and paint with POR-15. If the fuel outlet bases are cracked due to corrosion or if you have a holed area, repair with JBWeld epoxy, then apply POR-15 and repaint. While doing this, be very careful to not damage the three wires and the ground connection. If needed, get your old sender unit top plate, which may have rust and cracked pipes, rebuilt at a local radiator shop; they can clean off the rust and braze new outlet pipes into place. Much cheaper than replacing the whole assembly including pre-pump.

On re-installation, take a look in the tank with a flashlight and note the anti-splash bucket in the bottom. You've got to get the unit back into there without knocking off the filter sock -just follow the extraction gyrations in reverse without letting the sock go too far to the left or right so as to catch on the bucket. Also note that the bottom of the sender sleeve is spring loaded in a fully extended position. I find it makes the whole process much easier if you loop a string under the pre-pump so you can pull the sleeve back during initial installation (pull out the string once you get it vertical). During the final stages of re-installation you'll need to bump the sender unit up and down to get the unit to sit properly with the sender plate flush to the opening. As I recall, I found it best to install the rubber collar first then push the assembly into it. What matters is that the rubber collar is seated properly all the way round the opening lip and that the sender unit face is completed seated flush to the rubber collar before you hand tighten the collar. If you smell gas fumes a few days later then you know you didn't get the sender seated properly. Do not overtighten the collar or the threads will slip. If you must tap the ring to tighten it then don't go much more than about 1/4 turn. I highly recommend putting a 5" stainless steel hose clamp (available at places like Home Depot) around the collar to prevent the collar from expanding and stripping threads (do this with the hose clamp lightly tightened). Fully tighten the hose clamp when done. Apply spray asphalt rustproofing after installation.

Installation Tips [Colin] The Bosch pump assembly is both telescopic and spring loaded against the cover plate and seats into a receptor in the base of the tank to ensure that the pick-up screen sits at the very bottom of the tank. Unless you disable this spring feature temporarily it will engage too soon and prevent you from rocking the assembly. To disable this function pass a thin cord or or thread though the return fuel pipe of the assembly. Compress the telescopic portion, wedge it in this position with a cocktail stick or similar then tie the end of the thread to the end of the wedge. Fit the unit as previously described and then pull on the thread to remove both the wedge and the thread. If you lose the wedge from the end of the string it won`t cause any problems as it will float on the suface of the fuel and cannot get sucked into the pump.By far the easiest (possibly only) way to refit the assembly is to fit the gasket into the tank first, then push the assembly into it. A straight push may result in pushing the gasket into the tank, what is required is a relatively gentle push combined with slight rotary/rocking motion applied to the assembly. [Doug Bostrom] When replacing the tank pump/sender assembly, put a little vaseline on the surface of the pickup that mates with the wide gasket surface leading into the tank. By then positioning the gasket into the tank neck and inserting the pickup unit the job suddenly becomes much easier - the pickup practically dropped into place by itself. It is also helpful to put the gasket in place after getting the pickup unit prepositioned without the gasket being in the way. The gasket will stretch around the pickup, allowing it to be added to the stack quite easily.

Rust on Fuel Sender Top. [Editor] A frequent cause of fuel sending unit failure is rust. The design and placement encourages rust, which then loosens pipes and electrical connections and ruins the sending unit. The replacement cost is $350 and up, so you may want to consider rustproofing the area when you open up the fuel tank to replace a prepump or sock. Normal spray-on tar rustproofing does not work if the sending unit top has already begun rusting. Instead, carefully wirebrush the top, including pipe connections, and clean it off using alcohol or brake cleaner. Let it dry, then apply POR-15 rustproof paint. Once this dries, apply spray-on tar rustproof such as 3M.

Main Pump (In-tank for Bendix/Regina/Later Bosch Systems/960 Cars):

[Procedure from Kuba] I have a one-pump-only Regina in-tank system on a '93 940 wagon. The access to the tank in the wagon makes life really easy. But first relieve the fuel system pressure *and* have your wife handy with a fire extinguisher. Make sure she knows how to use it (how to pull the pin and how to squeeze the trigger). See Art Benstein's illustrated website procedure: http://cleanflametrap.com/ReginaFuelPump/ Helpful tools when you do this job: an LED headlight to illuminate the area.

Replacement Pump. [Editor] This pump is made by AC/Delco and may be obtained from aftermarket sources such as [FCPGroton]() for far less than from Volvo.

Removal. First clean everything with PBlaster before opening it up. You will need to disconnect the wiring, the top of the round cover of the sender assembly, and perhaps the large fuel filler hose. The fuel feed line (pressurized one) on newer Regina-equipped cars has a quick-disconnect which can be difficult to remove: pull the black plastic cylinder sleeve back and then pull the hose off. Most others have hose clamps. The clamp on the fuel return line is a spring type (although it may be equipped with a crimped-on hose clamp fitting, depending on the year), others are worm screw type. Just undo those and you're OK. The crimped clamp may require cutting. To reassemble the quick disconnect, just pull the cylinder sleeve, push the whole thing back on the metal pipe, and release the cylinder. The electrical wiring going to the sender is connected in left trunk well. Disconnect it there and pull it out working from under the car: do NOT attempt to disconnect it at the sending unit. You will need to see the slosh pan on the bottom of the tank to be able to clear the assembly when removing or installing it. Use a flashlight to see the pan, or remove the fuel. Either siphon the excess fuel out (NOT BY MOUTH!), or if your car runs just run it a little more till you go through most of the fuel. To get the assembly out, rotate it clockwise from 6 to 10 o'clock. You will likely need to peel out the tank seal and store it on the sender top, once clear of the tank, in order to withdraw the entire unit.

Reassembly Preparation. Don't even think of putting the rubber seal in yet. Just leave it out. You will be able to put it back later. If you insist on putting it in tank or on the assembly right now, you are making your life miserable. Get a piece of a cord. Make sure that it's won't dissolve in gasoline. A cotton knitting thread worked for me. Fold the cord in half to get a stronger version, push it through the vent fitting - the only "uncommitted" (as in nothing on the inside) fitting on the cover plate. Pass the cord under the *thicker* bracket (zinc-coated, not brass) that holds the fuel pump assembly together and back through the vent fitting. Pull the cord so that the movable part of the sender assembly goes against the stop in the topmost possition. Tie the cord outside around the fuel feed line. That way you don't have to constantly pull on it while wiggling the assembly to make it fit.

Reassembly. Take a good look at the yellowish anti-slosh pan on the bottom of the tank. See the high side plates? You'll need to maneouver the assembly around them. Put the assembly in through the hole in the tank so that the bend in it points more-or-less at 3 o'clock. Push the assembly in some more while rotating it counterclockwise. Make sure you know when it's vertical. You'll need to clear the left-side edge of the anti-slosh pan on the bottom of the fuel tank. In order to achieve that, you don't want to push the assembly all the way into the tank - push it in only as far as you need to rotate it. To properly seat the bottom of the sender on the center of the slosh pan, you need to make the final 10-20 degrees of counterclockwise rotation with the assembly tilted up inside the tank so as to clear the edge of the pan. When the assembly has cleared the edge you'll be able to finally get it to vertical orientation (end of clockwise motion). Then push it in fully (2-3" deeper compared to where it should be right now). Make sure it seats properly. This is impossible with the rubber seal in the way. [Tip from Philip] I discovered that the unit is spring loaded and collapses in itself about 5-6 inches as it rides up and down (like a telescope) within the larger part of the unit. Knowing this, I was able to install it by keeping it collapsed using a string and I was able to do this from the top (from inside the trunk). The UK Haynes manual suggests you compress the spring in order to install more easily: wedge full up with a match stick with a string attached and run out thru the vent pipe. Once installed, the string pulls the wedge free, letting the spring release properly into position.

Seal Installation. The rubber seal's purpose is essentially to keep the gas where it belongs - namely in the tank. To that end you'll notice that the side of the seal facing into the tank is split (bifurcated) - it looks like two concentric rings. Since the in-tank side of the seal has two concentric lips, it's next to impossible to get it to seat while the seal is on the sender/pump assembly cover. Now pull the sender assembly out so that the cover with its rim clears the tank. It will get messy. Spray a bit of WD-40 on the inside and outside of the seal, and onto the seal seating surfaces (cover and tank's rim). All four surfaces (inside/outside of seal and mating plastic surfaces of tank and cover) must be slippery. Don't overdo it -- spray at one point and then smear it nicely all over the seal and mating surfaces. Stretch the seal a tad and pull it over the sender assembly cover. Push the seal about halfway into the rim in the tank. With a rotating rocking motion (rock the sender in the seal slightly), slowly push the sender assembly's cover into the seal, and use it at the same time to fully seat the seal in the tank. After it's fully seated, pull the assembly out about 1/8". Feel the gap between the tank rim and the sender assy cover - make sure that the slight flange on the seal is present all around the cover. If you've pushed the seal improperly so that the flange made its way into the tank, pull the assembly out enough to be able to repeat pushing the seal halfway into the tank and following. With slight rocking, push the assembly back fully into the seal. It will obviously go only the same distance as you've pulled it out in step 8 above.

[Tips from C Weidner) I have the Regina style fuel system - one pump - and it’s in the tank. Pump replacement seems like a pretty straightforward job, and for the most part is. Two obstacles - the pump assembly was wired straight into the wiring harness; there were no plugs.

This required soldering. Nothing serious, just annoying and un-volvolike. The biggest hurdle was getting the pump assembly to fit back in the tank. There is a large, plastic, oval ‘cap’ that threads onto the plastic fuel tank - this cap is what snugs the assembly to the tank. AROUND the assembly is a rubber seal (about 2” deep) that sits between the assembly and the tank opening wall. I hope this makes sense. It was a bear. It wasn’t until my neighbor came over and got underneath the car, and I got out the vaseline (no funny stuff, I was crammed inside the trunk) to coat the seal, did we get the it to seat. IT took three hands. The secret was not to do the obvious/easier route and put the seal around the assembly, but to seat the seal in the opening and push the assembly through.

Regina In-Tank Fuel Pump

Gas More Than Empty But Can't Be Pumped Out. [Dan Ray] There are two marks on the edge of the tank stalk top, where all the hoses are clamped, that align with the weld seam in the gas tank. If for some reason the stalk is not in alignment, the pickup tube will be higher than the bottom of the tank and not allow for the use of a full tank: more gas will be left at the bottom that can't be sucked out. If you clean off the tank cap with all of the hoses, you will see a mark on each side, just within the plastic nut. Kind of like horizon marks, they follow the seam weld of the plastic tank. Align these for full use of the tank.

Fuel Gauge Failure: Fuel Level Sending Unit Repair

[Procedure From Nathan Babcook] Fuel Gauge failure seems to be rather common in 940 Volvos. I requested a received a lot of information before finally solving the problem. The Fuel Level Sending Unit and Tank Pump assembly is a fairly straightforward design. There are no a lot of moving parts to break, and if you are careful about your diagnosis you can avoid having to "crack anything open."

Diagnosis Proceedure. As discussed previously, be sure you test the gauge with a 1/2 watt 68 Ohm resistor. it HAS to be 68 ohms, 47 will not work! Nearly every radioshack stocks the 68s, they retail for around $1.00 for a pack of 5 (Part no. 271-1106) - check the radioshack website before you head over, as the employees frequently don't know what they have in stock!

Be sure the car is turned off! Disconnect and "bag" the negative (black) battery wire (is ued two zip-lock freezer bags) Also be sure you get the radio-activation-code - if you need it.

Find the sending unit plug and disconnect it (in the 1995 940 wagon it was a 4-wire quick connector located in the driver's side hidden compartment). There should be a Black, Red, Brown, and Grey/White wire. Note: the brown wire becomes a second grey/white wire in the where it runs to the sender unit itself - Nothing to be worried about! The red wire runs to the pump, the black is your ground and the grey/white and brown wires are your fuel level sending unit wires. [your wires may differ slightly in color depending on year]

Before you deal with the sending unit, be sure that your much-easier-and-cheaper-to-replace gauge is working. Bend ONE resistor into a "U" and insert it into the harness side wiring - one side into the ground (black wire) connector, and the other side into the brown wire connector (or grey/white, I forget, I don't think it matters). If your wiring harness and gauge are fine, the you should read approx 1/4 tank (after you reconnect the battery and turn the key to KPII). If you can't get this to give you a reading, suspect your gauge is at fault - a cheaper and easier fix or that your wiring harness is at fault (see the gauge fault diagnosis in the FAQ)

If the gauge and main wiring harness is fine, then your fault lies in the sender or the wiring to the sender. Use a multimeter (one capable of reading small scales like 1-250 ohms is best). Measure the ohms between the two grey/white wires coming from the sending unit. If the sending unit is perfect you should get a reading between 2 and 131. If you get no reading (i.e. infinity - an "8" on it's side) then there is a problem with the wiring or contacts inside the unit and you'll have to pull it.

Diagnosing and repairing the damaged nickle-plated contact is discussed elsewhere. I found that in my original unit and a spare that I grabbed from a junkyard, the contact strip was perfect and undamaged.

Pulling the Unit. Pull the whole sending unit. Once you have the unit pulled, drained of gasoline and dry, turn the unit over to be sure that the slide moves easily (you can hear the float inside the float canister sliding from top to bottom). If it doesn't then your problem is inside the canister (see "repairing the sending unit"). If it does move easily, you may not need to crack it open.

Break out your multimeter and measure the resistance again by touching your probes to the coils that stick out of the top of the float canister (hint: the two grey-white wires are sodered to them). Be sure you move the float up and down by turning it over and measuring it with the float at EACH end of the canister! If the coils and resistor contacts are fine you should get a resistance reading of around 2 at the top (full) and around 100+ at the bottom (empty). If you get a reading here, then you can assume that your grey/white wires are the problem. To check these wires, de-solder (or cut) the wires free from the coils (I marked one with a sharpie so that I could put them back if needed). After they are free, connect them to each other (twist or clamp) and measure the resistance at the plug-end of the connector. If the wires are fine, you should get a 0 Ohm reading. If not, then you'll need to replace the wires (good luck).

If the wires are fine, and the sending unit float is giving you proper resistance, then you can be fairly sure that the fault lies at the solder point.

The Repair. Clean up the wires and re-solder them to the coils. Be sure that you can get resistance at the plug end of the wiring. This worked for me. Although I'm not sure if it will hold up, I went ahead and installed some shrink tubing over the connectors as an added level of protection. If you can now get the proper resistance from the sender apparatus at the plug, you are in good shape.

Final Testing. Head back to your car and plug the sending unit into the harness (DO NOT put it in the fuel tank yet!!). Reconnect your battery and turn the key to KPII - BE CAREFUL!, when you turn the key, the pump should fire up and could make the unit jump, possibly falling and damaging it!!! It may take a few seconds for your gauge to respond to the repaired sender - particulary if it's been at "E" for a long time, but you should be able to turn the sender so that the float "falls" to the top, this should make you gauge rise to "Full" (eventually). Be sure you let it fall to bottom and be sure that your "low fuel" light comes on. Repeat to verify your repair. If all goes well, you may have just saved yourself $500.00 in parts and more in labor!!! Hint: don't run the pump longer than necessary since it is cooled by gasoline in the tank.

Reinstall. Replace the sender unit/pump in your fuel tank (easier to get into the tank, but harder to get that rubber seal and locking ring on) It's not fun, but think of all the money you just saved!

Fuel Main Pump Problems and Replacement
Why Do Fuel Pumps Fail?
[Tips from Counterman Magazine, August 2001] What causes electric fuel pumps to fail? Electric fuel pumps can fail for any number of reasons:

- Loss of current or low voltage - The pump can't run without electricity, so anything that prevents current or voltage from reaching the pump will make it stop. This includes corroded, loose or broken wiring.
- Dirt - Dirt, sediment or other debris in the tank can clog the pickup strainer, accelerate pump wear, damage the pump and/or cause the pump's check valve to stick open (which can cause a hard starting condition due to loss of pressure when the engine is shut off). When dirt has caused a pump failure, or if there appears to be a lot of dirt or sediment in the tank, the tank should be thoroughly cleaned to prevent a repeat failure.
- Rust - Corrosion inside the tank produces rust, which can flake off and plug up the pickup strainer and have the same damaging effects on the pump as dirt. Rust is caused by condensation, which occurs during cool, humid weather when the fuel tank is low. Keeping the tank full will minimize the formation of condensation. If the tank is badly rusted or leaking, it should also be replaced.
- Wear - Most pumps are capable of going 100,000 miles or more, but depend on lubrication and cooling provided by the fuel itself. Frequent driving with a low fuel level may occasionally starve the pump for lubrication and cooling, which can lead to accelerated wear or even pump damage. If a vehicle experiences a momentary hesitation when cornering, for example, it may be because the fuel is sloshing away from the pump and allowing it to suck air. Wear can also be caused by running at excessive pressure. A faulty regulator, check valve or crimped line can cause blockages that force the pump to run at a higher-than-normal pressure - so too can a clogged fuel filter. If the underlying problem is not diagnosed and corrected, it can cause the replacement pump to fail prematurely as well. Regina-equipped cars with the Bendix fuel system and the single AC in-tank fuel pump tend to fail before 100k miles.

Noise may sometimes be an indication of excessive pump wear. Noise can also be caused by a failing fuel pre-pump inside the tank. For proper engine performance, the pump must be able to deliver the specified fuel pressure and volume of fuel for the application. If it can't, the pump needs to be replaced.

Symptoms of failing main fuel pump.
Symptoms that may indicate low fuel pressure include hard starting, rough idle, hesitation, stumbling, loss of high-speed power, lean misfire (which may set an OBD trouble code) or pinging/knock due to low fuel pressure. These same symptoms, though, can also be caused by a defective fuel pressure regulator, a plugged fuel filter, dirty fuel injectors, a restriction in the fuel supply line, a leaky pump check valve, or a dirty filter sock in the tank. If the main pump runs continously when your ignition is at KPII, then your fuel pressure regulator or in-tank pump has a fault since pressure is not building up.

Bosch Under-Car Fuel Pump

Fuel pressure can be checked by connecting a gauge to the Schraeder valve service port on the fuel rail (later B230F) or teed into the fuel supply line at the fuel rail (earlier B230F). If an engine has no fuel pressure (cranks, but won't start), and there is no pump noise, the pump may not be receiving voltage from the fuel injection relay. There may also be a problem in the wiring to the pump, the pump ground or an open inertia safety switch.

Diagnosis:

- Check for a spark using a spark plug wire and a paperclip near ground. If you have a spark, then your fuel injection system is a candidate for further investigation. If not, then your ignition system is at fault.
- Next, you could replace (or use a spare) the fuel pump relay. Normally, when you switch on the ignition, but just before you actually crank it over, you should hear the fuel pump working, (a faint whine) then it stops (i.e. it is priming the system to pressure) If you hear nothing at all, then the relay could be bad (it is a green bastard stuck in the row of relays (usually top left as you look at it) behind the ash tray. You should remove the little shelf panel to get at it.
- Another thing you can do is undo slightly one of the unions in the fuel distributor, using a 12 (or 13mm) mm ring spanner. Normally, undoing one of these, there will be a spurt of fuel. If there is nothing, you have no fuel pressure.
- So far it could be the relay or the main pump. You could buy a new relay, slot it in and the car should go. If not, then it is your main fuel pump (or pump wiring, but that is less likely, as the connections to the pump are very solid and durable) You could disconnect the pump wires (you can do this without removing it completely) and get someone to crank while you test voltage across the connectors.
- You can also test current draw at the respective fuse using a DVM when the car is started. The main Bosch pump (all B23X engines) should draw around 6.5 amps; those engines equipped with Regina systems should draw 8.8 amps. The pre-pump should draw around 3-4 amps (non-turbo), 5.5 amps (turbo), 1.4 amps (auxiliary reserve tank only). B6300 engine fuel pumps should draw 6.5 amps through 1994; 8.5 amps thereafter. Too much draw indicates an overworked and about-to-fail pump, or a main

pump operating without a pre-pump (which would have zero draw).

- If you have an old relay, you can remove the electricals and solder a large wire between terminals 30 and 87/2. As soon as you put it in (even without the ignition on) the main fuel pump should start to run and keep running and car should start. If nothing happens, then your main pump is well dead. Don't forget to remove the relay and chuck it, or mark on it what you did to it as it would be really dangerous to use otherwise. It is a strictly 'get you home' or diagnostic.
- So it's your main fuel pump. The tank pre-pump can be dead (or dying) and the motor will still run if you have more than half a tank of fuel. Get a new one if you can, or a scrap one from a yard, but test it before you buy it. Order the piece of fuel line from the accumulator to beginning or main engine line from Volvo.

Changing the Main Under-Car Fuel Pump (Bosch LH Systems):

- *Note: If you have a Regina fuel injection system or a later 940 with a single Bosch in-tank pump, then your pump is inside the tank mounted to the fuel sender unit.*
- See the instructions for changing the fuel filter above for tool needs. It helps in the future to use anti-seize on all bolts and a little dab on the banjo bolts entering the fuel filter.
- Disconnect battery negative.
- Clamp off the front and rear fuel lines using hose clamps. Disconnect both fuel lines to the pump. The tank-to-pump line has a screw clamp; the pump-to-filter line requires a 17mm wrench with a backup wrench. This short line is fragile, so don't bend or stress it. Disconnect the filter-to-engine line as above.
- Disconnect the electrical lines by squeezing the connector tangs.
- Drop the cradle holding the pump and filter.
- Remove the fuel filter. Note orientation of filter: flow is toward the rear.
- Turn it over and loosen the bolt securing the filter clamp to the cradle. Remove the filter clamp.
- Clean out the usually rusted Torx screw in the pump clamp and loosen the clamp.
- Replace the pump. The threaded end goes toward the front.
- Replace the filter clamp and filter.
- Reconnect the pump-to-filter short connector, being careful not to bend it. Use a backup wrench.
- Install cradle and reconnect the fuel lines.
- Reconnect the electrical lines. Black goes to the black pump terminal.
- Test for leakage.

If you have a one-pump later Bosch or Regina system, see Fuel Sender and In-Tank Pump Replacement above.

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960 Fuel Tank Hose Failure. If your 960 experiences gasoline smells after fillup and occasional leakage at the tank, see the FAQ section for information about fuel tank hose failures.

B230K BiFuel Engine Ticking Sound: Fuel Pump. [Tips from Jaap Keyman] I posted on problems with my 740 estate 1987 B230K BiFuel (mainly LPG driven, carburettor type here in the Old World!): intermittent ticking noise, not from inside the engine, to be heard clearly inside the car, significantly less outside, fix relation to engine rpm, no difference when driving or static, no difference whether clutch depressed or not. The experiments done included replacing belts, checking exhaust shields and components and other extensive checks. Still the ticking noise remained intermittently present. I thought to have done everything, but finally after staring at the block........ I NOTICED THAT I FORGOT ABOUT THE MECHANICAL FUEL PUMP! This, together with the Pierburg carburettor is apparently not present in any US model 700, so does not show up in any publication on this board. Well, taking the pump away (I can drive on the "second fuel") and putting a plate on the hole in the block, cleared the issue fully. Throughout its life this car may have driven only 1000mls on regular gas and the rest on Liquified Petrol Gas, so the pump may have suffered in some way; or an issue may be in the fuel tank (hose rotten) causing "standing waves" in the fuel lines, which generate contact noise to the car body. Anyhow, long story, but hopeful interesting for those with mechanical pumps.

Auxiliary Tank. See Body: Accessories.

Fuel Pressure:

Fuel Pressure Regulator and System Pressure.

Operation of Fuel Pressure Regulator. To provide the exact amount of fuel the engine needs under all conditions, the pressure inside the fuel lines that supply the injectors changes. When the driver steps on the gas and opens the throttle, intake vacuum drops. To deliver the same amount of fuel, pressure has to go up along with injector on time. Likewise, when the driver lets up on the gas and the vehicle decelerates, less fuel is needed to keep the engine running. Fuel pressure can drop along with injector on time. The device that makes all of this happen magically is not the fuel pump (which runs constantly and provides steady pressure to the engine), but the fuel pressure regulator. On most engines, a fuel pressure regulator is mounted on the fuel rail that supplies the injectors. Inside is a diaphragm valve connected by a rubber hose to intake vacuum. When vacuum goes up, the valve opens and allows excess pressure to vent through a return line back to the fuel tank.

Effects of FPR Failure. [Tips from Mike W.] When the fuel pressure regulator fails, it either provides full pump pressure to the injectors, resulting in an overly rich condition (I've had two cars do this), or inadequate full pressure, in which case the car will barely run and have no power. This hasn't happened to me personally, but it apparently can. My experience with FPRs pressuring up and giving the engine too much fuel has been that spark plugs will be wet and/or carbon fouled, exhaust will be black and sooty, check engine light will come on, and the OBD will throw codes 113 (fault in fuel injectors) and/or 232 (fuel system compensating for rich or lean mixture at idle). Sometimes, the main fuel pump will even start squealing and get hot to the touch when running. A fairly easy test to see if the FPR is pressuring up too much requires disconnecting the fuel return line (back to the fuel tank) from the rear of the fuel rail. On my 940, this is a simple hose clamp. Be prepared for some fuel to spill. Now get several feet of rubber fuel line hose, slip it over the open end of the fuel rail, and aim it into a gasoline-safe container. Have an assistant start the car, and observe the fuel flow from the hose. You should get a strong stream of fuel, something on the order of 1/2 to 1 gallon per minute. If you get just a trickle or no fuel at all, the FPR is bad. [Tip from Mark Lundell] When you replace the FPR because of a rich burning problem, also replace the little vacuum tube and clean out the intake manifold nipple.

Fuel Pressure Regulator

Pressure Test: Specifications. [Jim Holst] The Volvo green manual states that the system fuel pressure for Bosch, Regina, non-turbo, and turbo 4-cylinder B2XX and 6-cyclinder B6304 engines should be 43.5 +/- 1.5 psi (or 300 kPa) static pressure. The rail pressure should be 43.5 minus the vacuum tester vacuum at the regulator vacuum port. This tells if the regulator is working. Residual or shut-off pressure should drop below 29 psi (200 kPa) in less than 20 minutes but not too quickly which could mean leaking injection and cold start valves. *Note that system components among Bosch, Regina, and Motronic are NOT the same: the part numbers and specifications differ.*

Bosch Systems:

- With engine at warm idle, FPR vac hose removed and plugged (simulating Wide Open Throttle/accelerating condition) pressure should be **43.5psi.**
- With FPR vac hose reconnected, idling fuel pressure should be about **36.5 psi.**

Regina Systems:

With engine off, the pump "hot-wired" at the fuel injection relay and FPR vac hose removed and plugged, pressure at the rail should be **43.5 psi**. That makes it the equivalent of Wide Open Throttle, but with the FPReg feeling atmospheric pressure, rather than the normal vacuum of a running engine.

Procedures, Tools, and Tips. [Symptom: Car won't start] I hooked up a fuel pressure gauge (in-line fuel pressure gauge;. it'll save you from guessing on your problem as to fuel pressure and clogged lines or filter. I've got mine from Summit part #SUM-800160 (60psi) $19.95) and found that no more than 10 psi was generated while running the fuel pump continuously, and the trickle sound got worse. I removed the vacuum hose from the fuel pressure regulator, and found a couple of drops of gas. Just as a check, I turned the fuel pump on for one more second.... YEOW!! I could have burned down the whole house with the stream that shot out the front of the regulator. Conclusion: No pressure to injectors, but plenty of raw gas supplied to the intake manifold, thence to the cylinders, and finally onto the ground under the exhaust manifold. No wonder the car wouldn't start. I have a new fuel pressure regulator now. [Tip: Smitty] Be real careful removing the vacuum line off the FPR while the engine is running. If you suspect a failed diaphragm, use your nose and eyes first to check for raw gas on the vacuum side of the reg, with the engine off. Then maybe proceed with a helper available to crank/kill the engine in case gasoline should stream out the front. [Art Benstein] Jumper the fuel relay to operate the pump continuously (listen for the pump in the tank) using an ammeter as the jumper around the fuel relay. When it was idling and would rev well, the pump would draw over 5A. Then place a cheap stick tire gauge on the fuel rail test port. The $2.00 pressure gauge fits well if you bring it up between the #1 and #2 runners on the intake manifold. It does emit a little fuel shower as you press it on, so take readings with the fuel pump hot-wired rather than with the motor running. And keep a fire extinguisher handy if you do this. [Al Stensby] I found a fitting to attach a test hose to the schrader valve on the fuel rail. It is a Number 705 made by Amflo. It should be available in any industrial supply store. I purchased mine at McFadden Dale in Anaheim, Calif for $1.58. [Jim Holst] The Volvo green manual states that the Regina system fuel pressure should be 43.5 +/- 1.5 psi static pressure. The rail pressure should be 43.5 minus the vacuum tester vacuum at the regulator vacuum port. This tells if the regulator is working.

Relieving Fuel Pressure When Opening FI System. See the link for tips on relieving system fuel pressure safely when changing a component.

Changing the FPR. [Andy Jameson] Relieve the system fuel pressure and put a rag under the area to catch what does come out.

1. Use a screwdriver to loosen the clamp holding the fuel line to the FPR.
2. Remove the two bolts holding the FPR to the fuel rail.
3. Pull the FPR out of the fuel rail; straight out toward the driver's side fender. It is just held in by an O-ring which should come out with the FPR.
4. Then pull the FPR off the fuel line by pulling it toward the front of the car.
5. Installation is the reverse, except you will use the two bolts to force the O-ring and FPR into the fuel rail. Lubricate the O-ring with a little motor oil or vaseline. Be sure to keep it straight and turn each bolt a little at a time in turn. If it gets too crooked going in, the fuel rail can bend or the O-ring can tear.

Noisy Fuel Pump: Bad FPR. [Tip from Chris Daunhauer] My fuel pump noise (both the old one and the new one I installed) turned out to be caused by a faulty pressure regulator up at the injector rail NOT by a bad pump. Parts counter man insisted that from my description of the problem I had a bad pump in the tank. He was wrong. Bad regulator was not letting excess pressure bleed off back into the fuel tank causing external pump have to work too hard. Thanks for the 2 suggestions, guys, they were both right. The electric pump delivers about 10 times as much gas to the injectors as they need. Excess is routed back to the tank. Could have been either a clogged return to tank line or faulty regulator. In my case it was the regulator.
Here's what I learned....
If the external electric fuel pump is noisy, pull the return line off the pressure regulator. Install a spare length of hose on the barb and run the other end into a can on the ground. Start the engine. Fuel should be rushing out of the hose leading into your can, even at idle. If this excess fuel that the injectors aren't using is NOT (mine was not) rushin out, there's a good chance your fuel pressure regulator (about $60) is stuck closed.
Volvo mech said he's put pressure gauges on cars w/ stuck regulators and the needle goes off the scale.

Noisy Fuel Pump: FPR Faulty. [Tip from Jeff] I have been fighting a noisy fuel pump, rough idling, and poor performance for the past 3 months and finally solved the problem. It may not be a faulty fuel pump. In my case it was not. I replaced pump and the new one was just as noisy. I checked the in-tank pump and it worked fine. Then I disconnected the outlet or return line from fuel pressure regulator and attached a piece of fuel line to it and stuck it in a bucket. Nothing came out with engine running. The fuel should have been gushing out. I replaced the regulator and I have a totally new car. It runs like a top with no pump noise. So before ruling out pump problems check the regulator output first it is easy and takes about 3 minutes to test.

Fuel Pressure Test Tool. See the FAQ file for a description. See also the above notes from Art Benstein, who used a tire gauge to test his system.

Fuel Pump Check Valve

Failed Check Valve. [Symptom:] My '84 244GLE is equipped with B23F engine and LH Jetronic 2 fuel injection, she doesn't want to start (read run) the first time -though cranks fine- when it has been sitting at least 6 hours. The car will start without hesitation on the second try. [Diagnosis:] It sounds like a classic case of failed fuel pump check valve, on the main pump under the car, left side, beneath the driver's seat (in LHD cars). The check valve keeps the fuel rail under pressure after shutting down. Under pressure the fuel cannot vaporize and cause a "vapor lock". This will usually only happen under very hot conditions. On fuel injected cars vapor in the line would only delay a start, not prevent it. The check valve also allows fuel pressure to build faster resulting in faster starts. They cost about $14 at the dealer and are fairly easy to install. Just go buy one at the dealer and they'll show you in the parts book where it goes.

Cruise Control Won't Work or Incorrectly Disengages/Re-engages: Diagnostics

Vacuum Diagnostics:

[Inquiry] My cruise control stopped functioning. Where do I start? [Response: John Randstrom] I have found that the vacuum servo diaphram that pulls the throttle open can spring a leak. I usually check these first, along with all of the electrical connections and vacuum lines and valves that are mounted to the brake and clutch pedal brackets. Check all the vacuum lines and the servo with a Mityvac tester and if they hold a vacuum, you have no leaks. If these valves do not seal with the pedals in the rest position, the vacuum will be bled from the servo and the cruise will not engage. [Response: John Sargent] Check the vacuum hose connections under the hood.The hose ends stretch with age and lose their grip on the hose barbs. The hose ends also split and leak. Even a small split right at the hose end will cause the cruise to fail, as will a loose fit on the fitting barb. [Response] Most common problem that I have seen is either split or disconnected vacuum hose, or mis-adjusted brake switch (at the pedal) or clutch switch (if manual tranny). Sometimes it is simply that the brake or clutch pedal is not fully returning - try lifting up on the pedal with your foot while driving and see if you can engage the cruise. In addition to the vacuum switch, check for operation of the brake light switch. I seem to remember that the vacuum switch will disengage the cruise simply by releasing the vacuum from the unit, but the brake light switch must activate in order to release the control unit signal. If you are just tapping the brake lightly to disengage the cruise (as I often do), but not activating the brake light switch, then it may simply re-engage as soon as vacuum is applied again. [Response] Pull hose loose at "T" fitting aft of throttle servo. Apply vacuum (suck on it, but make sure no one's watching) to fitting with hoses that run down to pump and into car to brake pedal defeat switch. If leaks are detected here then find split hose or go inside and find pedal switch fault. If no leaks detected then closely inspect the servo for splits or tears. The likelihood of electrical trouble is far lower than having a hose split or a leaking servo. See below for information about the vacuum pump.

Mechanical Diagnostics:

[Response: Robin Roemisch] My 740's cruise control throttle cable had come unwrapped from the spool. Its easy to catch if you're messing around the throttle body, and it comes off rather easily. Just wrap it back around and that should do it... [Response: Gene Stevens] In addition to the list John noted, two things I'd check first are brake light operation (#5 on his list), as every manufacturer uses them for a ground circuit path to the cruise controller, AND the item that made me a little crazy on mine... There's a vacuum release valve on the brake pedal that can bind a bit with age. Hold the brake pedal up with one foot while you engage the cruise control. If it now works properly, the release valve my be slightly open. Mine would vary speed on certain days, opposite of the way you'd expect. Flat ground would occasionally lose about 1 MPH per minute and settle in about 8-10 MPH below set speed. Start going uphill, and the car accelerated back to the set speed, and maybe/maybe not, do the 1MPH/minute thing again after getting level again. Going downhill would cause a faster drop in speed (odd, huh) and creep back up on level ground. The final answer was that the tilt of the car going up and down hills changed the effective weight on the brake pedal. Lift the pedal, and rock solid speed every time. [Response] There is a separate switch with a vacuum line attached for the cruise. If the car is manual tranny, the car would have two switches, one for each pedal. If the switch adjustment is marginal, i.e., there is not a definite "off", then the switch needs to be adjusted. It is adjusted the same way as the brake switch.

Electrical Diagnostics:
[Inquiry] My cruise control in my 1990 740 has failed. Vacuum hoses are fine. How do I test internally for the problem related to the push button control button attached on the turn signal lever? [Response: John Sargent] Before you start checking the switch, lets do the easy electrical circuit tests.

- Is the yellow wire connected to the back of the speedometer?
- Are the brake and clutch switches properly adjusted and carrying electricity? The brake and clutch switches get power from the brake light switch. Terminal 3 at the control unit should have power from the brake and clutch switches.
- Is fuse # 10 good? Is there electricity to the unit? Terminal 1, blue-red.
- Are both brake lights working? The cruise control supervises the stop light circuit, and if the stop lamps are bad, or the lamp failure relay dies, the cruise control will not work. [Note from John Sargent] There is a reason for this. The people who designed the cruise control did not want the cruise control to work if there was no input from the brake system to shut the cruise control off when stopping. The cruise control imparts a very small voltage to the brake light circuit. A very small amount of current flows (this is referred to as a supervised circuit) if the circuit is connected. A failure of the bulb failure sensor can have the same effect as having both stop lamps burnt out. As a result, if both your brake lights and your cruise control fail, then take a hard look at the bulb failure sensor.
- Check the wiring connections to the vacuum pump. Pull the hose off the vacuum pump and suck on it. The servo should operate the throttle.
- Is the turn signal unit plugged in? Remove the covers behind the steering wheel and inspect the electrical wiring for breaks. See the FAQ section under "Instruments" if you need to replace the stalk.
- Is the control unit plugged in? The control module is on the left side, under the driver's side kick panel
- Terminal 1 of the switch carries power to terminal 2 of the switch in the On position.
- Terminal 1 of the switch carries power to terminal 4 of the switch when the speed button is pushed (momentary contact).

Brake/Clutch Pedal Switches:

[Editor] There are two cruise control switches on the brake pedal: an electrical on-off brake light switch and a brake valve/switch. If you have a manual transmission, this latter will also be on the clutch. The brake light switch cannot be adjusted and can merely be tested for continuity ("on" when the pedal is depressed).

The brake valve should normally be closed and must not leak when the pedal is up. The brake valve comes in two varieties: an older style with a threaded plunger and a newer style with internal plastic catches on the plunger. With the pedals up, the valve is activated, the spring is compressed, the switch is on, and the vacuum valve is closed. The older brake/clutch valve can be adjusted (to about 1 to 1.5mm play between the plunger and the pedal arm) by removing the connectors and turning the valve to the correct play. The newer one has plastic catches in the plunger that hold it correctly: if these fail, replace the valve. Leaks in either valve or at the couplings require replacement or repair.

Vacuum Pump:

[Al Sichelstiel] Odd occurrence requiring a lot of diagnostic work: the cruise system would initially engage then disengage, as though a vacuum leak or a bad switch were at fault. The cruise would momentarily engage pulling the diaphragm into operation then lose vacuum almost immediately. After much diagnostic work, we found that there is a pressure switch inside the vacuum pump assembly that measures the vacuum level and bleeds off or increases the vacuum as needed. That switch in the pump assembly failed and was dumping vacuum at almost the instant the system engaged. Swapped out the vacuum pump assembly and it worked fine.

Cruise Control Surges: Worn Servo. [Inquiry:] What is the fix for surging with the cruise control ON. It tends to fluctuate 2-4 mph in level driving conditions. Real annoying. [Response: Abe Crombie] Look closely at the servo on the throttle housing that tugs the cable wrapped around the throttle spool. This can get a hole worn in it and the vacuum level that keeps throttle positioned evenly is impossible to maintain.

Cruise Control Onboard Diagnostic Codes.
[Editor] Later LH2.4 cars employing two diagnostic modules can directly read cruise control codes. Plug the module pigtail from the "A" unit (this unit has the pigtail connector, the test button, and the LED readout lamp) into position two on the "B" unit. The cruise control system for earlier LH2.4 cars without a "B" unit can be connected to the OBD system to read diagnostic codes. To do this, run a wire from the extra pigtail on the cruise control unit connector at the left side under the driver's kick panel to the OBD diagnostic connector in the engine compartment (the pigtail you plug into the various holes.) The system must be tested with the ignition "On" and after roadtesting above 35 km/h (22mph) since the unit does not store codes, only reports them, and erases all codes when the ignition is turned off. The following is a brief excerpt from the OEM manual.
There are two diagnostic modes:

1. *Mode 1: Self Diagnosis*

   Ignition "On" after roadtest, diagnostic wire connected. Press diagnostic button once for one second. Read the code. (If nothing flashes, see No Code.)Check for another code by pressing again for one second. Repeat until the first code is returned. This test returns various error codes from the road test.

Code	Fault	With Ignition & Cruise Selector "On" Check:
1-1-1	No faults detected; speed has exceeded minimum 35 km/h needed for test	• No fault
1-1-2	Abnormal speed signal	• Possible static in speed signal to control
1-2-2	No speed signal, or has not exceeded minimum 35 km/h	• Voltage feed (12V between terminals 10 & 11) • Ground location (0 ohm between terminal 10 and ground) • Speed signal • Wiring in circuit (speedo to control unit; speedo to rear axle) • With rear wheels raised and one rotating slowly,voltage at terminal 13 should oscillate 12V to +1.5V
2-1-1	Voltage feed or cruise control unit malfunction	• Minimum 10.5 V at terminal 11

2-1-2	Malfunction in the circuit to vacuum pump or regulator	• Test vacuum system first • 12 V between terminal 2 and ground • 12 V between terminal 10 and 11 • Ignition Off, selector On: Check wiring for resistance

1. *Mode 2: Component Test*

   Ignition "On", diagnostic wire connected. Start with cruise selector switch "Off" and the transmission in "Drive". Press the diagnostic button twice, each for one second. The LED shoud flash rapidly. Then perform the following tests in the order listed to test each component of the cruise control system. Faults may be pinpointed to the components or circuits noted.

Activated Component	Action	Code	Fault
Brake light switch	Depress brake pedal for one second	1-3-2	If no code: brake light circuit
Selector ON and OFF, brake and clutch valve	Depress brake then clutch pedal for one second	1-1-3	If no code: brake and clutch valve
Selector RESUME	Press RESUME for one second	1-2-3	If no code: resume button
Selector SET	Press SET for one second	1-3-1	If no code: set button
Start inhibitor switch	Shift transmission to NEUTRAL	2-2-3	If no code: start inhibitor switch
	If code 3-1-1 is reported during any test:	3-1-1	Several simultaneous signals: short in circuits

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Cruise Control Installation Instructions for 740 Cars. [Procedures from John Sargent]

All US 700 series Volvos come pre-wired for installation of cruise control at the dealership. Australian market 700 series, and possibly other market 700 series, do not come pre-wired for cruise control. The following instructions are for US market cars. Volvo used components from Hella on the 700 series cars, as well as 1986 and later 200 series. These instructions assume that you have the components in hand.

The following is a list of the components:
1. Turn signal control with cruise control function
2. Vacuum servo, two 10mm head bolts
3. Vacuum pump and regulator, 3 mounting screws
4. Control unit
5. Air valve. Automatic transmission cars use one. Manual transmission cars use two.
6. Rubber tubing, and tees.

There are a few model year differences in components.. The brake and clutch switches and their respective sockets for the 1985 and earlier models are slightly different. 1991 and later 740 use a different turn signal assembly to match the dashboard change. All 760 series come with cruise control, however the 760 series uses the different turn signal assembly with the dash change (1988). If you are scrounging parts, the turn signal assembly and brake /clutch switch(es) is the same on 6 cylinder cars and diesels. I have not tried it, but the CPU will probably interchange. The servo uses the same rubber parts on the diesel, but the bracket is different. I don't know if the 16 valve 740 uses the same servo and throttle pulleys.

Turbo and non-turbo use the same servo, throttle assembly, and control unit. The components will interchange between the model years except as noted above.

You will need a Phillips head screwdriver, an 8 mm and a 10 mm ¼" drive socket, a ¼" drive 3 inch extension, a ¼" drive ratchet handle, and a knife. On later cars (1990 on ?) you will need Torx tips to remove the steering column trim.

1. Remove the trim panel above the driver's feet. It is retained at the top by 2 Phillips head screws along with a plastic plug, and another plastic plug just above the hood release handle. The plastic plug just above the hood release does not need to be removed, as the panel will slide out from under it. Disconnect the heater vent from this panel, too.

2. Install the control unit. It installs just outboard of the hood release cable and the bundles of factory wiring. You should find a wiring connector with 8 wires, and one with 1 wire. Plug the wires into the unit. The 8 wire connector is polarized and will go on only one way. There are two nail head studs on the outer body panel. The bracket has keyed holes on it for installation on these two studs. The wiring connector end goes down. Optional is the installation of one self drilling screw at the front of the bracket. Both dealer and factory installed cruise controls are often anchored this way. I don't bother.

3. Install the brake switch, and clutch switch if manual transmission. Remove the metal clip and slide the switch into the hole provided. Install the retaining clip. Check the adjustment of the switch(es) with an electrical meter. I like to just tap the brake pedal and have the cruise control disengage. Plug the wiring harness connector into the switch(es). The connector is white and has a white/black and a blue/red wire. You may have to examine the area closely to find it, as it may be tucked into the other wiring in the area above the brake pedal. If the car has a manual transmission, there will be a connector for each switch. In this case, one connector will have two blue/red wires. The switches are in series, so which connector goes to which switch does not matter.

4. Route the vacuum hose through the large rubber plug in the left side of the firewall. There are several nipples cast into this plug. Cut the end off of one of these nipples for routing the hose. Some people route the hose through the hole filled by a single rubber plug. Connect the hose to the brake and clutch switches. A tee fitting is provided for cars with two switches. The vacuum portion of these switches will disengage the cruise control in the event the vent solenoid valve in the vacuum pump fails.

5. Install the vacuum pump. Your 8mm socket will drive the three small hex head sheet metal screws. There are three holes pre-drilled at the top of the reinforcing metal on inside of the left fender well, just under the brake master cylinder. Connect the wiring harness connector to the vacuum pump. This connector is gray, and has three wires in it. Sometimes this wiring harness is well buried with the wiring to the left headlights. If you look, you will find it unless (unlikely) that is has been removed. Connect the vacuum hose you just routed through the firewall to the rear hose nipple on the rear of the vacuum pump. Install the tee fitting near the pump. The tee fitting will connect to the hose from the servo. The front hose nipple is not used. It may be necessary to move the power steering hoses forward from the area where the where the vacuum pump mounts. This is made easier by removing the engine air intake hose, but is not necessary.

6. Install the turn signal assembly. If your car is air bag equipped, remove the steering wheel trim. Next, remove the old turn signal unit and install the new unit with a right angle screwdriver. If you don't have an air bag, it is easier to pull the steering wheel. Connect the 4 wire gray connector to the short wire harness from the turn signal assembly. Sometimes this connector is well hidden. If you can't find it, it is often incorporated with the harness connected to

the turn signal. Sometimes it is easiest to remove the instrument cluster to do this. While the instrument cluster is out, check to see that there is a yellow wire connected to the back of the speedometer. This is the speed pick up for the cruise control. The yellow wire is always connected at the factory, but could become disconnected with instrument cluster replacement, or service light resetting.

7. Install the servo on the intake manifold. Use your 10mm socket here. It is installed utilizing two tapped holes that are behind and below the throttle pulley assembly. Be careful not to pinch or kink any hoses between the manifold and servo. Connect a vacuum hose between the tee at the vacuum pump, and the servo.

8. Replace the throttle pulley assembly with the new unit. Use your 10mm socket here. This can be done without removing the snap ring holding the throttle pulley assembly together. Just twist the guide ring to the proper position, and the cable end will drop in. If you have to remove the snap ring be careful not to lose the pieces. Connect all three cables. Adjust the cable slack if required.

9. Go for a drive. Trouble shoot and adjust as necessary.

10. Replace the trim panel above the driver’s feet. Don’t forget to connect the heater hose.

Electrical: Engine Starting, Charging

Jump-Starting Procedures

Jump-Starting Procedures. When jump-starting a car with a dead battery, the proper procedures to ensure personal safety and car reliability are:

1. Ensure that the cars are not touching to prevent unwanted ground/earth paths. Do not allow the cable clamps to touch each other.
2. Put out cigarettes before opening the hoods. Wear safety glasses in case a battery explodes (more common than you would think!)
3. Turn both cars' ignitions "off".
4. Connect one end of red wire to positive (+) bad car battery terminal
5. Connect other end of red wire to positive (+) good car battery terminal
6. Connect one end of black wire to negative (-) good car battery terminal
7. Make last connection with other end of black wire to bad car *engine ground point* (such as a lift metal hook) away from the battery. This eliminates sparking near the bad battery, which may be outgassing hydrogen and could explode. *Do not attach the cable to the negative terminal of the dead battery.*
8. Start good car engine. *Stand away from the batteries.*
9. Start bad car engine
10. Turn on both car headlights (see below)
11. Disconnect in inverse order, being careful to keep cables and clamps from touching.

[Tip from Paul] The book "Bosch Fuel Injection Systems" by Charles Probst notes that after the jump and before cable removal one should put a load on the car by turning on headlights or the rear window heater. A lightly loaded car may experience a spike AFTER you remove the jumper cables since the regulator was set to supply a heavy load. You instantly switched from a heavy to light load and the voltage may spike. You may damage your fuel injection computer with this spike. Avoid it by engaging a load.

Note: You can print these instructions out, xerox onto a plastic sheet, and mount it near your car battery for on-site reference.

Alternator & Starter Applications and Parts. [Dave Stevens] Wood Auto Supplies Ltd. in the Huddersfield, Yorkshire, UK has an excellent on-line alternator and starter reference tool for parts. Visit http://www.woodauto.com to enter their site. They ship worldwide. For alternators/starters, if you know the Bosch (or Marchal or whatever) part number then enter it in the upper right search box. Each major listing will give you the specs, a list of equivalent or similar units, the Volvo part numbers, the years, models and engines in which it was used and a list of the component replacement part numbers and an indication of availability. Many of those components are linked to their own page with further information on the part including a typically long list of all the alternators/starters in which that part was used. If you don't have the alternator/starter number handy then you can use this vehicle search page: http://www.woodauto.com/woodauto/vehicle.aspx. First, make sure the upper right search box is clear (or you'll come up empty). Select Volvo as the manufacturer and then your particular model and/or engine. You'll then be given a list of the alternators and starts by model year and application. You may need to try a couple of model/engine/alternator/starter configurations to find the appropriate list of alternators/starters. From the list just start following the hotlinks to find the full descriptions and the parts you're interested in. Most are complete with pics. [Jay Simkin] Contact Barsanco in Centerline, Michigan (800-421-3374) for starter and alternator parts (diodes, etc.) to rebuild your own units.

Starter:

Starter and Solenoid Problems.
What causes a starter to fail?
[Tips from Counterman Magazine, August 01 & Underhood Service, May 04] Starter problems can be caused by worn brushes (carbon pads inside the motor that supply current to the rotating armature), by shorts or opens in the armature or field coils or by worn bushings that increase drag or allow the armature shaft to rub against the pole shoes. Continuous and prolonged cranking is very hard on a starter because it generates excessive heat. If not allowed to cool down every 30 seconds or so for at least a couple of minutes, the starter will be damaged by continuous cranking. Other failure modes include:

- "Zero engagement" or "no-clicking" activation of the starter solenoid. This can be caused by an unintentional activation of a vehicle anti-theft system. In other cases, a defective ignition switch, start inhibitor switch, or bad wiring harness/loose wiring connection can cause the problem. The most accurate way to test these components is to connect a DVOM to the primary wire connection on the starter solenoid. Using the min./max. feature found on most professional DVOMs or multimeters, record the voltage at the solenoid terminal when turning the ignition switch to the "crank" position. If battery voltage is recorded, the above components should be considered in good condition. If the starter clicks, but doesn't engage, the problem is usually caused by a faulty starter solenoid that's not engaging the starter drive gear. In most cases, replacing starter solenoids is not a cost-effective procedure compared to replacing the defective starter with a remanufactured unit.
- Starter motor is running but fails to engage the flywheel ring gear or when the engagement is rough and noisy. In most of these cases, the overrun or one-way roller clutch on the starter drive gear is worn or sticking. In the remainder of these cases, the flywheel ring gear itself is either worn, or has broken or missing teeth.
- Low-cranking speed issue caused by worn shaft bushings. The starter's amperage draw will be unusually high for the application. Also, when starter current draw is high, remember that battery voltage will often drop below 9.6 volts. This is enough to affect system electronics, which, in turn, will affect fuel pump operation. Engines must crank at about 200-300 rpm to activate the electronic fuel injection. When the ECU "sees" a strong, sustained signal from the crankshaft position sensor, it will activate the fuel pump relay in order to pressurize the fuel injectors. Without a reliable RPM signal indicating sufficient cranking speed, the ECU may not activate the fuel pump relay, thereby creating a cranking, no-start condition.
- Keep in mind that simply dropping a permanent magnet starter can fracture a field magnet, which may cause a variety of cranking speed symptoms.

Troubleshooting the Starter
In the Shop:
To accurately test a starter, you need a test stand that can measure amp load, voltage and rpm. A good starter will normally draw 60 to 150 amps with no load on it and up to 250 amps under load (while cranking the engine). The no load amp draw will vary depending on the type of starter. If the amp draw is too high, the starter needs to be replaced. The same is true if the starter doesn't achieve the specified rpm.
Sometimes the starter motor works fine but the drive gear won't engage the ring gear on the flywheel. If the drive gear mechanism can be replaced separately, there's no need to replace the entire starter.
A bad solenoid can also cause starter problems. The solenoid acts like a relay to route power directly to the starter from the battery. It may be mounted on the starter or located elsewhere in the engine compartment and is usually connected to the positive battery cable. Corrosion, poor ground at the solenoid mount or poor battery cable connections will prevent the solenoid from doing its job.
If the starter tests okay but fails to crank, another possible cause may be a bad ignition switch, neutral safety switch or clutch safety switch. A low battery and/or loose or corroded battery cables can also prevent the starter from cranking the engine.

On the Car:
When troubleshooting the starter, pay close attention to the wire/cable connections. The starter needs a healthy shot of juice to get going so you need to clean all contacts. Just because they appear OK when the starter is not engaged doesn't mean that they are good enough to do the job. Check ground straps. Make sure your fuses are clean. Check any other device on the starter circuit (if any).

> Make sure your battery is OK - turn your headlights, fan, rear de-mist etc. all on and check the voltage - should be at least 11V. If it's less than 9 or so you may not have enough power to turn the engine over.
>
> Test the battery terminals - should be clean and tight. If your starter won't turn I'd remove and clean them, then coat them with some Vaseline and put back. Also test the connection between the wires and the terminals - again, should be tight and clean. The usual symptom of loose connections here is that the starter solenoid 'clicks' but the engine doesn't turn.
>
> Test the + wire (the big thick one) connection on the starter. Again, this should be a good connection. The starter draws several hundred amps, and a connection that's not 100% is quite likely to drop most of the battery voltage across it.
>
> Make sure the starter is bolted to the engine properly - the current goes through the starter and block. Also make sure the engine is grounded - it should have a big earthing strap, or sometimes the battery - terminal is connected directly to the block - either way, make sure the contacts are good.

If all of the above check OK, simply put a wire from the battery + to the starter - connect it to where the thin wire goes. This should make the engine turn over (but not start unless the ignition is on). If the engine turns, it means that you have a problem in the wire between the ignition switch and the starter; If it doesn't, the starter is faulty: If you don't hear a 'click' the solenoid is to blame, otherwise the starter motor itself.

Starter Will Not Engage: Start Inhibitor Switch. [Symptoms: I have an 89 740GL that sometimes starts but sometimes does not. When I turn the key the car simply will not turn over: no starter response on key to "start". However, all of the panel lights, the battery level and starter assembly are good. When this happens I usually put the car in Neutral and then back in Park which usually works allowing the car to start.] [Response:] If your car is an automatic, like my wagon, make sure that the start inhibitor switch located under gear indication panel is not out of adjustment. A simple test is to push the selector forward or back a little in the P position (the only one the car should start in) as you turn the key. If the car starts, crawl under and adjust the rod just a little and the problem should be solved once and for all. Failing this option, check the switch and wires associated with the lockout switch. [Response: JohnB] Took about 250K and 16 years, but there it was: a potential pattern failure at the start inhibitor (neutral safety) switch. A nice square contact (should be rounded and smooth--the other one was) point due to wear and a relaxed copper alloy arm...the car wouldn't start unless the switch was compressed by hand (a get-home crutch, BTW!). And beware...the Volvo part comes with a new and cheaper connector that the dealer crutches by selling you four terminals and the late model socket for an additional $5.00!! You're supposed to clip the OEM chassis harness clip off and crimp the new male spade terminals on and install the late model socket so the new NSS can plug into it...I just used the old socket and spliced it onto the new NSS. This same NSS is used on the 9xx series....

Removing Starter. The top starter bolt is difficult to remove. To do this, you need some socket extensions with one around 36". At the bolt end, use a universal joint with an 18mm socket (for a 940; 740 may require 19mm) or a swivelling socket to get a firm grip on the bolt head. The other end is your ratchet or breaker bar, which will be at the rear of the transmission near the crossmember. There is no need to remove the crossmember and lower the rear of the transmission to get the two starter bolts off. Unless you are using a lot of extensions and a universal joint, you are going to have a hard time with this bolt. The placement near the crossmember allows you room to use the breaker bar. Do NOT drop the starter, which may fracture an internal motor magnet. Diesel starter: see the FAQ Section.

Diesel Starter Fails: Wiring Fault. [Inquiry:] I own a 1986 Volvo 740 Diesel. The mechanics have replaced the starter six times from March 1999 to July 1999. The starter itself is still under warranty, but each time I have to pay the installation labor, besides the headache of being stranded, towing, etc. I'm not a mechanic, but even I know that something is wrong, wrong, wrong. Does anyone have any ideas? Even a list of possibilities that I could have the mechanics check-out. [Response: Van Audekerce Remi/ Brandon] I have seen this quite a few times and it was always a short in the wiring harness that engages the starter when the engine is running. Most likely the place were the wires have rotted is where the wiring harness runs near the diesel pump. Cut the black sleeve open and check the wiring, most likely the wire insulation will fall apart. Check ground connections, the wiring harness, and battery condition. With a diesel starter requiring 2 kilowatts that comes out to 250 amps at 8.0 volts cranking. Any slight resistance will slow things down in a hurry. [Noel DeSouza]In my case, the grounding wire going from the battery to the engine was bad, so check the obvious first. Use one side of a battery jumper wire clamped so as to ground the starter body (the head of the starter-bolt is a good spot to clamp) and the other side clamped to the negative post of the battery, then try starting again. If it turns over, the ground wire or connections are bad.

Alternator and Charging:

Alternator Mounting Bushings. [Editor] Over time, the three rubber bushings securing your alternator in its engine bracket can compress, allowing the pulley to become misaligned with the crank pulley and accelerating belt noise and wear. You can replace these with OEM rubber bushings or aftermarket

polyurethane, which are more robust and do not compress as easily. The latter may be had from IPD.
To replace your bushings:

- Disconnect battery negative terminal
- Use penetrant oil to loosen the tension adjusting, securing, and bracket nuts but don't soak the belt
- Unscrew the 10mm tensioner adjusting bolt beneath the side of the alternator by about 1.5 cm. Remove the belt from the pulley.
- Loosen the 12mm bottom securing nut and remove it from the adjusting assembly
- Loosen the top long bolt and nut (12 & 13mm) supporting the alternator in its bracket
- Remove the bottom nut and bolt (12 & 13mm) holding the alternator to the bracket
- Swing the alternator up. Using a screwdriver, push out the old bottom bushing and replace it
- Swing the alternator back down and replace the bottom bracket bolt and nut
- Remove the top long bolt and nut and swing the alternator back to replace the two top bushings
- Replace the top bolt and nut and the securing nut
- Tighten the bracket nuts (not the securing nut!) and retension the alternator belt so you can press it down about 1/4 inch under moderate finger pressure
- Once you tension it, tighten the securing nut firmly and then back off the adjusting bolt so it bears no tension from the belt
- Reconnect the battery negative terminal

If you are interested in replacing the four air conditioning compressor bushings, see the FAQ file.

Alternator Not Charging. When the battery loses charge and the alternator appears not to be charging, here are some diagnostic tips:
Diagnostics. [Response: Danny Halamish] It sounds like it's probably the charging system. Here's what I would check (in this order):

- Battery terminals - clean? Good connection? Corrosion?
- Alternator (thick) wires - both plus and ground (if fitted) - make sure they are OK.
- Alternator brushes - if they are nearly dead, this can cause this.
- Harmonic Balancer: the alternator belt runs off the balancer. If the rubber insert deteriorates, the balancer shell will slip

If all that checks out OK, I would suggest you get a volt meter, and when the voltage reads a little low, measure at the alternator: It should be 14.4V. If it's much less, rev it up a little - does the voltage go up? If not, there is a problem. Also, with the engine running and the voltage low (i.e. when the problem happens) measure the following:
1. Voltage between the alternator power terminal and the battery "+" terminal should be well under 0.2V
2. Voltage between the alternator body and the battery "-" terminal should be well under 0.2V
3. Voltage between the battery "-" terminal and the engine block should be well under 02.V

Bosch Voltage Regulator

Voltage Regulator. If all this checks out but you still have a problem, the alternator voltage regulator may be defective. There are two screws holding it into your alternator. You don't even need to pull the alternator. Remove it and you'll probably find the two brushes (two black square spring loaded shafts) worn out. A good electrical shop can replace these, or a new regulato rfor either Bosch or Nippon Denso alternators is about $60. Install and, get a boost and happy motoring.

[Testing Bosch voltage regulator on 7xx/9xx cars: How can you tell if your voltage regulator has gone bad?. What tests can you do? [Answer:] The real purpose behind the regulator is to keep the battery voltage from getting too high. When my regulator went bad, voltage would increase with engine speed, going as high as 18-20 V. You can easily test the regulator function by using a voltmeter to test voltage between your battery and ground while the car is running. Look for voltage between 13.8 and 14.6. If your voltage is higher than this, you probably do have a bad regulator. Check the integrity of the regulator diodes on a Bosch alternator by using a multimeter to measure the voltage readings at the D+ terminal and B+ terminal. The voltage reading should be the same at both terminals. A difference of more than one volt would indicate faulty diodes and the need to replace the regulator unit. [Rick Ledbetter] Test the diodes by disconnecting one of the D+ or B+ leads on the regulator and connecting your probes: black is ground (use the alternator case for ground) and red is touched to the D+ and B+ terminals. At the component level, diodes will only conduct one way. They have to be tested out of circuit, so one lead has to be disconnected from the circuit. A simple continuity test on the meter will do the job. If you have a failure, the Bosch regulator/brush pack unit is easy to replace with the alternator in the car. If your battery has been overcharging, it can boil off electrolyte and may need to be topped off.

Exciter Current Through the Warning Lamp on the Panel. The alternator (charging) warning light in the instrument cluster feeds a small amount of electrical current to the field coils in the alternator when you turn the key on and the engine isn't turning. This excites the coils (electromagnet) and the alternator gets the magnetic field it needs to start charging as soon as the engine runs. When the alternator isn't charging at all (engine stopped) that wire to the alternator also provides a ground path for certain warning bulbs in the cluster, so they light up. Diodes in the network keep current from backfeeding into unwanted circuits. So if you have a bad connection for the alternator warning wire, the alternator won't start charging right away. But most alternators will self-excite once the revs get high enough (say 2000 engine RPM) and then they stay excited and charging, even at idle RPM. [Editor] To initiate charging upon startup, the small wire going into the rear of the voltage regulator must be at 12 volts. If this is grounded or disconnected (as, for example, through a loose instrument panel or chassis connector), your alternator will not charge. The idiot lights may or may not go on, but if they do and they remain on, then suspect this wire or the panel connector for faults. You can also rarely experience a flexible circuit board failure on the back of the panel. And make sure the alternator warning lamp bulb is not burned out. [John Randstrom] If you pull the wire off the alternator that comes from the dash board charging lamp and ground it, the idiot light should light with the ignition in the run position. If the lamp does not light then there is a problem with the bulb, the ignition switch, or the wiring/instrument cluster circuit. An easy way to see if this circuit is causing your no charge situation would be to connect a wire from the battery positive terminal through a small spare idiot light bulb(or any bulb with the same wattage and voltage specification) to the idiot lamp circuit connector on the alternator. The alternator should charge and the lamp should light when the engine is off, and go out when the alt. starts charging just like the original dash lamp should do. [Tip from Paul Golden] I removed my instrument cluster and did the continuity checks, sure enough the solder joints had come loose from the wiring. I fired up the soldering iorn and hit each solder joint with some fresh 50/50 flux core solder. Installed the instument panel and presto, all the lights work once again. Since then I have repaired that same problem in 6 different cars, 760, 3-960, 2-940 so it seems to be a regular problem.

Diagnosing Alternator Exciter Circuit Troubles. [Bruce Young] The "Battery", parking brake, brake warning, and bulb failure lamps should all iluminate when the ignition switch applies battery +12 to one side of all 4 bulbs and the other side finds a path to ground via that small red exciter wire from the panel to:
1) alternator D+ terminal, then

2) voltage regulator, then
3) alternator brushes and slip rings, then
4) alternator frame, then
5) Blue wire to engine ground.

These bulbs supply the required pre-excitation current to begin alternator charging:

- Battery light
- Parking Brake
- Brake Warning
- Bulb Failure

You can test for power to and thru the bulbs to the alternator D+ terminal by taking the red wire off the D + terminal and holding it to any *engine metal* (not the alternator itself) while a helper turns the Key ON and observes the warning lights.

Lights ON? = all is well to and thru the D+ wire.
No lights = check for battery voltage at disconnected red wire end
+12V present? = battery=>cluster=>D+ wire path OK (problem is in #1 thru #5)
No +12V = problem between battery and +12V side of cluster circuit

Alternator Removal and Replacement. Disconnect battery negative and the wires at the back of the alternator, carefully labeling each so you can replace them at the correct terminals. See the procedure above for removal of the alternator. See the FAQ file under Engine: Mechanical for removal of the alternator pulley.

Installing Rebuilt Alternators. [Joe Avsec] I just installed a remanufactured NAPA alternator and one of the housing srews vibrated loose after a couple of days. It vibrated to the point where it came in contact with the fins on the alternator pulley, breaking all of them off and making a terrible sound. [Kevin O'Brien] Had the EXACT thing happen with my last rebuilt alternator: the screw came out, put stress on the pulley, and loosened the main nut on the alternator shaft. [Editor] This suggests you use Loctite on these screws before installation.

Alternator Getting Weak; Regulator/Brush Replacement. [Symptom:] The alternator on a 740T / B230 engine is getting weaker, slowly but surely. What to do?

Regulator/Brush Change. [Editor] You likely need either a new regulator (screwed into the back of the alternator) or new brushes on the existing regulator. Swapping regulators is easy. The regulator has attached to it a set of brushes that contact the commutator. To replace the brushes, you will need to solder the new ones in place according to the instructions below. Also: Often the failure of an alternator is the result of a blown diode or a worn out bearing, etc. These parts are not expensive and their replacement is not difficult with the right tools. ($300+ alternator replacement cost for a burned out $10.00 part, what a scam!) With a little looking, I found a shop in my area that repaired the alternators (new bearings, brushes, leads, whatever else was needed) for about $70. All I had to do was get the alternator out of the car and bring it to them. This may be a way to go for your car. Note: regulators and brushes may be replaced on both Bosch and Nipon-Denso alternators.

Inserting the Regulator Back Onto the Alternator. [Randy Starkie] To keep the new, loger brushes from hanging up on installation, tip the assembly into place to position the brushes before straightening it up. After you push on it to straighten it the brushes are pushed back into the holders. Holding it in that position and then installing the screws usually works for me.

Soldering Tips: Earlier Wires Soldered to Terminals. Drill out the brush wire with a 1/16" bit where it is soldered to the brush holder. Brushes are available from Volvo for less than $4.00 (probably part number 1362710 for your car- they can check). Solder in the new brushes and replace the regulator/ brush assembly. [Tip from Chuck Jaxel] You should use rosin-core solder specific for electrical or electronic use. DO NOT USE PLUMBER's solder, you will create a bad connection. Solder should have shiny appearance when it cools, A dull gray looking finish indicates a cold joint, another bad thing. Practice on some old wire, find a junk radio or something and practice on that board, its not hard, just takes a couple of times to get it right. [Don Foster] When you solder the heavier alternator brush wiring, be aware that you might need extra heat if the braid (the wire going to the brush) is heavy, or if the connection is large. I don't know what heat range iron (Wattage) is in your "keet," but you might need a soldering gun (150-250 Watts) to deliver the heat. A small iron (25 Watts) may not do it. [Randy Starkie] There was a question about how to drill out the solder connection to facilitate the installation of the new brushes. I have included an image here that shows the assembly. I use a flat file to file the surface smooth. This gives a little more definition to the "target" area as well as providing a good surface to get the 1/16" drill started. Since the solder is soft the drill follows the path of least resistance removing the solder/leaving the holder intact (you will be drill towards the brush in each case). Once the solder connection is drilled out the old brush is released and basically "pops" out due to it's spring load. I apply paste flux to the lead of each brush. If you have trouble getting your solder to "stick" or flow out it is most likely because of the lack of flux. The new brushes from Volvo (part number 1362710- less than $4) have a solid wire lead on them that makes it easy to "thread" them into the brush holder. Pull them down far enough that the sides of the brush holder support the brush in an upright position. At that point bend the woven wire at a right angle to the holder to keep each brush positioned properly. Use a clip as shown in the photo to hold the brush gently against the spring. Apply the heat of an iron to the junction of the brush holder and the woven wire. Take a relatively small diameter piece of solder that has been dipped in the flux and touch it to the brush holder where the woven wire exits. Use enough solder so that the drill hole fills in around the woven wire (don't get over zealous here you don't want solder dripping out the backside into the brush holders). Trim the excess wire off and reinstall the assembly. Be sure to tilt the assembly as you position it so that when you press the assembly into place the brushes are pushed back down into the brush holders.

Soldering alternator brushes

Soldering Tips: Later Wires Crimped and Soldered at Terminals. [Tips from Don "Solder King" Foster] My '90 car has this later crimped-and-soldered connection. First, I flowed fresh, clean solder into the crimped connection. Next, I used a "solder sucker" to pull the solder out. Then I re-flowed and resucked. And again heated the connection and rapped it on the bench to fling out the remains of the solder. Then I was able to pull the brush out, leaving a tiny, crimped hole. Then I reamed the hole with a tiny ice pick and several jeweler's screwdrivers 'til I had the hole opened sufficently. Then I threaded the insulation over the new brushes' pigtails. Then I prepared and tinned the wire ends (new brushes) and tack-soldered on a 2' long piece of fine wire to use as a "leader." Then I threaded the spring over the pigtail. Then I stuck the end of the "leader" through the narrow hole, from the brush side, and used it to pull the pigtail through. Once I pulled enough through, I carefully (and gently) crimped the neck with cutters and then soldered the pigtail. I bent it over and solder about 1/8" down the outside and then cut off the excess. (You must pull enough through so that the pigtail will hold the brush properly in the holder but fully extended.) Before installing the VR assembly, I cleaned the internal contacts with a pencil eraser as well as cleaning the contact in the alternator. I also cleaned and shined up the screw ground and mating surface on the alternator case.

Alternator Regulator/Brush Reliability. [Inquiry] Is it wise to preventatively change out a 10 yrs old voltage regulator now? [Response: Gary DeFrancesco] The regulators themselves are fairly robust. It is the attached carbon brushes that wear out. If let go too far, the bushes become ineffective and the alternator stops charging eventually. I would pull the regulator/brush assembly out and have a look at it. If the brushes are less than about 3/16", I would go ahead and replace the assembly. An aftermarket assembly costs about $20. A Bosch unit runs about $50. I have installed both in my 2 745Ts this year. So far both are working fine. My gut feel is the Bosch assembly is going to last longer, but time will tell. I know there are those who say the brushes can be replaced and the regulator reused. If you have the tools and want to spend the time, go ahead. However, I do not know how much longer the electronics in the regulator will last. With all the heat under the hood, the electronics will eventually fail. Will they last through a second set of brushes, I don't know. So I just bypassed the question and put in totally new assemblies. Lets face it, $50 in the scheme of things is not a lot of money. Especially when one considers the time involved to solder in new brushes, the cost of the brushes (I know, they're cheap), and the cost of a big soldering iron (if you don't have one). [Response: JohnB] Only if you can't use a soldering gun and wire snips...costs about $10 or less for a brush kit. Prophylactically change out the brushes at 140K miles. Note that some folks have found that aftermarket regulators can cause poor voltage regulation and driveability problems: see Unexplained Driveability Problems: Bad Voltage Regulator . [Editor] For an older alternator, merely changing the brushes may not help much. You should rebuild it with new bearings and turn the commutator.

If you have flickering instrument panel warning lamps, see Warning Lights Flickering: Bad Alternator Brushes for a solution.

Checking Alternator Diodes. [Tip from Corey Glassman, “Electrical, Charging and Starting System Tips and Techniques”, Underhood Service, Sept 1999]

A Digital Multi-Meter's (DMM’s) accuracy and digital display make regulator/alternator diagnosing and adjusting easy. Be aware that many of the tests mentioned in this article may not work on your specific application. Some alternators can be damaged by full fielding for instance, others have a pulse width modulated field controlling charging. When in question, always follow the manufacturer recommendations.

An alternator generates current and voltage by the principles of electromagnetic induction. Accessories connected to the vehicle’s charging system require a steady supply of direct current at a relatively steady voltage level. You cannot charge a battery with alternating current, so it must be rectified to direct current.

Checking Ripple Voltage
Ripple voltage or AC voltage can leak past the rectifier bridge diodes and actually cause the battery to discharge. It can be measured by switching your DMM to AC and connecting the black lead to a good ground and the red lead to the "BAT" terminal on the back of the alternator. Do not connect the leads to

the battery, as the battery will absorb or "dampen" some of the AC. Run the engine at 2,000 rpm and read the meter’s display.

You may want to also load the system by turning on the rear window defogger and headlights. A good alternator should measure less than 500 mV (.5 VAC). A higher reading indicates damaged alternator diodes and may cause problems in the ECU.

Another way to check the integrity of the diodes on a Bosch regulator is to check the voltage readings at the D+ terminal and B+ terminal. The voltage reading should be the same at both terminals. A difference of more than one volt would indicate faulty diodes and the need to replace the regulator.

Use the Vehicle’s Radio to Check Alternator Diodes
Have you ever heard a whine from the radio that changes with engine rpm and isn’t rap music? You can use the vehicle’s radio to test the alternator’s diodes. Turn on the radio and select a quiet FM radio station. Turn up the volume and rev the engine from idle to 2,000 rpm and back down to idle. Listen for a small whine or "siren" noise in the background that follows the rpm change. The noise usually indicates excessive ripple or AC voltage leakage from the rectifier bridge diodes.

Verifying a Good Alternator
The battery must be fully charged before testing the alternator. Run the engine and verify that the no-load voltage is 13.8 to 15.3 V. Next, load the alternator to its rated output current with a carbon pile across the battery. If you don’t have a carbon pile, load the alternator by turning on as many accessories as you can. Run the engine at 2,000 rpm and check the current output with a current clamp. You may find that someone has put a number of additional loads on the charging systems increasing current demand from the alternator. Make sure that the alternator is rated to the application.

Where Is the Best Ground?
Technicians ask me this all the time. With the engine shut off, the battery supplies power to accessories and is the source of the best ground. After the engine starts and the alternator takes over, the alternator becomes the source of all power and the battery becomes a load and stabilizer. The best ground now is on the alternator case, located at the grounding point for the brush set, rectifier bridge and in some cases, the regulator. Where are they mounted? On the rear case half, and how is the rear case half attached to the front? Typically with four through bolts sandwiching the field between them. Most alternators use the front case half as the mount for the belt adjusters and block attachment. With the engine running, it is always a good idea to measure a voltage drop between the front and rear case halves to ensure great connections.

Testing Alternator/Battery Voltage and Amps.

Battery Load Test:

[Motor Magazine, Apr 2002] A load test indicates how well a battery can deliver current while still maintaining enough voltage to operate the ignition system. This is generally the preferred test for any battery in a late-model vehicle. A battery must be at least one-half to three-quarters charged for an accurate load test-preferably fully charged. A load test places a specific current load on the battery to indicate how it will perform under heavier demands, such as cranking. A good battery should deliver the specified current while maintaining a voltage of 9.6 volts or more for 15 seconds at 70 F. As noted earlier, a cold battery delivers less current than a warm one, so the minimum voltage specs must be compensated for temperature. At 30 F, minimum voltage drops to 9.1 volts; at 0 F, it's 8.5 volts. If you have a digital voltmeter with Min/Max recording capability, you can do a fast load test that yields quite reliable results. First, connect your voltmeter across the battery and select the Min/Max recording function. Now turn on the headlights and crank the engine until it starts. Finally, let the engine run for about 10 seconds, then shut it down. The minimum recorded voltage on your meter is the lowest voltage reached by the battery during cranking. The maximum recorded reading is the alternator recovery voltage after the engine started.

Charging Amps:

With the engine idling and no load on the charging system (lights and all accessories off, battery fully charged), the amperage output should be relatively low (typically less than 10 amps). With the headlights and heater blower fan on and the engine running at 2,000 rpm, the output should jump to a higher reading, typically 25-30 amps or more. Charging voltage varies according to underhood temperatures. Room temperature charging voltage is generally about 14.2 volts. As underhood temperatures increase, charging voltage drops down to about 13.8 volts. In very cold climates, charging voltage may temporarily increase to 14.8 or perhaps 15.0 volts.

Voltage Drop in Cables:

Test the voltage drop in the battery cables to ensure that corrosion or internal failures are not preventing a charge. [Tip: Jim Bowers] There should be less that 0.2 volt drop from the alternator to the battery + terminal. My car had a bad crimp on the lug at the alternator and after I bought it I had "no-starts" due to a depleted battery. After starting the engine while the battery was recharging, I measured 0.5 volts from the alternator stud to the wire just after the lug. I cleaned and soldered the crimp lug and while I was at it also replaced the regulator/brush assembly. I've had no battery problems for 5 years now.

Cautions:

Don't trust your volt meter in the instrument panel ! Always check voltage at the alternator & battery. If that alternator is weak you'll notice a drop in fuel economy because the fuel system tends to go rich as a battery dies. I replace around 40 voltage regulators in a year, and maybe 2 alternators. Be careful of chain repair operations, gas stations and tow-truck operators: Pep boys technician : "I'll do a quick battery test." Technician disconnects battery with ignition on and engine at high idle . Result: INSTANT $865.00 DAMAGE, blowing five relays, radio and other electrical equip. NEVER disconnect battery with engine running!

Alternator Wiring is Failing. [Editor's Note: See the section on "Baked Wiring Harnesses" in Electrical: Circuits, Relays for more information.] One quick thing to check is the ground wire that goes from the alternator to the engine block. That broke on me, resulting in my running off the battery with the same symptoms you have. It was not until I pulled the alternator that I saw the broken wire. Would have saved a lot of time to check that first. I have been through this on so many cars that whenever it happens, and the battery proves to hold a charge, I automatically yank the alternator and head straight for the local rebuilder. I couldn't tell for sure at first which alternator I had-turned out to be Bosch internal. I don't remember how much to rebuild, but it was considerably under $100.

[Symptom: idiot lights all go on; also, oil pressure gauge is erratic:] Having all the idiot lights go on at once is not as strange as it might seem. This will happen if the small wire leading to the back of the alternator is grounded. It will also happen if the alternator is not generating any current. When this wire is at ground potential, it is the same condition as before you start the car - hence the idiot lights are on so you can check they are not burned out. The wires for the alternator and also the o/p sender go around the front of the engine under the main crank pulley. (If you get under the front you will see what I mean.) Dripping crank seals often get oil all over these wires. Not to mention it is hot by the alternator. Flaky insulation may be at work. If you really want, you can reroute these wires around the right side of the car instead and splice into the harness at the firewall.

Battery, Terminals, and Wiring:

Slow Battery Discharge. [Inquiry:] I am having an electrical problem with my Volvo. About two months ago the battery went dead--slowly over time. It was an old battery, so I though nothing of it and replaced it. All was good for a month and a half, then it went dead again. With the car running I measured 14volts across the terminals of the battery (12 when stopped) and 14v off the main positive lead of the alternator. What is the problem here?
[*Battery Drain Diagnostics*: Response: Ross Gunn] To check to see if there is something draining the battery while the key is off, remove the positive battery terminal, and with an ammeter, measure to see if there is any current flowing from the battery to the cable (or, for more accuracy, use a low-amp induction probe ammeter to measure current flow through the battery cables.) If there is anything more than a couple of milliamps, try removing fuses one at a time to see if you can identify the circuit that is causing the drain. If this pins down a problem, a little more sleuthing through the offending circuit should tell you what needs to be done.
If there is no drain showing with the above test, the charging system is suspect. Try measuring the voltage at the alternator output terminal and battery pos terminal with all utilities (headlights, rear window heater, fan etc.) on high. Any difference in reading indicates a poor connection somewhere in the red cable from the alternator. Don't assume that a crimp connection of a terminal on the cable is good. Corrosion can introduce enough resistance to prevent proper (any?) charging when there is a significant load on the system (cold, dark, wet/snowy winter evenings). I have experienced this on a 20 year old Brick.

[*Battery Drain Diagnostics*: Chris Bowne] I agree with Ross Gunn that the best way to trouble shoot a discharging battery is to find the source with the engine shut down and a multimeter (set to measure DC current) in series with the positive battery terminal lead. Other places to check besides the fuse block for drain paths are the alternator and voltage regulator (if not internal to the alternator).
Disconnect/reconnect the connections on them, one at a time, and monitor for drain. I had a problem on a Ford Taurus once where the voltage regulator had shorted, and was the cause of the drain. You may or may not find a source of a drain like this merely by pulling fuses. In fact, you could end up with all the fuses pulled, and still have the drain, like I did!
Someone on an earlier posting of this thread mentioned checking to see if his alternator was providing output by lifting the battery + terminal connection WITH THE ENGINE RUNNING. DO NOT DO THIS! Many solid state regulators will be damaged/destroyed by this condition. (And in turn may compound the causes of the battery drain you are troubleshooting!)

Battery Drain Tips. [Tip from JohnB] Check the specific gravity of the cells...if they're accessible.
With a fully charged battery, either from your battery charger or the alternator, disconnect the battery and measure the voltage, measure it again 12 hours later and it should be virtually the same, maybe .1v less, no more.

Reconnect the battery to the car and turn on the headlights on full bright for 10 minutes and every accessory in the car...if the battery dies in 10 minutes replace the battery. Otherwise, battery voltage should remain above 10.5 volts or so after this test. There are load testers available in auto parts stores for about $30 or so that will do a higher load test (couple hundred amps through a resistance load bank) in about 10-30 seconds against a red/bad yellow/weak green/good voltage scale.
If these tests still have you with a good battery, then you just have to trace down the current drain, circuit by circuit.

Tool Tips for Short Circuits. See the Special Tools section of the FAQ for suggestions on tools capable of rapidly locating shorts in wiring harnesses.

Starting Problems and Battery Cable/Terminal Corrosion.

Terminal Corrosion and Starting Problems:

[Inquiry:] Car cranks strongly but will not start. [Response 1: Jim Rothe] I've been discounting -- actually, completely ignoring -- any possibility of battery terminal corrosion, mostly because I've always had strong cranking power. But in light of last night's incident (and the prior one time occurrence) of starting with the help of a jump start, I'm going to re-check these things. I'm reminded of incidents with my RX-7 last year, when I was able to crank it strongly and it wouldn't start. I replaced the battery a few weeks later when the starter motor started sounding weak, and then my intermittent no-start condition miraculously disappeared. I've since found out that early rotaries tended to be a bit more susceptible to weak sparks (compounded by old, low compression, engines) than other cars. Food for thought.
[Response 2: Eric Anderson] I may be covering something you have already checked, i have not re-read all your posts but several things you have written have rung some bells on micro-corrosion. I work for Lockheed and spent years (and some of our tax dollars) chasing this buggaboo down and around. MicroC exists everywhere and is aggravated by substantial temperature changes. It is a microscopic or larger film of corrosion that can build up on both positive and ground connections with a preference to the ground connection, however auto's positive connection are just as susceptible. Have you thoroughly cleaned the battery connections, tightened and applied an anti-corrosive (exide cro-guard, etc)? removed the starter B+ (positive cable) and brush the lug and the stud it attaches to plus all washers and mounting points. retightend and apply antiC? Same applies to ground connections.

[More Battery Cable Tips from Paul Grimshaw] The battery grounding cable on Volvo 700-series cars fitted with the 2.3 litre engine is constructed of braided steel, crimped to lugs which secure it in place. Over time, chassis and engine bay vibrations may weaken the grounding wire. Furthermore, the effects of salt-induced corrosion can adversely affect the crimped portion at the lugs--resulting in a poor electrical contact. Any ground failure, whether total or partial, can play havoc with electronic systems and can lead to the failure of the car's engine management computer and/or mass airflow sensor Given the risk of failure of this part, it's advisable to regularly inspect the ground cable and replace it as a precaution every couple of years.

Diagnosing Corroded or Malfunctioning Cables and Wiring Using the "Voltage Drop" Method:

[Motor Magazine Mar 04] Measuring the resistance from one end of the cable (the battery) to the other end (the starter) will not reveal a problem. That's because your Digital MultiMeter places an almost unmeasurable load on the cable when it measures its resistance. Because the load is so small, the DMM will show a very low resistance reading, as long as even just a few of the strands in the battery cable are still good. The DMM can't tell the difference between a good cable and a bad one with this test. What's needed is a test that will reveal the cable's performance when it's in operation and under a load. To test the negative battery cable, attach the DMM's negative lead to the negative battery terminal. Don't attach it to the terminal clamp; we want to test the whole circuit from end to end. Attach the positive DMM lead to the starter motor body or the engine block. Set the DMM to the 0-40 volt DC scale, then have an assistant crank the engine while you watch the DMM display. Any voltage reading shown represents the voltage that has been dropped between the battery and the starter motor. Typically, a ground cable that's in good condition will drop .1 volt or less. Don't accept a voltage drop that's greater than .3 volt. A cable that's causing starting problems may be dropping far more than even these modest amounts. Voltage drops may occur at any point in a circuit. It may not be practical to replace all of the suspect wiring, so it will be necessary to pinpoint exactly where the voltage drop is occurring. It's relatively easy with something like a battery cable because there are only a few joints or connections in the circuit. If there's a voltage drop, the likely suspects are the cable itself or the terminals at each end. Cleaning the connections and replacing the cable should take care of the problem.

When a circuit is longer and more complicated than a battery cable, save time and keep your diagnosis focused by using the "split half" method. Divide the circuit in half, then perform a voltage drop test on one half at a time. Find a convenient connector somewhere in the middle of the circuit to mark your halfway point. Conduct a voltage drop test on the front half of the circuit while it's under load. If no significant voltage drop is found, move to the rear half of the circuit, then retest. Keep dividing the remaining segments of the circuit in half until you've narrowed it down and have conclusively located the voltage drop. Many circuits on today's vehicles are designed to carry very low voltage and amperage. Ohm's Law reminds us that any added resistance in these circuits will have a direct effect on their ability to perform as designed. Voltage drops measured in tenths or even hundredths of a volt can be significant and will cause problems.

Cleaning Battery Posts and Connectors:

[Editor] You can clean the battery posts and cable connectors safely by:

- Disconnecting both cables and keeping them clear of the battery
- Mixing a baking soda solution in water
- Wiping that on the surface of the battery and on the connectors, then rinsing (this removes acid). Rinse the tray as well.
- Cleaning grease off with rubbing alcohol and a rag
- Polishing up the posts with either fine sandpaper or a metal brush
- Cleaning the terminals with a metal brush and fine sandpaper
- Inspecting them and the cables for damage, broken strands, etc. Replace if needed.
- Reassembling with the little red and green battery anti-corrosion washers (they really work!) under the terminals and then, once the cables are secured, spray the post, connector and exposed part of the cable with anti-corrosion spray (a red lacquer you can buy in the battery section at KMart, Walmart, etc.)

Your biggest problem will be corrosion damage inside the cable, which is tough to fix. See battery cable connector repair for procedures.

Connector Under Battery Tray? [Inquiry] Whilst cleaning up (minor) corrosion under the battery tray on my '85 765T I found a rubber device (inserted into the tray) with a cable which leads off to a (disconnected) 2-wire plug. Where does it go? What does it do? [Response: Abe Crombie] It is a temperature sensor that affects the voltage regulator activity. The idea was to alter the voltage as battery temp changed. The voltage needed to charge battery without overdoing it and risking electrolyte evaporation varies with the temp of battery. This noble engineering feat was fraught with troubles though as the sensor could (and most times did) get attacked by acid and the temp value would be wrong. The result was exactly the thing the sensor was there for, i.e., it would overcharge. There was a service bulletin 13 years ago saying to disconnect the sensor plug on back of alternator. The voltage regulator would revert to internal temp regulation when the sensor resistance went infinite.

Unexplained Drivability Problems; Rotting Battery Wiring Harness. Last weekend, I uncovered the 1989 780T to show a friend. I haven't driven it in a while, so I took him for a ride, so he could appreciate a well built Volvo w/ A/C that works. The car ran well, but seemed a little "late". After glancing at the gauges, I noticed the volt meter reading low. I don't trust the volt meters in Volvos, but felt the need to check alt. output anyway. At the battery (new OE), the output (input, actually) was 12.9V. No good. I could hear the alternator charging, but checked the regulator/brushes anyway. No problem. I checked the output at the alt. and the output was 14.1V Good. This car has a battery cable "Harness". After cutting it open, I found the insulation to be gooey and loose. Current was flowing between + and -- through the insulation. After replacing the harness, everything came back to "like new!" The car's acceleration was impressive, not just "good". The ECU said thanks, and the slight drop in fuel economy went away. Reason # 14.2 to use a good battery. 12.9 just doesn't cut it. The problem was wiring this time, but sometimes just changing the battery returns life to a Volvo. Check your electrical system thoroughly.
[Editor's Notes:] See the 960 section for a detailed discussion of battery cable connector repair procedures.

Car Battery Failure: Diagnostics.

Service and Diagnostic Tips:

[Motor Magazine, April 2002] The most basic battery services are simple inspection and cleaning. Following are some fundamental steps:

- If the battery has removable cell caps, check the electrolyte level. It should be above the tops of the plates or at the split-ring indicator in each cell. If electrolyte is low, add mineral-free drinking water or distilled water. Do not overfill.
- Check battery terminals, cable connectors and metal holddowns for acid corrosion, and clean as necessary.
- Check cables for broken or corroded wire strands, worn insulation and defective connectors. Replace defective parts.
- Look for cracks in the case and loose terminals. Replace a battery with these defects.
- Check the battery tray and holddown parts for looseness, corrosion or other damage. Clean, tighten or replace parts as needed.
- Inspect the battery case and cover for dirt, grease or electrolyte condensation, and clean as necessary. You can clean a battery with a solution of baking soda and water to remove corrosion and electrolyte deposits. Make sure to keep corrosion and the cleaning solution off painted surfaces. Remove heavy corrosion with a stiff-bristle brush. After removing corrosion, clean the battery with a detergent/water mixture, then rinse with clean water. Disconnect the battery cables and clean them with the baking soda solution. Scrape battery posts and the inside of cable terminals with special brushes or scrapers. After cleaning the battery and cables, dry them with a clean cloth or low-pressure compressed air.

[Inquiry:] My battery died at 40 months; is this normal? [Response: Tim Curry] This could be a "normal" failure of the battery, but check a few things first.

1) Battery cables. Positive side will be more likely to have a build-up of crud or bad connection, but check both cables. Is it clean at the connection? Is there corrosion at the cable/end where it joins the clamp itself (grey stuff at the wire insulation or a thickening/bulge of the cable somewhere in the insulation). Remove both cables, clean the terminals (wire brush), use the red & green felt rings under the cables to preserve the connection. Tighten both cables.

2) Get a multi-meter and measure the voltage between the battery terminals with the engine off. If it is less than 12 volts, you have a battery or charging system problem. Use jumper cables and get the car started. After you remove the jumper cables, check voltage with the car running and no lights, AC, radio playing. Should be over 12.7 volts and 14 plus volts if the idle speed is raised a little. If this is the case, your charging system is good, but your battery (or cable) is bad.

3) If you don't show an quick increase in voltage, check the fan-belt. If it is tight, check the voltage regulator at the back of the alternator. It would be easier to work on it with the alternator removed on some cars (turbo especially). There are 2 screws that hold the regulator in place on the back side of the alternator. These screws hold a brush assembly in place against the internal shaft of the alternator, carbon blocks on a spring assembly attached to the holder. The carbon brushes wear down with time and do not put enough pressure against the armature to make good contact. Often the alternator is good, while the brushes have worn out. The part costs less than $30 (US) and is available from shops with a decent electrical parts supply.

4) It could be the battery. Here in Tucson, the average life of a battery is 28 months (from the Exide corporation). Our problem is not cold cranking ability, it's the heat. If the plates inside the battery are exposed to heat, subjected to constant cranking, or given a "quick charge" there is a lot of heat generated inside the battery. The metal "grid" expands due to heat, the "paste" inside the grid is loosened and begins to fall to the bottom of the battery or swells in place. This will eventually cause a build-up of metal in the bottom of the cell which can "short out" the cell.

A break in the grid or swelling, a loose plate, an old battery, too much heat (or cold) and a dead battery is the result. Don't buy a "lifetime" battery. It will cost $100 and still fail before your life is over. Buy a moderately priced battery with 4 years of life for $35-$40 and you will be spending $10/year, not $30/year. Plan on setting your clock at 4 years and start saving for the next $40 battery.

Car Battery Replacement Tips.

Purchasing Tips:

Sourcing US Batteries. [Consumer Reports] Most auto batteries are made by just three manufacturers: Delphi, Exide, and Johnson Controls Industries. Each makes batteries sold under several different brand names. Delphi makes ACDelco and some EverStart (Wal-Mart) models. Exide makes Champion, Exide, Napa, and some EverStart batteries. Johnson Controls makes Diehard (Sears), Duralast (AutoZone), Interstate, Kirkland (Costco), Motorcraft (Ford), and some EverStarts.

[Tips from Rich:] Being involved in the telecommunications power business since Mr. Bell was a pup, I have some knowledge about batteries. If there were any additives that are useful in the long term they would be commonly used. There are not. As to size, buy the biggest heaviest battery that will fit. Typical car batteries are around 50 amp hours and weigh around 45 pounds. Some parts chain may sell you a cheap, light battery with a warranty, but they are counting on you not owning the battery when it goes bad. Since batteries do not like to be used a small battery is stressed more when cranking and when charging. Sure, a low charging rate is best for a battery, but you have no control over that. At some speed your alternator puts out 70-100 amps. Deducting 20 amps for fuel pumps and ignition the rest is going into the battery.

Car batteries are designed for high-rate discharge (cranking) and a reasonable life of 5 years. Other designs optimize other types of service. Marine "Deep Cycle" batteries accept repeated full discharge conditions. Telcom batteries are designed to sit there for 10-20 years with charging voltage applied and ready for the very infrequent discharge when AC power fails. UPS batteries are similar but due to the competitive consumer market they will not last very long.

Design considerations include a space at the bottom of the case so that material that falls off the plates can accumulate. Eventually it piles up enough to short out the plates. Longer life batteries have more space but they also have less lead and therefore less Amp-Hour capacity in a given size. The 20 year batteries have a lot of extra space added for a long life seal where the post comes out of the case. It is the nature of a battery to eat away the post seal. When it does you get the white powder. Felt washers and grease do not keep the acid from eating the seal away. The white stuff is the end result of the seal failing and efforts to remove the white powder do not cure the problem.

It is useful to remember that there is no magic in batteries. Every manufacturer understands the chemistry perfectly. The only difference is in the PR and advertisment depts.

The biggest battery you can fit has a chance of having more space below the plates and a better seal. When Johnson Controls made the Die Hard batteries they were good. Now that someone else makes them they are not so good. Since Interstate distributes J. C. batteries that is what I buy. You will not hurt the alternator with a bigger battery. I always had good luck with OEM Volvo batteries but I understand that the 850s had a battery vith frequent failures. Sounds like the Purchasing Dept saved the company a buck or two but gave the reliable cars a bad name. This is not the first time that has happened, and will not be the last.

[BatteryTips from Tim Curry:] I talked to Exide here in Tucson a while ago and found out a bunch about batteries. Basically, here in the heat, they last an average of 28 months. If you buy a "lifetime battery" for $100 and it lasts 3 years (heat is bad for batteries) you spent $33.00 per year. Pro-rated? Oh yes, that saves you (you pay some every three years). If you need cold cranking amps, the plates are thinner and there are more of them to make more juice in a limited container. They also heat faster under a load. Heat them once without enough electrolyte (low on water) and you get the dreaded China Syndrome, cooked plates. They distort, shed some of the lead and it settles to the bottom of the container of the low cells. Get enough and the plates ground out internally to each other if the level reaches the bottom of the plates. Hot weather batteries? They use smaller plates and more electrolyte (it acts as a coolant inside) to cover them so a low "water" condition isn't as bad. Trade off is cold cranking amps (who needs it at 115 degrees, the car is always warmed up). Best buy? A commercial battery (truck fleet types) that you keep charged and full of electrolyte. 5 or 6 years at $65. How long do most people keep their cars? $33 / year or $10 / year? Next bet is a 4 or 5 year wonder from Wally's World for $29.95. It will last for as many years as stated and you will buy another, so its cheap. Oh yes, the battery, alternator and starter are a SYSTEM! Don't buy an 18 wheeler battery to start your VW or the alternator may be unhappy. Don't buy a motorcycle battery to start your Volvo, the starter pulls too many amps, the alternator will cook it from charging too fast and the starter will poop out from not enough current to get the job done because of heat $$$$$. Now you need one of each.

Battery Explosion; Wiring Chafing. Received panic call from wife that '88 740 Volvo just went completely dead on road and smoke was pouring out from under hood. When I arrived, all electrolyte

boiled out of battery and battery cable insulation melted. Turns out was a direct short where cables pass under engine. Volvo neatly bundles both cables in a plastic sheath. Unfortunately too tight against bottom of engine and cut through. Dealer was no help and said they never heard of such a thing. Same response as to bad solder joint problem in my overdrive relay. A new battery and cables cured the problem. Volvo later issued a recall for battery cable chafing.
[Technical Note from UK Volvo Club, 700 Section] On 700's the front suspension crossmember has the heavy battery-to-starter cable running over its nearside front edge. These were the subject of a recall some years ago as they chafed, leading to a big electrical short (and under-bonnet fires in some cases). Apparently, most cars were caught, but the odd unmodified one must still be about. The recall modification involved fitting a sheathed clip, which lifted the lead away from the cross-member. It's screwed to the nearside front cross-member inside the fixing point of the lower suspension arm.

Note: This file describes generic procedures and those specific to AW70 and ZF series transmissions found in Volvo 7XX and 940 four-cylinder and PRV-6 cars. For information about the 960/90 series AW-30 electronic transmissions see the separate FAQ file.

Maintenance:

Transmission Service Procedures .

Checking the Fluid Level. To check the transmission fluid level:

- The engine and transmission must be hot (so drive the car for 20 minutes or so)
- The car must be parked on level ground with the handbrake on.

- The engine must be on.
- Start in "P", then cycle through all the gears, ending up in "P".
- Then check the fluid level at the yellow dipstick. Reinsert the dipstick with the notches toward the rear to avoid jamming it in the tube.

Checking Level When Fluid Is Cold. [Ken C] I've found that when I have the ATF level correct (based on a warmed up transmission and the proper dipstick scale for the temperature), there is also a way to reliably confirm proper fluid level when the engine is stone cold and not running....e.g., after you've let the car sit overnight. On the dipstick, above the plastic part that has the two temperature-specific scales, there is a little rectangular notch on the metal portion. Assuming the fluid level is correct, and the car is stone cold and you haven't started the engine yet, if you withdraw the dipstick and wipe it off and then reinsert it, then upon withdrawing it for this second time the fluid level should be on that notch. This does NOT work if you just withdraw the dipstick and look at it -- you MUST withdraw it, wipe it off, and then reinsert it before withdrawing again to read the level.

Service Procedures. [Inquiry] I am considering doing the 20k transmission service. What do I need to be aware of? [Editor] Easy: just unscrew the tranny pan drain bolt, drain, and refill with the same quantity to the correct mark on the dipstick. You will need a funnel with a long, thin neck to fit into the drain tube, and a drain pan. Use a socket on a breaker bar (12 inches or longer) to "break free" the pan bolt, which may have a little corrosion. Be gentle putting it back. [Response: Chris Herbst] Volvo no longer recommends dropping the pan and cleaning the screen on the AW70 as a matter of routine maintenance, even though there is a strainer in the transmission. Neither it nor the pan need to be cleaned unless major problems have arisen. This is from a recent Volvo Tech Service Bulletin that dropped the recommendation, still found in most owner's manuals. You do still need to drain and refill the pan regularly, though. [Editor] Many owners highly recommend a fluid flush on a periodic basis, say every 60-80k miles. This removes all residual dirt in the fluid.
Drain Plug. Watch out putting the transmission drain plug back in: recommended torque is only 13-17 ft-lb in this soft pan. . The pan is very soft and I stripped the last one that I did. Also use a new aluminum washer if possible. Bolt size is 10mm by 1.50mm thread pitch.

Fluid Specifications. Use Dexron fluid in your AW or ZF transmission. The latest Dexron Spec is III-H and it is all backward compatible to the Dexron II or III listed in your owners manual. Even better: buy a synthetic fluid such as Mobil 1. In the Lubrizol "knowledge Base" site at www.lubrizol.com, they note that two European commercial vehicle automatic transmission makers have posted specs for mineral oil versus Group III hydrocracked and full synthetic automatic transmission fluid lifetimes:

Transmission Maker	*Drain Interval using Mineral Oil Fluid*	*Drain Interval using Group III Synthetic*	*Drain Interval using Full Synthetic*
Voith	60k km/ 40k miles	60k km/40k miles	120k km/80k miles
ZF	30k km/20k miles	60k km/40k miles	120k km/80k miles

This is an indication of the value of synthetics in normal use. Mobil 1 ATF is a full synthetic meeting Dexron III specs. Castrol Syntec is a Group III hydrocracked fluid meeting Dexron III specs.

Safety While Working on Transmission. [Editor] Note that you can accidentally shift your transmission while working around the linkage beneath. To be safe, don't rely on "park": use jack stands and chocks to hold the car secure.

Any Bands to Adjust? [Inquiry:] I recently acquired a Volvo with an AW-70 in good condition from my brother-in-law. I am planning to flush the ATF and replace the filter in the near future. My friend suggested adjusting the bands while I have pan off. Is this a reasonable thing to do? Does the AW70 even have adjustable bands? [Response: Abe Crombie] The AW55/70/71/72 and BW55 don't have bands. These gearboxes use friction discs as brakes. Disc brakes don't require (nor is there any way for) adjustment.

In-Line Filters. I've had one for a year and due for a replacement and "surgery" next year. But my unit is made by Tekonsha (#4350A.) It is call "MagFilter" and goes in the A/T return line. In addition it has a very strong magnet ring inside, you stick a nail to the plastic cover and it will hold it. Should be replaced every 15K to 20K mi. and it's about $28Cdn. I've been running with this setup in -36F (-38C) no problems. It filters down to 30 microns. For more info call Tekonsha 800-325-5860 (for your local distributor) [Note: IPD now sells this filter for both A/T and P/S line applications; Wix sells the same unit under their label.] After I changed it I opened the used one. I found that the magnet inside was foul with metallic particles (it looked like grease, because the metal dust was mixed with ATF).
Return line: The top line is the return line. You can check it by connecting a hose to the end from radiator (disconnect the "+" wire on the ignition coil) and try to start the car, you'll see ATF coming out of the line on radiator end. [Another note:] Hurst now makes a filter unit that splices into the transmission fluid lines. It uses a Fram oil filter as the filtering element. [Note from Jim Bowers] Hayden makes a barbed fitting (#390) that connects to the radiator fitting and allows the hose to be slipped onto the barb.

7XX/940 Fluid Flush.
Rationale:
[Editor] If your car has sluggish shifting, especially when cold, or you would like to remove all dirt and old fluid from your transmission, consider a complete fluid flush instead of just draining and refilling the pan. *"But my mechanic told me if I flush the old, brown fluid, the transmission will fail! He won't touch it."* [Robert Ludwick/Kane Leung] Sadly, you don't have to pass an IQ test to be a mechanic (i.e. "Bubba taught me this way an' that's how ah do it!") But another reason why shops say this is liability. Brown fluid means the tranny is has suffered wear from neglect. They change the fluid for $50, and say one week later, your tranny dies ... would you blame yourself for not taking care of it sooner, or the shop because they were the last ones to do anything with it? Flush it anyway: it works. *Caution: If you have a ZF transmission, see below.*

Procedure:
I recently changed the trans. fluid in our '92 940 using the cooler line disconnect technique. Here is the easiest way to do it:

- Obtain either IPD's transmission flush hose or a clear vinyl or plastic tube (3/8 inch I.D.) about eight feet long, three or four gallon milk jugs calibrated with a permanent marker in quarts, and a transmission fill funnel with a long, thin neck. Have at least your tranny capacity (approx 9 qts.) in new fluid on hand. 3/8vinyl hose is a tight fit (heat it in water to get it on); 1/2 inch I.D. will require a clamp.

- Buy 12 quarts of new fluid. Highly recommended: synthetic such as Mobil 1 Synthetic ATF.
- Remove the transmission dipstick with the yellow top and put the tip of the funnel into the filler pipe. Press down firmly on the funnel so that it stays in place. If need be, use some wire to secure the funnel so that it doesn't come out or fall over.
- Drain all the oil from the transmission drain pan (2-3.5 qts depending on model).
- Refill 2 qts into the filler tube.
- The transmission cooler return line is the top line entering the top fitting at the radiator. Using two wrenches (one as a counterhold wrench so you do not crack the fitting at the top of the radiator), remove this cooler line. Penetrating oil can help loosen threads. Pull back gently on the cooler line to separate it from the radiator. Push the transmission fluid line slightly aside (use a cable tie to hold it, if necessary).
- Connect the clear plastic hose to the radiator fitting by pressing it on the thread, lubricating with ATF as needed. Fish it through over or through the grill and into to a gallon milk jug on the ground.
- Turn on the engine. Fluid will start draining out of the tube into the jug. The fluid does not drain out all that fast - ~25 seconds for 2 qts - and stops when you stop the engine.
- Watch the fill rate on the side of the jug and have a friend refill at the same rate into the filler tube. [Editor's Note: have a friend engage parking brake, apply the main brake, and place the transmission in "drive" for a minute to flush out other parts of the valve body and torque converter.]
- After approximately nine quarts, you will notice fresh fluid flowing out of the hose. Stop here.
- Button things up (do not overtighten the cooler line fitting), check final level, check for leaks, etc.

Everything worked very well - the only pitfall was that I ended up overfilling the trans. a bit (~3/4 qt) - I think I must have been a little off every time I estimated I had drained 2 qts. So finally I had to pump all that out of the filler tube while checking the level - a bit of a hassle but not too bad. [Tip: if you overfill, just unscrew the pan bolt slightly and hold it while the fluid drips out to the quantity required. Messy but easy.]
Flush By Draining the Torque Converter? [Frank] Some Euro indy mechanics have suggested that a better flush is achieved by first draining the torque converter. Not true: this creates a large air gap and forces the tranny to run dry while it refills. The Volvo OEM flush procedure is through the cooler lines as noted above.

A/T Fluid Needs Changing; Late or Poor Shift Quality.
Delayed Transmission Engagement When Shifting into Gear:
[Inquiry:] The drive gear engages late when shifting from P to D in my auto transmission. [Response: Marc] The problem you describe can be attributed to either a low level of transmission fluid or a stuck valve body. If the fluid is low in the torque converter, it will take additional time to transfer the engine power to the transmission, as the power is transmitted through a fluid by spinning up a plate with fins on one side and the fluid spinning up a secondary plate with fins on the other (thus keeping fast changes in the engine power output from damaging the transmission).

I would recommend that, if you have not recently (within the last 6 months) changed the transmission fluid and transmission filter, you have this done. In my area, the change runs as low as $49.99 US, including parts & labor. If you have the Haynes manual for your car, take it with you if go to anyone other than the dealer, as the fluid may have to be drained in a non-standard way via a transmission fluid cooler return pipe (non-standard compared to other brands of vehicle). This service will also clear up most sticky valve bodies, as the new fluid reliquifies old gummy deposits...[Editor's note: see also Fluid Flush]

Late or Poor Shift Quality While in Gear:
[Symptoms:] Late or poor shift quality. [Response 1:] Since this is an unknown as to when the transmission was serviced I would recommend a power flush. Wynn's/Kendall has a machine that connects to the line to the cooler. Then they add a detergent and run the car for about 20 minutes with it off the floor and in different gears. Then they go from a recirculation mode to a change mode and add new fluid while discarding the old. This gives a full change including the torque converter. It will cost from $60 to $95 but I think it is well worth it about every 100000 miles with normal change in between. I think both my ZF and AW worked better and smoother afterwards. Call around and you should be able to find some shop that does a power flush.
[Response 2:] How dirty was the fluid was when the transmission was finally serviced? Your transmission has no bands, just clutches. When pressures are right for a shift, fluid pressure is directed to the clutch(es) that is/are to lock up. If there is a lot of clearance due to wear in the clutch packs, you usually get a delayed and hard shift. If the valve body has a problem, it could cause reduced pressure to go to the clutch pack, causing a slip as it shifts. The most common problem is governor pressure loss due to a worn output shaft bearing. Even after the output shaft bushing is replaced, the problem could still exist because while the bushing was bad, excessive wear to the transmission case where the shaft goes through, is common. A pressure test will in most cases will pinpoint the problem. This is reason # 71 for servicing the transmission at normal intervals. Every 20,000 miles is recommended. It's pressure test time.

Intermittent Shift Failure: Clogged Filter
[Inquiry:]   After starting, everything goes well, the transmission shifts, but in a short while, suddenly, the transmission becomes disconnected, losing traction; moving, I accelerate and the motor increases revolutions but the car behaves as though it were in neutral. I must stop the motor, wait a moment and repeat the operation. While the problem is occurring, if I accelerate in neutral I hear a slight buzzing noise of gears even though the transmission has not engaged. The oil is new. I changed the kickdown cable. [Response: Abe Crombie] The things you list sound like a stopped up filter inside transmission pan. Did the pan get removed and the filter inspected? The filter is a fine metal mesh strainer and can be cleaned in most cases. I didn't read your previous post of a month ago so I do not know how this started but using shop clothes to wipe off things inside transmission or to wipe the pan when it is off, can introduce lint that the transmission filter will catch when it is running. The debris on filter then starves the transmission pump for oil. The transmission pump will whine when operating with excessive vacuum on its inlet due to a plugged filter. When you stop and shut down engine, the lint falls off the filter and it will work again for a period of time until the lint is sucked up onto filter once again.

ZF22 Transmission

Fluid Drain. [Procedure:] ZF 4HP22 Transmission Fluid Change. This is passed along for the 740 owners with this transmission. I have the same transmission on my Peugeot and found out that if you leave the car for a few days on with the front end on jack stands, the fluid in the converter will slowly drip out. This way you can get an almost complete drain before refilling. [Tip] HEAT is the biggest enemy of every tranny (especially in automatics). I've got a ZF on my 740 and synthetic ATF dropped the tranny temperature from 92C to 60C (driving in a summer for about 40min. in a city). I've measured the temp. on the tranny metal line, the temp. of the fluid itself is most likely higher.

ZF22 Preventive Maintenance. [Fitz Fitzgerald] There are many people putting a lot of miles on ZF transmissions, but the transmissions are more prone to failure than the AW trannys. A few words of advice for preventive maintenance on ZFs:

1. Do not rev the engine in Park or Neutral: this will tear one of the forward clutch packs to pieces.
2. Change the fluid at the specified intervals and be sure to remove and clean the pan before the first fluid change. Performing a fluid flush without removing the pan can break up some sediment in the bottom which will be sucked up into the takeup and act like sand in the bearings and valve bodies. Feel free to toss in a larger magnet before putting the pan back on.
3. Run synthetic trans fluid if you can afford it. Mobil 1 full-synthetic is worth the improved longevity.

Transmission Mount Replacement. [Editor] The rubber transmission mount will compress over time and need replacement. To do this, support the front of the car on jackstands. Place a jack under the transmission pan with a board to distribute force and jack up enough to support the transmission. Remove the rear support cross member and change the transmission mount, reinstalling in reverse order.

AW70 Transmission Mount, Courtesy FCPGroton

AW-70/71 Transmission Life? [Inquiry:] Any thoughts out there on the life expectancy of an AW70 tranny. I've got a 745 with 145K and it seems strong. I flush the fluid every summer. I know some think this is not good, but it seems to work. Are the AW70's rebuildable or do you just replace them? [Response 1:] I had a minor problem with this tranny (worn check valve in the valve body, which caused it to shift hard between 1st and 2nd gear). When it was fixed, I also asked about the tranny in general, and I was told that these units usually require a rebuild at about 350 000 kilometers, or more than 200 000 miles. And only the clutch and brake packs need to be replaced, usually all the bearings are still OK. [Response 2:] They can go 250 K. They can be rebuilt, that box is shared with several Toyota rear drive 4 cyl models in the early to late 80's.

Transmission Line Crack Prevention. [Tip from Tony P] My lines actually rubbed together long enough to cause a leak. I removed the clips and installed a compression fitting to repair the leak. Then I cut some sections of rubber hose, slicing them lengthwise so that I could slip them over the transmission line. Then, using a zip tie or tie wraps as they are called, I secured the rubber hose around the transmission lines to stop chaffing.

Transmission Model Information. See the table in the Model Information file.

Troubleshooting:

Stripped Trans Drain Plug. [Inquiry:] Did a routine fluid change. Detected a slow leak from the plug area a few days later. Removed plug. Threads were stripped. Purchased new plug. Unable to get a tight fit since threads in pan probably also be damaged. No leakage yet, but I fear that plug may eventually loosen, I'll lose fluid and destroy the tranny. (so much for preventative maintenance.) Replacing the fluid pan seems to be the obvious solution. I would appreciate any suggestions on a good source for a pan, or alternative solutions to the problem. [Response: Simon Eng] No need to replace the pan. There is available a kit specially designed for this purpose. My mechanic has several sets and he let me borrowed one of the sets. First check what size is the plug. Let say it is 12 mm by 1.5 mm. The kit for this size has a drill bit and a tap with 14 mm by 1.5 mm. You drill the drain hole with this drill bit, then thread the hole with the tap. There is an insert that has 14 mm by 1.5 mm on the outside and 12 mm by 1.5 on the inside. Screw this insert intp the hole and use the supplied expander to expand the insert and to position it on the threaded hole. Now the insert is firmly anchored. If the old drain plug is still in good shape, reuse it; otherwise get a new plug. [Response 2: Kane] Naturally, in upsizing the plug, you'll need to tap new threads for the hole too. Drill the hole smooth, then tap - you don't want the new threads crossing the old ones. You may also try "chasing" the existing hole with the exact tap size and thread count as the current plug. Sometimes this is all that's necessary to clean the remnants of the old plug and whatever else is stuck in the threads. This assuming that you do have a tap and die set. Otherwise, plucking a pan from the junkyard may be the best bet.

Removing Oil Pan. [Editor/Jay Simkin] In a pre-1990 700 series, removing the pan is simple: just remove all the 10mm bolts and drop the pan. In a 1990+ 700/900 car with the intermediate exhaust bracket mounted to the rear transmission housing, removing the pan gasket is a major undertaking because the bracket interferes with both the bolts and the pan itself. Here is how to do it if you must:

1. Drain the pan and loosen the fill tube fixing nut. If this is stuck, see below.
2. Support the front of the transmission with a jack, using a block of wood on the casting just ahead of the pan. The block of wood is needed to go on top of the jack to allow the trans to be lifted, so the trans support can be removed. That block of wood cannot be more than 1 1/2" wide, or it will interfere with access to the pan bolts. Before you begin, make sure you have clearance to remove

the pan and its bolts.

3. Remove the rear transmission cross member support that holds up the output housing. There are five bolts that hold the trans support: two at either end, and one in the middle.This is a great time to replace the very inexpensive transmission mount.
4. Remove the casting that mounts between the transmission rubber mount and the rear output housing. This loosens the exhaust pipe bracket.
5. Take a hard look at the exhaust pipe bracket and note how it interferes with the two rear pan bolts even with a 1/4 inch drive 10mm socket. To improve future access to the pan bolts, remove the bracket. On the end closest to the driver's side of the car, removing 1/4" of metal (starting on the part of the bracket closest to the ground, and going upwards, around the curve in the bracket, and about 1/4" past the curve) will allow unimpeded access to the trans pan bolt. However, on the end closed to the passenger's side of the car, the bracket runs directly over the head of trans pan bolt. I did pare the bracket back, up to the reinforcing bend. However, no amount of metal removed from the bracket allows unimpeded access to the trans pan bolt. The only thing that will work is bending the bracket, so that there's clearance for a socket to be inserted, between the bracket and the trans pan wall.
6. Remove all the pan bolts and drop the pan. Clean the pan and screen if needed.
7. Make sure the pan sealing surface is flat and not dimpled, using light taps from a ball peen hammer to correct any dimples. Replace the gasket (no sealer or adhesive!) and install the pan. Torque all bolts to 4-5 ft-lb.
8. Reinstall the exhaust bracket and the rear cross member.
9. Reinstall the fill tube nut, making sure you use antiseize to prevent corrosion and seizure.

Fill Tube Removal. [Editor] What should be a simple task while removing the pan often turns into a major nightmare because the fill tube nut seizes up. If this happens to you, try to remove the nut but realize that you can pull the pan with the fill tube still installed:

- Use plenty of PBlaster all over the nut and let it soak for a day.
- Use a quality open-end wrench and adjustable wrench as backup. No Chinese tools here. Under no circumstances should you **not** use the backup wrench, as you will tear the transmission pan. [Tip from Glen] You need to hold the big nut steady and try to turn the

smaller nut. The big nut is actually not a nut at all. It is a threaded flange with hex sides. It does not turn. If it turns, you have ruined the pan. I place a relatively large crescent wrench (open end adjustable wrench) on the filler tube "flange nut," with the end of the wrench pointed toward the rear of the car. If you orient the wrench jaws correctly, you can brace its handle on the flange of the transmission pan (the flange where the gasket is located). It' a tight fit, but it works. I then use a smaller crescent wrench to turn the small nut ccw. The first wrench prevents excessive torque from being applied to the filler tube flange where it enters pan. I sometimes need to use a breaker bar (steel pipe with one end flattened to fit over the wrench handle) with the small wrench to generate some extra torque.

- Use heat from a hot air gun or a torch (flammable! caution!) if needed.
- See the photo for a tip from Tom F. to gain more leverage. "To remove the filler tube, I wedged a 4X4 betwixt a crescent wrench and the frame then used a small jack to encourage the filler tube nut to turn. It fought back all the way. The last three turns took two of us pulling the wrench using a bar through the combination wrench’s closed end."
- If you cannot remove the nut without destroying either nut or pan, you can still pull the pan with the tube installed by removing the two starter bolts that hold the fill tube. It is not essential to be able to remove the fill tube. If these are seized, then you should call it a day and forget the entire procedure.
- On reinstalling the fill tube, make sure you use antiseize to prevent this from happening in the future.

Using a Block and Jack to Help Remove the Fill Tube Nut

Kick-Down Cable Adjustment.

Function of Kickdown Cable. [Discussion from Abe Crombie] The kickdown cable is used to regulate a pressure in the transmission valve body. This is called throttle pressure. The throttle pressure is effectively a pressure that "tells" shift valves in transmission how hard you are pushing the throttle and these shift valves now have a contest to see if governor pressure or throttle pressure is going to win. This pressure is also used to apply the clutches/brakes that engage a gear and the higher pressure goes along with higher engine power at higher throttle. Firmer shifts are a result of higher throttle pressure. If throttle pressure wins the contest the trans remains in lower gear, if governor pressure wins the trans upshifts. Governor pressure is directly related to driveshaft, and thus road speed. If you tighten cable you increase throttle pressure and the whole shift point/road speed "map" goes higher. If you loosen cable the shift point map moves lower. The trans throttle cable (kickdown cable) also depresses a valve if you (or the throttle spool) pull the cable all the way out past that hard spot which is a detent to make you aware of the actual kickdown feature. The kickdown valve increases the throttle pressure drastically above the linear rate that you get from the rest of the throttle pedal travel range and makes the gearbox goes to lowest possible gear allowed at the road speed you are at when you activate it.

Adjustment of Cable. The kickdown cable has no adjustment at the transmission end, it's fixed. All the adjustment is under the hood, at the throttle spindle. To adjust, loosen the cable housing jam nuts until there's plenty of slack in the cable. Pull on the cable, then let it snap back in. Listen carefully, and you'll hear the cam that the cable is attached to in the automatic transmission click up against its stop. Try this a few times, so you'll know the sound. Now adjust slack out of the cable, keep testing by pulling and letting go of the cable, always listening for the click inside the transmission. As you take more and more slack out, there will be a point where you've tightened the cable just enough so the cam inside the transmission can no longer click up against the stop, because the tightened cable won't let the cam go back far enough. When you reach this point where you just stop hearing the cam click against its stop, the cable is adjusted properly. [Don Foster] Loosen the cable to soften the shifts, and shorten (or tighten) the cable to cause the tranny to shift harder and at higher RPMs. Be sure to keep notes of which way you adjust the cable and by how much so you can restore it to original position if you're unhappy with the results. "Loosening" the cable means to adjust the cable housing (outer sheath) so the inner core is looser around the throttle spool. This means adjusting the housing (outer sheath) TOWARD the throttle spool. This has the effect of providing a bit more "slop" in the core, which is wrapped on the spool. Thus, it becomes looser. If you want to tighten the cable, adjust the cable housing so it backs away from the throttle spool, effectively pulling the core tighter. Normally you adjust in turns or "flats." A flat is one flat on the hex head where you fit the wrench, six per full turn.

No More Adjustment Length Left? [Inquiry] At the maximum extension of my kickdown cable, the car's not shifting as soon as it should. What can I do, now that I've run out of adjustment length? [Response: Justin] Check to see if the cable sheath has come out of the crimped metal part at the end. On my car, the sheath pulled out of the metal ferrule at the end of the cable. This had the effect of shortening the kickdown cable by about 2 inches and the car would not shift correctly no matter how far I adjusted it. While you can try re-crimping it, the solution is likely to be a new cable.

Failure Modes of Kickdown Cable. [Chris Mooney] The kickdown cable can fail due to corrosion or a break in the sheath at either end (usually due to leaning on it while working on the engine from above). Dirt, dust, grime, sludge, wearing through and fraying, all take their toll and cause extra resistance. The cable is retracted by a fairly weak spring to prevent excessive resistance at the accelerator pedal - the downside is that a bit of dirt or a cable housing that's worn through and collapsing on itself will keep the cable from retracting smoothly. Replacing it is the only sure fix. But try unhooking it and pouring some ATF or synthetic engine oil down the cable into the cable housing, while you work it back and forth. It'll help a bit. Add this to your regular lubrication routine to keep things loose. [Gary Horneck] I took the cable end off the throttle linkage and taped a little foil collar/funnel on the end. This way I was able to hold the cable upright and fill the funnel with tranny fluid. I filled the little funnel several times over a 2 hour period. All that fluid went down the sheath and has freed up the cable.

Kick-Down Cable Replacement.

Diagnosis. If either end of the cable is cracked, the ferrule is loose, the metal strands under the plastic sheath cover have pulled loose from the ferrule, or the cable is binding in the sheath, then it needs replacing.

Repair Procedure. Parts are about $100 - $75 for the kickdown cable, $25 for tranny pan gasket and filter. It's about an 1-1/2 hour job, very messy though as you must drop the tranny pan. You kind of need an assistant to help with the cable, and a long pair of narrow vise-grip pliers. Basically :

Kickdown Cable

- Drain the transmission of fluid.
- Unbolt the dipstick/filler tube from the transmission sump (may be "very" difficult and require a giant pipe wrench). More fluid will run out.
- Unbolt and remove transmission pan. More fluid will run out.
- Unbolt and remove the transmission filter. More fluid will run out. You now have access to the cable and tranny innards.
- Have somebody fully extend the cable, this will rotate the internal valving fully. Clamp onto the rotating valve (where the cable attaches) with the narrow vise grips immobilizing the valving (it is spring loaded). With a second set of narrow pliers remove the cable end from its recess in the valve actuator. [Tip from Ian Billerwell] I recently replaced cable on my 89 745 with AW72L and found a handy tool to rotate the pulley. A bit of coathanger wire 6 to 8"long with 90 deg. bend only 1/4". In my pulley there is hole in the side near where the cable locates, I found it a cinch to rotate pulley. [Tip from Bean] I tried needle nose pliers to squeeze two of the locking tabs together but to no avail. Instead I put a medium sized screwdriver in the middle of the plug (from below) and whacked it with a hammer. This released the plug with no effort at all.
- Remove the cable & sheath - friction fit in transmission, bolt-on at throttle body.
- Re-assembly is reverse of disassembly. Careful not to remove the vise grips until the new cable sheath is seated in the tranny and the cable end is attached to valving

[More Tips from Don Foster] Replacing the cable is straightforward. If you have the pan already off, swapping in a new cable should take only a few minutes. Look in where the cable attaches, and you'll see a cam-like or pulley-like gizmo around which the cable wraps. You can (carefully) turn this with a sharp tool or screwdriver (it's spring loaded.) You'll be rotating it against it's return spring, and as I recall it's a little tricky. Once rotated to the fully extended "full throttle" position, stick a screwdriver in to wedge it and you should be able to pull the cable end free of its hole. The old cable will disengage -- it has a round thingy at the end fitting into a recess.
The tranny end of the cable housing friction-fits into the tranny housing. I'd clean and blow-dry the outside area before removing the old cable. As I recall, you can "pop" if out with a screwdriver -- and "pop" the new one in similarly. I used a touch of synthetic grease on the O-ring-like seal.
Once installed, you install the upper end and adjust it so it just slackens when the throttle's at idle. Also, you should be able to hear the tranny valve "clunk" slightly when it slams back to idle. Install the small crimp around the cable core about 1/8" upstream of the orange rubber gasket. This crimp is sorta important -- it prevents excess cable from entering the tranny and keeps the cable in the pulley groove.

Park-Reverse Lockout Button Repair. [Inquiry] The other day on my 1990 740 GL w/auto trans, the little thumb button / reverse lockout, whatever, popped and popped up.It looks like some kind of retaining ring or clip used to locate the rod. It can now be completely removed and it is a bit stiffer to shift. I've been leaving it in neutral and using the hand brake to park and wonder if it is a terribly involved job to get down into the console to fix it. [Response: John B] The thumb button can be replaced easily...get a new one and pop it on. Make sure you get it right front to front...it can be installed backwards and feels funny. If the rod itself has come up, you're in a little bit of a problem. I went through a fix on our 87 760T and the key is the spring steel roll ring that is used to hold the rod to the bracket down in the guts of the shift selector. A nail won't work...bends and the rod pops out. We tried several solutions and finally ended up replacing the entire shifter assembly for about $250 in parts, including club discount. Good thing, too, because the wire for the OD was dissolving and surprised the heck out of me it wasn't grounding and causing the OD to shift out randomly. The new shift selector feels better than new, BTW. Easy to remove the entire shifter assembly, but make sure you either mark the adjustments on the shifter rod to the trans and the stay rod, or be prepared to readjust the linkage.

Transmission Not Shifting Out of Park: Shift Lock Solenoid

Symptoms. [Inquiry] My transmission will not shift out of park when I step on the brake. [Response: Bob] Shift lock solenoid not releasing. Possible causes, brake light switch, micro switch in shifter assembly. Micro switch most common. Access shifter by removing console; on passenger side near indicator is a small black switch with a metal lever. Switch about 1 in. long @1/2 in wide, mounted with a small round metal clip. There are two black wires. You have to unbolt the shifter and lift up slightly to access switch, but don't have to disconnect anything under car. Be careful removing switch retainer as its easy to break the small plastic post the switch mounts to. To test, short the two wires together with key on and brake pedal pressed. If it now comes out of park, replace or bypass the switch.

Repair Notes. [Editor] This is a known frequent-failure item, in part because the ridiculous design of the switch mounts on two small plastic pins with push fasteners to hold it on. The switch itself does not last long. If you replace yours, install the new one in such a way that a replacement can be easily installed.

AW70 Shift Lock Microswitch

Shift Lock Switch Replacement. [Tips from Tom Irwin] Lately, my AT has been failing to allow a shift out of "PARK" about 90% of the time. I have to press the Shiftlock override to get going. This car was serviced in 1996 under the recall campaign to replace a defective shiftlock microswitch inside the shifter console. The "A-hah!" went off in my head because I have been substantially underwhelmed about the abilities of the dealership where I purchased the car.
I got out the books and went looking for trouble. To get at this thing, it is advisible to remove the following parts, roughly in this order [applies to both 960 and 940 as noted]:

- [960:] Both Right and left knee bolster covers. Two screws on the left and one on the right cleverly concealed behind a snap lock cover. Un-buckle and un-snap them the rest of the way. NOTE how they slide out of a plastic extruded support molded in to the kick panels. Dum-Dum's at Volvo dealer had jammed them back in, over and under these supports and tweaked them all to hell. It took awhile to get 'em back in right. Had to let them bake in the sun for a while to get a little pliable.
- Take out the ashtrays and fuse box cover (940) in the front.
- Pull up on your E-Brake. Slip a finger under the screw concealment panel and wiggle it side to side till it pops up.
- Remove two screws that secure left and right side of center console shifter and emergency brake cover to the transmission

tunnel.

- [960:] Remove the two screws holding your armrest/cupholder to the junk box. NOTE: If you have ever dropped that armrest or otherwise treated it rough, you will see cracks in the hinge guides that support your release latch on the armrest/cupholder/ junk box cover. Now is an excellent time to put a small drop of super glue (NOT the gel stuff) right there. It will wick in to the cracks and reinforce them.
- Empty ALL your junk out of the junk box. Use a small slotted screwdriver to lift out the screw concealment panel in the bottom of the junk box. It is tough to see, use a flashlight. Remove two screws from the bottom of the junk box.
- Lift up whole center console assembly from the rear, a few inches. Put two fingers under the wood-look trim around the rear seat ashtray bezel. Push up on two tabs and lift ashtray bezel up and away. NOTE: The little light bulb that is supposed to light up your rear seat area and the inside of your junk box usually is dead, now is a great time to replace it.
- Lift whole center console up and away and remove it from the car. NOTE: This too is a good time to scrub down the plastic mold of the center console, scrape off old food, spilled drinks, whatever. You will no doubt find a couple of dollars down there between the seats. Now you can vacuum out the seat tracks where heretofore you could not get down there with the skinniest of attachments.
- Disconnect seat heater wiring switch and lamp connectors and remove the emergency brake and shifter cover. You will have to maneuver it around the brake and shifter. If the seat heater switch lamp is out, now is the time to replace it.
- [960:] Disconnect the wiring harness that goes to the shifter, (960 Left side, 940 right) Re-route the harness end around so you have enough slack to raise the shifter a bit.
- Remove 4-10mm bolts that secure shifter. Raise shifter up an inch or two. Lift up the dust flap on left side of shifter.
- There it is, a snap-acting microswitch. If you are in "PARK", it should be pushed closed by the metal pin moving with the shifter handle. The switch mounts on two fragile plastic pin extrusions from the shifter body. Two spring type retainers are supposed to be pushed on to the pins after switch is installed over them. In my case, one spring lock retainer had fallen off of the pin and was laying in the soundproofing insulation, the other one was working loose from the other pin.
- I took off the switch, cleaned it adjusted the lever, and tested it. Then I reinstalled it and pushed the lock retainers on really tight. [Editor: if you are going to take the whole thing apart, you might want to install a new switch. Cost is around $20. Replacements come with crimp connectors; anticipating future repairs, I used removable spade connectors insulated with heatshrink tubing. DON'T drop the small push nut fasteners when installing them: use sticky adhesive or the like on your fingers]
- Put everything back in reverse order and it works every time now. [Editor: lifespan of these things seems like around three years.]

Disabling the Entire Park-Shift-Lock System:
[Editor] Cursed 940 park-shift-lock microswitch! My 95 has been through two of these in twelve months. They are a small pain to replace, but bearable until the park-lock solenoid died. I have been parking in "N" and pulling the emergency brake handle to hold the car: it won't go into "P". Worse, this solenoid costs over $100 and is buried inside the shifter assembly. Worst of all, it is a positive locking device, so if it fails, or if the microswitch fails, it locks the car either into or out of park. I prepared to remove the entire idiot-proof locking assembly and be done with this annoyance. Here's how to do it:

1. Remove the center console between the seats, along with the tray containing the seat heater switches and the ashtray.
2. Drive the front of the car up on ramps. From beneath, unhook the locking palnut and unbolt the shifter assembly arm-to-transmission rod. It is probably rusted so use PBlaster. Disconnect the overdrive solenoid wire.
3. Unbolt all four shifter mounting bolts at each corner.
4. Tie off the key-removal cable at the front of the shifter and pull the ball out of the catch.
5. Pull the shifter assembly up and maneuver it so that you can work on it without pulling the wires.
6. Remove the rubber seals on both sides of the shifter box. Unhook the locking palnut on the lever side. Pull the plastic lever arm off. Note that it is parallel with the shifter knob.
7. On the side opposite the arm, use a punch to drive out the center pin.
8. Pull the shifter out of the box, being careful about the wiring.
9. The microswitch is on the passenger side, just beneath the cover, resting on two plastic pins. The park-lock solenoid is on the passenger side at the bottom, also affixed to pins. Remove the locking push fasteners and pull out the microswitch and solenoid, which are wired together. Cut the wires, leaving slack if you ever change your mind, and tape off any bare wires.
10. Re-assemble in reverse order, again being careful about the wiring. When you are underneath, clean the overdrive wire connection and preserve with silicone dielectric paste.
11. Now your car runs just like my 1990. Just don't start the car without putting your foot on the brake. Don't "pull an Audi" through the garage door.

Reverse Lights Not Working: Backup Light/Neutral Safety Switch. [Inquiry] My back-up lights and safety neutral switch are not working. How do I repair this?

Neutral Safety Switch

[Response: Rob Bareiss] Your neutral safety switch is beneath the shift indicator plate on the right.

1. MAKE SURE CAR IS BLOCKED
2. Remove ashtray.
3. Remove two screws in bottom of black console tray under parking brake handle (Torx screws on your later model 740)
4. Remove clip at front of tray under ashtray.
5. Adjust shifter and park brake handle position to allow you to pull tray up, forward, unhook, then back and twist to get over the shifter handle. The tray is split up front to allow this.
6. The neutral safety switch is a black pie-wedge shaped thing right on the side of the shift lever. Probably 2 more Torx screws hold it in.

Automatic Shifter is Loose or Moves.

Safety While Working on Transmission. [Editor] Note that you can accidentally shift your transmission while working around the linkage beneath. To be safe, don't rely on "park": use jack stands and chocks to hold the car secure.

[Symptoms:] The shifter on my 745GLE (automatic) is really loose. When I put it in park, I heard a metallic clunking. I can move the shifter about a half inch at the top forward and back (no side to side movement) when it is in any position. [More Symptoms on an AW:] Last week I noticed I had to over shift my '89 700's AW to get the car to go in gear. In general the shift lever was quite sloppy. 2. The automatic shift lever on my 1992 940 Turbo sedan is very loose when it is in "D" drive. It moves forward and back way too much. So loose that it looks like it moves all the way into "N" and all the way back to "2". [Dave Stevens] Apart from climbing under the car to inspect the shifter linkage bushings, do the following. Put the gear selector in Reverse with the ignition switch on (and of course with the brakes set). If you move the shifter back and forth in its detent position and the backup lights go out then the bushings are definitely gone.

Curing Gear Shifter Looseness and Rattles [Tips from Mark] A loose shifter lever is a common 700\900 series Volvo affliction. Fortunately, the most common cause of looseness and rattling is easily fixed by replacing three small rubber bushings in the shifter linkage. Replacing or adding spacers or bushings where shifter connecting rods attach to the transmission can also fix looseness and noisy operation relatively easily. Completing the procedures listed below will eliminate or considerably reduce sloppiness in your shifter. Each of the three sections below details a corrective procedure for a different section of the shifter linkage. Read all three before proceeding with repairs to ensure maximum success. Before making repairs to the shifter linkage assembly discussed in the first two sections, your Brick must be raised and secured in a safe manner. It is not necessary to raise the car to make repairs discussed in the last section.

Shifter Bushings

1. *Replacing Rubber Shifter Bushings.* The illustration shows how the shifter mechanism is arranged and where the three donut shaped bushings are located. Once the bushings have been located on the car, remove the c-clip that holds the linkage rod on the pin or arm. Take the rod off the pin, remove old bushing, if there is anything left of it, install the new bushing and replace the c-clip. Be sure not to lose the clips that hold the linkage together don't take the whole thing down - do one end at a time and save your self the grief of not being able to remember which way it went. These bushings can be purchased at the dealer or certain aftermarket parts vendors. With normal use, these bushings will need to be replaced every two to three years to maintain the “new” feel of the shifter. The bushings are a little easier to get in their holes if you let them soak in some very hot water first, this makes them a little more flexible.
2. *Tightening Shifter Linkage Rod.* As the illustration indicates there are two places where shifter linkage rods attach to the

transmission. One attachment place is the movable gear selector lever. The other connection point is where the short, double bent shifter rod attached to the longest lever from the shifter connects to a fixed spot on the transmission body. To correct any looseness here a bushing must be placed around the clevis pins that secure the linkage rod to the transmission housing. I fashioned a bushing from a very short length of clear vinyl hose with a 1\4 ID and 9\16 OD. I do not know what kind of bushing was installed at the factory since it was completely missing where I made this repair to my car. The vinyl tubing, however, does an excellent job eliminating slack and preventing any rattles. Now is a good time to inspect the overdrive wire as well, since insulation can wear in this exposed location.

3. *Finding the Source of Shifter Rattles In the Console.* Remove the console panel around the shifter and look into the shifter well. A coin or a pen may have fallen through the shifter gate and is now rattling around.
4. *Adjusting the Shifter Linkage Adjustment* [Dave Stevens] It's very easy to check shifter linkage adjustment. With the gear selector in Drive, note the freeplay from the detent position to the stop when moving the shifter forward. Then in 2nd, note the freeplay from the detent position to the stop when moving the shifter rearward. The freeplay travel at both ends should be equal. If not and provided the nylon bushings are intact, adjust the trans shifter linkage accordingly.

Your shifter can also move due to transmission mount failure. A small amount of movement in response to drive train movements is normal.

Removing Shifter Knob and Overdrive Switch.

740 Cars.[Tip from RHaire] To remove the shift knob, carefully pry any chrome trim off. Note it has a seam that will allow you to open it up. Place a baggie over the knob to contain flying parts. Take a crescent wrench and open it just enough to slip around the shifter shaft and place it up against the knob. Tap up on the wrench with a hammer and you will knock the knob up and off. [Response: Editor] To remove the overdrive switch, pry it out from the head of the shifter. This has two small wire connectors entering it. Check that the wires are not abraded and the connectors are intact and firmly mounted inside the switch. If you need to replace the switch, realize that the wiring goes down the column, out the bottom of the shifter assembly, then far up into a connector behind the relay panel, and is a pain to replace. Try to repair the switch if you can; if not, wire in a new switch at the shifter.

940 Cars. [Tips from Jay Simkin] Tools needed: soldering iron (25-40 watt), needle-nose pliers [bent tip], pocket knife or utility knife.

1. Remove overdrive switch from knob housing. Using tip of utility/pocket knife, pry the over-drive switch from the knob. Little effort is required to do this.
2. Get slack in wires to overdrive switch. Using bent-tip needle nose pliers, grip the insulation sheathing around the wires that go to the switch. Pull GENTLY. There is perhaps 1/4" of slack to be had - and you will need it - but you must pull gently on these wires. They are thin. (If you break them, the shifter will have to be removed and disassembled to replace this harness. This is a non-trivial task.)
3. De-soldering wires to overdrive switch. Once you have the switch body outside of the shifter knob housing, use white-out to mark one side of the switch box and the wire that runs to that side of the switch. Use the soldering iron to separate the wires from the switch body. If the wires have been spot welded, cut the wire as close to the switch tab as possible but do not cut off the tabs

themselves. Set the switch aside.

4. Removing the shifter knob. The gear shift knob is held to a hollow steel shaft - square in cross section - by small tabs on the inside of the polymer knob. These tabs are not destroyed when the knob is removed. Rather, they are pulled out of recesses in the metal shaft. The tabs reseat when the knob is reinstalled. Move the shift lever to the "2nd gear" position. Grip the shifter knob with both hands and pull upwards using a robust tug. It will release suddenly. Protruding from the gear selector housing, you will see a square steel shaft, with a plastic shift unlock rod inside of it. Nothing need be done with these: There is no link between the plastic rod and the button. The top of the plastic rod bears on the underside of the button, mounted in the top of the shifter knob.
5. Attaching guide wire. To ensure proper routing of overdrive switch wires inside the shifter knob housing, solder the end of a piece of thin, flexible wire to the end of one of the overdrive wires. Thread the guide wire up through the channel in the shifter knob housing, and out through the opening for the overdrive switch.
6. Installing the shifter knob. Making sure that the opening in the shifter knob faces towards the back of the car (and the shifter button faces the console), put the shifter knob onto the square shaft. It will slide freely, until it comes to about 1/4" from the bottom. As the shifter knob slides downwards, pull gently on the guide wire, to pull the overdrive wiring harness up towards the overdrive switch housing opening. Once you can see the end of the wires through the opening in the knob, use the bent-tip needle nose pliers to pull the wires out through the opening.
7. Seating the shifter knob. Using the flat of your hand, press down firmly on the shifter knob. This will seat it. It will self-lock into place: you will feel the “clunk” as it self-locks. The plastic rod inside the square metal shaft will self-position against the underside of the shifter knob button. Check that this is so by moving the gear selector through its positions. It should do so.
8. Re-installing the overdrive switch. Using your soldering iron, attach the overdrive switch wires to the switch tabs. Put the key in the ignition and move the key to position two. Press the over-drive switch button several times. If the arrow-head indicator on the right side of the warning light row at the bottom of the cluster goes from "on" to "off" as you move the switch button, you have a good contact. If not, re-solder and repeat the test.
9. Closing-up. Push the overdrive wires into the recess, gently. Press the overdrive switch back into its recess.
10. Re-test. With the ignition key in Position II, function test the over-drive switch again. If it does not cause the arrow-head indicator to go "on" and "off" each time, remove switch from shifter knob housing and check the solder joints.

Not knowing that the shifter knob is not linked to the shifter's internal mechanism, I dismantled the shifter, which I bought at a salvage yard. If you want to remove the knob at a salvage yard, you need only cut the over-drive switch wires, and pull the knob free. Only the overdrive switch wires keep the shifter knob from being removed without tools.

To Remove Coins or Objects in the Shifter Well: [Jay Simkin]

1. Use a three-prong gripper (you press the button at the top, and the prongs emerged from a coiled-wire sleeve; release the button and the progs retract, closing around an object).
2. Put a lump of butyl rubber (a black, sticky rubber sealant used on auto glass, etc., and available at auto glass stores) at the end of a dowel rod, and go "fishing" for the coins. If the butyl rubber is pressed against the coin, the coin will not fall off, and you should be able to extract it.
3. Use a Shop Vac crevice tool to suction the coins from wherever they've lodged.

Shift Indicator Lamp Replacement. See the Electrical: Instruments section for instructions.

Shifter Detent Button Pops Up. [Inquiry] The button on my shift automatic shift lever popped up yesterday. This won't allow the lever to be moved into park. I pulled out the button and shaft and it looks like it is attached at the bottom with a circlip. What's the fix for this? [JohnB] The shift detent rod is attached/held into the detent mechanism with a hardened steel roll pin. The roll pin is available from the dealer. To reattach it to the detent mechanism separate the rod from the big square button...you may be able to save the button but chances are you'll need a new one. You'll have to remove the center console cover to get at the shift mechanism and you may have to remove the neutal safety switch to get at the detent mechanism. Anyway, remove the old roll pin from the detent mechanism and put the detent rod in past the two holes in the detent mechanism. Start the roll pin in one side and use a pliers or pry bar to get the roll pin in past the notch (what you think is a circlip setting is a groove all the way around the rod) and into the hole on the other side.

Put everything back in you had to remove to get to the roll pin and take your old saved big square button or a new one and snap it onto the detent rod. Be aware the big square button goes on either way, but one way the button has a symmetrical relief to the shift selector knob... wrong way and it sits up at an angle! If this doesn't work you'll have to remove the entire shifter assembly...disconnect the AT linkage under the car, disconnect the OD wire from the solenoid...there should be a connector between the solenoid and the wire (it was yellow on my car), disconnect the torque stay from the shift assembly, disconect the electrical bits from the shifter inside the car, remove the four bolts holding the shift selector mechanism and lift the gear selector assembly out. You should now be able to get to the roll pin easily. Since you have everything out, now is the time to replace any plastic bushings that are worn or missing and I would probably replace the OD wire too. The part that goes under the car (through a grommet in the shifter assembly) gets oiled and contaminated and the insulation turns to putty and eventually flakes off. The 87 OD wire on our 760 went about 2 years ago.

Auto Tranny Refuses to Reverse: Mount Replacement. [Inquiry:] My 87 764 Turbo has 124K miles and the AW 71 transmission has been serviced every 25-30K miles. Recently it has started to "refuse" to go into "R" gear after 10-15 miles of operation in "D". The selector seems to operate normally with all the usual detents, but the transmission is still in pseudo-"D" when the selector is in "R" as the car will creep forward. Putting the selector into "P" results in a slight lurch forward and then the transmission is properly locked in "P". [Response 1: Rick] Sounds like the linkage is miss-aligned. That is, your gear lever isn't aligned to the gears positions on the transmission. [Response 2: Michael Jue] It could be something more (read: internal) but I'd concur with Rick on this being the first course of inspection. Something else you should seriously consider...especially if the shifter is maladjusted as above: the rear transmission mount. I'd been having a number of small niggly shifter issues in which the shifter "felt" right but the indicator never showed in the clear windows at the base of the shifter. Then, finally the neutral safety switch failed to work. Diagnosis: bad transmission mount. Sheared the rubber mount from the metal surrounds. Easy fix (see below). All symptoms disappeared.
Changing the Transmission Mount:
[Tips from Michael Jue and Dan] Jack up the car and support the transmission with a jack. Use a rag or block of wood to prevent

scratching the transmission case (don't support it under the pan!). Remove the nut in the center of the mount/crossmember that holds the mount to the transmission. Remove four bolts securing the cross member, then lower the cross member. Unbolt the mount from it and install a new one. The job takes about 30 min.

Transmission Output Shaft Bushing.

Why Replace the Seal and Bushing?
...we replaced ours ('89 745) a few months ago, at approx. 115,000 miles. Why? I noticed that the output shaft was spraying a bit of oil onto the underside of the car... and my experience teaches me that such leaks only get worse, plus tailshaft play accelerates other wear. [Tip from Randie Starkie] My experience is that the bushing needs replacement about every 150,000 miles. I personally have never replaced a seal without the bushing being bad. The seals seem to hold up as long as the bushings aren't worn.

Let me say that this is not necessarily bad or that you don't have an output bushing worn and a seal leak. First, when the bushing's worn, you usually get some driveshaft vibration, or"humming/drumming" in the car. So when the new bushing's in, it's noticeably quieter. (That was my experience on my '83 and '86 GL's, both receiving the bushing & seal at around 200k.) Second, if the machined outer surface of the companion flange is worn where the seal rubs, there's a possibility of driving the seal 1/8" further into the housing so the new seal "sees" a fresh, non-worn surface. It all depends on how the original was mounted. You should try shaking the driveshaft radially at the transmission and see if there is any lateral movement...if you're unsure try shaking a known good one. Also, you can replace the seal yourself and leave the bushing alone...it will seal for awhile, perhaps a LONG while. Last point ...when replacing seals like these, check the metal part that the seal rubs against...if there is a notch you can catch your fingernail on you probably need to replace the metal part too...a rear axle pinion flange is easy but a driveshaft yoke you have to replace a U-joint, etc. (some people think U-joints are easy.)

This is part of what I'd refer to as preventative maintenance. I was quoted a price of $300-$350 to replace the seal/bushing. Bought the parts for about $45 (parts replaced were output shaft bushing, output shaft seal, rear housing gasket) and performed this operation myself in about 3 hrs, including setup/replace/cleanup time. Pulling the housing is relatively straightforward once the tranny's supported and the cross member and mount are removed. I believe that there are six bolts to remove and the housing's in your hand. Have a new gasket on hand and make sure that both mating surfaces are completely clean with no trace of the old gasket. You don't want to have to do this job a second time because of leaks.

[Another tale:] The tail housing removal is really pretty simple. I just finished replacing a transmission in my '89 744 project car. The tail housing was cracked and we initially hoped to replace only the housing, but Volvo wanted $253 for it and the junkyard had an entire AW70 for $400. Anyway the Dexron is still in my hair from finishing up the job, so my experience is as fresh as it gets. [Another Tip] Now is a perfect time, while you have the drive shaft disconnected and good access from below, to replace the tranny mount and the tranny linkage bushings.

Identification: Bushing versus Bearing:

[Note from Abe Crombie] The 93 through '95 model AW71 gearbox has a ball bearing instead of the earlier bushing. You can tell by looking at the output flange where driveshaft attaches. The bushing style has no bell shaped slinger/protector for the seal; the bearing type has this type flange. The slinger/protector prevents you from seeing the seal. The standard flange on the bushing versions allows you to see seal on tailhousing. The bearing can't be used in place of the bushing as it requires a different output shaft in rear of trans; and it is costly. This style has an oil seal at the rear of the housing and an o-ring inside. Repair is simple: just pull the housing off and replace both the seal and the o-ring.

Trans Bushing (not bearing) kit

Procedural Notes:

What you're going to do is take out the bolts that connect the output flange to the driveshaft, support the tranny and remove the rear transmission mounting bracket. Four bolts hold the tail housing to the rest of the transmission case.

Tool Rental:
[Editor] There is a tool available that pulls the old bushing out. It is no longer available from IPD due to "quality control problems." [Cautionary Tale regarding the IPD tool:] I attempted to replace the tailshaft bushing/seal with IPD parts and their rental bushing removal tool that allows this to be done quickly and easily without removing the tailshaft housing. The removal tool didn't function quite the way I had imagined. The puller's center bolt got tighter and tighter until it sheared off about two inches from the bolt head. But wait, it gets worse...   I removed the tailshaft housing and discovered the removal tool shaft is wedged into the tailshaft end bolt hole and I can't get it out. There were wire lacing threads around the hole so I don't know if my tranny is toast or not. The tailshaft housing was removed without damage. The broken bolt is currently stuck in the tailshaft end bolt hole (no better way to describe it).[Another Tale:] The exact same problem happened to me on my 240 this past weekend with the same tool. Amusingly enough, I was able to get the broken bolt out by using a pipe wrench, and a LOT of elbow grease. Although there was some slight thread damage in the hole in the output shaft, it wasn't severe, the bolt ultimately torqued up with no problems, and I haven't had any more trouble with it. This is what was recommended by my mechanic, when I called him. After the bolt from the tool has been successfully extracted, spray WD40 into the bolt hole, holding a white cloth underneath to catch what comes out. This is to flush out any loose threads that would cause MORE trouble. Then experiment with threading the driveshaft collar's bolt into the hole, to determine the extent of the thread damage. If it appears as though the bolt will be ruined and won't torque to spec, the hole will need to be re-tapped.   IPD, incidentally, was gracious about the problem, and agreed to refund my money. Since I didn't have any major transmission damage, I didn't ask for anything else.

[Procedure Notes 1:]
Start with the driveshaft bolts while the car is still on the ground. That way you can roll the car a little to get to all 4 bolts *easily*. If you're driving up on ramps like I did, this won't work and you'll need a crow's-foot wrench (my 9/16" worked fine) to get to the ones on the top of the flange. A generous supply of profanity helped in my case... It's a good idea to mark the output flange and shaft flange so you can mate them up when the time comes to put it back together [critical for proper driveshaft balance.] Once the bolts are out, push the driveshaft toward the rear of the car and it will pop out of the flange. You can shove it up above the flange to get it out of the way. Raise the car up (jackstands, ramps whatever)if it's not already and drain the tranny fluid. Put the selector in Park and use a 30mm socket to remove the

bolt in the center of the flange. This bolt holds the flange to the output shaft. Once it's out you can pull the flange out of the housing. Remove the 15mm nut in the middle of the transmission mount (rear end of transmission). Support the pan with a piece of wood held up by a floor jack, just enough to take the pressure off the tranny mount. You should see the mount bolt come up slightly. Then remove the four bolts that hold the mount to the chassis. The mount will come off, and the tail housing will be clearly visible. Four bolts (14mm I think) hold the housing to the main body of the tranny. The top and bottom bolts are different lengths, so note where they came from. With a little "gentle persuasion," the housing will come off. On my particular car, the PO slid it into a ditch and caught the end of the center mount bolt which cracked the housing. This also saved me the trouble of taking off the "L" mounting bracket. It won't have to come off if you just plan to replace the seal. The seal is easy to get to and *looks* like you could pry it out with a screwdriver, but I have never tried this. You're going to end up with a roughly 6x6x8 inch housing which you can work on at your leisure. If you don`t have the tools to remove/replace the bushing, you can just bring the housing to almost any auto service shop and they will be able to press a new one in for a few bucks. Plan for about 2 hours under the car to get it out. If the gods of rusted bolts are on your side, it could be done in 45 minutes or so, I'd guess. Nothing is particularly difficult about the operation. Although I recently told someone to shoot me if I ever said it, "installation is the reverse of removal" (BOOM). See orientation notes below. The center flange bolt only holds the flange to the shaft; no pre-tensioning or any of that other technical stuff.

[Procedural Notes from Bill Lauber:] Volvo AW70 Rear Bushing Replacement

Regarding Volvo Automatic transmission AW70 rear bushing replacement ...I found significant play in the end shaft and proceeded to get the parts from my local Volvo dealer. The bushing was quoted at $36 with the seal at $11 and the gasket for about $5. I checked the yellow pages for a automatic transmission parts house .. found one and learned the following. They carried every thing I needed, the only difference being I carried the parts out for a total including tax of $9.70. A entire rebuild kit for the Volvo automatic was quoted at $108.00 and the dealer said the Volvo AW70 was one rebuild an individual could be successful with. I have installed the bushing, seal and gasket and all is working well.

Procedure:

I used drive on ramps at the rear wheels not the front. This keeps excessive loss of ATF fluid when removing the rear housing. HINT, with front wheels blocked from rolling, elevate one side of the rear all to allow rear wheel to spin on one side. This allow all to spin for easy access to drive shaft bolts as long as the transmission is in neutral and the emergency brake is off.

1. Place support under transmission pan that can be raised and lowered as needed A board between the support and pan will help distribute the weight normally handled by the rear transmission support which has to be removed.
2. Remove rear transmission support bolts from car frame and end of transmission and remove cross member
3. Disconnect speedometer hold down bolt at transmission then unscrew cable from transmission
4. With transmission in neutral, disconnect end of drive shaft from transmission
5. Insure transmission is in park
6. Remove transmission shifter link’s rear pin ONLY allowing link to move out of the way
7. Remove 30mm bolt from rear of shaft on transmission. Remember step 5 ... pull out shaft end

8. Remove all 6 bolts holding rear housing
9. Remove housing HERE COMES THE ATF! (you will lose about a quart)... you may have to tap with block of wood to break loose from gasket. be gentle so not to crack the housing
10. HARDEST STEP for me ... remove the old gasket material [Editor's Note: See Removing the Gasket]
11. Punch out the old seal and bushing ... the seal was easy ... the bushing requires care not to crack the housing. You may want to have a machine shop remove and replace the bushing. I was successful but could just as well messed up at this point
12. Install seal & bushing in housing [Editor's Note: See Bushing Orientation]
13. Install housing with new gasket and six bolts
14. Insert shaft with some ATF on bearing, seal and shaft. [Tim] After the flange is installed it will fit tightly in the new bushing.
15. Torque shaft bolt.
16. Hook up shift linkage
17. Shift to transmission to neutral
18. Install drive shaft and bolts spinning elevated rear wheel for easy bolt replacement
19. Install speedometer cable
20. Install cross member ... elevate transmission as required
21. After removing car from ramps check ATF and add as needed.

[Another Procedural Note from Don Foster:]

The parts you'll need are: new bushing; new seal; new gasket. In general, the procedure is:

1. Jack up the car -- from the rear may be preferable.
2. [Editor's note: mark the flange and shaft for proper balanced re-assembly.Carefully mark the linkage placement before removing it from the side of the tailshaft housing.] Drop the driveshaft at the tranny -- I don't think it needs to be removed any further, only pulled aside.
3. Remove the companion flange -- I used an air gun (with the tranny in park). Some purists among us will probably tell me how wrong that is -- but both cars logged at least 50k flawless miles since.
4. Drop the crossmember -- you might want to support the tranny.
5. Remove the speedo cable.
6. Position a pan under the rear of the tranny -- some fluid might decide to get in your face. Transmission fluid will run out when you remove the piece the driveshaft was bolted to (flange?) as well as when you loosen the tailshaft housing so be prepared with a pan to catch it.
7. I think you need to remove the tranny mount bracket from the housing to gain access to the housing bolts.
8. Unbolt the housing from the tranny. Pull back gently -- a little tapping may be helpful.
9. Knock the old seal out of the housing. The oil seal is the metal ring/lipassembly with rubber molded around it. Both the rubber and the metal ring/lip come out.
10. Note the orientation of the old bushing as a reference for installing the new bushing. Note as well the orientation of the hole to the groove. in the housing. Examine the inside of the housing -- note there is a 1/4" gap, or opening, under the bushing, at the bottom of

the housing into which you can cut.

11. Using a hacksaw blade, cut through the old bushing into this opening. Note the orientation of the original and align the new bushing the same way.
12. "Peel" the old bushing inward and it'll pull right out.
13. Scrape off any gasket material (most frustrating part of the job.) [Editor's Note: See Removing the Gasket]
14. Wash the housing, insuring that all chips are removed. [See Chip Removal]
15. Be sure to prelube the new bushing and new seal before final assembly. Position and orient the new bushing -- and using either a proper bushing/seal driver OR a socket of the correct diameter (perhaps with a 6" extension on it), drive the new bushing into position. I've found it slides into position easily, with only slight tapping from a hammer. [See Bushing Orientation]

    [Tip from Randy:] My automotive supply store has a full service machine shop and I never mess with this stuff- I take the tailshaft to them and have them press in the bushing. For the seal I apply a coating of grease to the outside diameter and tap it into place with a socket just slightly smaller than the diameter of the seal.
16. Examine the new bushing to confirm the edge was not dented -- if so, clean it up slightly with a fine rat-tail file (and rewash). Be careful to not damage the main bearing surface of the bushing.
17. Drive the new seal into position. I like to use a touch of Permatex aircraft gasket sealer, but it's not necessary.
18. Clean any remaining gasket from the mating transmission surface.
19. Install the new gasket. Again, I like to use a touch of gasket sealer, but it's not required.
20. Lubricate the bushing and seal with ATF.
21. Position, install, and tighten the housing.
22. Wash the rear flange, lubricate the bearing and seal surface, and slide it over the splined tailshaft. [Tim] After the flange is installed it will fit tightly in the new bushing.
23. Install and tighten the nut. I'm sure there is a proper procedure and torque.
24. Install the speedo cable.
25. Lift the tranny and install the mount bracket and crossmember. This might be a good time to install a new mount.
26. Connect the driveshaft. [Editor's Note: 30 ft-lbs.]

AW70 Tailshaft Bushing Orientation

[Tip from Randy:] On assembly be sure to bolt the linkages according to the marks you made before disassembly. Don't forget to check the transmission fluid level, particularly if you lost some during this work.

[*Removing the Gasket: Randy*] I've replaced two bushings and both times the most time consuming part of the job is removing the gasket between the transmission case and the rear housing from the transmission case. There isn't a lot of room to work your way around with the various tools to scrape the gasket off. I found a single edge razor blade worked best for me, and the second time I did it I was armed with a spray on gasket remover which helped a whole lot. Spray it on, let it soak, scrape a little.... repeat numerous times, being careful not to dig into the soft aluminum case when you become frustrated and begin to use that sharp wood chisel that always worked so well on removing gaskets from cast iron casings. Also it would probably be in your best interest to take extra pains to protect the exposed portion of the

transmission from consuming the gasket pieces and various bits of underbody debris you will rub off with your arm- I wrapped mine in a clean rag (the rear of the transmission, not my arm)
[*Chip Removal: Paul Seminara]* Replace the bushing, when you do the rear seal. Indeed the bushing will wear and sometimes the wear will be from small bits that wear the tailshaft flange as well. This is especially so on high milers. This usually will require replacement as well.

AW-71 Auto Trans Output Bushing Orientation Question. [Inquiry:] In replacing the auto trans output bushing, which way does the hole in the bushing go? [Response: Patrick Petrella] I did get the bearing issue resolved. Ended up talking with a mechanic in Colorado, who seemed to know what he was talking about. Volvo was essentially no help. Someone sent me jpegs of two pages out of the Volvo trans shop manual, which clearly stated that the new bearings come with no hole in the side. I went back to the parts counter at Volvo and was shown that all their bearings HAD the side hole. A never-ending spiral of confusion. So this Colorado mechanic said he had done this repair on many AW71 trans, and that the orientation of the side hole was not critical, but should NOT be lined up with either slot in the tailshaft housing. He puts the sleeve bearing in with the hole at the top. So that's what I did. I would like to know what the hole is for. Maybe used during manufacture of the bearing, with nothing to do with operation?

Seal Leakage in AW70L Transmission. [Inquiry:] Oil is leaking from my AW70L transmission at the shift linkage shaft on the right side of the tranny housing. Does anybody know how it is to replace the seal(s)l ? [Response:] That shaft goes through the tranny from one side to the other, with a seal on each side. On my '83, the seal had simply popped out of the transmission housing, and only had to be gentle pushed back in. The bad news is that -- at least in my experience -- access to the seal is restricted by the exhaust pipe. Dropping the pipe first made it much easier. One thing I'd advise is to first clean up that area of the transmission, particularly if it's been leaking for awhile. A lot of dirt and grime will accumulate -- and you want the area as clean as possible before installing a new seal. I washed it down with parts cleaner, hit it with compressed air, and let it dry.

AW-70/71 Hard Shifts.

Symptoms. The AW71 in my '86 740 used to shift very hard from 1st to 2nd gear. This shift is the first shift and it usually happens at about 20 km/h (depends on how hard you accelerate). It felt almost like getting rear-ended. [Editor] Hard 2-3 shifts are also symptomatic.

Try the Easy Things First. [David Hunter] A flush may cure the shift problem. On my 88 740 at around 240K I encountered delayed shifting from 1st to 2nd and 2nd to 3rd. Also had OD problems. After checking the common causes such as kickdown cable, OD relay and solonoid I elected to do a flush with Mobil 1 synthetic. The results were immediate and dramatic: all problems went away. In addition, check the kick down cable adjustment regarding those hard shifts. You may be pleasantly surprised.

Worn Valve Ball. [Toni Arte] The real cause for this problem is a worn valve ball in the transmission valve body. This ball is the "15C" in the picture. This is a picture of the lower valve body. A replacement valve ball is available, you can order it from your local Volvo dealer. The part number is 1377746-1 (small blue valve ball). [Tip from Herman] You may need gasket kit p/n 271292. Before you do the job, buy the OEM manual: the manual number is TP 31642/1. The manual is for AW70/70L,AW71/71L, and AW72L. The L means lockup, check the tag on the tranny before you buy your gasket kit. For detailed instructions, see Brad Wightman's excellent illustrated writeup.

AW-70/1 Valve Body and Valve Balls

In my case the 5.5 mm valve ball was worn to about 2 mm size. Note that the valve body can be accessed through the oil pan, so it's not necessary to drop the transmission. A competent transmission shop should be able to change this ball. In my case the cost was about $100, this includes two hours of labour, new gaskets and fluid. [More from Herman] Great care needs to be taken upon disassembly however it's an easy job with some potential of going very wrong. I tried the wrong way first. I disassembled enthusiastically and lost one ball of about 15, dropped a retaining pin and then wasted 2 hours scratching my head and agonising about the lost ball. A friend had a dead AW71 and let me take it apart for reference. This time I followed the manual and compared the two valve bodies. The job was dead simple once I went about it the right way. GET THE MANUAL and follow the steps that get you to opening the valve body up. The manual says nothing about the balls so you need to locate them and note ON PAPER where they go. There are a lot of balls and things that can go flying and falling into your parts cleaner. Following the steps in the manual however, takes away that risk. As in the photo on that page, my ball was worn to half the size of the new one and was blown out from its seat and had gone somewhere else. I think I replaced about 5 maybe 6 quarts of fluid (I use only AMSOIL). Make sure you have a lot of good quality paper towel (cloth fibre won't break down should it get into the gubbins) for the job and a large clean well-lit bench surface.

[Tip from Gary De Francesco] Rough 1 - 2 shifts are a possible sign of a worn rubber ball in the valve body that regulates how fast the various clutches and brakes are applied. As the ball wears, the fluid flow rates in some of these regulating passages can increase which will cause the various hydraulic actuators to engage faster. This will feel like a sudden and rough engagement. On the one hand, with fast engagement, there is little chance for the clutches and brakes to slip. This means less wear, and hence a longer lasting tranny. On the other hand, these fast engagements result in a bit of jarring to the occupants of the car. The solution is to have the valve body serviced. This can usually be done without removing the tranny. So you have to decide. Can you live with a little jarring, or do you want to spend some money and see if it can be smoothed out.

Overdrive Relay and Function:

Overdrive Operation. [Roger Scott] The "overdrive" electrical circuit works works like this -- the A-70/1 automatic transmission is a 4-speed transmission, but, unless the "overdrive" solenoid is energized, it is by default a 3-speed automatic transmission. When you hit the "overdrive" button what really happens is you de-energize the solenoid, disabling 4th gear; you get a downshift to 3rd gear and the "up-arrow" light on the instrument panel.

Basic Diagnostics. [Roger Scott]

- Check fuse 12: intact, ends are clean and it fits tightly.
- Check for fraying or severing of the wires to the solenoid - under the car on the left side of the transmission. Pay particular attention to the metal retaining clamp near the front end of the shift lever where the wires pass through.
- Make sure the wires to the switch on the shifter head are in good order. You can remove the relay and test for continuity between terminals 1 (15 on the relay) and 4 (86 on the relay) which are the switch wire terminals.
- You can test the relay and solenoid by jumpering with a spade-terminal jumper wire. Pull the relay, jumper between terminals 1 (15 on the relay, or +12V) and 3 (87 on the relay, or the solenoid). This bypasses the relay and energizes the solenoid directly. Or run +12V directly to the solenoid through a long jumper wire from the battery.
- [Don Foster] All this having been noted, 90%+ of overdrive failures result from relay solder cracks. See below for instructions for relay repair.

Relay Problems and Repair:
[See Relay Locations for a detailed picture of relay location and removal instructions.] [Symptom:]I have a friend with a '90 740 automatic and he is having intermittent OD problems that seem to be weather related. It won't go into OD when the weather is cold. Is the relay on the relay tray? If so, which one is it? [Diagnosis:] Yes it does sound like an OD relay. If I remember correctly on 740 it is by the Ashtray/FuseBox. It is pretty common component failure on the bricks. It will be a white Hella relay. Pretty simple to change. The relay is about $40-43 through Mail order from dealership. In my case I was "sure" it was the wiring, switch or solenoid, as the relay "looked" just fine. But as soon as I replaced the relay, all

Overdrive Relay

problems disappeared. The relay is about $40 from the dealer, or you can probably find it cheaper from a second source...it appears to be a standard Hella relay.

[Response 2: Michael Daley] I have just repaired the o/drive relay and rather than pay the UK£40 that the volvo dealer wanted for a new one, I took the top off the relay - all that was wrong with it was a cracked solder on the circuit board. Fixed with a soldering iron in 5 minutes, saving myself £40!!

For a more detailed discussion of relay repair, see Relay Repair vs. Replacement.

[Another OD Symptom:] I have a '93 940T with an AW71L transmission (or so I've been told...) Today I was driving on the highway and it momentarily dropped out of overdrive into 3rd, at the time I was at minimal throttle. I dismissed that as a hiccup. An hour later (after making a couple of stops)I began driving and I noticed that the tranny would not go into OD, 3rd gear was the max. All of the other shifts are perfect. I tried pressing the OD cancel button a few times, and I checked the related fuses - no changes. Am I looking at replacing the overdrive solenoid on the tranny? If so, can anyone give me a part# and/or approx. price? [Response: Abe Crombie] It is an AW71 no L. The turbos didn't get the locking torque converter feature. The trouble sounds like the typical OD relay failure. The relay is behind the ashtray in the fuse/relay panel. I believe it is white on that car and square in profile. The fuel system relay is the one to the left that is rectangular.

Shifter Overdrive Switch:
[Inquiry] My overdrive will not lock out and the relay is fine. [Response: Editor] The switch on the shifter is likely bad. To replace it, see the link above.

Solenoid:

If your overdrive engages late or not before the transmission warms up, first try replacing the relay and flushing the fluid. If this does not solve the problem, a new solenoid often will.

AW 70/71 Overdrive Problems: Wiring to Solenoid, Solenoid.

Electrical & Wiring Problems:

[Rob Bareiss] The overdrive solenoid should click on and off with a very noticeable click. You need to be sure you're getting 12 volts at the solenoid. If you haven't got 12 V, you need to check the wires at the OD relay socket in the fuse box and thence to the solenoid itself. My '88 has had numerous problems with the electrical connections at the OD relay on the fuseblock, so I would be checking there first. *Wiring Connector:* [Eric C] The plastic wiring connector which connects to the overdrive solenoid (attached underneath the car at the rear of the transmission) can come loose. In my case, it snapped in place yet had 2mm of play and was not snug. I cleaned out the connector with contact cleaner, allowed it to dry, then used heat shrink tubing to keep the connector in the snug position after snapping in closed. It worked; no more overdrive problems. [Another Tip] Sometimes there is corrosion in the joint between the connector and the wire..it may look fine and even will light a test lamp but will not allow enough amps across it to fire the solenoid. Take it apart, clean and deoxidize, then reassemble with silicone grease. *Wiring.* [C. McGrew/Scott] Check the wiring under the car from the shifter to the solenoid. It tends to deteriorate near the shifter and at the connector leading to the solenoid itself. Jiggle this to find internal wiring breaks. If you install a new solenoid, then also install more chafe guards (3 inch pieces of hose) all along the wire. Make sure that the white wire that comes down from the shifter does not ground out on the car due to worn insulation.

Solenoid Operation/Diagnosis:

[Rob Bareiss/Scott] The solenoid is normally closed, cutting off the fluid flow necessary for 4th gear or "overdrive". When energized with the overdrive arrow light "off" the solenoid opens up and allows the trans to shift into 4th. The solenoid must pass fluid through when energized, or it's either not working or plugged up with dirt. Just because it "clicks" does not mean it is passing any fluid. The first test is to park in a quiet place, open the drivers door and switch the OD on and off while listening for a click under the car. If you don't hear it then it is bad. If you do hear a click that does not necessarily mean it is good: it could be dirty and not passing fluid. [Steve Sakiyama] There have been a few posts on autotrans overdrive problems (won't shift into 4th) when the brick is cold. The problem disappears when the car warms up. I have an AW71. When cold it would not go into 4th (OD) until the car had been driven for 10 minutes. This would happen more and more frequently until it was a regular pattern. I checked/dealt with fluids, OD relay, wiring, and downshift cable but the ultimate problem was the overdrive solenoid which sits on the side of the tranny. Although I had bench tested it and it seemed fine, an experienced tranny tech said "it just doesn't sound and feel right". Replaced it with a used one (with the two inner o-rings), and the brick is fine. [DougC] According to Bentley, with the solenoid in your hand and disconnected, you should cover the oil passages between the o-rings, and blow through the hole on the end of the solenoid. The valve should be tight, and no air should pass through. With it energized with 12 volts, you not be able to blow air through with the same holes uncovered. It says also to check for blocked passages and damaged o-rings.

Overdrive
Solenoid

Solenoid Removal/Replacement:

Tools. What kind of special wrench do I need to get 2 bolts out of solenoid to remove it? Doesn't appear to be much room for tools or hands. [Tip from R Haire] Support the transmission with a jack and remove the cross member. Then lower the trans as little as possible to give you enough room to CLEAN the area around the solenoid until it is spotless before ever attempting to remove it. Do NOT lower it so much you crush the distributor cap against the firewall. To remove the solenoid, you need a stubby angled 12 mm wrench. It is kind of snug up in there. A "gear wrench" is ideal to turn the bolt. [Tip] I have used a short (approx. 6") angled/bent 12mm open end wrench that I heated and bent myself. Access is difficult: you may have to remove the linkage and drop the transmission support (placing a jack and large wood plate beneath the pan to support the tranny). [Tip] Bend a flex socket handle to fit and use a 12mm socket on the end to remove the solenoid bolts. [Tip] Use a smaller 1/4 inch drive socket set to remove it.

Access to OD Solenoid Bolt with 12MM Bent Wrench

Dirt. [Rob Bareiss] Replacing the solenoid requires that NO dirt get in that transmission. Lots of brake cleaner, Gunk, power washing, and probably use of a toothbrush and more brake cleaner will get the area acceptable. You might follow up with compressed air delivered by a J-tube to remove dirt and little rocks lodged up behind the solenoid. Haynes suggests the use of a sheet of cardboard over the trans, up against the tunnel to keep grit from falling in from above. Dirt and transmissions disagree.

Don't get any dirt into the solenoid when you replace it. This is a filthy area and it's easy to do this. The plumbing internal to the solenoid unit, which has a right angle turn at the valve seat, can plug up. You may have to pull the OD solenoid, rig it up to the battery to turn it on and blow it out with WD40, carb cleaner, compressed air, or any similar pressure source, preferably with a little straw to get down into the holes. [Editor] One user reported that removing the solenoid and turning the engine over seemed to pump enough oil through the recess to clean it out and enable operation. This is messy, though. [C. McGrew] My transmission was leaking fluid and was oil soaked from an engine rear main seal leak. The solenoid rubber cap becomes brittle and then it's good bye. Be sure to buy the two o-rings for the solenoid. Coat o-rings with plumbers or silcone grease for sealing and ease of install. It's not that bad getting your fingers in the correct position to replace the two bolts. Re-torque to 7-12 ft-lbs to tighten the solenoid bolts.

Eliminating the Solenoid and the Manual Downshift System:

You can also pull the solenoid entirely, replacing it with a metal plate, and remove the ability to use the button to manually shift down into third. See the link below for IPD's solution to solenoid troubles.
[E. J. Ohler] Forget about a new $150 solenoid and $50 relay: take the solenoid out, cut the wire off, grind a small groove between the center hole and aft hole in the solenoid face, and reinstall to allow fluid to move and disable the solenoid as a solution to solenoid troubles. Use a Dremel 1/8 inch grinding tool (the metal is hard so you will use two) or a diamond bit. Clean the matching holes in the tranny using drill bits the same diameter, but don't drop them into the transmission. Replace the outer O-ring but not the inner where the groove passes through. From start to finish this is a 3 hour job that saves you a lot of headaches. You don't need the manual 4-3 downshift in most instances anyway.

Solenoid Modification for OD Troubles

Solenoid with Ground 1/8 Inch Groove

Solenoid Quality Reports:

[Tip from Dan Marino] My recently-installed Scantech OD solenoid failed. I discovered that the rubber top cap (the part where the electrical wire attaches to the solenoid) had totally split away from the metal solenoid valve parts. Basically, the top blew off of the thing. The result, massive transmission fluid leakage. My conclusion is that this ScanTech overdrive solenoid suffers from poor quality construction, cheap-o materials, and design flaws. The next day I was able to pull an original Volvo overdrive solenoid from a junker for a cost of $5.25. A quick comparison showed the Volvo part to be of superior design, more metal, and less plastic/rubber.

Overdrive Switch Replacement. [Kevin] Last summer I had the entire shifter assembly apart replacing the overdrive switch and cleaning out 9 years worth of crud built up in the bottom of the pan. All you need to do is set the parking brake, put the transmission shifter in neutral, and pull the handle straight up: it just 'snaps' into position. The overdrive switch is about $35 (US) from the dealer and it's just a matter of threading the lead down thru the shaft and back up to plug in to the connector on the front right portion of the 'hump' behind the ash tray. You'll have to remove the ash tray in order to reach it, and you may need to remove some other stuff: look to the right of the fuse bus.

Solenoid and Overdrive Removal. [Ken Crossner] For you folks who wish their automatics were simply completely automatic without any tendancy to fail and lose 4th (especially during this "gas crisis" time), IPD came up with a solution! They're selling a Solenoid Bypass Plate (product code MD7071K - $39.95.) Remove the solenoid, cover the hole with this plate, and you're left with a 4-speed automatic transmission -- the 4th (OD) gear works normally, and you can dispense completely with all the other components (relay, shifter switch, wiring, etc.). Nothing left to fail, ever! You merely lose the ability to manually downshift into third gear, which you probably never used much anyway. [John Orrell] there is a almost "free" way of doing this. Remove the stock solenoid, remove the inner O-ring and machine/grind a groove in the face of the solenoid between the two small holes. Replace the outer O-ring (not exactly free, but cheaper than 39.95) and reinstall the solenoid.

IPD's Overdrive Blockoff Plate

Lockup Torque Converter Function for Turbos?
[Inquiry] Can I install a locking torque converter in the non-locking transmission in my turbo car? Fuel economy is better with the AW70/71L units than with the AW70/71. [Fitz Fitzgerald] A 700 series Volvo Turbo car would have come fitted with an AW-71 transmission (non-lockup). The 71 series are a bit stronger mechanically speaking, and there are some differences in the valve body to help it respond better to the torque and HP curves of a turbo engine. US market Turbos (and quite possibly the rest of the world too) never received "L" series automatic transmissions. I think Volvo was concerned about the extra horsepower from the turbo engines having some potentially damaging consequences to the lockup clutches and/or other bushings/bearings inside. More importantly, the Turbocharger's response curve is directly dependant on the engine RPMs and if you had the lockup engaged, the engine RPMs are now directly coupled to the vehicle speed. Much of the extra torque and horsepower that a turbocharger can provide requires that the engine can rapidly climb the RPMs. Aisin Warner lockup trannies aren't well known for the ability to quickly disengage the Lockup TC, unless you drop down to 3rd gear in which case the response is almost instantanous.
To convert any AW70 equipped car to AW70L, you must swap both the transmission and the torque converter, since the valve body controls and additional converter clutch are different from the non-lockup versions. The torqure converter has the lockup clutch inside it, and the transmission has a special valve body and hydraulic actuactor that enables/disables the clutch. You can't just swap the valve body either, you need to swap the entire tranny. If you are looking to install an "L" series tranny in a turbo equipped car, they did make an AW-71L series tranny and it can be found many of the 940 non-turbo wagons. The US spec turbo cars only received the AW-71 during their entire production run. This should be "plug and play" but make sure your detent/kickdown cable is properly adjusted after installation. If you tighten this cable, the transmission will shift at higher RPMs, if you loosen the cable, it will shift at lower RPMs (this will effect every shift point, not just your 3-to-4 shift). Find the spot that's best for your driving habits.

[Inquiry:] My 1989 745T with AW71 has a lock up torque converter that is locking and unlocking too much. At some speeds and loads and boost levels, it constantly locks and unlocks until I either back off or speed up. [Response: Abe Crombie] A US market spec Volvo rear wheel drive turbo doesn't have a locking converter. If yours has a locking converter the ID plate on driver's side of gearbox will read "03-71L" or possibly "03-70L" if someone has changed it. The lockup control in either case is a function of it being in 4th gear and governor pressure reaching approx 50 psi. A lock/unlock at threshold of locking speed can be caused by a worn bushing in tailhousing allowing the gov. pressure to fluctuate. This can be checked by attaching a trans press. gauge and reading the gov. pressure at speeds around 45-55 mph to see if the pressure is stable as speed is brought that range gradually.

AW7X Diagnostic Notes.

Governor Pressure Test. [Tip from Abe Crombie] The governor is best checked with a gauge attached to the tap point on driver's side of trans on case just forward of tailhousing joint. This plug is a 8mm X 1.0 bolt. The gauge fitting used is an o ring sealed hollow bolt with a cross-drilled bolt that goes through fitting in hose from the Volvo special tool gauge. You may be able to fashion something like this. The gauge needs to be able to read 60 -70 psi at least. The pressure should correspond more or less to the road speed once you get to 10 mph or above. Approx 1 psi per each mph.

ZF-22:

ZF22 Damage in Park. [Inquiry] I have a 1986 740 GLE. I took the vehicle for emissions testing in March. Part of the test is to rev the car for several minutes while they check the high idle (2500 rpm). My transmission started slipping badly when I left, and lost all forward gears the next day. I replaced it with a junkyard tranny (I know its a risk, couldn't afford a rebuild) and the car has run great for about 3,000 miles. My tags have expired, so I went back for another emissions test (it failed the first time). Unfortunately, it failed again, but this time, it would hardly move. I made it about 1 mile, then had to be towed. I was told by a transmission shop that the ZF 4HP22 transmission cannot be revved in park without causing damage and that a bulletin went out to all emissions testing facilities. A dejanews search found several old posts saying smog tests would kill this transmission, something about after being in forward gears then put in park, some pressure is still on the clutches and will wear out clutch pack A. This seems to apply to Volvos, BMWs and Jags with the ZF 4HP22 transmissions. The emissions testing people have called me 5 times since yesterday, they seem concerned and are having my car towed to have the transmission checked. They will not admit to any bulletin, but obviously seem concerned about liability. My question: does anyone have any info on these transmissions? I have heard of a Volvo bulletin on this, and an EPA bulletin (may be just California EPA, not sure). Bulletin numbers or a copy of the bulletins would be great. I'd like some facts to present them with since they are listening, but so far just have a little info from old newsgroup posts, and from a conversation with a transmission shop.
[Response 1: Mark Aarabi] What you have heard and read is absolutely true. Yes, there is a TSB out.(Volvo TSB 2525, 9/91, for all ZF-equipped 1985-88 740 non-turbos).. and Yes, there was a memo from EPD to all emission testing facilities about this concern (at least here in Georgia). What state are you in and do you have any idea what type of equipment they use for testing? The software on most BAR97 equipment will automatically bypass the 2500 RPM section of the test on these particular vehicles. [Response 2: Bruce] Most all emissions center should be aware of this problem. Other cars have the same problem that use the ZF tranny. As the one post stated the test machines will by-pass the rpm test with a ZF tranny. The emission shop should replace your tranny. But getting them to admit fault and do it could be a problem. For others reading this, 1985, 86 and 87 only 740's used the ZF tranny. (Editor's Note: ZF-22 cars have "P-R-N-D-3-2-1" on the shift quadrant and NO overdrive button on the shifter.) Turbo models use the AW-71. For the above model years, if the gear shift lever does NOT have an OD button you have a ZF tranny. With an OD button you have the AW-71 tranny. One way to test the emission on a ZF tranny is to raise the back wheels off the ground, put the car in drive and rev it up to 2500 rpm for testing. In gear it will not do harm. In neutral or park and revving, the tranny pump does not pump oil. I was told this by a transmission repair center.

Volvo Technical Service Bulletin on This Problem:
[Editor's Note: Summary of Volvo TSB 2525, 9/91:] Before beginning the "High Idle Emission Test Sequence" make sure the car is at

operating temperature. Place transmission into "park" and switch the ignition off for 30 seconds. Restart, but DO NOT move the selector through the forward or reverse gears before or during the test and DO NOT EXCEED 2000 RPM. The first stage of the test is at 1850 rpm for 30 seconds, the second stage is at normal idle for 30 seconds. If you fail the test and have to do it again, then DO NOT proceed with the programmed catalyst preconditioning test sequence. Abort the test, place the transmission into "park", precondition the catalyst at 1850 rpm for 4 minutes, then allow the engine to revert to normal idle and check the tailpipe emissions. Under no circumstances must you exceed 2000 rpm during any part of the test.

Reasons for Transmission Failure:
[Jim Bowers] Here is what I have learned from various inputs, some on Brickboard, some from BMW related sources. The transmission apparently leaves some residual pressure on the clutches when put in P and/or N. If the engine is "revved" in this state the clutches get burned. [Martin] I rebuilt a used ZF and learned some about the slipping #1 clutch pack, too. The input shaft was originally sealed with metal rings which were prone to leak and leave some pressure on the clutch pack during all conditions, causing it to fail early. The rebuild kit (non oem) however contained redesigned teflon rings packed with some information on the issue. During rebuild I also discovered there are some other poor design issues in this tranny. Light alloy clutch cases which will wear rapidly, some strange sealing designs between valve body/housing and in my case also a pair of blown bearings. I used parts out of two trannies since the actual ZF problem seems to be the horribly expensive hardware, making a complete swap desirable if the worn out unit needs anything more than clutches/sealings. AW trannies does seem to be better designs, without expensive failure spots like these of the ZF.

ZF Preventive Maintenance:
[Fitz Fitzgerald] There are many people putting a lot of miles on ZF transmissions, but the transmissions are more prone to failure than the AW trannys. A few words of advice for preventive maintenance on ZFs:

1. Do not rev the engine in Park or Neutral: this will tear one of the forward clutch packs to pieces.
2. Change the fluid at the specified intervals and be sure to remove and clean the pan before the first fluid change. Performing a fluid flush without first removing the pan can break up some sediment in the bottom which will be sucked up into the takeup and act like sand in the bearings and valve bodies. Feel free to toss in a larger magnet before putting the pan back on.
3. Run synthetic trans fluid if you can afford it. Mobil 1 full-synthetic is worth the improved longevity.

If the transmission fails, swap it for an AW.

ZF22 Fails; Swap for AW? [Inquiry:] The ZF4HP22 tranny in my '86 740 just started spewing fluid from inside the bellhousing (1 pint/ mile). Given the reputation this tranny has, I'm undecided as to whether I should rebuild it or replace it with an AW71. Has anyone done this swap? [Response:] Do the swap. Any AW70 or 71 will work from 82-on. The basic gearbox is the same, but some are better or stronger than others. If you're going to buy one from a junkyard, get one from the latest years possible. (89-93 non turbo, since they have a lock-up converter.) If you use an earlier gearbox, you will need to plug the speedo drive hole in the output shaft housing. I don't remember if the flex plate is the same or not, you may need that. The driveshaft is different. If you order it from the boneyard, tell them you're doing

the conversion. Remember that the car didn't know what transmission it was going to get, so the interchange is "bolt in." I think if you get the necessary parts (with relatively low mileage) for under $1000.00 you did all right.
[Response: Dick Riess]   Actually quite easy to do:see the Auto Transmission Conversion: ZF to AW FAQ file describing how to do this. . Best bet is contact someone like Strandbergs in WI 800 448 5121 and they literally send you a good used unit plus all parts. I did an 86 740 couple of years ago and works great. Here are the parts you will need: transmission, cross member, transmission mount, drive shaft front half, gear selector unit, relay for overdrive on AW unit, some wiring. Get good wiring diagrams to help you out. [Response: Kane] All 4-cylinder trannies bolt up fine, including pre-'86 240 series ones. One difference is the speedo ... the pre- had a speedo gear at the rear tailcone, where as the 740's and later 240's had an electronic pickup sensor at the differential. That tailcone can be swapped with one that doesn't have the output gear.

Transmission Removal:

Transmission Removal. [John Orrell] Don't consider trying to remove your transmission with either a dedicated transmission jack or a $40 transmission adapter for your floor jack from Harbor Freight or the like. Here are the steps to remove your transmission:

1. Set parking brake and disconnect battery negative/earth
2. Release kickdown cable at throttle pulley and remove dipstick
3. Use floor jack under the front suspension cross member... in the center.
4. Jack it up to maximum lift range of the jack and put quality jack stands under the front factory jacking points. Don't use cheap or undersized stands.
5. Let it down on the jack stands.
6. Put floor jack under the center of the rear differential.
7. Jack up the rear end as far as the jack allows, make SURE that the car does not rock the front jack stands forwards or backwards!
8. Put another set of jack stands under the rear factory jack points and let the jack down.
9. Drain oil from transmission
10. Disconnect oil cooler lines from radiator - use a counter hold wrench at the radiator to prevent damage. Also disconnect lines at transmission. You will bathe in oil. Remove line holder at bellhousing (l -10mm bolt). Remove lines from engine bellhousing.
11. Loosen nut holding filler tube - dipstick holder from oil pan. Once pan is drained, put plug backs in and block holes vacated by lines and filler tube.
12. Disconnect shift levers from transmission. Two E clips.
13. Disconnect driveline at back of transmission and front of differential.
14. Support transmission with a transmission jack, safely secured to the tranny.
15. Remove center support bracket. Total of 6 bolts. You will need the plate for mounting the new drive shafts.
16. Remove exhaust pipe support near the back of the transmission. Not on all cars.
17. Remove nuts from exhaust pipe to manifold (3).

18. Remove bolts holding exhaust pipe to bellhousing.
19. Free exhaust pipe from exhaust manifold.
20. Remove aluminum engine support bracket under the engine. This binds engine to bellhousing.
21. Remove 4 bolts holding torque converter to flexplate. You will need to counterhold the flexplate.
22. Loosen and remove starter bolts.
23. Remove distributor cap and rotor. You don't want to crush it against the firewall. Alternatively, support the engine using a hook at the rear connected to an engine lift.
24. Remove transmission crossmember. Two bolts on each side and one nut holding transmission to the crossmember. Remove the bolt from the transmission - need to tap with a hammer once the crossmember is removed.
25. Remove all bellhousing bolts. The top bolts can be reached from above using a 19mm wrench.
26. Carefully pull transmission back until clear of bellhousing and lower. You will probably take another transmission oil bath, especially if the torque converter decides to come out. Best to cross wire in the torque converter to prevent it from slipping out: wire from ear to ear of bellhousing portion on transmission. Remove transmission from under the car.
27. Remove flex plate - loosen bolts in a cross pattern. For a counterhold to secure the flywheel, install a very strong C clamp through the starter hole in the block, squeezing on the front and back of the flywheel.
28. Mark or know the position of the flexplate on the crankshaft, as it prevents timing problems later.

Installation. This is generally the reverse, but position the torque converter and orient the flex plate correctly on reinstallation. Remove and install new rear main engine seal:see instructions for this as well as other items skipped in these instructions. Torques on reinstallation include:

- Fluid dipstick tube to pan nut: 90 Nm (66 ft-lb)
- Torque converter to carrier plate bolts: 50 Nm (36 ft-lb), torqued alternately in a cross pattern
- Torque converter housing bolts to engine: M10 are 42.5 Nm (32 ft-lb); M12 are 72.5 Nm (52 ft-lb)
- Center support: 26 Nm (20 ft-lb) tightened alternately in steps of 7 Nm (5 ft-lb)
- Oil pan bolts to transmission body: 5 Nm (3.5 ft-lb)
- Coupling flange on output shaft: 45 Nm (34 ft-lb) using Loctite
- Oil cooler connections on side of transmission: 25 Nm (18 ft-lb)

Bellhousing Bolt Removal. See the discussion in the Engine: Mechanical section.

Torque Converter Alignment on Transmission Reinstallation. [Inquiry] Why is the shaft on the torque converter that goes into the transmission slotted on both sides of the end of the shaft? [Response: Chris Herbst] Those slots have to be aligned with the oil pump on the inside (they fit over the extrusions or dogs inside the trans). If you don't line them up you'll chew up the torque converter and the drive gear inside the transmission, which basically means getting another transmission. In addition, your oil pump will not engage. In other words, alignment on reinstallation is very important. See also the notes on alignment related to engine rear seal installation. [Jerry Andersch] When the torque converter is properly seated it should sit 1/2" below the bell housing flange. If it's flush with it, it's not seated all the way. With the tranny slightly angled up (bell housing higher than the tail)work the TC back and forth until it seats, sliding down 1/2" of so below the bell housing flange. When installing the tranny make sure the BH is slightly higher as you move the box into place, so the TC does not slide forward and out of place. Bolting the autobox into place with the TC not properly seated can damage the transmission.

Rebuild Information:

Rebuild or Replace? [Inquiry] The transmission in my Volvo is fading and needs to be rebuilt. What should I do? [Response: Rob Bareiss] Not worth rebuilding. Good used ones are SO CHEAP that there's no reason to pay $900 for a rebuild, vs. $250 for a junkyard trans. The downtime is a lot less too- pull yours and chuck it, bolt in the new used one, 4 hours you're done. Compared to 3 days on the bench waiting for the rebuild...[Response: Rhys] The Aisin Warner 70 is an excellent trans, very long lived. A good used one is always an easier way to go. The rebuild kit for soft parts is only about $150.00, but if you need any hard parts, the cost goes up dramatically. And rebuilding one is a challenge the first time. You'll need the factory manual, which covers the BW55-AW70 trans. Very good publication, but pricey.

Replacement Tips. [Jerry Andersch/Others] See the FAQ section on rear engine seal replacement for more information.

> *Used Transmissions.* [Marlin Mangels] When you buy a used transmission to replace your failed unit, get one with pink (not brown) fluid to make sure you are not acquiring a soon-to-fail unit. Buy one that comes with its torque converter. Torque converters vary in application and matching the TC with the tranny may be difficult if you don't have the original. Used transmissions may be sourced from junkyards anywhere. Pay attention to model and lockup function on the identification tag.
>
> *Pulling the Tranny*. Best technique is to use a rented transmission jack. In my experience, after trying to get the fill tube off without success I gave up and removed the tranny with the pan and tube in place. It is possible to drop and reinstall a new tranny with it still attached; just make sure you have someone guide it up while you're doing it because it will get caught. On reinstallation, once you get the tranny lined up make sure to use the rear of the tranny to push it into place; this is the only way to do this. Attempting to force it in by putting the mounting bolts in doesnt work out very well. If you have a problem getting it to line up with the engine i suggest you get a floor jack from a friend and jack the front of the engine up just a little (but not by much or you might cause damage in areas not intended.) Don't tilt the tranny too far forward or your torque converter will fall out. If you have to pull the pan off, be ready for a mess. Fluid will continue to drip for a long time. You need a large pan to catch the dripping oil. If you plan on re-using the kick-down cable, be sure to secure it as you remove the transmission. I broke mine at the plastic fitting where the cable enters the transmission.

Torque Converter. The TC will pull straight out ... or fall out if you tilt the tranny too far foward. I removed my replacement pick & pull convertor to replace the main front seal. I let the TC drain into a clean coffee can to get all the old ATF out of it. After replacing the seal and pouring some AFT into the converter it's very important to seat the TC properly on the oil pump drive ... The converter should slip onto the drive and seat below the edge of the bellhousing, not flush with it. Turn it back and forth until it slips in to place. If it's not seated properly or slips forward out of seat as you install the transmission in your Brick, the oil pump drive will not be properly engaged and things will get chewed up when you start the motor. A properly seated conveter will sit about 3/4" below (or back from) the front edge of the bell housing.

Engine Rear Seal. Now is a perfect time to renew the engine rear seal, which requires removal of the transmission.

Parts Renewal. I removed the TC and then using a seal puller removed the front main seal. Slathered a generous amount of ATF of the new seal and carefully seated it so it was not cocked. Make sure you lube all new seals. I also replaced the cross (selector) shaft seals,solenoid and cooler line o-rings, kickdown cable o-ring and kick down cable, pulled the pan and cleaned it and the pan magnet, pulled the mesh filter screen and cleaned it, and replaced the pan gasket. Replaced the rear bushing, oil seal, and gasket. I also put in new nylon shift linkage bushings and overdrive solenoid o-rings. All this is a lot easier to do when the tranny's out of the Brick ... and if done correctly will assure you not a drop of ATF will leak out of your new autobox. On reinstallation, I replaced the kickdown cable. I filled the new box with approx 8 Qts of Mobile 1 synthetic ATF and a dose of Lube Guard.

Valve Body Service. See Brad Wightman's illustrated FAQ description of the valve body service in AW-7X series transmissions. Don't so this without the Volvo illustrated OEM manual.

AW Transmission Parts and Rebuild Information. [Tip from Frank] The AW (Aisin Warner .... Asia's version of Borg Warner) is the most common import tranny out there from Toyota to Isuzu. There are several good service books, better than Volvo's own technical publication. My suggestion is to call either of the two suppliers below & ask for the best novice book they have (Trans Mart will even give you the info to get it yourself if you wish, but Trans Star won't). Read the book cover to cover before touching the tranny. I'd even go so far as to suggest you get the service updates manuals from the same location. If you decide to rebuild your unit, here are the best places in the United States for a transmission kit & parts:

- Trans Mart (division of ATC Distributing) phone# 800-633-3340 (they'll give you a number that is closer to you). GREAT customer service
- The next best is Trans Star 800-321-8830 (they're a little higher on parts & their customer service is good.)

Transmission:Automatic AW 30-40

Note: AW 30/40 series electronically-controlled transmissions are used on Volvo 960 and 90-series six-cylinder cars.

Maintenance: See the Automatic Transmission section for generic data also applicable to AW 30/40 transmissions.

Checking Fluid on 960/90 Transmission. [Inquiry] How do I check the transmission fluid level on my 960? [Responses] Look way down just behind the throttle body intake assembly, low on the drivers side near the firewall and below the brake fluid container. You'll see a square yellow dipstick which doesn't have a handle on it. It which accepts a 3/8 inch drive extension: stick the socket extension on it, reach down and depress the hold-down clip, and pull it out. It is sometimes easier to reach from the side of the car, reaching down low. I just reach down and pull it out myself. You'll need a long funnel to put fluid in. Be sure that the car has been driven 15 minutes or so, stop, move to and stop in each gear about 5 seconds, and back to park. Check fluid level. Don't overfill by even a small amount.

I extended the dipstick with an old clothes hanger . I cut off both ends at the bottom and looped one end into a hole in the dipstick and made another loop at the top end of the hanger so I could pull it up. It really makes life easy if you check your trans fluid frequently.

960/90 Fluid Flush. [Tips from Mike Hale] I was riding in my Dad's 95 960 when I noticed that the shifting was a little rough. My Dad had mentioned that he also notice a pause at about 80mph when letting up off the accelerator-- It felt like the car coasted for a second or two before the gears kicked in…like putting the clutch in and letting it out on a car with a manual transmission. He had taken it to the dealer before about the problem while it was under warranty and suggested they change the transmission fluid. "Volvo says that transmission fluid is permanent…it doesn't need to be changed" the dealer said. Well, anybody with a shred of common sense knows that no fluid is "permanent"…it breaks down and gets dirty over time. So I told my Dad we'd change the fluid this weekend…what a difference it made. Not only is the coasting problem above fixed, it also shifts so smooth, you can barely feel it. As we drained the tranny, we were both amazed and disgusted at Volvo for saying it wouldn't ever have to be changed and at how dark the fluid was. For about 17 bucks we got the job done. [Al] Just a quick note on the results of my AW-30 transmission flush. 97 960 66,827 miles. Unbelievable how much the quality of the transmission shifts have improved. It made a huge difference to the plus side.

Because the transmission cooler is a little different than other RWD Volvos, I've outlined changing the fluid below. Note: IPDs new transmission flush hose DOES NOT work on 960s as they advertise ("all RWD Volvos to 1998")…the fittings on the 95- 960/90 are different. I called them after I received it and was told that they hadn't actually tried it on a 960/90 series…it didn't sound like it would work.

Materials:

- 12 Pack Case of Dexron III/Mercon ATF (Costco has Chevron brand ATF for $10.79/ case)
- 4’ Length of clear Vinyl tubing with a 1” Inside Diameter (available at Lowes or Home Depot for $2/ft or from IPD.)
- 1” Hose Clamp
- 14mm wrench
- 17mm open end wrench
- 1” open end wrench
- Metal Hangar
- 3 1-gallon jugs (or equivalent sized bucket) with quart markings—I used an old antifreeze bottle with the markings already on it and a sight line on the side.
- Funnel with ½” outside diameter hose about 1½’ long—Used to fill transmission through dipstick hole.

Procedure:
Start by pulling the dipstick. On 960s, there isn’t a dipstick handle. It’s easiest to reach under the car from the driver’s side and follow the dipstick tube up OR if you have a long ½” extension bar, you can push it into the top of the dipstick and pull it out. Without a ½” bar, push up the dipstick until it's all the way out (and either grab it or let it drop to the floor). Unwind and bend one end of the hanger so it will hook in one or more of the holes on the dipstick. Insert the tube from the funnel into the dipstick tube…you’ll probably have to push it in from underneath the car. Pull it up on ramps (if you have them)—the transmission pan is angled in the rear where the drain plug is so this drains more fluid (14mm drain plug). When finished draining, pour what you drained into a premarked bottle and pour that amount of fresh ATF into the tranny (approx. 2qts). Push the car down the ramps onto level ground.
Unscrew the top cooler line at the radiator by using a 1” wrench as a counter hold so you don’t break the connection. Pull the cooler line out of the 1” brass screw and push it gently aside. With the hose clamp already over the 1” vinyl hose, push the hose over the 1” brass screw and tighten the hose clamp (real tight ‘til it begins to form to the sides of the brass nut). Put the end of the hose in the bottle/bucket. Have helper start the engine and let it idle (do not push the accelerator). Fluid will begin to fill the hose and bottle. If the hose is inserted into an antifreeze bottle with a tight fit, push the hose in slightly at the mouth to allow the bottle to vent (otherwise it may expand and explode). Allow 2qts to drain (Tell the helper to shut off the engine just shy of 2 qts as some in the hose will continue to drain when the engine stops). Add two qts of fresh fluid (+or- depending on how much you drained. Repeat until you’ve drained 8 qts and you see clean fluid. Tip: as you do this, drain each 2 qt run into gallon jugs so you can keep an accurate tally of how much you’ve taken out relative to the number of empty bottles of fresh ATF you put in. Carefully remove the hose and drain any fluid in it into the jug…note how much and add that amount in fresh fluid. Replace the cooler line and dipstick. Run the engine and shift through the gears. Take it for a short spin to heat up the fluid for measurement. While running the engine in Park, pull the dipstick, clean it off, reinsert it, and pull it again to

measure…note the position on the HOT markings. If its low, add a little (keep in mind that if the HOT marking says you're ½ qt low, it won't take ½ to fill it because the ATF from the bottle will expand when heated. If it's overfilled, open the drain plug slightly to get some out. That ought to do it…enjoy your revamped transmission!

Fluid Specifications. Use Dexron fluid in your AW-30/40 transmission. In the Lubrizol "knowledge Base" site at www.lubrizol.com, they note that two European commercial vehicle automatic transmission makers have posted specs for mineral oil versus synthetic automatic transmission fluid lifetimes. Voith allows 60k km drain intervals on mineral oil and Group III (hydrocracked semisynthetics) ATFs and 120k km intervals on full synthetics, both in Dexron III specs. ZF allows 30k km for mineral oil, 60k km for "part" synthetic, and 120k km for full synthetic, again in Dexron. This is an indication of the value of synthetics in normal use. Mobil 1 ATF is a full synthetic.

Fluid Level. [Editor] Some anecdotal evidence exists that fluid level in the AW 30/40 is very important: even a small excess may cause strange transmission noises. So don't overfill your transmission.

Flush By Draining the Torque Converter? [Frank] Some Euro indy mechanics have suggested that a better flush is achieved by first draining the torque converter. Not true: this creates a large air gap and forces the tranny to run dry while it refills. The Volvo OEM flush procedure is through the cooler lines as noted above.

Changing the Filter. [Editor] To replace the filter screen, remove the pan. The gasket used is a silicone paste. To remove the pan once the bolts are off, use a rubber mallet and gently hit the pan from all sides a few times until it falls down. Use care since there will be about one quart of fluid left in the pan. Clean up the tranny pan and scrape off all the old gasket material. Remove the magnets in the pan and wipe the metal shards off, then take some clean ATF fluid and wipe the insides of the pan. Use Volvo gasket material, RTV, or rubber gasket material when replacing the pan. Torque spec on the pan bolts is 65 IN-lbs; on the filter bolts is 7 ft-lbs. Merely draining the pan, instead of flushing, will require about 6.25 quarts of fluid.

Transmission Model Information. See the table in the Model Information file.

Troubleshooting the AW 30/40 Series:

Transmission Not Shifting Out of Park

Symptoms. [Inquiry] My transmission will not shift out of park when I step on the brake.

[Response: Bob] Shift lock solenoid not releasing. Possible causes, brake light switch, micro switch in shifter assembly. Micro switch most common. Access shifter by removing console; on passenger side near indicator is a small black switch with a metal lever. Switch about 1 in. long @1/2 in wide, mounted with a small round metal clip. There are two black wires. You have to unbolt the shifter and lift up slightly to access switch, but don't have to disconnect anything under car. Be careful removing switch retainer as its easy to break the small plastic post the switch mounts to. To test, short the two wires together with key on and brake pedal pressed. If it now comes out of park, replace or bypass the switch.

Repair Notes. [Editor] This is a known frequent-failure item, in part because of the ridiculous design of the switch mounts on two small plastic pins with push fasteners to hold it on. The switch itself does not last long. If you replace yours, install the new one in such a way that a replacement can be easily installed.

Shift Lock Switch Replacement. [Tips from Tom Irwin] Lately, my AT has been failing to allow a shift out of "PARK" about 90% of the time. I have to press the Shiftlock override to get going.   This car was serviced in 1996 under the recall campaign to replace a defective shiftlock microswitch inside the shifter console. The "A-hah!" went off in my head because I have been substantially underwhelmed about the abilities of the dealership where I purchased the car.
I got out the books and went looking for trouble. To get at this thing, it is advisible to remove the following parts, roughly in this order [applies to both 960 and 940 as noted]:

- [960:] Both Right and left knee bolster covers. Two screws on the left and one on the right cleverly concealed behind a snap lock cover. Un-buckle and un-snap them the rest of the way. NOTE how they slide out of a plastic extruded support molded in to the kick panels. Dum-Dum's at Volvo dealer had jammed them back in, over and under these supports and tweaked them all to hell. It took awhile to get 'em back in right. Had to let them bake in the sun for a while to get a little pliable.
- Take out the ashtrays and fuse box cover (940) in the front.
- Pull up on your E-Brake. Slip a finger under the screw concealment panel and wiggle it side to side till it pops up.
- Remove two screws that secure left and right side of center console shifter and emergency brake cover to the transmission tunnel.
- [960:] Remove the two screws holding your armrest/cupholder to the junk box. NOTE: If you have ever dropped that armrest or otherwise treated it rough, you will see cracks in the hinge guides that support your release latch on the armrest/cupholder/junk box cover. Now is an excellent time to put a small drop of super glue (NOT the gel stuff) right there. It will wick in to the cracks and reinforce them.
- Empty ALL your junk out of the junk box. Use a small slotted screwdriver to lift out the screw concealment panel in the bottom of the junk box. It is tough

to see, use a flashlight. Remove two screws from the bottom of the junk box.

- Lift up whole center console assembly from the rear, a few inches. Put two fingers under the wood-look trim around the rear seat ashtray bezel. Push up on two tabs and lift ashtray bezel up and away. NOTE: The little light bulb that is supposed to light up your rear seat area and the inside of your junk box usually is dead, now is a great time to replace it.
- Lift whole center console up and away and remove it from the car. NOTE: This too is a good time to scrub down the plastic mold of the center console, scrape off old food, spilled drinks, whatever. You will no doubt find a couple of dollars down there between the seats. Now you can vacuum out the seat tracks where heretofore you could not get down there with the skinniest of attachments.
- Disconnect seat heater wiring switch and lamp connectors and remove the emergency brake and shifter cover. You will have to maneuver it around the brake and shifter. If the seat heater switch lamp is out, now is the time to replace it.
- [960:] Disconnect the wiring harness that goes to the shifter, (960 Left side, 940 right) Re-route the harness end around so you have enough slack to raise the shifter a bit.
- Remove 4-10mm bolts that secure shifter. Raise shifter up an inch or two. Lift up the dust flap on left side of shifter.
- There it is, a snap-acting microswitch. If you are in "PARK", it should be pushed closed by the metal pin moving with the shifter handle.   The switch mounts on two fragile plastic pin extrusions from the shifter body. Two spring type retainers are supposed to be pushed on to the pins after switch is installed over them. In my case, one spring lock retainer had fallen off of the pin and was laying in the soundproofing insulation, the other one was working loose from the other pin.
- I took off the switch, cleaned it adjusted the lever, and tested it. Then I reinstalled it and pushed the lock retainers on really tight. [Editor: if you are going to take the whole thing apart, you might want to install a new switch. Cost is around $20. Replacements come with crimp connectors; anticipating future repairs, I used removable spade connectors insulated with heatshrink tubing. DON'T drop the small push nut fasteners when installing them: use sticky adhesive or the like on your fingers]
- Put everything back in reverse order and it works every time now. [Editor: lifespan of these things seems like around three years.]

Disabling the Entire Park-Shift-Lock System:
[Editor] Cursed 940 park-shift-lock microswitch! My 95 has been through two of these in twelve months. They are a small pain to replace, but bearable until the park-lock solenoid died. I have been parking in "N" and pulling the emergency brake handle to hold the car: it won't go into "P". Worse, this solenoid costs over $100 and is buried inside the shifter assembly. Worst of all, it is a positive locking device, so if it fails, or if the microswitch fails,

it locks the car either into or out of park. I prepared to remove the entire idiot-proof locking assembly and be done with this annoyance. Here's how to do it:

1. Remove the center console between the seats, along with the tray containing the seat heater switches and the ashtray.
2. Drive the front of the car up on ramps. From beneath, unhook the locking palnut and unbolt the shifter assembly arm-to-transmission rod. It is probably rusted so use PBlaster. Disconnect the overdrive solenoid wire.
3. Unbolt all four shifter mounting bolts at each corner.
4. Tie off the key-removal cable at the front of the shifter and pull the ball out of the catch.
5. Pull the shifter assembly up and maneuver it so that you can work on it without pulling the wires.
6. Remove the rubber seals on both sides of the shifter box. Unhook the locking palnut on the lever side. Pull the plastic lever arm off. Note that it is parallel with the shifter knob.
7. On the side opposite the arm, use a punch to drive out the center pin.
8. Pull the shifter out of the box, being careful about the wiring.
9. The microswitch is on the passenger side, just beneath the cover, resting on two plastic pins. The park-lock solenoid is on the passenger side at the bottom, also affixed to pins. Remove the locking push fasteners and pull out the microswitch and solenoid, which are wired together. Cut the wires, leaving slack if you ever change your mind, and tape off any bare wires.
10. Re-assemble in reverse order, again being careful about the wiring. When you are underneath, clean the overdrive wire connection and preserve with silicone dielectric paste.
11. Now your car runs just like my 1990. Just don't start the car without putting your foot on the brake. Don't "pull an Audi" through the garage door.

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960 AW30-40 Shows Overheat Codes after Mountain Run. [Inquiry] We took the 960 up the mountains. The ambient temps were in the low 60's. We topped out at just above 2,000 feet. No trailer, just 220 pounds of 'persons' between the two of us and maybe 100 pounds of gear in the trunk. As we are climbing up the last of the twisty's, I missed a switchback and had to make a tight 3 point turn. The trans went rough into reverse and started to just not act right. With a mile to go, the mode selector and dash arrow goes berserk. The lights are all blinking REALLY fast! I just throttled back and eased into the campground. This morning, no lights. We got out OK. Got home and pulled the codes... 235 Fluid Temperature too High. (above 300 degrees) Now I am running Mobil One ATF, freshly serviced just last month. My load was light, compared to what the vehicle is rated for. And the lights went out when it got cooler, so I don't suspect a defective sensor. What could be failing inside the transmission to cause, or add to an overheat condition? [Response: Abe Crombie] Hard pulls at lower revs in higher gears causes this. Driving uphill for a distance at lower revs in either of gear ranges 3 or 4 will build oil heat due to the stall speed of torque converter. Next time pull it down into a lower gear. The transmission has a two-stage overheat program. The first stage locks up a bit sooner in the upper two gears. The second stage (when arrow blinks) goes to full pressure, shifts up sooner, and locks torque converter in second gear as well as third and fourth. The lights do blink for a stage two overheat until the temperature of the oil falls below approximately 280F. It is very easy in E mode (even in S mode) to get an unlock in 4th without a downshift to 3rd or to get unlock in 3rd without a downshift to 2nd. No need to worry about a fluid change if you had synthetic in it. The normal routine would be to drain and replace fluid, drive car, and if transmission functions okay, then send it down the road.

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960 AW30-40 Self-Destructs in Hot, Hilly Climates. [Cautions from Rafael Riverol] Leaving your 960 stock with OEM radiator, no cooler, and cheap transmission oil, together with dealer maintenance according to the schedule, has resulted in a new transmission in every single one 960 I know about in Puerto Rico at around 50k miles. Not only are we talking about thousands of dollars, but a much worse never ending tale of woes and headaches. Volvo technicians tell horror tales throughout U.S. To help prevent this, install a transmission cooler. The factory kit is a simple bolt on, but not cheap. I bought one for my 960 (1995) for $385. Of course, you should also use synthetic transmission fluid. Mobil is a good choice and readily available. If you are careful, you may want to install a Magnefine transmission oil filter ($20, from their website) and perhaps a transmission fluid temperature gauge. If you want to mount the gauge on the pillar you can get a pod from the MVP website for about $30. If you have a 960, I emphatically recommend you do all the above and watch your radiator and coolant like a hawk for any signs of contamination transmission oil particularly in you have the Volvo plastic radiator. But if you do the above, you should be OK as the transmission on the 960 is a Warner (Asia) unit closely related to the one in the Lexus. Be safe or you will be sorry.

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960 With AW-30/40 Has Busy Shift: Electrical Glitches. [Inquiry:] I have a '92 960. The car has 95,000 miles. I have noticed that the car seems to shift frequently. The best way to describe it is that it is "busy". It is more pronounced in traffic when there is a lot of stop and go. It seems as if it slipping in and out of gear. I have had it at the dealer twice and they agree it is "busy", but can not give me a reason. Any ideas?
[Response: Abe Crombie] The mileage on that car and the symptoms make it a candidate for a failing throttle position sensor. This can be monitored by their Volvo scan tool on a drive while it is overshifting. The transmission computer uses this signal read directly from TPS by Fuel computer which passes it on to trans computer. You could unplug the TPS (this will set code/turn on check eng light) and drive the car and see if it shifts less and holds gears better. There will be a default signal from ECM to TCM when the signal is missing.   [Inquiry: Similar Problem] '93 960 ran smooth and quiet before I brought it in for tranny service, and it still does. But since the servicing, the tranny searches around a bit at times. The tach indicator will jump forward and back, then forward again, and ther car lurches. [Response: John O] Changing ATF will not make the trans act up unless someone put in the wrong fluid (like Ford Type F, not likely). What I've seen a couple of times with early 960s (especially '92s) was a corrosion (oxidation) problem affecting the

large electrical harness connectors on the left, upper area of the transmission, seen from under the car and near the dipstick area. Remove the plugs from the bracket, unplug them and spray inside with electrical contact cleaner, let it dry then re-install with silicone dielectric grease smeared insided the wire connectors. I've seen this help a couple of our customers who previously experienced unusual trans problems and worth trying before condeming the trans itself. [Tip from Tom Irwin] Those connectors can be hard to separate: use caution, they crack easily.

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960 AW30-40 W/E Lights Flashing: Gear Position Sensor PNP Switch Replacement. *PNP Symptoms.* If both W and E are flashing and your UP arrow on the dashboard is on, the (in)famous PNP switch is the most likely cause of your symptoms. If you can read error codes, if the code is 313, it is the PNP switch. It is good to shift a couple of times from P to L and back to 'refresh' contact points in PNP. [Rafael Riverol] Usual failure mode is: the PNP switch fails on the highway, AT enters "limp home" mode (fourth gear in D and third L), ATF then overheats, orange arrow and E,S,W lights flash,and ATF smells burnt. OBDI reads missing or shorted PNP signal and overheated ATF.

What Not to Do. [John Roberson] If your PNP switch is failing, try moving the shifter several times to reactivate the PNP and then restart the car. If it starts in first gear, not third, and shifts fine through all gears until stopping then you can drive the car. If it is still stuck in third do not drive as the tranny will heat up and cause real problems.

PNP Diagnosis. Put the trans in PARK. Turn the key to #2. Step on the brake and attempt to shift out of Park. Does it happen? If so, your PNP is working.

AW30 PNP Switch, Courtesy FCPGroton

PNP Description. [Inquiry] Does anybody know where the starter inhibitor switch or neutral safety switch is located on the transmission for a 94 960 w/ automatic trans. Also tips on removing it would be much appreciated. I think it is sticking when cold. Starts OK on initial start up for the day, or when warm or hot, but when turned off when cold (anything less than 15 minutes) will not crank. Battery, alt., starter all check out. It seems the trans is not sending the signal to the ignition switch. [Tips from B and Stan Sexton] The PNP or gear position sensor is located on the right side of the transmission case. It slips over the manual linkage shaft and bolts to the case. The wiring routs to the left side of the trans, where it is attached to a short metal rail toward the front of trans. The pigtails are long and the clips are released by squeezing with a needle nose plier from atop the trans pan lip.

Mine gave out at 48,000 miles. When it fails, you will have 3rd gear only and the check engine and tranny dash lights will go on. The switch R&R at a Volvo dealer runs between $300 and $400. I decided to buy the switch from Nils Sefelt Volvo in Houston on the Internet for $110.00 plus $8.00 shipping UPS instead, and do the labor myself. [Tip from JohnG] DO NOT purchase an aftermarket (Scan Tech) switch. Spend the extra $10-$10 and get an OE one.... trust me.

PNP Replacement. [Procedure by Walt Poluszny/John Gislason]

Removing PNP Switch:

1. Do not undertake this until you have the replacement switch in hand: cleaning the old one will not work.
2. Raise the front of the car; jack stands are preferable.
3. Chock wheels and put transmission in Neutral.
4. Apply penetrating oil to the six (4 front, 2 rear)14 mm exhaust pipe nuts.
5. If needed, remove three 10 mm bolts that hold on the O2 Sensor wiring to the trans. cross member.
6. Remove one 10 mm nut and three plastic wire retainers for O2 Sensors on frame above Cat. Conv.
7. Loosen all six 14mm exhaust nuts, drop the rear of the pipe. Remove 3 of the 4 front 14 mm nuts so that 1 nut is still holding the pipes up. Pipe should swing from side to side to make clearance to the PNP switch. [Editor] Plan on rusted nuts which may have to be cut off.
8. If needed, remove two 10 mm nuts & fender washers holding heat shield above Cat. Conv. on
9. If needed, disconnect 17 mm trans. cooler return line on transmission. This line is usually installed very tight and dry. I suggest buying a very good quality flare nut wrench and soaking it 4-6 times overnight with PBlaster or a penetrating oil. Use two wrenches, one on the fitting itself and the other on the nut. You will have to give it a whack to pop it loose then apply teflon tape to the threads when you re-install. [James Steven] This step may not be needed. I was able to remove and replace the switch with the exhaust and cooling line in place; putting the gearshift in neutral permitted rotation of the switch housing until it cleared the cooling line.
10. Allow trans fluid to drain from fitting before continuing (approx. 1.5 quarts). Drains slowly, will take about 1/2 hour.
11. Remove 12mm bolt from top of PNP switch. Caution : it is easy to round this nut. It has a small head and is soft. Use a six point socket and take it slow.
12. Pry 4 metal retaining fingers away from 22 mm nut on PNP Switch shaft.
13. Remove 22 mm nut on PNP switch.
14. Evenly pull PNP switch off trans shaft.
15. Cut cable tie above PNP switch on the wiring harness.
16. Clip the remaining three cable ties and loosen the metal retainer on the drivers side of the transmission holding the PNP switch wiring harness

17. The PNP Switch wiring harness is the middle of three wiring connectors attached to the front of the transmission on the driver's side.
18. Slide the middle connector approx. 3/8 inch forward. This will release the connector from the mounting bracket making it easier to separate the two ends.
19. Grip the connectors with both hands ensuring you are squeezing the clips on each side of the connector to release it while pulling the two pieces apart. They are in very tight and will require some force to separate. I had to spray the connector with penentrant to help loosen it.
20. You can now pull the PNP switch out from either side of the transmission.

Installing the New PNP Switch:

1. Install new PNP Switch over the slotted trans shaft and feed wiring harness over the top of the trans to the driver's side.
2. Optional) Add a rubber (neoprene) washer to the 12 mm bold between the PNP switch and the washer so that the bolt won't have to be installed too tight and the switch won't rotate after adjustment. The bolt is soft and has a small head and can easily be stripped so be careful.
3. Add a drop of blue (medium strength) lock-tite to the end of this 12 mm bolt before installing and securing the PNP switch.
4. Install securing washer with 4 small fingers over the slotted shaft and secure with 22 mm nut. Torque to 5 ft. lbs., then bend the fingers over the nut so it can't back off.
5. Adjust PNP switch in one of three ways in order of preference:
    1. Use tool 9995475 and align PNP switch such that the fine line is visible thru the slot in the tool. Then tighten 12mm bolt (torque unknown, but it does not need to be too tight because of the rubber washer).
    2. Turn ignition on (do not start), put Transmission in Reverse and rotate the PNP switch until the backup lights come on. Rotate switch until the back up lights go back out and center the switch. Then tighten 12mm bolt (torque unknown, but it does not need to be too tight because of the rubber washer).
    3. Line up PNP switch such that the indicator line on the switch is vertical and parallel with the slotted trans. shaft (with the trans. In Neutral). Then tighten 12mm bolt (torque unknown, but it does not need to be too tight because of the rubber washer).
6. 6. Add a new wire tie above the PNP switch replacing the on removed earlier. (optional)
7. Reconnect trans. Cooler return line.
8. Install Cat. Conv. heat shield with two 10 mm nuts and fender washers
9. Reconnect exhaust pipes, torque 14 mm flange bolts to 30 ft. lbs, and bolts at the rear of the cat. To 18 ft.lbs.
10. Re-attach one 10 mm nut and three plastic wire retainers for the O2 sensors to the chassis.
11. Re-attach the three 10 mm bolts holding the wiring harness for the O2 sensors to

the transmission cross member

12. Plug the new connector to the wiring harness and slide the connector back onto the bracket.
13. Add new wire ties where appropriate to keep wires from chaffing, being sure the new wiring harness is in the metal clip as well.
14. Check all connections for leaks and/or chaffing.
15. Add new ATF fluid to makeup for amount lost. (approx. 1.5 quarts)
16. Start vehicle, check for exhaust and transmission fluid leaks.
17. Back car off of ramps or remove from stands and test drive the car thru all ranges L, 3, D, N, R, P.

An autopsy of the switch reveals it is really a very simple electrical contact switch but subject to moisture and salt contamination .There are numerous springs keeping electrical contact certain. After opening it up, it appears that on one side of the switch, the grease is yellow and looks new, on the middle and right side of the switch it is as black as carbon and a strange texture making me think the knife-slide contacts are arcing and burning the grease. This black 'stuff' finds it's way between the contacts causing a fault.   I figure it will fail without warning and need replacing every 4 years.. After replacing the switch, you can reset the tranny light by pulling out fuse # 14 (if I remember right: the drivetrain diagnostics fuse.) The check engine light takes a mechanic with a scan tool to reset. Go to an independent Volvo place and pay him to do it (another $32.00).

PNP Preventive Maintenance? [Rafael Riverol] To avoid such headaches and AT replacements at a cost of several thousand dollars, perhaps maintenance should include PNP overhaul (cleaning the inside electrical parts and regreasing, and perhaps replacing the wire loom or patching it with electrical tape if frayed) when we flush ATF every two or three years. I found I did not have to touch exhaust pipe or ATF line to get to the PNP switch. So it can be overhauled with little trouble, particularly if the car is on a lift, and expense. This would be a good time to clean and repack with dielectric grease AT electrical connectors on the driver side of AT by ATF filler tube.

960/90 Shift Indicator Bulb Replacement. [Peter Penguin] -- Depending on the year, the AW 30 gear shift lever light can be easy or extremely hard to replace. the 1995 (and possibly 1994) have the light bulb mounted in a small square plastic holder (about 1/4 inch square) with two wires about 24 inches long. The bulb is not replaceable by itself (the entire set up is about 20 dollars). There is no discussion in the factory manual how to replace it (or even where the wires go). It is a real pain -This is what you have to do:

- Remove every thing from around the shift unit (this includes both side panels, all of the plastic housings, the ash tray and the fuse unit). See above for tips. Do not try to take apart the shift unit itself.
- Look at the drivers side of the shift unit and you will see two wires (white and

yellow) going into the lower part of the middle of the drivers side of the shift unit. pull those wires straight down and the plastic housing and bulb will pop out. The wires themselves loop beneath the fuse unit, then along the passenger side of the shift unit, then beneath the passenger floor mat.

- You will have to have a narrow snake about 12 inches long to feed the wires beneath a heating duct in the left side of the passenger floor (very tight clearance). The connector is on the left side of the passenger compartment about ankle height (below the carpet). Once you find it, it is easy to replace the wires in the housing.
- Feed the new wires back into place.
- Now comes the fun part. The new bulb housing just snuggly fits into a square hole at the bottom of the left side of the shift unit. If you use a mirror you can see it. You have to get it just right (it takes time) and it is a very awkward hand position - but you can do it.
- Now put everything back together. I suppose you could cut the wire just below the fuse unit and splice in the new wires. The bulb is friction welded to the connectors in the plastic housing. I have not yet figured out how to replace just the bulb. I decided to tackle this myself late last year.

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960 AW30-40 Converter Locks Up and Does Not Disengage Correctly. [Symptom] My 1992 960 shudders when the transmission locks up. Most times it works fine except for repeated locking and unlocking in slow traffic. Occasionally when trying to stop the converter is reluctant to unlock and the whole car shudders until it drops to 500 rpm when it finally unlocks. [Response: AreJohn] See DCS43-02-1194 Sticking Lock-Up Solenoid, AW 30-40 960 1992, which describes your problem to a tee. Fix is to replace the lock-up solenoid and is a common problem. The part lists for about $250.

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960 AW30-40 Torque Converter Module Fried. [Tip from Jim Bowers] The TCM, which governs torque converter lockup, in the AW3-40 can fry through the wrong voltages leaking into the module. A common way for this to happen is for the ground connections to get bad. This allows kick-backs from actuating coils etc. to get by snubber/protective circuits. Do the things that ensure the grounds stay good! Always disconnect the battery, or otherwise ensure the circuits are un-powered, before plugging or unplugging connectors in the system.

On-Board Diagnostic Codes for AW-30-40 Series Automatic Transmissions. [Tips from Tom Irwin]
These electronically-controlled transmissions also contain a diagnostic code series that you can access easily from the engine DLC module (the same one as used for the ignition and fuel injection codes.) Note that this Mode 1 procedure for code retrieval works only

for OBD-I (pre-1996) 960 cars.

1. Open DLC, (Diagnostic Link Connector) insert Test lead into hole #1.
2. KEY IN position 2, engine NOT running.
3. Push and hold DLC button for >1second, but, <3 seconds and release. (have your pen and paper ready)
4. Codes are three digits, separated by pauses, so a "314" would look like: " -*-*-*- (pause) -*- (pause) -*-*-*-*-"
5. After a longer pause, additional codes will be given, when you see the first code again...you have returned to the starting point.
6. Code "1-1-1" means all Clear, no codes set.
7. To erase codes, all codes must have been read off at least once, then press and hold the button for >5sec. release, wait for LED to light, then hold button for >5 sec again. And you are cleared.

There is also a self-test mode 3 you can enter which is a two man job. One enters the code through the DLC and the other guy is under the car feeling for each solenoid and other device to activate in sequence. Then, you can run through all the gear positions and modes and the DLC will respond with a code that shows the input was good or not. Good for isolating bad components.

Diagnostic Trouble Code Table for AW 30/40 Series Transmissions: Mode 1

1-1-1	No faults found by onboard diagnostic (OBD) system
1-1-2	Solenoid S1 short-circuit to battery voltage
1-1-3	Transmission control module (TCM) fault
1-1-4	Program selector open-circuit or short-circuit to ground
1-2-1	Solenoid S1 short-circuit to ground or control module fault
1-2-2	Solenoid S1 open-circuit
1-2-3	Solenoid STH short-circuit to battery voltage
1-2-4	Mode selector faulty or short-circuit to ground

1-3-1	Solenoid STH open-circuit, short-circuit to ground, or control module fault
1-3-2	Transmission control module (TCM) fault
1-4-1	Faulty load signal from ignition control module (ICM)
1-4-2	Oil temperature sensor short-circuit to ground
1-4-3	Oil temperature sensor circuit, open circuit
2-1-1	Transmission control module (TCM) fault
2-1-2	Short-circuit to battery voltage in solenoid S2 circuit
2-1-3	Throttle position signal too high
2-2-1	Short-circuit to ground in solenoid S2 circuit or control module fault
2-2-2	Solenoid S2 open-circuit
2-2-3	Throttle position sensor signal too low
2-3-1	Throttle position sensor signal sporadic
2-3-2	Speedometer signal missing
2-3-3	Incorrect speedometer signal
2-3-5	High oil temperature
2-4-5	Break or short-circuit in torque-limiting signal circuit
3-1-1	RPM signal from transmission missing
3-1-2	RPM signal from transmission faulty

3-1-3	FAulty signal from gear position sensor
3-2-1	Shift time too long
3-2-2	Incorrect gear ratio
3-2-3	Lock-up slips or is not engaged
3-3-1	Short-circuit to battery voltage in solenoid SL circuit
3-3-2	Solenoid SL open-circuit or control module fault
3-3-3	Short-circuit to ground in solenoid SL circuit or control module fault

Transmission Removal. See the FAQ section for AW-70, which is similar to that for the AW-30.

Maintenance and Operation:

M-46 Fluids and Fluid Change.
Fluid Type:

[Tip: Paul Seminara] The M46/M47 transmissions require Type F auto tranny fluid: NOT

Dexron. It takes about 2.4 quarts if you can get it all out. I pumped in the new synthetic Type F (Amsoil Supershift Racing Transmission Fluid; product # ART.) . No wonder Volvo mandates type F. Shifts the best of any fluid I have tried. OD works flawlessly. [Editor: Redline MTL is also recommended.] According to Duane Hoberg, I should stick with a product without friction modifiers, and of the type directly recommended. [Duane] Your trans needs Type F ATF ONLY. Northern locations and winter eliminate the 30W oil option since you regularly get below the 10 C low point for the oil option. Dextron or Mercon ATF is NOT usable in manual transmissions not designed for that fluid. It does not have the resistance to "squeeze out" or the "cling" necessary to stay between the gears as they mesh. You will end up with metal on metal as you drive, increasing wear and heat. The heat will eventually deteriorate the fluid so it no longer lubes well. After that point is reached, the tranny will go down hill fast.

Drain and Filter Cleaning Procedures:

[Inquiry] I'd like to change the fluid in my trans and was wondering if anyone had any good tips? How many quarts and what type to fill with? Is it hard to refill, should I get a pump? The tech page says there are 2 filters that should be cleaned in the OD section, are there any gaskets or seals I should buy first. Is the OD section fairly easy to take apart to get to those filters?

- *Fill and Drain Plugs.* [Jim Holst] To check the oil level, put the car on jack stands or ramps (safety first!!) Look at the driver's side of the tranny. There you'll see two plugs screwed into the side of the tranny. The lower is the drain plug, the upper is the fill plug. Clean the dirt away from the upper plug and unscrew the plug. NOTE: I recommend you use only a 6-point socket on this plug. Sometimes the plug will be frozen into the tranny and will be rounded off with a 12-point socket or, worse yet, a Crescent wrench. This is specially a problem with the aluminum case M47. If worse comes to worst, weld a 17mm bolt on to the plug. When you have the plug out, stick a finger into the opening and see if you can feel the oil. The oil should come up to the opening. Replace the fill plug. [Zee] Before draining anything, make sure you can loosen and remove the FILL plug. Yes, the FILL plug. Mine is frozen in and I already have drained the old juice out the drain plug below. Now I have to invent a method for filling the unit via the drain hole instead!
- *Filling.* [Zee] Use a little hand pump.
- *Gaskets and Overdrive Filters.* [Duane] The only gasket is the one for the Overdrive since it shares fluid with the trans. The only filter (actually a screen, up above a 3x5" rectangular cover on the bottom of the OD and easy to unscrew) is for the overdrive and needs a "special" wrench (homemade or from IPD) with two pins on it to remove the plug to access it once the OD pan is off. That filter is metal mesh and can be washed with mineral spirits or kerosene. [Tip from Mike Froebel] I've found you can remove it with two punches and a large adjustable wrench if you have 3 hands. Take the OD cover off to drain that....you'll need the gasket for this. Note the orientation of the cover so you can install it the same way.

Flushing Procedures:

[Paul Seminara] Get the overdrive access plate gasket from a Volvo source. First make sure fill plug comes out (see above). Drain tranny. You can easily see and access the planar screen.

Clean well with an evaporating solvent. You'll need a special tool to open the lid to the cylindrical chamber with cylindrical OD screen. Clean this. Button up and fill with inexpensive petroleum type F (DON'T use Dexron), drive for 1000 miles or so. Drain and refill with Synthetic Type F, such as Amsoil Supershift. Go 10,000 miles drain and refill. Check filter screens again at this point if you are thorough; sometimes crud from unknown locations will be deposited on the cylindrical screen.

Manual Transmission Shifting Troubles. [Inquiry:] My Volvo 745T has gradually been developing a shifting problem over the years and it has recently become a lot worse. I have the manual transmission and I find that I have trouble putting it into first gear and to a lesser degree second gear. These problems occur about every 4 out of 5 times I shift into those gears. They either go into those gears smoothly on the first try or completely refuse to go in(requiring a 3-2-1 shift maneuver). The other gears work fine and the car is generally in good mechanical shape. It has been suggested that this problem may be caused by shift cables or possibly the synchronizers on those gears.

Clutch Adjustments. [Response 1: Jerry Andersch] I'd start by making sure the clutch cable is properly adjusted. There should be about 1/8" slack in it before it begins to pull the release arm. Adjustment is made under the car at the end of the clutch cable. Threading it in or out will produce the right amount of slack. If the cable is out of adjustment it may not fully disengage the clutch and as a result getting it in to first gear from a dead stop and shifting to other gears, may be difficult. Of course there could be other problems but I'd begin here with the easiest and virtually cost free potential solution. Hope this is the answer. [Response: Rollie] I had similar problem after I replaced the clutch but it turned out to be an adjustment that I'd made on the shift linkage.

Worn Clutch. [Inquiry] My 740t 4sp w/od started having trouble getting into gear. First didn't grind but I could not get it onto gear. If the car had been running a little while it would go into any gear just fine. Still a little rough on first and reverse. Master cylinder was bled; the clutch looks new. [Response: Don Foster/Colin] Despite the apparently new clutch, it sounds as if the clutch is dragging. Often, this occurs with a worn clutch as the thin material bubbles, buckles, or tears and folds over, jamming between the pressure plate and flywheel -- even when the clutch is depressed. In your case, the clutch disc may be warped so that it remains in contact with the PP or flywheel. Another possibility is that the splines on the input shaft may be gunked, rusty, worn (having a "notch"), or damaged such that the clutch disc binds and can't move when the clutch is depressed. This could keep it in light contact with the flywheel. If your pressure plate springs or fingers look uneven, that suggests that when the t/o bearing pushes on them, the pressure plate lifts unevenly and won't fully disengage from the clutch disc. Sometimes that can happen from riding the clutch (or a misadjusted clutch) -- the friction from constant contact can heat and soften the fingers, causing several to bend slightly. It's also no good for the t/o bearing. Check the condition of the pilot bearing; if this is not totally free to turn It will cause the clutch to drag.

Fluid Change. [Response: Robert Abel] I had this problem in my M46 (190,000 miles). In fact, it got so bad that I was locked out of gear in traffic once - that was a fun one. Changed the fluid to synthetic 10w30 motor oil. Ran the car for a week. Changed the fluid again. Problem fixed.

Now shifts easily every time. The only thing I can figure is that the old fluid was not allowing the synchros to properly rotate. Once the new fluid had its chance, everything's good. [Response: Ozzie] The guy I bought my car from at 129K was selling the beast because of the 1st, 2nd gear problem. I changed the fluid to find it a little better, then I changed to Redline MTL. This stuff works wonders, its a little expensive (8 or 9 bones a quart---you need two), but not near what a new/used tranny costs.

Shifting Technique. [Ozzie:] A couple of tricks for you M47 owners with 1st gear problems: either shift into 2nd then 1st, or shift into 1st as you're coming to a stop. The synchros engage better. Another trick I learned a month ago, for those with a worn clutch and the grinding into reverse problem....put that puppy in first, then slide it into reverse--NO GRINDING--just another trick to put off replacing the clutch and surrounding pieces and parts (rear main seal,etc.)

Overall Diagnostics. [Response: Gary DeFrancesco] Your problem sounds like the beginnings of what I experienced with my M46 tranny last year. In my case, the problem came on somewhat suddenly, then progressively got worse. After awhile, I no longer had 2nd gear at all.

How many miles are on your tranny? Has the oil ever been changed? Unfortunately, many auto manufacturers do not consider changing the manual tranny oil a regular maintenance item. Hence, there are manual trannys out there with a lot of miles on the factory oil, and they sometimes fail. In my case, I think the tranny oil was first changed at 164,000, which is shortly after I bought the car. At about 175,000, the shifting problems started. I think the wear was well underway when the oil was changed, by then the it was too late to prevent the long term problems. I tried Redline MTL in a desperate attempt to revive the tranny. It did not work. I ended up replacing the tranny with another one from wreck.

In your case, I would go ahead and change the oil. Look at the magnet in the drain plug. If there are a lot of metal filings, then there is some significant wear occurring. Maybe a good synthetic oil such as Redline MTL will help. I think your synchros are starting to go. Don't know what a set of synchros cost, but being a Volvo part.... Such a repair will require a total tranny tear down, so you should also replace all the bearings and seals. Since your problem is mostly with 1st gear, you may have a problem with the 1st gear damper if you car is equipped with one. If this is the case, you may also need a 1st gear wheel which is obscenely expensive.

If an oil change does not help, and your clutch is working fine (if you get grinding into reverse, then your clutch is not releasing correctly which can cause your shifting problems), then you may want to look for another tranny from a wreck. Try to find one with some known history, relatively low mileage, and evidence of being maintained (ie., oil changes). Finding a M46 for a 745T can be very expensive. I was getting quotes of $650 - $950. Remember, a 740T with manual tranny is not a common configuration in the US. I ended up getting a M46 out of a 240. These trannys are much cheaper ($300 - $400 range) and are the SAME tranny as what goes into the 740. The only differences I could find was what was bolted to the gear box to make it mate to the different cars. Swap these few parts (shifting cage, selector rod, tranny mount, and maybe the drive shaft coupling and clutch fork), and the tranny is ready to go right into the car. No other changes need to be made.

Test Driving a Manual Transmission. [Tips from Volvo TSB 890-43-4, 06/97, courtesy of Service Technicians' Society] Systematic testing and diagnosis continues to be a primary rule

for technicians. Some problems, though, can only be confirmed while driving the car. Shifting and noise problems can be tricky without a standardized procedure within a particular shop. Volvo has outlined a manual transmission test drive procedure that would apply to most, if not all, manuals. The first step is preparation with checking the transmission oil level before test driving. Transmission warmup also is needed before the test drive. Volvo states that manual transmissions with an aluminum case should be driven for about 20 minutes to achieve normal operating temperature.   With the car stationary, engine idling, clutch pedal depressed and shift lever in Neutral, release the clutch pedal and listen for mechanical noise. Note whether the noise occurs with the pedal depressed or released. Repeat this step 10 times to check for intermittent noise. With the car stationary and the engine idling, fully depress the clutch pedal and wait three seconds, put the lever into Reverse, then 1st gear, and then Reverse again. Move the lever to Neutral and release the clutch pedal. Repeat the procedure, but wait for 20 seconds instead of three. Note any changes: differences in noise or difficulty in selecting gears after the different wait time.
Check the point of clutch engagement, and whether the clutch sticks or causes noise when the pedal is depressed. Put the lever in Reverse and accelerate to about 2500 rpm, listening for any noise and noting any other problems.   Next, drive the car on a highway with little traffic. Select 1st gear, and accelerate, shifting 1-2 and 2-3 at about 4000 rpm. Then shift 3-4 and 4-5 at as high an engine speed as can be done safely, but no higher than 4000 rpm. Engine brake the car, downshifting through all gears at about 3000 rpm. Note any difficulties selecting a gear, whether gears jump out of engagement, and whether there is any noise during any shift. Repeat the test, upshifting at 5000 rpm and downshifting at 3000 rpm.
Drive the car in 4th gear at about 60 mph and begin 1 minute of constant acceleration, as traffic and speed limits allow. Upshift to 5th gear, release the clutch for a moment, depress the clutch and downshift back to 4th gear. Repeat six times, noting any problems.   Whether you elect to use this procedure or develop a modified one of your own for local conditions, being able to repeat the sequence to demonstrate a problem is a plus. The test procedure also helps to confirm that the repair fixed the problem. A re-test need not repeat test steps that initially were satisfactory. However, there’s always the slight possibility that another problem occurred as a result of the repair procedure. Become a creature of good, thorough habits when diagnosing. Unpredictable procedures will mislead you more often than not.

M-46 and Overdrive:

Manual M-46 Laycock Overdrive Unit: Basic Operation. [Discussion and Analysis by Duane Hoberg, from whom parts may be purchased]
The following describes the power flow and the fluid flow for control of the Laycock OD.

Refer to the OD diagram for the numbers.

- *Non-OD Operation*. Assume the output shaft from transmission through center of OD. During Non-OD operation, splines on end of trans shaft mesh with Sprague clutch cam (67) and internal of planetary carrier (70). Cone clutch (43) is pushed onto annulus / output case (55) by springs (51) through bearing (46)and its carrier (44).
- *Reverse and engine braking*. Trans output shaft turns the planetary carrier (70). Since planetary carrier gears (75) are in contact with the sun gear (78) and the annulus case

(55), and the cone clutch (43) is in contact with output case (55), the complete system acts as a locked unit. The Sprague clutch freewheels allowing the case (55) to "turn backwards".

- *Forward gears one through four*. As for reverse adding transmission output shaft drives Sprague cam (67) jamming rollers (66) against output case (55) eliminating slippage of cone clutch under higher torque and load conditions.
- *OD engagement*. At all times transmission output shaft is rotating, fluid is being pumped by pump (12) through check ball (18) through filter (30) to passages leading to the actuating pistons (49) and the solenoid (39). This fluid, under about 15 PSI, is always present behind the actuating pistons (49), at the top of the Pressure Relief Valve (between 22 & 23), and at the rear most port on the solenoid.

- *Non-OD fluid control and flow*. The solenoid not energized, blocks the fluid from reaching the area under the dashpot (just above 24). The pressure generated by the pump is sufficient to push the relief valve (between 25 & 27) down and the fluid is dumped through the side of the relief valve onto the trans output shaft just forward of the cam follower to bathe the cam (not shown inside 13) and the bearing (46). The 4 springs (51) have enough pressure to overcome this pressure and keep the cone clutch (43) pressed against the annulus case (55).

- *OD actuated*. Solenoid energized. Solenoid internal piston moves toward front of solenoid piston bore, opening path between the back port and the middle port on the solenoid bore. This action also blocks a port on the front of the solenoid bore plug.
- Fluid is now free to pass to a metered port between the solenoid housing and the bottom of the Pressure Control Valve Dashpot (above 24). Since this is a very small opening the pressure build up is slow to allow a slow buildup of pressure. Since the dashpot has a larger surface area than the top of the relief valve (between 25 & 27), the dashpot will push the relief valve up closing the relief port and increasing the pressure behind the actuating pistons (49) and the underside of the dashpot.
- As the pressure increases behind the actuating pistons, the pistons push on the bars (52) which then pulls the cone clutch (43) off the annulus case (55) and into the brake ring (42) which stops the cone clutch (43),bearing (46), and sun gear (78) from spinning. As the cone clutch unit slides on the trans output shaft, the planetary gear carrier (70) is still driven by the trans output shaft.
- When the sun gear stops spinning, The planetary gear carrier (70) still driven by the trans output shaft, spins the planetary gears (75) on the stationary sun gear (78), and cause the annulus case (55) to rotate faster than the output shaft of the transmission. The Sprague clutch (66 & 67) allows this by freewheeling since the output case (55) is still linked to the transmission output shaft splines.Engagement fluid pressure is maintained by the springs (below 25) inside the dashpot (above 24) pushing up on the relief valve (between 22 & 23) and fluid pushing down on the relief valve from above. Excess pressure is dumped through the side of the relief valve as in non OD operation.

- *OD disengagement*. Solenoid power is removed. Inner solenoid piston is returned to "normal"position by a spring between the plug on the end of the solenoid bore and the piston. Solenoid reverts to blocking the fluid from reaching the area under the dashpot. Pressure that is under the dashpot bleeds back through the meteringport and passes from the middle port on the solenoid bore through the front plug hole and into the OD.

- As the fluid under the dashpot bleeds off, the Pressure Relief Valve (between 22 & 23) falls, reopening the side port dump. Pressure behind the actuating pistons falls allowing the springs to push the cone clutch back onto the annulus case. Since the sun gear is now free to rotate, the drive reverts to through the Sprague clutch.

That is the operation of an OD in a LARGE nutshell.

Manual M-46 Overdrive Fails to Engage: Basic Diagnostics. [Inquiry:] 740T car has a 4 speed manual transmission plus overdrive. The overdrive is the push-button type on the end of the shifter. When the car is hot it will not shift into overdrive. I just changed the transmission fluid and cleaned the strainer but I still have the problem. Here are some basic conditions:

- It's not leaking.
- The light always comes on when I push the button.
- It never shifts by itself but it does occasionally slip out. This happens when it gets hot and I try to drive in OD at about 40-45 MPH.
- The relay has never been changed or worked on.
- It started happening suddenly. The problem seems to have started around the same time as the weather got warmer. I wonder if the problem may have actually started sometime over the winter but the cold weather delayed the effect. It is usually below zero here (Atlantic Canada) all winter.
- The oil & strainer looked fine. I was expecting the worse.
- It doesn't make any funny noises at all.

[Response 1: Duane Hoberg] In all the OD's that I have worked on (net included), electrical problems rank the highest. Second is bad seals on the solenoid piston allow fluid past and allowing a self-engage situation. Third is bad piston seals on units prior to 1985.
[Response 2: Basic Diagnostics by Paul Grimshaw]

> First check the fluid. Very important to have the correct fluid and level in an M46.
> Second check the OD switch and wiring. The former can die a painful death (causing intermittent problems) and the latter can be chaffed as it runs under the carpet and through the transmission tunnel.
> Third, check the oil pressure in 4th gear. Pressure is critical as it is used to engage/disengage the OD. Connect a pressure gauge to the port directly below the OD solenoid valve. Pressure should read 21 psig at 70 km/h or ~40 mph. On OD engagement, pressure should rise to 520-600 psig. If the pressure is not within this range (typically low) replace the solenoid valve.
> If all is correct and the OD still slips, remove/clean the relief valve located at the bottom of the OD unit. Note: you must replace the transmission cross member to do this. While you're doing this, replace the OD filter (located under a plug directly beside the relief valve.
> Next, replace the OD switch in the transmission case. If the unit still slips, there is a (big) problem in the OD clutch. Have the unit rebuilt.

Further O/D Functional Notes. [Abe Crombie] See Duane Hoberg's extensive M-46 notes above and the OD exploded parts diagram] The OD is engaged by closing a relief port with the od solenoid. The relief port is connected to the lower portion of the relief valve. When the relief valve is "relaxed" it regulates a pressure of about 1 bar (15psi+/-) and the apply pistons for od don't have enough pressurre to lift and engage cone clutch to cause od shift. When the solenoid closes the relief port the relief valve gets its spring compressed and now regulates a pressure of 30 bar (450 psi) and the pistons lift the cone clutch of the output shaft outer annulus and pull it into the brake ring which causes the planetary gears to increase output shaft---->overdrive. You may need to do more than to unscrew the relief valve plug and filter plugs and blow through the hole you will see in the relief valve bore just above the threads. When you back up if the od attempts to try to engage it will try to lift the cone clutch off the annulus and reverse will slip. The only power flow in reverse is by the cone clutch inner lining being pushed onto the annulus by the piston return coil springs.

Filters & Fluid. A frequent cause (not yours) is clogged filters inside the OD unit. Can be cleaned (with white spirit) without removing gearbox or OD. Also synthetic ATF (or redline MTL) will help. The reason it does not engage when the car is warm is that the gearbox oil is also hot - and thus thinner, so it's pressure drops. Synthetic oils do not change their properties (so much) when heated, this is one of their advantages.

O/D Relay. [Duane Hoberg] Relays for the manual trannies rarely fail, whereas the automatic tranny relays drop like flies after a frost. Manual transmission relays (blue) and automatic relays (white) are two different devices and ARE NOT interchangable. To diagnose a suspected relay problem, watch the reaction of the dash light. If the dash light illuminates when you push the button on the shifter, the relay is OK and your OD not engaging is caused by something else. IF the dash light does not come on, you have either a blown fuse or a 4th gear switch that is not working. Plug your relay in and with the engine OFF, ignition ON, shifter in 4th, try to engage the OD. If the dash light comes on, does the solenoid by the OD unit click at the same time? If it clicks and still no OD, you need new actuating piston seals to get your OD working again. If the dash light does not come on, pull the shift lever further to the rear and right and holding it there try the button again. If the dash light comes on then goes out when you move the shift lever, the 4th gear switch is bad.

Bosch relays can have a habit of becoming intermittent and/or temperature sensitive due to solder cracks on the boards.   See the FAQ file on relay resoldering if you need to do this.

Electrical Wiring to Solenoid. Check the wiring to (and connections at) the overdrive solenoid.

Basic O/D Electrical Diagnostics. There are a couple of good diagnostics and inspections that you or a willing mechanic can easily perform. Given that you changed the oil, at least you know where the OD is, so maybe you and/or a friend can dive right in.. Try these:

> Wire up an indicator light to the "hot" terminal on the solenoid, and confirm that there's 12 volts present when the OD engages -- and that the test light goes out when OD disengages.
> Then the question is, when you push the button but the OD fails to engage, did the light

still come on? How is the condition of the ground lead at the solenoid, and is it solidly connected to ground?
If the light fails to come on (when it should) then the problem is electrical and not inside the OD. You can confirm this by feeding 12 volts to the solenoid directly -- note that you must only do this in forward gear (reverse OD is not healthy!).
If appears that the solenoid is getting power but OD fails to engage, the next candidate is the solenoid itself. Sometimes a shop will have a known-good one to substitute (which is good, because they're not cheap). Sometimes an enterprising mechanic can disassemble, clean, and reclaim a solenoid -- but I wouldn't hang my hat on it (I've done a couple). If the problem is the solenoid, replace the OD solenoid NOW! My OD acted like this for a year and a half, then the overdrive turned into tiny bits and ate up the shaft from the transmission too

Rebuild. Finally, it may be time for an OD rebuild. The OD uses the pressure of the oil in the tranny to engage. When the tranny is cold, the pressure is greater, so the OD works. When it gets hot, the pressure is less so the OD does not work. You really have two choices, find a reputable shop to rebuild your OD, or find a used OD. If you are playing around with extra boost in your car, you will want to have the OD rebuilt to handle the extra power.

Manual M-46 Overdrive Self-Engages. [Tip from Duane Hoberg:] If the "clutch" only slips in second gear and no other, and the OD does not appear to function, you have a problem with the solenoid on the overdrive allowing the OD function to "self engage" without input from you.

The solenoid in its OFF position acts as a stopper to keep fluid from an area that creates the pressure build up necessary to move parts internal to the OD and "engage" the "fifth" gear. When ON the solenoid valve moves only 1/8 to 3/16 of an inch and allows the fluid past. The seals internal to all this are two very small O-rings. There can be over time a small amount of leakage past the "end" O-ring and into the electrical area of the solenoid. If this leakage is great enough the valve cannot return to the OFF position and the OD then becomes self engaging. There are all sorts of causes for this to occur, age is one and poor electrical contact which causes heat which bakes the O-rings hard being another.

The solenoid has to be removed and shaken to test it. Yes, that is the test. It must rattle freely or it is bad.

In case anyone is wondering how this can be: Normal drive in the OD for gears 1 to 4 is via a Sprague clutch. (Only works in one direction and very very positive). OD is via planetary gearing which requires a stationary sun gear to accomplish. Hydraulics push the sun gear carrier (which almost everyone calls the cone clutch) into a brake ring which is part of the outside case of the OD. During the transition from Sprague clutch drive to planetary gear drive, the planetary gear drive is trying to make the output shaft move faster but cannot because the sun gear is not stationary and the Sprague clutch is just sitting there trying to drive but cannot. It is this in between area where "slippage" occurs.

The pump in the OD is a piston style driven off the output shaft of the transmission. The pressure necessary to move (not engage just move) the internal parts of the OD begins at around 15 mph and with good actuating piston seals is sufficient to maintain OD contact at about 25 mph. Second gear range in the M46. After that, the OD is engaged and the OD "doesn't work" when the button is pushed. Only because it is already engaged. Change the OD solenoid.

Cleaning the OD Solenoid. [Duane Hoberg] If you have problems with the OD engaging and disengaging, clean out the OD solenoid. There is fluid inside which is preventing the solenoid from returning to the OFF position. Since the OD pump works constantly, if the solenoid is "ON" and enough pressure is being created, the OD will engage as you describe. Cure is remove the solenoid, then remove the small retaining clip from the barrel end. (NAPA tool 3150 or equivalent) DO Not separate the brass barrel from the coil body. You may never get the same compression joint the factory achieves. Then remove the small plug with an O-ring pick or similar. There is a small spring just underneath the plug. The main piston requires patience an a little bit of luck. With repeated stabs toward a soft landing spot, the piston should work itself out. Once the piston is out, insert a small drift or stiff wire smaller than the piston. This has to be long enough to push an iron slug inside the main body clear of the end of the joint between the brass barrel and the coil case. Using an electrical contact cleaner with its extension spray tube, spray inside the barrel up past the drift or wire and clean out the inside of the coil area. The wire should keep the slug from acting like a sink stopper. When clean reassemble, preferably with new O-rings. Lube sparingly as you do not want any fluid getting into the coil area. A properly functioning solenoid should click very sharp when activated and released. When out and shaken it should sound like a baby's rattle. A solenoid O-ring kit from Duane Hoberg is $5.20.

M-46 Overhaul and Rebuild Procedures. [Extensive Discussion courtesy of Duane Hoberg] Tips on dismantling and overhauling the Laycock J type Overdrive. The identification plate is on the passenger's side of the overdrive unit. Numbers refer to parts as numbered on the attached OD drawing. See the more detailed discussion at Overdrive Rebuild: M-46 Transmission which includes a parts list and another link to the diagram.

- After removing the OD from the vehicle, clean the outside well.
- Prior to separating the OD housing, remove the rear output flange (61) if necessary. A pipe wrench is suitable for holding the flange.
- Remove the nuts (53) holding the bars (52) over the actuating pistons and remove the bars.
- Remove the nuts and washers (82,83,84)holding valve body (2), clutch ring (42) and rear case (54) together gradually. Working your way around the case, loosen each nut a little at time to release the tension from the springs (51) gradually. Note the two copper washers and possibly plastic "sleeves" on the upper pair of studs. These washers and sleeves will have to be replaced on the same two studs to prevent leakage after reassembly. With a soft (brass or plastic) drift, drive the brake ring (42) from whatever case it stuck to, working around the ring for even removal.
- With the rear case separated from the brake ring, remove the return springs (51), cone clutch (43), bearing and carrier (44 through 48),sun gear (78) and the planetary gear system (70 to 76) as a unit from the front of the annulus ring/output case (55). The cone clutch may stick a little but will release as the inside of the cone clutch has clutch material

in contact with the output case. The planetary system may decide to stay with the annulus case and is OK to remain with the case. If needed, to remove the annulus case from the rear case, put the nut (64) back on the output shaft and strike with a plastic mallet to drive the case from the bearing (59).

- Removal of the one way roller clutch (65 to 68) requires a special tool or lotsa patience and grease to reinstall. It is not recommended that this clutch be removed unless damaged. By inserting your thumb into the center of the clutch, it should turn one way and one way only. If using your left thumb inserted into the center, rotation counter clockwise should occur. Clockwise rotation should lock the bearing and try to turn the case.
- To remove the bearing (46) from the cone clutch (43), remove spring clip (48) and sun gear (78) from cone clutch. Spray a little penetrating lubricant of choice at the joint between the bearing and the cone clutch. Using two pry bars, place bars between cone clutch and the bearing carrier (44) at a point other than the flanges. Pry the bearing off the clutch. Remove the retaining clip (47), flip the carrier over, and drive the bearing out of the carrier with a drift or similar device.
- Reverse is the opposite of disassembly.

Warnings:

- The thrust bearing (46) can be driven into the carrier (44) by drift around the outer race if the carrier is on a flat stable surface. A press method is preferable but not necessary. The bearing (46) MUST BE PRESSED onto the cone clutch (43) with a vise and spacers or what ever. A socket on the back of the cone clutch with bolt through bearing and big washers that put pressure on inner race and the bearing "boss" of the cone clutch only. If bearing is driven on to cone clutch with an impact method or the pressure on the cone clutch is not directly under the inner bearing "boss" the cone clutch integrity will be compromised. READ AS guaranteed failure in many pieces with many dollars to repair OD unit.
- The thrust washer (56) under the roller clutch (65) fits into a mating recepticle in the annulus (55).
- The gaskets (80 & 81) are not interchangable.
- The two copper washers (83) are installed on the upper two studs to prevent a possible leakage condition after reassembly. Some OD's had plastic "seals" around the studs instead of copper washers. Leave these in place or replace with eight to ten turns of Teflon tape. Just enough to contact the inside of the mating hole in the rear case. Tighten the case nuts (84) gradually and in a criss cross pattern to pull the cases together and load the springs (51) evenly.
- To reseat the annulus case into the rear bearing (59) (or bearing and annulus into the outer case), use a spacer of some sort to push against the inside of the rear case (54) to allow the flange nut (64) with a washer to pull everything into position.

M-46 Leaks. [Inquiry:] My M-46 overdrive leaks; does this require dissassembly? [Response: Abe Crombie] The leakage is most likely from the upper two nuts/studs on the OD unit. These are sealed with cone shaped nylon pieces that get forced into threads. Clean it up and then drive a block and see if it leaking there. If so then you only need to remove nuts and clean the stud and case with brake cleaner spray and then apply sealant (silicone, permatex, etc) to the studs liberally and then re-install nuts. If you have to remove OD then just before you lift car kill it in reverse so that the splines in OD will unbind from the trans output shaft. The OD will slide right off if this is done.

Manual Transmission Overdrive Solenoid and Switch.

Solenoid. I checked at a few volvo dealers for the cost of a volvo OD solenoid and the price was between $195 and $215. Then I ran into the Gear Vendors (World's largest supplier of Overdrive Auxiliary Transmissions) at the Los Angeles Roadster Show. Their price for new OD solenoids for the Volvo is $100. I spoke to Homer Eubanks at 800/999-9555 (customer service rep) and he was very, very helpful diagnosing a problem I had with my OD when it would go off/on/off/on/off and finally off. He told me that the OD needs servicing and when that is done that I should have the screen cleaned and air blown through the small oil holes that go to the solenoid.

Relay. [Duane Hoberg] Manual transmission relays (blue) and automatic relays (white) are two different devices and ARE NOT interchangable. For diagnostic tips, see above.

Fourth Gear Switch Replacement. [Jim Holst] The OD would not stay in overdrive unless I held the gearshift lever hard down and to the right. This indicated a bad 4th gear switch on the transmission. All the manuals say to put a jack under the tranny, remove the bolts on the cross member where the tranny mounts, and lower the tranny to get room to put a crowsfoot wrench on the 4th gear switch (top of tranny). The switch takes a 7/8" socket. Here's my short cut for replacement. I found that my oxygen sensor deep socket, the type with a slot in the side for the sensor wire, was a 7/8". Not only would it slip on the switch but the end of the sensor socket had a hex shape which would take a 1" open end wrench. I put the socket on the old switch, gave about a 1/3 turn with the 1" wrench and the switch came out the rest of the way with just my fingers. Reversed this to put the new switch in. Took about 10 minutes for the job once I realized the sensor socket would work. If you have this sensor socket remember it may work for this job too.

Manual Overdrive Clutch Slipping. [Inquiry:] I posted a message about this problem a couple of weeks ago, or so, and one respondent suggested engine mounts, but after inspecting them, I doubt that they are the cause of this problem. The car is an '89 740 Turbo with M-46 plus P overdrive. When the car is good and hot, the overdrive clutch seems to slip. Starting out in 1st gear, I get a lurch, during which the engine revs slightly, then settles to normal. Sometimes, in any forward gear, in overrun, the engine drops back to idle, as if the overdrive was neither engaged nor disengaged and was freewheeling. In reverse gear, I get a loud gear whine, and the car proceeds at a clearly much lower ratio for 20 - 30 yards, then lurches into its normal ratio. At these times, the overdrive will not engage at all, but it doesn't feel like the direct drive has disengaged, because there is no freewheeling. In cool weather, or when the car is not stinking hot, the overdrive works perfectly. The electrics for the overdrive all check out. The car is new to me, has 85,000 miles, and seems to have been very well cared for and driven lightly. Should I just assume that it has the wrong kind of oil (i.e. Dexron), or should I consider other things? Is Redline really the magic bullet for these units, or is Volvo's stuff better? The Volvo manual seems to suggest that Volvo's oil is only good where ambient temperatures remain above 10 degrees Fahrenheit, not a safe assumption here in the Boston area. If incorrect oil is the likely culprit, what should I do to clean out the old stuff? [Response:] Try draining the trans and O/D. Clean both screens in the O/D. The one under the rectangular plate as well as the one on top of the big plug once you get the cover off. Type F will work fine for the trans./O/D. O/D's can slip both unengaged as well as engaged. They usually slip when engaged though. This is a first step and it's a lot easier to do them pulling a gearbox.

Manual Overdrive: New Pistons and Seals Needed. If your M46/OD starts dropping out of overdrive in hot weather, the likely problem is worn overdrive actuating piston seals which allow leakage of hydraulic pressure. The original blue teflon seals are not available from Volvo or anyone else because according to TSB 43-14, new pistons and seals replace the two piece teflon/o-ring seal and piston. The new seals will not fit the old pistons due to differences in the grooves. See John Sargent's excellent illustrated discussion of how to replace these seals and pistons. Replacing these pistons will likely restore your O/D's ability to shift when hot.

M-47:

M47 5-Speed Noise in Gear: Bearings Bad. [Inquiry] Ever since I purchased the car in November, that M-47 transmission just moans and groans. 1st,2nd,3rd and 5th are the offenders. 4th appears to be OK. The car has 165,000 kms on it. Is this a common issue or is the result of poor maintenance in regards to the tranny oil? I recently changed the oil to find it a nice shade of silver. It's obvious the damage has been done. I'm just wondering if this is to be a continuing concern and if it is, are there any tricks to keep it from occurring any time soon. [Response 1: Mike Froebel] I hate to say, but what you're seeing is bearing bits. One of the bearings is coming apart, probably on the countershaft. It's only going to get worse, I'm afraid. The reason you don't hear it in 4th is because that gear is not a gear at all, the trans just joins input to output shaft. This puts no load on your bad bearing. The trouble with a bad bearing is once the hard surface of the bearing parts has worn off, there is nothing to prevent rapid deteriation of what is left. In this type of transmission, then the gears don't mesh properly as the shaft with the bad bearing moves around. And of course, all the metal particles grinding everything else. Then instead of a small parts and large labour bill, you have a large parts and larger labour bill. I would have this fixed ASAP. As far as only working on one part of the transmission, I wouldn't recommend it, take the whole thing apart and see what is wrong. Or try to find a used one, rebuilding these takes time and patience, and not very many have any experience. [Response 2: Paul] Mike is right, what you are hearing is noise from a bad countershaft bearing. Don't let this go on, because aside from damage to other bearings, the alignment between the gears on the Input/Mainshaft and the countershaft is changing, and those parts will add zeros to the parts bill in a hurry. Make sure this job is done by someone who has done Volvo tranny's before if you want it done right.
[Response 3: Henrik] If you see metal parts in the oil - don't replace just the bad bearing! Look

for a used M47 instead. Just a few hours of labour (two actually if you are handy). The metal parts has probably made serious damage to other bearings in the gearbox. In Sweden, you can get a used M47 for about $180 and it's not worth the money to rebuild the box and take the risk of making things worse and end up buying a used box.

M-47 Shift Linkage Causes Hard Shift. [Tip from Art] M47 transmission, 294,000 km. It has always been hard to shift into 1st and sometimes 2nd gear. I replaced the fluid with Redline MTL this summer and it improved the shifting on the higher gears, but not 1st. After a particularly frustrating drive to work the other day (about 10 mi. of stop and go traffic jam) I had noticed that if I pushed HARD left on the stick, it would slide nicely into 1st, but if I pushed left then hard forward, no way. If I lifted the reverse knob and was careful, easy shift into 1st.
Chiltons says there is no adjustment of the linkage, Haynes has instructions for adjusting the reverse detent plate as part of shift lever removal. The detent plate prevents moving the lever so far left that you accidently go into reverse instead of 1st. Mine apparently was preventing the lever moving left far enough to allow smooth shift into 1st.
Really easy job [notes apply to 240: 700 should be similar]. Lift the rubber boot from the carpet. The two bolts are right there. I adjusted mine by trial and error and the easiest shifting is when the detent plate is quite far to the left, more than the .06 inch clearance limit in the book. I'm a happy camper again, all gears shifting with two fingers pressure. [Comment from Steve] The key indicator would be that worn synchros allow the gears to clash (crunch)as their job is to cause two shaft to match speeds. Silent gear changes that take a lot of effort are usually a clutch which does not fully disengage or as you found out, the shifter itself

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Clutch:

Clutch Replacement

Clutch Replacement Tips. [Nigel Sheerwater]

A reasonably easy job if you follow Haynes: takes me about 4 hours start to finish on my own. Done it in 2.5 hrs with a mate which aint bad considering the garage time and we only use ramps. Some small hints....not in any order

- Put a supporting plank across the two strut tower tops and tie the back of the engine to it to support it so you don't smash the distributor against bulkhead.
- When car is on ground loosen (don't undo) the engine to gearbox / starter motor bolts and then retighten as they are pigs to get at if tight.
- I jack the car onto ramps but this is optional but can be done if clutch has gone. I also stick a couple of axle stands under other supporting bits. If things do go wrong then it's better that the car lands on these rather than you.
- You may have to undo the bolts holding the bellhousing to gearbox using a long extension rod to reach them.
- Use good quality allen wrenches if clutch is held on with allen bolts.

- Thoroughly clean new pressure plate to get rid of protective grease and wash your hands before you touch the plates on assembly.
- Don't cut corners...buy the full plate/bearing pressure plate kit.
- If gearbox is out check for leaks on real engine crank oil seal.
- You do need a jack and an alignment tool; a friend is handy.
- The slave cylinder can corrode in and the spring clip is a pig.
- If you split the driveshaft MAKE SURE YOU MARK IT as noted in Driveline.
- After all is reassembled slacken the centre prop shaft bearing and let it settle.
- There is a reinforcing plate engine to gearbox. do the gearbox up first before fixing plate on.

Other Preventive Maintenance Needed When Changing the Clutch? [Inquiry:] Our 88 740 Turbo Wagon is in need of a new clutch. Any suggestions as to other work to do while doing the clutch? Rear oil seal? Shifter bushing? Is it a given that the flywheel should be re-surfaced? [Response: Gary DiFrancesco] While replacing the rear oil seal, pilot bearing, and throwout bearing, also look at the clutch fork. It is not unusual for the pivot point on the clutch fork to wear (clutch fork is about $45 at the dealer.) When my '87 745T had a new clutch put in, the pivot point was worn so badly, you could see holes in the metal. If not replaced, the pivot point would have eventually failed and the clutch would have been useless. Also look at the pivot bolted to the bell housing. This rubs against the clutch fork pivot point and can get deformed. It should be smooth and round on top. If there is wear, replace it. It is easily removed with a socket (19mm I think), and the bell housing does not need to be removed to do it. When putting the clutch fork in, put some grease on the pivot point. [Response: Dick Riess] By all means replace the rear seal. Also pilot, throwout and you may as well go for the clutch kit which includes a new pressure plate. To have a super smooth engagement you could have the flywheel resurfaced also. [Response: Tom Frisardi] Only reface the flywheel if there's a problem. Usually there is, especially in the form of hairline cracks. Sometimes refacing won't cure this. A fresh flywheel face feels better, to me at least. Other things that I've had trouble with in the drivetrains of my 740's that you might want to look out for have been the center support bearing, the rear transmission mount and the flexible coupling on the output flange of the transmission. [Inquiry] Is there something special I should request from the machine shop doing the flywheel resurfacing? So far I've heard two methods, using a lathe (like for turning brake rotors?) and using a surface grinder. I'm strongly leaning towards the latter, as I've never had good luck getting rotors turned. [Response: Don Foster] Use a surface grinder: it leaves a better, flatter surface. Check the teeth on the ring gear -- if some are obvously hammered, reinstall the flywheel so the worn teeth do not naturally stop in alignment with the starter.

Clutch Pedal Engagement. [Inquiry] The clutch pedal on my 95 940 Turbo has to be pushed all the way to the floor to allow reasonable gear changes. Is this normal? Its very difficult to drive after being used to a cable clutch that disengages quite high up. I've tried bleeding it, and the orignal owner history also shows the dealer bled the clutch. Should I replace the slave / master? [Response: Jerry Warren] The hydraulic system is supposed to be self adjusting. If it has leaked to the point that it go air in it then that could acount for the action of the clutch. Unless the slave cylinder is leaking there is not reason to replace it. The same goes for the master cylinder. There might be an adjustment on the rod. If there is then you could use that to change the height of the pedal disengagement. More than likely the rod will be solid. Before you consider replacing either, if you determine that has to be done, look into rebuilding the units. Kits should be available. Be careful what fluid you use. My favorite is Castrol. I never had a problem using that fluid. I did when I use American brands.

Replacement, Conversion & Installation

Transmission Replacement Tips. [Phil]

Cost of Replacement. My M47 type II 5 speed developed the dreaded 5th gear syndrome exactly as described in the FAQ section of this site. I called local shops, but no one was overly enthusiatic about working on a manual transmission and a rebuilt transmission from Volvo was quoted as $2023USD part only, no labor. After a few Internet inquiries, I finially located a replacement tranny from a 1991 240 and had it delivered. I spent $550 for the tranny plus $125 for shipping from CA to NY. I also replaced the rear mount while I was at it. Clutch was done 30K miles ago so I didn't touch it. All totaled I spent about $725 USD.

Shifter Set Screw. Don Foster indicated that removing the M-47 shifter dowel pin set screw can be somewhat of an adventure. Well Don, you were correct! Soaking with PB Rustbustet didn't help and after rounding out the set screw allen head, I resorted to drilling it out, being careful to creep up in size and drill just large enough to be able to remove the interlocking dowel pin. Luckily, I have a set of metric taps and was able to retap the shifter eye. My Volvo dealer did not have a replacement set screw, but I was able to find a metric replacement from the local harware store. I did have to grind a point on the new set screw to engage the dowel pin groove as the purchased set screw had a flat cup end and did not fit into the dowel machined cross groove.

Procedure. As for removing the transmission, I supported the car on 4 jack stands and fashoned a transmission cradle out of a scrap 2x12 with supports. This cradle proved useful for sliding the tranny around on my garage floor and providing a flat surface from which to jack.[Editor: You can rent a tranny jack which is safer.] I used manual tools, 1/2 inch breaker bar and swivel, and a floor jack to support the tranny. Weight of the tranny is around 90 lbs. The breaker bar, swivel and extension worked like a charm to remove the dreaded top starter bolt. I also dropped the front exhaust pipe, to gain better side access and have room to move around between tranny and floor pan. The entire job took me several hours on Friday and most of Saturday. Other than having to tap the shifter set screw, nothing unplanned came up.

Replace Broken M-46 with Unit from 240 Car.
[Tips from John Sargent/Tom Fachetti] Volvo switched to a more robust Type P (from the earlier Type J) OD unit in 1987. These two overdrive units are not interchangeable. The M46 transmission with its OD in the 240 is a direct substitute for the M46 with OD in the 740 car. The

740 car will have the alloy case with P type OD, while the earlier M46 will have cast iron case and J type OD. The two OD types will not interchange since the transmission output shafts are different. I installed an M46 with J type OD in my wife's 745T. It functions perfectly. You do have to move the throwout arm ball stud, but the bell housings are the same. The output flange is different, but it is easy to change that too. The bell housings are identical, but have the ball stud in different locations. The throwout bearing arm is different, but all you have to do is use the one from your 740T.

[Tip from Gary DiFrancesco] Over the holiday break, I replaced the sick M46 tranny in my '87 745T. The sick M46 no longer would go into 2nd gear and repair costs were potentially out of this world. Many of the bone yards I contacted for a 740 ready M46 usually wanted big bucks for one, ($650 to $950). Yet, M46s for a 240 were relatively cheep, ($250 to $350). A few knowledgable yards confirmed my idea of using a M46 from a 240 and adapting it to a 740. I obtained a 240 M46 and intalled it over the holiday break. I can say with confidence (based on my experience) that a M46 from a 240 will easily fit into a 740!
These are the changes I needed to make to the 240 M46 in order for it to fit in a 740:

1. Swap the tranny mount and bracket, (2 to 4 bolts)
2. Swap shifting cage, (4 bolts)
3. Swap the selector rod, (1 pin)
4. Swap clutch fork and move fork pivot point, (240 clutch has a cable, 740 uses hydraulic)
5. Swap drive shaft couplings, (1 nut, My 740 uses a rubber coupling instead of a u-joint)

These changes are all easy and fast. Knowing what I know now, I can make these changes in maybe 20 minutes. Once done, the tranny installs into the 740 without difficulty or need for further modification.
In my situation, the 240 M46 I obtained is an earlier version that had the iron case. This is the version with the lower 1st gear ratio which is desirable. The later Al case M46s had a higher 1st gear ratio that could pull a house off its foundation.
The 240 M46 came with a Type J OD unit. I was figuring on swapping it with the Type P OD from my sick M46 since I have a B230FT engine. Unfortunately this swap was not possible. The output shaft of the 240 M46 (with iron case) was about 3/16" longer than the shaft from the Al case M46. So the Type P OD would not go onto the iron case M46 all the way. Furthermore, I found the spline on the iron case M46 was shorter and slightly smaller in diameter than that of the Al case M46. I am not sure of the reason for the changes in the output shafts and OD units. Obviously there have been some design changes over the years that has caused some incompatibility with these parts. I put the Type J OD back onto the iron case M46 and am driving the car just fine. If anyone can shed some light on these design changes, it would be greatly appreciated. If a Type P OD can be obtained that will properly fit my iron case 240 M46, I would like to get one.
The Type P OD is stronger than the Type J OD, hence it is used on the Turbo cars. Can anyone tell me where the weakness of the Type J OD is. Is the weakness only an issue when the overdrive is engaged? Or is it an overall weakness that affects the OD unit whether it is engaged or not? Since I don't hot rod this car, am I correct in assuming that a Type J OD will be fine? After all, many 240 owners with Type J ODs tow boats and tent trailers which put a fair amount of stress on the OD even when not engaged. I don't hear anything about that being a problem. Since I don't tow with this car, running with a Type J OD seems to me to be okay if I

don't hot rod. Any thoughts on this train of thought would also be greatly appreciated.
If nothing else, it is good to know that a 240 M46 can very easily be installed into a 740. This can be a real $ saver for the few of us whose 740 M46 gets sick.

Replacing Turbo Manual Transmission with Non-Turbo Model. [Tips from John Sargent] My son wrecked his 744T with manual transmission last summer. His replacement 1984 760T had an automatic, and he badly wanted a manual transmission in the car. The M46 with P type OD in his wrecked car had been giving some OD trouble, and I told Evan that we wouldn't replace a good automatic transmission with a bad manual transmission. I was able to buy a good 1987 M46 with J type OD very cheap. A P type OD is stronger, but J type is quite adequate for the job, and all Volvo did on the early turbo cars with J type was have the ECU disable injector number 2 when shifting into OD (or so the service manual says). I told Evan the J type would survive quite fine if he shifted sensibly in and out of OD. Turbo 700 series cars with manual transmission have a hydraulic clutch. Early Normally Aspirated cars have a mechanical cable clutch; later NA cars have the same hydraulic clutch as turbos. On turbo cars the ball stud for the throwout arm is between the throwout arm opening and the input shaft as pictured to the right.

M46 Turbo Transmission

M46 Non-Turbo Throwout Arm Stud Location

On normally aspirated cars the ball stud for the throwout arm is on the opposite side of the input shaft as pictured left.

In order to use the NA transmission in the turbo car all you have to do is remove the NA ball stud, and then remove the turbo ball stud and screw it into the NA transmission bell housing. The bell housing has a hex socket cast into it with a threaded nut in it just waiting for you to use. The ball stud from the turbo transmission is internally threaded has a metric stud that screws into it and also fits the nut in the bell housing socket.

Converting an Automatic to Manual Transmission. While manual 740s may be found in the US, no 940 or 960 cars were ever sold here with manual transmissions. Elsewhere, the 940 non-turbo used the M47, as did non-turbo 740's and 240s. The 740T, 940T and older 240 used the M46. The 960 used a 5-speed called the M90. There is a great deal of info, and occasional imported parts collections being sold, regularly on Turbobricks.com. Some 740/940 cars have been converted from automatic to manual, but very few 960 cars have been converted in this country- the supply of conversion parts is small, and there aren't really a lot of 960s to begin with. In addition, the conversion will be rather expensive, with the cost of an imported M90 being probably close to $2000 to get it to your doorstep.

For a discussion of the techniques and parts needed to convert an AW-70/71 to manual, see the file discussing such a conversion.

M-46 Overdrive Overhaul and O-Ring Repair and Replacement

Author: Duane Hoberg

This information is intended for private use and convenience only. Please do not use for commercial gain. The accompanying overdrive ("OD") parts and assembly Image.gif file is NOT intended to be the diagram that dictates your overdrive parts purchase and/or assembly. It is for reference only and could be superseded by the diagram at your local Volvo dealer. All rights to the diagram remain with Volvo. Buy parts from Duane.

Text that follows assumes above average automotive repair knowledge. If you can R & R the head you can do this. This job should take 5 to 6 hours barring major problems without removing the transmission. This is only a compilation of tips that will make the job go smoother not a complete how to do it.

I strongly suggest obtaining the Bentley Manual or the Volvo Service Manual as an assist in diagnosing and evaluating the OD unit. Going through the effort to R&R the OD then not having it work because of a broken/damaged/corroded wire, switch, or relay will destroy your day. As preventive replace the 4th gear switch on the side of the trans. Also use the accompanying diagram and text below to help in reassembly and keeping track of which O-ring goes where, (some are so close to the same size that size alone will not help you place them correctly).

Parts needed: Most are special order. I suggest replacing all the following gaskets, seals and o-rings or ordering all as a preventive measure. To order the correct parts you will need the number off the unit that is on the right side of the unit. The number begins with 27 then 115xxx and a serial number. Take in the whole number to your parts supplier. There is a complete list of all overdrive parts in the table below.

Numbers that follow the description or are in the text are referenced to the accompanying diagram and may not coincide with the diagram the parts counter utilizes.

Gaskets and Seals:

1. Gasket between OD unit and Rear trans housing. (Not shown on this parts listing)
2. Gasket between the OD unit housing and "pan". (36)
3. "Washer" for the filter plug (31)
4. Seal ring for OD solenoid (41)
5. O-rings
6. Rear output seal if leaking (60)

The list of O-rings below is according to internal diameter and thickness. They are cross referenced to the part number ( ) on the OD diagram. [NS] indicates Not Shown.

O-Rings, listed from smallest to largest diameter:

1. Top Pressure Relief Valve (22*) Thin
2. Two for the outside of solenoid (40) Thin
3. Pump Sleeve (11) Thin
4. PRV inner piston (24) Medium
5. Speedometer drive body (NS*) Thick
6. Pump Plug (20) Thin
7. Lower PRV and PRV Sleeve (23*&27) Thin
8. Two for the actuating pistons (50) Thick
9. PRV Plug (29) Thin

*The two rings for the prv valve seat (22 & 23) need not be replaced if the seat is not easily removable (explanation later). The Speedometer seal need not be replaced unless it is leaking.

Tools needed:
1. standard metric set 11mm to 18mm (sockets, wrenches, extensions, etc.)
2. torque wrench
3. jack stands (4) or ramps and 2 stands or lift if you are so lucky
4. garage floor jack NOT A BOTTLE JACK

Special tools needed:
1. An adjustable spanner wrench or Volvo Tool #2836. For my OD unit control plugs,

I used a "Martin" adjustable spanner wrench #482. The machinist I borrowed it from stated that spanner wrenches are usually available at bearing supply companies. Their website listing vendors is: http://www.martinsprocket.com. For a homemade version, see Special Tools.

2. 4.5mm Allen wrench for speedometer gear OR 5/16" Allen wrench for later models (YES it is American Standard if you have/had a Tamper proof "spider" fitting with a Red Plastic cap over the screw).
3. 11mm offset box wrench for some of the OD to rear trans housing nuts.
4. 11mm "C" curved box wrench for the two top OD to rear trans housing nuts. Better yet find a short 11mm wrench about 4 inches long. Some have cut off a wrench just to make the job easier. For a homemade version, see Special Tools
5. 25mm or 1" thin wrench for OD solenoid. (I ground the sides off a Craftsman crows foot to allow it to fit even if the OD is on the vehicle). Looks just like the Volvo Special Tool. [Tip from Bob Haire:] I use a 1" open end cut to about 5-6" length and ground to 1/4" thick. The short handle allows the wrench to fit up in the tranny tunnel and get a good bite. I use a big box end as a leverage handle on the shank of the 1" wrench.
6. A wood block to place between the transmission and the jack.
7. Some contrivance that will allow you to fill the transmission when finished reassembling. See end.

Procedure and Tips.
1. [Abe Crombie] Put the car in Reverse and dump the clutch to kill the idling engine as the last
thing you do before repairs are started. There are two splined hubs contact the trans output shaft, one from the OD one-way clutch and the other from the OD planetary gear set. The splines get loaded in two opposing direction in every gear except R and when the OD is engaged. The grasp of these two splined hubs from opposing directions gets a pretty good lock on the trans output shaft.
2. Drain transmission and OD unit. When removing OD "pan" catch the filter screen (35) which will fall out when the pan comes down.Remove the Overdrive unit. See Bentley Manual.
Tip: Support the transmission forward of the support cross member and remove transmission support and clean the nuts/studs on the OD as best you can. Clean studs allow fingers to remove nuts instead of wrenching them all the way off. See below.
3. Using the 11mm "C" wrench (or shortened wrench) and 11mm wrench (alternate between them if necessary), remove the two nuts & lock washers at the top of the OD housing to rear trans housing, one each side below the bottom of the shift lever. The nuts are located to the transmission side of the unit just above the front of the "pan". If you do not have the short version of the 11mm wrench, you may have to carefully push the trans to the side to gain enough room to get the wrench to fit on the nut and move it. DO Not use the open end of the wrench, it will not fit properly and will round

the nut making removal of the transmission necessary. I found this out pulling the OD from a vehicle in a salvage yard and had to drop the whole trans to get on the nut with a six point socket. Not fun on a 98 degree day. These two nuts are the most difficult to remove and install. Be patient, I could only move them 1/12 turn at a time until the lock washer was free then used my fingers.

Carefully lowering the transmission slightly helps. There is not much clearance between the firewall and the valve cover with wires and hoses in between. There are a total of eight nuts and studs. Some studs will come out, that's OK. Leave the bottom two until last.

Flex the OD unit by pushing up (do not jack it up or you will bend the output shaft of the trans) on the rear of the unit to allow just enough clearance to get a screwdriver or pry bar between the units to help pry the units apart. Do not drive the pry bar/ screwdriver between the units.

Remove the OD unit from the output shaft by moving it straight back in line with the transmission (about 15") while supporting it.

> [Potential problem: OD seized together] I didn't unload the splines as noted above. Now, loosening the eight 11mm nuts as described above, I can not get OD unit to come apart. I'm currently not trying to make the break at rear of transmission cast iron housing, but at the next joint back which has 8 - 11mm nuts in a roughly round pattern.
> [Response: Rick Mordahl] The proper thing to do is to run the car up to speed on stands, engage and disengage the od 4 or 5 times, then with the od engaged, let the wheels coast slowly down to a stop. Do not disengage od with the switch or put the trans in neutral until the wheels stop after you disengage the clutch. The reason to do this is that the cone clutch, when it disengages quickly slams back into place and puts tension on the splines in the planetary. [See Crombie note above.] If the tranny is out of the car, take the oil pan off, and pry the bearing carrier/cone clutch assy towards the front of the transmission. While wiggling the cone clutch, pull the od back. This is actually a whole lot easier to do with the trans still in the car- the top two 7/16 nuts (remember this is english) are a bit tough to remove, but not impossible. As you pull the od back, rotate the shaft to allow the pump eccentric to disengage smoothly from the pump. Do not beat on things or you will break stuff, and that is not necesary. Be persistent, wiggle the cone clutch and it should come off.
> [Response: Duane Hoberg] Separaton is difficult at times. Prep as follows. Remove the solenoid. This will remove all hydraulic pressure, if any, inside the OD unit. Also, rotate output shaft of OD in clockwise

direction as you look at the rear of the OD. Bang with a plastic mallet just "forward" of the point on OD rear case where it tapers to the output flange as you rotate the shaft. Then: With a plastic or wood mallet, tap firmly around the adapter ring where you removed the bolts while applying side pressure at the rear of the OD with your hand 180 degrees opposite where you are hitting. Hit on the adapter ring toward the transmission. A manual impact wrench so to speak. Work around a couple of times. This is usually easier with the OD in the car as more pressure can be applied without moving the tranny although you cannot get around the whole OD. Kinda hard to hit with the car body in the way . IF the OD does not move away from the adapter, do not drive anything between to separate the case. You will most likely crack the adapter. If a space opens up and you can get a screwdriver or similar in without driving it there, use it as a lever and push on the output flange area of the OD opposite to open up the other side. Insert another screwdriver and pry apart. It usually lets go with a pop if you are using this method by now. If all above fails, you will have to remove the rear case of the OD and dismantle forward and it still may be difficult if the pump cam follower is holding the unit in place. [Response: Aceman] There is an aluminum sleeve in the OD unit that rides on the out-put shaft of the transmission. That shaft is a cam. It is cast steel. If the trans has been allowed to run low on fluid the alum sleeve will seize on this cam just like a frozen bearing. the only way is to break it loose. Chances are you will need to go to the bone yard and buy another od unit for parts.

4. Clean well, disassemble the valves, replace O-rings lubricating well with ATF and reassemble. Tips for Overdrive O-rings: Be sure to lube well with fluid before reinstalling.

Remove the OD solenoid (39) from the unit AND the pressure port plug (8) just to the right of the pan. This will allow whatever fluid still left in the unit to drain out as you work and not cause problems by creating a vacuum as you try to pull some of the pistons out.

There are two metal bars visible from the front of the unit (52). Remove them and remove the pistons (49) below them. The seals around these are usually what is causing the OD not to work.

You will probably have to use a pair of pliers to pull the pistons from their bores. They may be a little difficult but if you did step A you won't be pulling against the fluid still in the passages between all the valves and pistons. Sometimes pushing on the other piston helps push the other out.

Removing the O-rings (50) from the pistons. The trick I like to use to remove O-rings is by using a pair of narrow needle nose pliers. Open the pliers and grab the O-ring at points about 90 degrees apart, squeezing the pliers causes the ring to stretch up so the pliers can clamp on it (or I can slip a toothpick underneath it) without touching the piston. Doesn't mar the surface of the piston that way. With new O-rings the pistons will take some effort to install. That's good.

Removing the center plug (19). (Check Valve) It will seem very stiff as it has an O-ring (20) on it. Just underneath the plug is a spring (17) which holds a check ball (18) into a dimple on a plate (16) inside a pump sleeve (10). All parts are necessary. DO not loose them. The pump sleeve can be removed by pushing it out from inside the front of the OD unit while supporting the piston and cam socket (12 & 13). There is a flat and slot to one outer side of the sleeve. The sleeve must be reinstalled in the same orientation with the slot toward the hole the screen fits into in the bottom of the unit. Remove and replace the O-ring on the sleeve (11) and plug (20). Lube all well and reinstall. NOTE: The pump piston (12) cannot be removed from the cam follower(13) without damage, leave them attached. When reinstalling the piston and cam follower assembly, it (12 & 13) must go into the sleeve (10) before the sleeve is seated in the housing. Install the cam follower with the sloped side of the cam follower toward the front of the OD.

The pressure relief valve (21) has many parts and must be replaced in the same sequence and relationship. See M-46 Overdrive Pressure Relief Valve Tool for information on building a tool to remove this valve. The plug (28) too has an O-ring (29) on it and will be stiff. Pull the piston with a pair of pliers. Spacer washers and shims (25) are located between the inner spring and the control piston. The outer sleeve (26)can be removed by inserting your thumb, bending your thumb, then pulling the sleeve out. Mine came out without much effort. Some are more difficult than others. Sometimes you need to hook the hole toward the bottom of the sleeve to pull it out. Be careful to not scratch the bore. The seat (parts between 22 & 23) at the top of the bore requires a special tool to remove. A piece of stiff wire bent into a hook will work just as well if the seat O-rings (22 & 23) allow it to come out. If it doesn't want to release with a little effort do not take it out. The O-rings are holding it in place and are still good. (the later from three different shop's mechanics). The hole in the outer sleeve when reinstalled should line up with the hole in the casting.

Reinstallation:

Clean surfaces between the OD unit and rear trans housing, install gasket on OD unit, rotate output shaft of trans with eccentric cam so cam lobe is in the extreme down position. Liberally lube the cam. Then lube the cam follower (13) on the OD.

Position cam follower on OD unit in position straight up, centered L & R on hole in housing and pump piston all the way down.

Align the splines at the bottom of the opening that the trans output shaft inserts through. This is best done with a long thin screw driver. The second set of splines will only turn one way. They will turn very easily in the correct direction. Do not force.

Slide OD over output shaft of trans rotating rear flange to help align splines. The unit should slide up until about 1/2 to 3/4 of an inch from the trans. Check alignment of the cam and socket. Adjust position of the cam and follower using the rear output flange. Slide the OD rearward without allowing the studs to clear the holes. With a very sharp forward motion push the OD forward. It will seem to hesitate at the point where the cam contacts the socket then slide "home" as the socket (13) adjusts to the cam. This may take a few tries. Mine took 8 tries over 20 min. Each time I realigned the cam and follower before trying it again and before I tried the sharp forward motion.

Refill with fresh fluid as able. DO NOT use Dexron. It will allow bad things to happen inside your TRANSMISSION....the OD could care less. Your fluid choice is limited to Type F ATF, a straight 30w Motor oil if temp never gets below 20 degrees F. or a synthetic trans fluid that is Type F specific. Other synthetic transmission fluids not Type-F specific can cause problems within the OD by being too slippery.

I used a fill device I got from K-Mart that screws to the bottle, has a twist type on/off valve with about a 12" length of clear vinyl tube about 1/2" in diameter. It just fit inside the trans fill hole, and allowed me to turn the bottle upside down into the area just below the intake manifold. Dumped 2.4 quarts into the trans and spilled maybe 2 to 3 ounces after the unit was full. Slick little device.

M-46 Overdrive Parts List.

See the exploded diagram at M-46 Overdrive Exploded Parts Diagram

Overdrive parts for Volvo Type J Overdrive units are available through Duane Hoberg: ODGuru at kc.rr.com . All numbers referenced to Volvo drawing PV 430 42559. Email for current prices and availability.

Part # with NA are not available through this source.

Volvo Illus. #   Part Description   Required

1	Factory Reman. Overdrive Unit	1
2	Main Casing	1
3	Stud	8
4	Stud Short (bottom 4)	4
4a	Stud Long (top 2)	2
5	Relief Valve Ball	1
6	Relief valve spring	1
7	Relief valve Plug	1
8	NA	
9	Pressure Port Washer	1
10	Pump Body & #11	1
11	O-Ring	1
12 to 15	Pump Plunger Kit	1
16 to 18	Non Return Valve Kit	1
19	Pump Plug	1
20	O-Ring	1
21	Complete Assembly Not Available	
22	O-Ring	1
22a	Relief Valve Assembly	1
23	O-Ring	1
24	? Only In Kit? Unable to cross reference	
24a	Dashpot sleeve	1
25	NA	
26	NA	
27	O-Ring	1
28	Dashpot Plug	1
29	O-Ring	1
30	Filter	1
31	Washer-Pressure Filter	1
32	Plug-Pressure Filter	1
33	Oil Pump Sump Cover	1
34	comes with sump cover #33	
35	Suction Filter	1
36	Oil Sump Gasket	1
37	NA	
38	NA	
39	Overdrive solenoid	1
40	O-Ring	2
41	Solenoid Washer	1
42	Brake Ring	1
43	Sliding Member (Cone Clutch)	1

44	Thrust Bearing Housing	1
45	NA	
46	Thrust Bearing	1
47	Circlip-Retaining	1
48	Circlip-Sliding Member	1
49	Piston Operating	2
50	O-Ring/Operating Piston	2
50a	NA	
51	NA	
52	Bridge Piece Kit	1
53	Locking Nut	4
54	Rear Case	1
55	Annulus	1
56	Thrust Washer	1
57	Front Annulus Bearing	1
58	NA	
59	Rear Annulus Bearing	1
60	Rear Oil Seal	1
61	NA	
62	NA	
63	Flange Washer	1
64	Flange Nut	1
65	Clutch Assembly	1
66	Clutch Cage	1
67	Clutch inner member	1
68	Oil Thrower	1
69	Spring clip	1
70 to 77	NA	
78	Sunwheel	1
79	Circlip-Sunwheel	1
80	Rear Main Case Gasket	1
81	Rear Case Gasket	1
82	Locking Washer	6
83	Copper washer	2
84	Nut	6
	Numbers 85 & Up Not Shown	
85	Gasket, Adaptor to Casing	1
86	Gasket Kit (36,80,81,85)	1
87	Overdrive O-Ring Kit (11,20,22,24,27x2,29,40x2,50x2,94)	1
88	Bearing Kit (46,57,59,60,99)	1
89	Oil Pump Cam	1
90	Woodruff Key for Cam	1

91	Circlip for cam	1
92	Spring Ring for Cam	1
93	Speedo Output Bearing	1
94	Speedo Bearing O-Ring	1
95	Speedo Gear Oil Seal	1
96	Speedo Connector	1
97	Speedo Conn. Hold DownBolt	1
98	Ring Spring	1
99	Roller Set	1

For further illustration, see the **M-46 Exploded Parts Diagram**

Placement of Jack Stand to Unload Output Shaft

M-46 Piston Replacement. [John Sargent] My son's 1984 760T with M46/ OD recently started dropping out of overdrive in hot weather. The problem is worn overdrive actuating piston seals. The original seals had a blue Teflon sealing ring, and the seals give trouble with age. The upgraded new pistons use a nice fat rubber o-ring which gives better service. I ordered two new pistons (part number 6814454), and two new o-rings (part number 6814455-9), and the gasket (part number 380618-9) between the OD and the transmission. Once I had the parts I jacked the rear of car up, ,started the engine, and shifted through the gears and into OD. Once into OD I stuck the clutch in and hit the brakes. This procedure unloads the pressure on the transmission output shaft splines so the OD will slide of of the transmission. You can also shift into reverse and very firmly let the clutch out and achieve the same thing. The picture to the right shows where I like to put my jack stands.

The next step is to remove the driveshaft and transmission crossmember. The transmission will drop slightly, and this helps lots to get at the eight 7/16" nuts which hold the OD to the transmission. I use a fine tooth 1/4" drive ratchet and 7/16" socket to remove the eight 7/16" nuts. This will nicely let you get the even the top two nuts. The ratchet and socket might not work on a 240, but they do the job fine on a 700 series. Be sure to clean all of the dirt you can from the joint between the OD and transmission. It is easier to clean it off before it gets on to the inside parts. Sometimes a little gently tapping on the output flange helps get the OD off of the transmission. If you didn't unload the OD from the transmission output shaft, you are going to be wishing you had.

The new (black o-ring) and old (blue o-ring) pistons can be seen to the right. They fit tighter than the old pistons, even before the seals go into the bore.

Old & New Pistons and Seals

Overdrive with New Pistons and Gaskets

The OD with new pistons and gaskets is shown left. Clean the back of the transmission off and remove all traces of the old gasket. It will look like this when you are ready to slide the overdrive back on. It might take several tries to get the pump collar (for lack of a better description) around the cam on the output shaft. Slide the OD back on and start re-assembly.

Once done, re-fill with type F ATF or synthetic motor oil. This overdrive works perfectly again.

Transmission Output End

Lubrication:

Differential Oil Maintenance

Checking the Oil Level:

- *Solid Rear Axle.* Remove the fill plug at the top, insert your finger, and make sure the oil level is up to the bottom of the plug hole. When you reinsert the plug, coat it with antiseize so you can remove it from this rusty environment next time. Snug it up and don't overtighten or strip the threads.
- *Independent Rear Suspension Rear Axle.* [Dennis James] To check the oil level on an Independent Rear Suspension differential, look for a threaded plug about even with the driveshaft on the driver's side. It is not on the back side of the assembly, but on the front where the driveshaft bolts to the pinion shaft about three inches to the right (looking at it from under the car at about the position of the rear-driverside seat.)

Why Change the Oil? [Tips from Brake and Front End Magazine, Jul 02 by Larry Carley] [Volvo] differentials use hypoid gear oils that also contain extra amounts of "extreme pressure" (EP) additives. Limited slip differentials also require their own special additives. Most of these lubricants are long-lived and hold up well for tens of thousands of miles. But none will last forever. The combination of heat, shearing action and oxidation eventually breaks down the oil and reduces its ability to lubricate and protect. Normal wear inside the gearbox and differential also produces metallic debris that ends up in the oil. Since there’s no filter to remove these contaminants, the fluid becomes more and more abrasive as the miles add up. The only way to get rid of the contaminants and restore the lubricating qualities of the oil is to drain and replace the fluid. The oil level inside a manual transmission or differential is critical for proper lubrication because there’s no oil pump to route the oil where it’s needed. The oil is churned by the whirling gears, which "splash lubricates" the moving parts. If the fluid level gets too low because of a leak, therefore, the bearings and gears won’t get enough lubrication. The result can be galling, seizure and total destruction of the unit. Oil is also necessary to cool gears and bearings. The total oil capacity of most manual transmissions, differentials and transfer cases isn’t very much (typically a couple of quarts or less), so it doesn’t take much fluid loss before parts start running dangerously hot. If a transmission or differential is whining and making noise, it’s too late to add oil. The damage has already been done. Adding a higher viscosity oil may quiet it for awhile, but once wear has taken its toll on the gears and bearings there’s no magic cure other than to overhaul the unit and replace the worn parts. Another reason for changing the lubricant inside a manual transmission, transaxle, transfer case or differential is to improve cold weather operation. Most conventional oils thicken as the temperature drops. This increases friction, drag, fuel consumption and the effort needed to shift gears. ...Synthetic gear oils have a lot of advantages compared to conventional petroleum-based oils. Synthetics are more stable, flow more easily at low temperatures, reduce friction and operating temperatures, improve fuel economy and generally provide superior all-round lubrication and protection under a wide range of operating conditions. [Editor] Highly recommended for all seasons, all temperatures, all uses: synthetic 90 grade differential oil. Mobil 1 75W-90, or Valvoline, Castol equivalents in 75/85-90 grades. See below for LSD/ALD oil information.

Differential Oil Vent Tube. If you change your oil and find it frothy or foamy, make sure the differential plastic vent tube is not allowing water into the lubricant. Re-orienting this might be necessary.

Re-Filling Rear Axle Lube.

Identifying Leaks. [Tip: Editor] I make a habit of every so often spraying a little cleaner on the rear axle housing just aft of the pinion seal, as well as the gas tank near the seal, and washing the car in one of those car-bottom automatic washes. This allows me to see a clean axle housing when I inspect it occasionally and know at once when the rear pinion seal is leaking. The seal is a wear item and I have gone through them most frequently when the car is used in short trips on bumpy roads. Sure enough, I looked underneath last night and found the telltale spread of dark oil being blown both aft under the axle and sideways onto the gas tank. These are prime indicators of a leaking seal.

Draining the Differential Oil. Before you drain any oil out, **make sure** you can open the fill plug at the top of the differential. An oil suction gun will leave much of the oil in the axle; draining through the drain plug or lower bolt hole makes more sense.

- *Earlier Axles With Drain Plugs.* Drain the oil by removing the fill plug at the bottom of the differential case.
- *Later Axles Without Drain Plugs. [Inquiry]* How do I drain and refill my rear axle housing when it does not have a drain plug? [Response: C. McGrew] The later axles do not have drain plugs so just remove the bottom cover bolt and let the oil drain through the bolt hole. If it does not drain because of dirt, secure a new gasket and remove the cover.

Refilling the Axle. If you don't have a suction gun, buy a quart of axle lube for $2 at Walmart and an eight-foot piece of 3/8 inch vinyl tubing at a hardware store. Hook the oil bottle up to the tubing, route the tubing over the rear wheel, have wife hold the bottle in the air while you put the other end into the fill port, and slowly the oil will siphon down the tube into the axle housing. It took a little while, but it didn't leak and was a quick and easy way to refill the axle. [Tip: Abe Crombie] I've pumped hundreds of quarts of diff/gear lube at home by cutting the screw on top to a size that will take a piece of clear vinyl 3/8" tubing with a very snug fit. The you puncture a small hole near top of gear lube jug. With tube on very bottom of container and sparing application of air from your compressor via a blower nozzle, you can make quick work of adding the lube w/o assistance. Don't rush it or you'll rupture the gear oil jug.
[Tip: Peter Cohen] StaLube sells small pumps ($5) that afix to gear oil bottles; visit NAPA.

Refill with Mobil 1 or Valvoline synthetic in a 75-90 grade.

Limited Slip Differential Lubricants. [Editor] If your car has a Limited Slip Differential (a dealer-installed option in the 1031 axle), then use a rear axle oil with a limited slip additive. The axle may have a tag specifying "anti-spin oil", which means an LSD additive.

Automatic Locking Differential Lubricants. [Note from Michael Asmussen, Torque Control Products Division of Eaton Corp.] We recommend the following lubrications for our 1041 automatic locking differentials:

1)Texaco 2276; Synthetic 75 W90; GM Part # 9986115
2)Texaco 9622; Mineral based 80W90; GM Part # 9985290
3)Texaco 2080; Synthetic 75W140 (heavy duty applications); GM part # 9985991
Note - All of the above lubes are preblended with friction modifier. No additional modifiers are necessary or recommended. As far as other lubes are concerned, any standard GL 5 lube will work, but the units perform optimally with the three listed above.
[Comment from Castrol:] Thank you for contacting Castrol regarding Syntec 75W-90 GL-5 gear oil in your Volvo 1041 differentials with an Eaton Automatic Lock. You may use SYNTEC gear oil with full confidence.
[Comment from Mobil:] Mobil 1 Synthetic Gear Lubricant meets the GL-3, GL-4 and GL-5 API ratings. If the manufacturer requires the use of a GL-4 rated lubricant ONLY, then you should not use Mobil 1 Synthetic Gear Lubricant.

Driveshaft:

Disconnecting Driveshaft for Towing. [Inquiry] I am in the process of moving and need to disconect the driveshaft on my 740 in order to tow it behind the truck on a dolly. Any suggestions on the best way to go about this? See the FAQ discussion. Reassembly using the alignment marks is important to preserve the balance of the driveline.

Driveline Vibration Diagnosis . [Inquiry:] My 740 has developed a nasty vibration. First of all it acts as if it needs a tune up and I just replaced the plugs and wires. But the vibration that I was experiencing before the plug and wire change did not go away. The car vibrates the most when it shifts from 2nd to 3rd. I can't tell if its the engine or the drive train. [Response:] I have an '87 740 - same problems. Here's what cured them:

- motor mounts
- transmission mounts (change at the same time as motor mounts)
- exhaust manifold gasket
- tighten exhaust heat shields (listen with stethoscope with engine idling)
- transmission to exhaust support bracket similar to 940 (available from volvo dealer for less than $100)

Done. quiet. finally. Sounded like an old tractor before. now a car again.
[Another Symptom:] I have a 87 745 with 260K miles, and I am experiencing a vibration and droning noise upon acceleration in any gear (AW70) between 2200-3500 rpm's. The droning noise seems to subside at speeds in excess of 80Mph. The noise also subsides if I drop the car into Neutral -- and so does the vibration. Please let me know what your experience was with this & how to best fix the problem.

Diagnostic Tips on Driveline Vibrations. [Tim K] Join the droning/ vibration club! Sorry about the sarcasm. I too, have this very same problem. Change the rpm range slightly (2500 - ?) I've really never paid attention to the max range on the rpm's. However, I'm getting ready to tackle the problem within the next few weeks. I've decided to let a more seasoned professional tackle this one, though. I've done the research on the archives, put it on the board for feedback and have done some additional research. I've eliminated engine vibration by having engine mounts and transmission mounts changed (recommend you do them all at same time). Since yours is an 87, you are likely to have the hydraulic motor mounts so check to make sure that you have more than 1/4" clearance between the engine oil pan and cross member. If not, replace all the mounts (not just the engine mounts). Second, make sure that all exhaust is intact and matches factory spec as far as exact hangers and routing. Next, check the center support bearing for excessive play. This can be heard usually first when the car is coasting on deceleration as a humming or droaning noise. Lastly, check the transmission tailshaft for leakage. If any visible signs of leakage, it's time to replace the tailshaft bushing as a worn one will allow the drive shaft to move in a more elliptical path -- creating the very noise that you describe. My guess is that a combination of the center support bearing and the transmission tail shaft is your culprit. I hope this helps. [John Sargent] A friend had experienced the same drive line vibration problem in his wife's 700 series with AW71 transmission, and only 130,000 miles. Rod said the problem was cured by replacing the tail shaft bushing. There was no oil leak, but there was plenty of drive shaft vibration when starting from a stop, especially with a full load. He added that he recently had the same problem on a customer car with 140,000 miles that had half the problem cured by the output shaft bushing replacement, and half the problem cured by the carrier bearing replacement. [Tip] On both manual and automatic transmission cars, the transmission output flange bearing can fail or move within the flange housing, causing driveline vibration and requiring a new flange housing and bearing. [Steve Oakes] I started with the assumption that for the shaft to be out of balance it must be deformed in some way. With one rear wheel of the car safely lifted I ran the motor with the car in gear and scribed a mark of the driveshaft in front of the center bearing using an awl: the awl scratched through the paint on one side of the shaft, marking the (presumably) heavier side deforming toward the awl point. I attached a hose clampto the shaft with the heavy side opposite this mark and voila, no more shudder. After replacing the center bearing and the engine and transmission mounts a few weeks ago, I removed the hose clamp and the vibration was obvious as soon as I pulled out of the driveway.

Driveline Take-Off Vibration: Shimming May Be Required. From Volvo Technical Service Bulletin 45/102 Jan '91. [Symptom:] Take-off vibrations at low speed, especially with high acceleration and/or heavy load, can occur in some cases. [Solution:] Before you conclude this is the problem, make sure your engine and transmission mounts are in good shape. The level of driveshaft vibration can be reduced by changing the vertical position of the center support bearing. The support bearing is bolted to a bracket, which in turn is bolted to the underside of the car body. Adding shims or washers between the car body floor and bracket will shift the bearing down. Adding shims inside the bracket between the bracket and support bearing will shift the bearing up. Best results differ from car to car. Start with a change of 6mm (1/4") upwards. If results are not acceptable, try positions from 5mm (3/16") downwards to 12mm (1/2") upwards from the original position. Note that clearance between drive shaft and fuel lines must be at least 20mm, and between drive shaft and the fuel tank at least 16mm. Shimming upwards should not exceed 12mm (1/2") and after re-positioning the center support bearing housing should not contact the floor pan.

Center Support Bearing Noise. *Symptoms.* I have an '88 740 GLE Turbo with 113K miles and a 3 speed auto with electric overdrive. Just the other day, I started noticing a faint whiny noise coming from the front of the car (it wasn't the turbo!). Over the next day or two, the sound became more apparent. It ranges from being a faint whiny sound to a loud howl that turns heads on the street with no apparent pattern. It comes from directly beneath the shifter. It is not related to engine speed, and is just as audible while coasting in neutral as it is in any gear. If I drive for more than about 10 minutes, it seems to go away until the next time I drive. I can't get in to have a mechanic look at it until Monday, but in the meantime, perhaps one of you kind folks might have some suggestions as to what it might be?

Driveshaft Support and Bearing Within Boot

Diagnosis. [Response: Mike Froebel] Classic hanger bearing noise. This is located just in front of the center universal joint on the driveshaft. There is a plate that is bolted to the frame rails with 2 bolts per side, the hanger bearing support is bolted to this plate with 2 bolts. The bearing lives in this support.

Lubricate It First. [Cliff Pope] Try oiling the carrier bearing first. You don't need to dismantle anything. Drop the cross member, pull back the rubber support, brush off the dirt, and carefully prise back the plastic seal a bit, just enough to get some oil in. Spin it several times and add more oil. I've never had a noisy one that didn't respond to this treatment. Mine squealed horribly at about 200,000 miles. It's now on 355,000 miles and still silent.

Bearing Replacement. It is generally a good idea to replace bearing and support together, especially when the bearing is going bad. It is quite an easy job to do yourself, but you need some kind of puller or press to remove/install the bearing from/to the driveshaft. Just take the driveshaft to a machine shop where they will be able to remove the old bearing for you, and press on the new one, unless you have access to a hydraulic press. Or use the method outlined below. It's a very tight fit pressing the bearing into the mount and alternative c-clamp or mallet and block of wood methods don't work. Do not pound on the driveshaft or new bearing or you could damage the splines so you won't be able to put the two halves back together, or the u-joint, or maybe change its shape just enough to put out of balance. Just to make it more fun, your car could have 2 different driveshafts each of which take a different bearing and support. Measure the distance between the hanger bearing and middle u-joint and use the following Volvo part numbers:

if the distance is: 4" --> 1340501 support and 183265 bearing
8" --> 1209820 support and 181549 bearing

[Response 2: Zippy] It probably is the carrier bearing. Often they don't act up until they get warmed up from driving. The only real way to pinpoint the problem is to put the car up on a lift and let the car run in gear (wheels are hanging free) and listen with a stethoscope for the noise. Drive train howl is usually the carrier bearing, often a rear wheel bearing and if you have had a differential pinion seal replaced recently, incorrect pinion to ring gear preload.

Other Parts to Examine. [John Orrell] The U joints on our bricks are darn near bullet proof. Since your mechanic will have to remove the driveshaft to replace the carrier bearing, they will let you know if the U-joints need replaced. No slop, no grind, no problem. But check the pinion shaft input on the rear diff. I thought I had a bad carrier bearing, but it turned out that the rear pinion bearing (and gear) was chewed to crap. Usually, a carrier bearing failure is associated with a burning rubber smell. No smell, think pinion. If this is the case, replace the entire rear end with a good salvage unit.

Center Support Bearing Replacement. [Procedure from Dana Manner]

Here's an account of my recent experience in replacing the driveshaft center support bearing and bushing (or carrier) on my '88 740 GLE 155k miles. This process avoids the need for a puller and press. Symptoms: Growling and whining noise that was speed dependant coming from beneath the car. Initially, I lubricated the universal joints and replaced the center U-joint that was very stiff and missing the grease fitting, but this did not eliminate the noise completely.

Parts and Tools Needed. After reading the process described in the Haynes manual, I decided that their method was not going to work for me since I do not have "V" blocks to support the driveshaft bearing while driving or pressing the bearing off of the shaft. I don't have access to a hydraulic press, and I wanted to try and do this myself. My method is adapted for the somewhat crude tools that I have available to complete the task. I used a 6" three legged gear puller to remove the bearing; two short (approximately 1 inch long) pieces of 2 inch Schedule 40 PVC plumbing drain pipe to press the bearing into the bushing cup; and a 12 inch piece of 1.25 inch iron nipple pipe to drive the bearing and bushing assembly back onto the shaft. Warning: This process completely destroys the rubber bearing carrier bushing, so you will need to purchase a new one with the bearing. There are several different driveshaft diameters and U-joint combinations used in the 700 series. [John Sargent] The turbo cars all had the larger driveshaft and it is 2.00" diameter. The smaller driveshaft was used only on the cars with the 1030 rear end, and is 1.75" diameter. The large diameter driveshaft was sourced from two different manufacturers. Neither the VIN code or the VIC (Version Identification Code) tell which driveshaft your car left the factory with. Measure your driveshaft and make sure you buy the correct parts.

Bearing Removal Process. Remove the driveshaft from the vehicle, making sure to mark the original alignment of both the splined end and the transmission flange end to their mating parts. Now, take a serrated steak knife (Volvo special tool "Ginsu 2000") and cut away as much of the rubber bushing as possible to expose the metal cup that the bearing is pressed into inside the bushing. Take your time, first cut the rubber holding the outer metal frame of the carrier bushing away and then whittle the rest of the rubber off, bit by bit. This will leave you with the metal surface of the bearing cup that you can now "catch" with the jaws of gear puller. Clamp the shaft in a bench vice, and apply the gear puller to the shaft so that the jaws are now pulling against the bearing cup that you just exposed from under the rubber, and the puller's center bolt is centered in the recess in the splined end of the driveshaft. Don't set the jaws of the puller on the front bearing protector ring that is mounted on the driveshaft; with this method, you will leave that in place. You will be pulling against the outer race of the bearing, and you are pulling the rear bearing protector ring off at the same time. Caution: There is a possibility that the bearing will come apart and be destroyed under tension, so be careful! Apply liberal amounts of penetrating oil to the shaft and inner bearing race, and give it some time to work. It is helpful to have a second set of hands (a helper) hold the legs of the puller tight against the bearing cup as you get the puller set and begin to apply tension. After the bearing is broken free (after a loud pop, in my case) continue advancing the gear puller bolt until it is completely free from the shaft.

Installing New Bearing Into Cup. The new bearing and carrier bushing came separately from the parts store, so you will need to drive the new bearing into the cup of the bushing. Based on the diameter of my bearing, I used the two short pieces of 2 inch PVC plumbing drain pipe to press the bearing into the cup in my bench vice. By placing one piece of pipe on either side of the bearing resting against the outer bearing race on one side, and the bearing cup on the other, squeeze this stack of parts in the jaws of the vice until it is seated in the bushing. I applied some silicone lubricant to the rubber to help the bearing slide past the rubber and into the bearing cup more easily.

Installing the Assembly Onto the Shaft. Now lubricate the drive shaft and the inner surface of the inner bearing race with some oil to prepare it for being driven onto the shaft. I took the rear bearing protector ring to Home Depot with me, and found that the inside diameter (the diameter of the splined end of the driveshaft was just smaller than the inside diameter of 1.25 inch galvanized iron plumbing pipe. I purchased a 12 inch length that was threaded on both ends (this is a stock item, a 1.25" x 12" iron pipe nipple, the threads are not needed for this at all). Slide the bearing and bushing assembly onto the shaft (make note of the original orientation, the bearing is exposed to the rear and covered by the rubber bushing in toward the front of the car), and seat it by hand. Slide the iron pipe over the end on the driveshaft and onto the inner race of the bearing. Don't install the rear bearing protector ring yet. Drive the pipe evenly with a hammer, tapping (or maybe beating) the bearing home onto the shaft. Then remove the pipe, and seat the rear bearing protector ring (a kind of a half donut shaped thing) onto the shaft.

Drive it home onto the shaft evenly with iron pipe, as was done with the bearing. Check for free rotation of the bearing and for trueness of alignment of the carrier bushing by spinning the assembly around the shaft. If the carrier wobbles (as mine did) because of poor alignment of the bearing inside the bushing's bearing cup, drive the outer race of the bearing into the cup with a punch and hammer, supporting the bearing cup from behind, on the edge of your bench or vice. This may take a little trial and error to get the alignment correct to eliminate any runout or wobble.

Replacing the Driveshaft. Replace the driveshaft, making sure to align it to the makings on the mating components that you made prior to removing the shaft from the car.

Vibration in Drive Shaft. [Note 1:] Even with the 2-piece driveshaft, rear axle pinion angularity is very critical to smooth operation. If the nose of the rear axle is too high or two low, the rearmost U-joint will be extremely "busy", and you often can get this kind of thundering at specific speeds. It's very fiddly to get adjusted correctly, but often paying careful attention to this will solve such a problem. [Note 2:] My first take on all of this is that the driveshaft was re-installed "out-of-phase" when all of the axle work was performed. There is a specific orientation shown in all Volvo service manuals. The driveshaft is balanced as a two-piece unit from the factory...so the orientation between halves must be preserved when servicing is performed. See Driveshaft Out of Alignment See also *Driveline Take-Off Vibration: Shimming May Be Required* and tailshaft bushing

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U-Joints. *Failure Symptoms:* Vibration in 90 745, AT, that is sort of a low moaning sound. It varies with road speed but not engine speed. It's almost like (snow) tire noise, but doesn't change with road surfaces (and I don't have snow tires!), or a bad wheel bearing, but doesn't change with turns, etc. It's gradually (very gradually) getting worse. If I let up on the accelerator, it disappears for a moment, then returns on deceleration. Finally, the groan virtually becomes a grind with deceleration to a stop. So, U-joint or driveshaft bearing, maybe? {Diagnosis:] Just went through the same thing. I think you're right about the U-joint. In my case, seized rear UJ; all four trunions/needle bearings dry and trashed. Only way to check is remove rear portion of driveshaft and check UJ for smooth taut movement. In my case, the rear portion of the two piece driveshaft can be separated from the pinion flange (in order to check UJ) without loosening anything else. 14mm?Interestingly, the bad rear UJ was also causing a rear end vibration, similar to warped rear rotors, under brisk deceleration at less than 10mph. [Response: Matt Cary] In my case a bound-up U-joint was causing excessive driveshaft vibration. Usually a bound-up u-joint will cause rumbling or vibration, particularly at slow speeds and/or hard take-off from a stand-still. The vibration causes excessive transmission output shaft bushing and rear seal wear. If your car is 10 years old or 150,000 miles, it's probably time for driveshaft r&r. It's easy to remove the driveshaft (4 bolts at each end, and the center support: be sure to mark the balanced shaft for reinstallation). Then you can feel the movement of each u-joint by hand, which is the only real way to inspect them. Be careful... sometimes the u-joint feels OK by hand but when it is under torque load it binds up. It's probably better to replace them all... about $12 and 30-45 minutes each. IF YOU REPLACE U-JOINTS: make sure you mark the driveshaft prior to disassembly so that you preserve the balance.

Lubrication. [Randy Starkie] Grease fittings in a replacement u-joint are a good thing. The original OEM u-joints have set screws that can be removed and a 1/4-28 fitting can be installed. An occasional shot of grease from a disposable mini grease guns (which will fit in the limited space) should insure a lifetime of service. On the 740 cars a hole needs to be drilled in the plate blocking a straight shot at one of the fittings once the fitting is installed; a step drill can be used with the plate still in place. You can also just remove the Allen screw and use a grease gun needle fitting to grease the u-joints, then reinstall the Allen screw which will prevent water intrusion through the Zerk fitting.

Driveshaft Alignment. [Inquiry: I dropped the driveshaft to replace the center bearing and failed to mark the alignment. Now it vibrates. What do I do?] [Response: Dennis Hamblet:]

The front section must be kept in the same alignment with the back section. The only approach I could suggest if yours appears out of whack is to remove the center bolts and rotate the rear shaft 1/4 turn then try it again. If it cures the vibrations you're home free, if not, rotate another 1/4 turn till you've tried all 4 combinations.

Drive Shaft index marks

[Response 2: Warner Bowles] I believe that the yokes of the universals at the centre bearing have markings on them from manufacture which indicates the correct alignment. You will have to clean off the paint and any other build up which has accumulated on the yokes to see them. A second alternative is to ensure that the yokes on the universals at the centre bearing are parallel, (ie in the same plane). This will result in the universals working together rather acting against each other. If worse comes to worse you may be 180 degrees out but should still reduce the vibration. [Tom Irwin] Drive shafts are dynamically balanced, which is why some of the flange bolts are longer than the others. When removing, you should mark the position of each bolt too. [Response 3: John Yuristy] Since you pulled the centre connecting spline apart, and there are about 17 teeth on there, you could have got it back together haphazardly in almost that many different orientations. Only one is right, and you can probably find it again by knowing how the yokes should be oriented w.r.t one another. If you did not take apart any U joints while you had it out, and therefore also possibly rotate the half-shafts in the process, then you get to try once or at most twice to get the original position. The vibes come from both the U joint yokes not operating with the right geometry, and also if you have lost the shaft mass balancing which was done originally.

So, orientation of U joint yokes should look like this if text can make an image.

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[]-o]--------[]---[o-----------------o]-[]

1  2   3    4   5        6        7  8
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where 1 is the front flange, 2 is U joint, 3 is front half shaft, 4 is centre bearing and spline, 5 is U joint, 6 is rear half shaft, 7 is U joint, 8 is rear flange.

Put it together this way, and if it still vibrates, take it off again, and reverse one half shafts 180 degrees on the spline so it still looks the same as above. If you think about it, those are the only two positions where the orientation looks the same.

Remember when you get it right, mark the shafts with a paint stripe or punch for next time. I would also mark the yoke arms as well, i.e. the ones not welded to the shaft. I expect the balancing allowed for weight imbalance in these too, when they were in the original configuration. You can`t be too careful. I have never found any factory marks, and the rust and crud I have seen would hide them right up until when you obliterate them removing the rust and crud! FWIW I spent over $100 getting two half shafts balanced at a shop here, not easy to find a shop with a lathe that can do this, had to go back twice, and a couple of new U joints died from re-assembly before the day was done. Still not perfect.

Index Marks on Driveshaft. [John Sargent] Every 740 drive shaft assembly which I have seen has alignment arrows. Each drive shaft on either side of the sliding spline has this arrow which is supposed to point at each other when the drive shaft halves are coupled at the sliding spline. Sometimes the arrows are covered by undercoating and grime, but they are there. You can see the arrows by the splotches of yellow paint. Often the arrows and yellow paint are not visible until you do some thorough cleaning of undercoating and road grime. If your own indexing marks have been removed, use these arrows. Note: some drive shaft splines are keyed so that they can only be assembled in one way.

Driveshaft Bolt Removal Tips.
Flange Bolt Access. [Tip from Bill D.] I had to unbolt my drive shaft yesterday to replace the transmission bushing. I couldn't get a good angle on the wrench to unbolt it from the differential so I needed a impact wrench or a longer handle. Since I had neither I used my socket handle and was able to use my hydraulic jack to lift the end of the handle thus loosening the bolt enough to ratchet them off by hand. I had to roll the car back and forth and do this four times to get all the bolts. Would have been easier if the rear end was up on jack stands.

Drive Shaft Flange Bolt Removal. [Tip from Alan Carlo] To be able to loosen the bolts on the drive shaft flanges I purchased the socket that fits the bolt head, 15mm I think but you should check the size, in a 6 point configuration. I ground it down on the end that goes over the bolt head until the recess was as deep as the bolt head. Then grind the upper shoulders, near the square that fits on the ratchet, to gain clearance. Test it as you go. You can use an open end wrench to hold the nut. Try PBlaster or heat from a torch to get the bolt really hot; this will sometimes break free the threads enough so you can get them out. This should help in the drive shaft removal. Be sure to mark the flanges, bolts, and the u-joints, relative to each other, on the front and rear shafts so they can go back the same way.

Rear Axle and Wheel Bearings:

Rear Axle Identification.

Solid (Live) Rear Axle or Multilink? How do I tell if my rear axle is solid or multilink? [Response: Rob Bareiss] If you look under the back of the car, and see a big round differential in the middle of a tubular axle, that's the "live" or regular "solid axle" rear. If there is a big framework in the center and long control arms running from center out toward each wheel, then it is multilink (Independent Rear Suspension). The only cars with IRS are: late 760 sedans, 940SE sedans, all 960 sedans, late 960 wagons, and S&V90's.

Rear Axle Identification Tag

Axle Model? [John Sargent] The axle identification decal is on the left rear side of the differential and covered with undercoating. I use either solvent or brake cleaning fluid applied with a rag to reveal the decal. If the axle serial number has a "S" preceding it, then the pinion seal uses a collabsible spacer.

Pinion Seal.

Symptoms of Failed Pinion Seal. [Inquiry:] 90 740 GL wagon, manual trans. with 197,000 miles. Recently noticed small drip puddle below rear differential, originating near the U joint/drive train. Seems like a pretty heavy weight oil. Is this a pinion seal? What's involved in replacement/ repair?

Volvo or Aftermarket? [Editor] This is one seal that HAS to be Volvo OEM and not aftermarket. Experience on Brickboard and with local mechanics shows that only the Volvo OEM seal from a dealer results in a reliable repair. Don't buy an aftermarket product.

Which Seal Spacer Do I Have? [Inquiry] [Response: Brian Sullivan] Find your axle serial number - should be a plastic tag with a bar code and some numbers on the driver's side axle tube, facing the rear of the car. You might have to clean off some gunk to see it. If you have the letter "S" preceding the serial number, you have the collapsible spacer (and therefore lower torque spec) No "S" means no collapsible spacer, and higher torque spec. The actual seal you need to replace is the same for both arrangements. I don't know which number on the tag is the serial number - but as you can see, I didn't have an "S" preceding either number - so no collapsible spacer, in my case.

Seal Replacement. [Procedure: Abe Crombie/Dennis] Replacement of this seal will require removal of driveshaft, marking it so as to preserve original relationship as it was balanced in-car at assembly. Remove the pinion flange that the drive shaft bolts to, first marking it in relation to pinion so as to preserve its position since it may have more throw (run-out) if not put back into position. Drain the rear differential oil. [See below] First remove the center flange nut, the remove the flange with a puller; no hammering allowed!. Seal can be removed by any reasonable means that doesn't scratch the opening in diff housing where seal fits. You can put a good-sized screwdriver in between the seal and the pinion shaft and pry it out. It will distort and tear but will come out. Or you can take a small chisel and tap it into the little crease that exists between the edge of the metal seal and the edge of the diff housing (*be CAREFUL not to damage the differential housing!!*). This will cause the tin seal housing to bend over and loosen it's grip on the diff housing. Do this at least 50% of the way around that outer edge and then put a large screwdriver in next to the pinion where the flange was and use it to lever the seal right out. It should pop out with no problems if you did it right. Carefully clean the flange where it contacts the seal. Make sure you install the seal right way around: "outside" is stamped in the metal seal ring. Put a little lube on the seal surface so it won't rotate dry and then tap it in place. The new seal will need to be driven in evenly to be just below flush with front of diff housing unless it is one with a lip that stops it when the lip contacts the diff housing. If you have a socket that is about the size of the seal use that to get it in even, if not just keep at it gently until it is seated evenly all the way around. Re-install flange as marked and then refit nut (volvo recommends new nut) to a torque depending on whether your seal uses a compression sleeve or not. *No compression sleeve:* 148 lb-ft. NO IMPACT WRENCH ALLOWED, TORQUE IT!!! *Compression sleeve:* 49 ft-lbs; ignore any instructions to count rotations. [tip thanks to JohnB]. Failure to torque it properly will result in the pinion bearing being overloaded which will kill the bearing and place the pinion/ring gear relation ship in a new, different, and noisy relationship that will result in replacement of a bunch of parts ($$$$$). Oh, don't forget to fill it up with gear lube when you're done.

Pinion Seal

Flange Torque. [Editor] Re-torque the flange coupling bolts and nuts as follows: if you have M8 bolts, torque first to 22 ftlb (30Nm) then angle tighten another sixty degrees. If you have M10 bolts, then torque to 37 ftlb (50Nm) in total.

Flange Nut Removal Tool [Dave Farrington/Tom F] Replacing the pinion seal is really pretty easy, but the trick is to remove the u-joint flange to get at the seal.You need a good home-grown counter-hold tool to remove the pinion flange nut! I took a piece of angle iron around 28 inches long when I cut it down. Then I took the rear drive shaft that I had just taken out of the car and marked two holes of the u-joint flange near the edge of one leg of the angle iron. I then bolt this length of iron to the pinion u-joint flange, but I still have a problem. That is I can't get at the center nut holding the pinion flange in place. Easy to fix: just mark some clearance around the socket you plan on using - it presumably fits that nut. Then grind some of the angle iron off.

The tool looks something like this:

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Flange Removal Tool

Bad representation, but hopefully it gets the point across. I bolt this tool to the flange attached to the rear end and bracketing it against the ground, I have something to work against to loosen that nut. I removed the pinion nut using a 1 3/16 socket. Since the teeth on the socket were recessed in about 1/16" in from the edge, I ground down the edge so that it would get a better bite on the shallow pinion nut. The opposite end of the "counter hold tool" rested on the floor. The breaking torque of this nut, if torqued to 150 ft-lbs, is about 180 ft-lbs. With the nut off, I can pull the pinion flange off using a harmonic balance puller (Harbor Freight has these) and get at the seal to replace it. Re-installing the flange is easy: it should slide on far enough that you can get the nut back on the end of the pinion and pull it in place by tightening the nut.

Pinion Leak: Vent Plugged. [Tip: Ted Tatham] My recently acquired 93 945 with 79k had a pinion seal leak. Seal was replaced under warranty. After 1000 miles the leak was back. I removed the fill plug and tried blowing into the axle vent hose by mouth, but air wouldn't flow. I removed the hose and found it packed with mud right where it goes on the nipple on the axle. My guess is the mud was placed there by a small wasp or other insect. This breather hose is on the right hand side about 4 inches or so from the differential housing. It's about a foot long and fairly thin and it comes off the top of the axle. The upper end is open and should be inserted into a rubber grommet in the chassis.

Speed Sensor Seal. [Inquiry] I have gear oil coming out of the back of the differential where the wires go into it. What needs to be done to fix this? [Mark Stites] You will need a new o-ring for the speed sensor.

Wheel Bearing Oil Seal. [Inquiry:] 1990 740: oil leaking from rear right side axle down to the inside of the wheel rim. Could this be the inside oil seal or the wheel bearing/seal assembly? [Response: Various] Remove the caliper, rotor and handbrake shoes and the four bolts securing the halfshaft retaining plate. Save the shoe clips. Re-install the brake disk wrong side out with the nuts tapered side out and use it as a lever to pull the halfshaft out, or use a puller. With the shaft out, you can replace the inner seal. The outer seal, the bearing & retaining collar are pressed on really tight on the half-shaft. You'll need press tools to remove them. While it is possible to use hand tools (like a curved crowbar) to remove the seal, be VERY careful you do not scratch the axle housing surfaces. Chances are the bearing might get damaged when you attempt to pull it off, so budget accordingly. You can drive the new seal in using a cast iron pipe fitting and a hammer. The pipe fitting should be slightly smaller in diameter than the seal so that you can drive it in until seated without damaging it. Clean oil off the brake components very carefully, or replace them, before you reinstall.

Wheel Bearing Replacement. [From the OEM Manual]

Type 1030, 1031, 1041 Live Rear Axles. Parts required: new bearing, new inner and outer seals, new locking ring, new brake caliper bolts

1. Remove rear wheel; brake caliper (tie it back onto the rear spring to avoid hose damage); brake disc; brake pads
2. Remove the four pressure plate bolts behind the wheel hub, forward of the brake caliper
3. Reinstall the brake disk on the hub, positioning the conical ends of the wheel hub nuts outwards, and use the disk to pull the drive shaft out.
4. Using a long screwdriver, remove the bearing seal. Clean the inside of the rear axle tube.
5. If your car has electronic traction control (ETC), remove the ETC toothed wheel on the shaft by pressing it off using two vee blocks
6. Using a bearing press tool or special tool 5212, remove the bearing and the locking ring.
7. Grease the new bearing by packing it thoroughly with grease an dmaking sure the grease penetrates inner spaces.
8. Grease both inner and outer seals by packing the space between seal lips with grease.
9. Place pressure plate and outer seal in correct position on the shaft.
10. Place greased bearing and new locking ring on the shaft.
11. Press bearing and locking ring back onto the shaft until they are seated in position.
12. ETC-Equipped Cars: Using a cylindrical drift or special tool 2412, press the ETC ring back onto the shaft.
13. Install inner seal using a cylindrical drift or tool 5243.
14. Install drive shaft and pressure plate together with brake pad retaining springs. ETC cars: use care since the toothed wheel passes the inner seal.
15. Tighten pressure plate bolts to 40 Nm (30 ft-lbs)
16. Reinstall: brake pads; brake disk; brake caliper (using new bolts and tightening to 60Nm (44 ft-lbs); wheels.
17. Adjust handbrake cable.

Type 1035, 1045 Independent Rear Axles. Parts required: new bearing.

1. Remove: rear wheel; brake caliper retaining bolts; caliper (tie it up to the spring to avoid hose damage); brake disc (marking position relative to pin); brake pds; handbrake cable
2. Remove: bolt securing support arm to wheel bearing housing. Tap out the arm. Remove

bolt and nut securing lower link to wheel bearing housing.

3. Remove bolt securing track rod to wheel bearing housing.
4. Withdraw track rod from wheel bearing housing, using a small claw-type puller and a 50mm M12 bolt.
5. Remove: nut securing drive shaft to wheel bearing housing; nut securing upper link to wheel bearing housing; wheel bearing housing. Keep the shims and note locations.
6. Press off the hub
7. Remove circlip retaining the bearing in the wheel bearing housing.
8. Press the bearing out of the housing, using a cylindrical drift or special tool 5085.
9. Withdraw inner race from hub using a puller or special tool 2722 and counterhold 5310.
10. Press on the new bearing. Install the circlip.
11. Press on the hub using a counterhold on the inner race to avoid damaging the bearing. Use special tools drift 5088 and counterhold 5085 or equivalent.
12. Install wheel bearing housing on drive shaft; drive shaft nut; shims between upper link and housing; nut securing upper link to housing.
13. Pull wheel bearing housing outwards at top edge and tighten upper link nut to 115 Nm (85 ft-lbs) to ensure correct wheel alignment.
14. Turn wheel bearing housing outwards and insert lower link. Insert bolt securing lower link.
15. Pull wheel bearing housing inwards towards final drive to ensure correct wheel alignment. Tighten link to 50Nm (37 ft-lbs) and angle tighten to 90 degrees.
16. Install support arm (tighten to 60Nm [44 ft-lbs] and angle tighten to 90 degrees) and track rod (tighten to 85 Nm (63 ft-lbs)
17. Install handbrake cable in wheel bearing housing; brake pads; brake disc in correct position; brake caliper (tighten to 60 Nm [44 ft-lbs]; wheel (tighten to 85 Nm [63 ft-lbs].
18. Lower car and tighten drive shaft nut to 140 Nm (103 ft-lbs) and angle tighten to 60 degrees.

Tips. [Gene Stevens] If you jack it up so the side of the axle housing that you are pulling is slightly higher than the other (even an inch higher), then you won't have gear oil leak out when you pull the axle. Remove the axle assembly and leave the rest of the job to an automotive machine shop. Just remember to replace the shaft seal while it's apart.

Limited Slip Differential. [John Sargent] The Limited Slip Differential was fitted as a dealer option to certain 1031 rear axles. The LSD add-in for this axle is a Dana PowerLock with Volvo's name on it and a tone ring for cars with electronic speedometer. If your car has it, it likely also has a metal tag on the cover specifying the use of "anti-spin oil" for the differential, meaning rear axle oil with an LSD additive.

Automatic Locking Differential. [Inquiry] In which cars was the Automatic Locking Differential fitted? Do they require special lubricants? [Response 1: Abe Crombie] Volvo came out with the ALD in 91 as std equipment on 940 Turbo engined models and then std on 960 the next year. I believe it was std on all 940's 94-95. It was fitted to S/V90 as part of the "cold weather" pkg. in 97-98. If the Id tag on a Multi-link version 1 says 1045 it's an ALD. If the solid rear axle on a 91 or later is marked 1041 it's an ALD. If the label on a multi-link version 2 (95-98 with leaf spring) is marked 1065 it's an ALD. ALL cross-country or 70 series AWD are ALD in rear. The LSD was a dealer installed accessory and never fitted in factory to my knowledge. Those can be detected by the jack-one-wheel-up-and try-to-turn-it method. Usually they are tagged as LSD if the installer and subsequent servicers don't discard the tag. Response 2: Ceferino Lamb] They are called locking differentials rather than limited slip diff (LSD) because they lock up entirely. In old muscle car lingo I believe this design was called a Detroit Locker. There are no clutch packs as in LSD, so the gear oil required is standard gear oil, not LSD gear oil. I supposed synthetic hypoid gear oil would be best. They have internal dogs that catch when one wheel spins, locking left and right wheels together 100%. It's not the most subtle device, and can cause some pretty amusing powerslides if you're running elevated turbo boost. Above about 25mph centrifugal force keeps the dogs from engaging. But if you start spinning at a lower speed the rear end will stay locked up no matter how fast you spin, until you let off the go pedal. [Response 3: Michael Sestina] Eaton Corp makes the axle. it works great on our 93 945. I don't believe they require special fluids.

[Notes from Eaton on their at http://www.torquecontrol.eaton.com/]
How the Eaton Automatic Locker Works:

> During normal driving conditions, the differential operates as a conventional "open" differential. But as soon as wheel slip occurs in either forward or reverse, the locking mechanism engages. A flyweight governor in the differential responds to differences in speeds. During normal driving, the governor does not influence differential action. But whenever one wheel's speed substantially exceeds the other's, which only occurs during wheel slip, the governor spins rapidly causing the flyweight to open. The flyweight then catches a latching bracket and begins lockup. During lockup, a self-energizing clutch system causes a cam plate to ramp against a side gear. This ramping compresses the disc packs that are inserted between the side gears and the case. The ramping increases until both axles turn at the same speed (full lock) which prevents further wheel slip. The entire locking procedure takes a fraction of a second and is unnoticed by the average driver. Unlocking occurs when both wheels regain traction.

How the Limited Slip Differential Works:

> Carbon discs behind each side gear are pre-loaded with a central spring assembly. This spring force, added with the pinion/side gear reaction forces, increases the clamping load on the carbon discs as input torque increases. The bias torque of the differential increases in proportion to the input torque. Pyrolytic carbon with a texture of cloth is bonded to steel discs. These discs are then alternated with non-patterned steel discs creating a clutch pack that's virtually indestructible under abusive testing and operation. Due to the texture of the carbon discs, special lubrication requirements are eliminated and there are none of the chatter or noise problems associated with paper and steel friction materials.

Rear Axle Failure. [Tip from Counterman Magazine, Jan 02] The most common cause of rear axle bearing failure is leaky wheel bearing seals or differential seals or gaskets. A loss of lubricant allows the bearings to run dry, overheat and fail. Any bearing that is loose, feels rough when the wheels are rotated or is making noise needs to be replaced. Replacing both bearings (left and right) at the same time is recommended to reduce the risk of the other bearing failing. A rear wheel bearing failure may allow the axle to pull out of the vehicle, causing the wheel and tire to come loose.
[Editor's Note] Do a regular "driveway mechanic" check when you pull out of your parking spot to find leaking rear axle oil. My experience is that pinion seal failure is the most common cause of loss of rear axle lube and subsequent axle failure.

Differential and Rear Axle Exchange. *Gear Ratios.* [Inquiry] I have a 1986 740 non-turbo with a manual transmission and the differential is shot. I have purchased a differential from 1986 740 turbo automatic to put on my car. I know the bolt pattern is the same but wonder if the gear ratios are the same and whether the engine will rev higher or lower and any other possible side effects. [Response 1: JT Charger] Using a little gasoline or solvent, you can clean the left side of the axle tube, so the sticker can be read. it is probably covered with undercoating now. the part # & axle ratio is printed by Volvo on this sticker. With the car up in the air, the sticker will be on the left side outer tube of the housing, visible from the rear of the car, after being cleaned with solvent. [Response 2: Paul Grimshaw] The gear ratio for the US-spec manual transmission cars is 3.31:1. Autobox equipped 700 series cars will have either 4.10:1 (Aisin Warner 72 equipped B2304 engines), 3.73:1 or 3.91:1 -- the latter two ratios used with Aisin Warner 70/71 and ZF 4HP 22 transmissions. Your shift speeds will be different if you have changed the rear axle ratio, but if you have a tach that should not pose a big problem. Fuel economy -- particularly during highway cruising will suffer from the shorter rear axle ratio too. A benefit, however, will be quicker acceleration.

Carrier Compatibility. [Inquiry] I have been looking for a limited slip differential for my 83 760 GLE. I have been told that this differential is a Dana 30, which is also used on some Jeep models. I have a chance to purchase a limited slip unit that was an OEM for the 200 series. Can anyone confirm (with a great deal of confidence, since I may base my purchase on the advice) that the 200 and 700 series differentials will interchange? [Response: Abe Crombie] On the back side of axle tube on left (driver's) side is a label covered by undercoat. Clean this off and see if your model is a 1030 or a 1031. Then determine (label in same place on 240's) if the 240 is the same model. IF they are the same model then the carrier will interchange.

Rear Axle Exchange. [Inquiry]I am planning on getting an axle from a yard and swapping it in. Are all of the 200 and 700 solid rear axles the same except for gear ratio? [Response: Rob Bareiss] If you have decided not to just install new bearings and seals (that's really quite easy on these cars), you can replace the entire rear axle unit. Solid rear axles among 740//940 cars are not all the same, unfortunately. They will however, bolt in and work. The important thing to figure out is whether the new axle comes from a car equipped with ABS or not. The 760T and 740T cars will likely have ABS, and the base models will not. However most cars after 1991 DO have ABS, turbo or not. So that's the key. Otherwise, the "tone ring" for the speedometer is different and it'll read way off. Early and late parking brake cables are completely different and incompatible.That was my experience last year, fitting a late model axle to a 1988 745. Ideally there will be a tag on one of the axle housings indicating a model number (DANA 1030, 1031) but I wouldn't bet on it being there. Better to just match up models and find the right axle. The axle does come off the control arms quite easily: 4 nuts. Then the hoop or clamp that actually holds it on is released. I had a LOT of trouble with the bolt for the bottom torque arm on the one I installed. If it doesn't come right out on either car, prepare for a fight. Try to get both torque arms with the new axle; just remove the bolts on the forward ends. That will give you a second option in case the rear bolts are really tough to remove.

Differential Rebuild. [Inquiry] What is the best way to rebuild my antislip differential? [John Sargent] I found it was cheaper to have a Detroit TrueTrac installed than to rebuild the Volvo unit.

Axle Ratio Change. [Inquiry] How can I alter my rear axle ratio? [Peter Fluitman] The only cost-effective way to alter rear axle ratios is to exchange the entire axle with a used unit. Changing gear ratios requires an all new carrier, internal parts, and tools to set up the clearances.

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760 Independent Rear Suspension Vibration. [Symptom:] I have a 760 Turbo with independent rear suspension. When I start off from a stop with a heavy load, there is a fluttering in the drivetrain that feels very similar to worn U-joints or CV joints. The U-joints are new and the CV joints feel fine as far as I can tell. [Diagnosis:] Probably slightly worn CV joints. Not worn enough to snap/click/knock yet but enough play between the balls and "grooves" to allow the load based "flutter." In my experience, unless there's an obvious knocking or the CV boot has been ripped awhile, it's tough to determine CV condition without removing, disassembling, cleaning and
inspecting. If the inner and outer CV joints are identical, as a temporary fix, swap the axles end-for-end so that load wears a different part of the joint.

760/960 CV Joint Removal. [Inquiry] It has been suggested that I not use an impact wrench on the rear CV joint of my driveshaft, but to lock the wheels and use a hand tool. Why?[Response: Tom Irwin] The driveshaft on your car is a 2 piece propeller shaft assembly made of a lightweight, rigid, tubular alloy. At the factory, it is dynamically balanced on the vehicle to correct for extremely minor balance issues that would not affect a drive shaft of a more robust design. The corrections are accomplished with tack welded weights and extremely minor deviations are tuned out with the various length bolts. It is my educated opinion that using an impact wrench could transmit low frequency, high amplitude shock waves up the tube and a high level of vibration throughout the driveline and in close proximity to the overly delicate rear end gear set. If you manage to throw it out of balance, your driving experience will not be good. And dynamic driveshaft balancing is a specialists ART. Don't expect to get it fixed at the Goodyear for $39.99. Bottom line.... the impact wrench may work just fine.... but that shit is expen$ive when it breaks. Why take a chance? Oh yeah... and those bolts are a thin walled hex head with a narrow shank. What if one is rusted and you snap it off with the gun? In addition, the bolts are different: make a template from cardboard with holes for each bolt to keep track of them and assist in reinstallation.

Rear Axle Ratio Table. [Courtesy of Simon Dodd]

How to Measure Axle Ratio on the Car. [Rob Bareiss] Here's how I compute axle ratio: Make sure the car's in neutral, and can't roll. Block the wheels and release the parking brake. Raise one rear wheel. Make sure you have an open differential- not limited slip. If you can spin just one rear wheel, it's a regular differential. Make a mark on the driveshaft or pinion shaft of the differential- doesn't matter where, just so you can see it clearly. Use "white-out" or something. Make note of the position of the valve stem or mark the tire too. Turn the tire 20 turns (10 for a limited slip and you need both tires off the ground). Count the revolutions of the driveshaft. When you finish, note the approximate position of the shaft relative to the starting position- only approximate. You should get something like 37 1/3 turns of the shaft, or 41. Divide by 10 to get the actual gear ratio. 41= 4.10, 37.3 = 3.73, etc.

Year	Model	Engine	Tranny	Rear Axle Ratio
1983	760 GLE TD	D24T	M46	3.54
1983	760 GLE TD	D24T	BW55	3.15
1985	740 (any)	B230F, B230FT	M46	3.31, 3.54
1985	740 GL, GLE	B230F	ZF 4HP-22	3.91
1985	740 Turbo	B230FT	AW71	3.73
1985	760 GLE TD	D24T	M46	3.54
1985	760 GLE TD	D24T	ZF 4HP-22	3.91
1986	740 (any)	B230F,B230FT	M46	3.31, 3.54
1986	740 GL, GLE	B230F	ZF 4HP-22	3.91
1986	740 Turbo	B230FT	AW71	3.73
1988	760 GLE	B280F	AW71	3.73
1988	760 Turbo	B230FT	AW71	3.73
1989	780	B280F	AW71	3.73
1989	780 Turbo	B230FT	AW71	3.73
1990	740 GL	B230F	M46/M47	3.31, 3.54, 3.73
1990	740 GL	B230F	AW70L/AW71	3.73,4.10
1990	740 GLE (16v)	B234F	AW72	4.10
1990	740 Turbo	B230FT	M46/M47	3.31, 3.54, 3.73

1990	740 Turbo	B230FT	AW70L/AW71	3.73,4.10
1990	760 GLE	B280F	AW71	3.73
1990	760 Turbo	B230FT	AW71	3.73
1990	780 GLE	B280F	AW71	3.73
1990	780 Turbo	B230FT+	AW71	3.73
1991	740	B230F	M46/47	3.31, 3.54, 3.73
1991	740	B230F	AW70L, AW71	3.73, 4.10
1991	Coupe (780)	B230FT+	AW71	3.73
1991	940 Turbo	B230FT	M46	3.31, 3.54, 3.73
1991	940 Turbo	B230FT	AW71	3.73
1991	940 SE	B230FT	AW71	3.73
1991	940 GLE (16v)	B234F	AW72L	4.10
1992	740	B230F	AW70L, AW71L	3.73
1992	740 Turbo	B230FT	AW70L, AW71L	3.73
1992	940 GL	B230F	AW71	3.73
1992	940 GLE (16v)	B234F	AW72L	4.10
1992	940 Turbo	B230FT	AW71	3.73
1992	960	B6304F	AW40	3.91
1993	940	B230F	AW71	4.10
1993	940 Turbo	B230FT	AW71	3.73
1993	960	B6304S	AW30, AW40	3.31
1994	940	B230FD	AW71	4.10
1994	940 Turbo	B230FT	AW71	3.73
1994	960	B6304S	AW30, AW 40	3.31
1995	940	B230FD	AW71	4.10
1995	940 Turbo	B230FT	AW71	3.73
1995	960	B6254S, B6304S	AW40, AW43	3.73, 4.10
1996	960	B6304S	AW40	3.73
1997	960	B6304S	AW40	3.73
1997	S90, V90	B6304S	AW40	3.73

1998	S90, V90	B6304S	AW40	3.73

[Volvo Maintenance FAQ for 7xx/9xx/90 Cars](#)

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Rear Suspension Identification. *Solid (Live) Rear Axle or Multilink?* How do I tell if my rear axle is solid or multilink? [Response: Rob Bareiss] If you look under the back of the car, and see a big round differential in the middle of a tubular axle, that's the "live" or regular "solid axle" rear. If there is a big framework in the center and long control arms and little constant velocity flexible driveshafts running from center out toward each wheel, then it is multilink (Independent Rear Suspension). The only cars with IRS in the US/Canada market are: late 760 sedans, 940SE sedans, all 960 sedans, late 960 wagons, and S&V90's.

Nivomat or Normal Shock? Nivomats have springs integral to the shock absorber. See the Illustrations.

Nivomat Rear Shock Abosrber

Normal Rear Shock Absorber

Rear Bushings. [Symptom:] When you accelerate from a stand still or when you decelerate suddenly, you could hear and feel a jerk from the rear. This is when the rear suspension is beating the chassis as it is taking up the clearance due to the worn bushing. [Diagnosis:] Try this: Jack up the rear end of the car and first with the car in neutral and the park brake off, turn the drive shaft back and forth quickly. You will see if there is much play in the torque arm bushings. The rear end will actually swing back and forth. With the weight off the rear end, you should be able to pry on various portions of the trailing arms close to the bushings and notice if there is excessive play. If your trailing arm bushings are bad, you'll need a special tool to take them out and press them back in. The torque arm can easily be taken out and the bushings pressed in and out.

"Clunk" in Rear End: Bushing Diagnosis. [Inquiry:] 87 740 wagon with 190k, M46 trannie, new to us. Have replaced shocks, struts, u-joints, trannie mount and center support bearing on

driveshaft, and some front bushings. Acceleration from standstill in normal traffic results in a "clunk" which seems to come from rear end. Trannie output bushing and pinion bushing have no play. Wheel bearings are good. Nothing is rolling around in rear of car or spare tire well. The only thing I can figure is bushing(s) in rear, but which one(s)? (none are visibly broken up, although I haven't yet given them the prybar test.) Can anyone guide me to the most likely culprit on this one? [Response: Steve Seekins] I would focus on the rear suspension bushings. There are 7 - two on each of the torque rods and three on the sub frame to body mounts - one at the front and two at the rear. I would suspect the subframe mounts, probably got accelerated wear from soft torque rod bushings. The Haynes manual is adequate for procedures here. Of course you should first check for loose upper or lower shock mounts or loose sway bar mounts. If the lower shock mount has loosened, check carefully for elongated hole in trail arm - if so, consider replacing the trail arm if tightening the bolt does not do the job.

Rear Suspension Vibrations. *Panhard Rod Bushings.* My 745 with a solid rear axle has a single arm with large rubber donut bushings connecting the underside of the differential to the frame just ahead of the diff. The lower rubber donut has gone really soft, allowing about 15 degrees of angular rotation of the rear axle; enough to seriously deflect the drive shaft under acceleration at low speed and causing the U joints to grumble loudly. At speeds over 15 kmh the noise is gone; I suspect the momentum of the drive shaft resists the deflection and the acceleration force is lower. The side bushings are fine; also I have a heavy IPD swar bar. *Loose Rear Shock Bolts.* After hearing vibration that I thought was coming from the rear axle, I grabbed the shock absorber and found there was a very small amount of movement. I tightened up the lower and upper mounting bolts and presto !! Noise be gone ! Amazing how much noise there was coming out of that little bit of movement on that one rear shock. If you've got some knocks coming out of one or both of the rear corners of a 940, try tightning up those shock bolts before you spend a lot of time trying to find a problem with one of suspension bushings.

Multilink Rear Axle. [Tip from ImportCar Magazine, Apr 2003] The multi-link suspension systems, which independently suspend each rear wheel, allow for improved ride and road handling, and for each wheel to be aligned separately. The only failure we’ve seen is the upper carrier housing bushing, as it’s made from rubber and has a plastic housing that cracks over a period of time. Volvo offers a tool to cut the repair time in half, with no need to remove the complete center housing and use the hydraulic press. Multi-link suspensions require alignment any time the suspension components are disassembled. When aligning, start at the rear first setting up the camber, then the toe. Caster is fixed by the design of the suspension and cannot be changed, except by replacement of damaged parts.

Rusted and Stuck Bolts: Removal Techniques. See the link for more ideas.

Rear Spring Replacement. [Inquiry:] I am thinking about installing new springs and shock in the rear of my live axle 745. How do I do it?] Regarding putting together a detailed procedure for REAR spring replacements on a 745, basically anybody who knows which end of a ratchet is which can do it. This is one of the easiest things I've done to that car. It pertains to 7xx/9xx wagons with "live" (aka non-IRS) axles as well as sedans.

1. Chock the front wheels.
2. Loosen the lug nuts.
3. Elevate one rear quarter of the car with the jack, and place a jack stand under the rear jacking point. A convenient place to lift is the front of the trailing arm.
4. Remove the wheel.
5. Place a floor jack under the trailing arm, close to the jack stand and not in the way of the wheel when it is lowered. Jack up the trailing arm slightly to unload the lower shock mount. Loosen the lower shock mount (requires 18mm wrench for inner nut). [Tip from Chris] MAKE SURE you have a **floor jack under the trailing arm** when you remove the lower shock bolt or that side can fall to the ground, ripping the rubber brake hose in the process. If the brake hoses appear strained, then unbolt the line mount above the wheel to relieve them.
6. Remove the 15mm bolt holding the upper spring seat in place. If you're replacing a Volvo spring, chances are it is not a variable rate spring, so you can get to the nut with just a ratchet wrench and a socket. If you're removing a variable rate spring, however, you'll probably need a fairly long extension. Examine the spring placement so you can replace the new one in the same manner.
7. Lightly tug on the spring at the top and pull it out. I did NOT have to remove the brake caliper on either side, and I did not find the exhaust system to inhibit the removal or installation on the passenger's side. I began the replacement, prepared to remove the calipers, if necessary, but I found that there was plenty of clearance there, and I didn't have to touch them.
8. When you get the spring out, inspect the rubber seats and the large curved washer for wear or deterioration. Replace if necessary.
9. Reinstall the top seat and washer and insert the spring bottom first, making sure you install it in the rubber seat.
10. If you're replacing your springs with variable rate ones (recommended), you'll need a long extension for your socket to reattach the upper spring seat because you won't be able to get your ratchet to fit comfortably between the coils until about halfway down the spring's length.
11. Re-attach the upper spring seat, torquing to 45 Nm (35 ft-lb). This was the most time-consuming part of the procedure -- getting that nut's threads to start was a bit tedious.
12. Reinstall the shock bolt, coating it with antiseize first. Use your floor jack to re-align the sway bar end link so the bolt end will go through. Don't pound on it to make it go through. A mirror helps to align this. Re-torque to 85 Nm (63 ft-lb)
13. Reverse the above steps for the remainder of the installation.

A brief note: For replacement springs on a wagon, I recommend going with "cargo coils", which are variable rate springs. I purchased a set of MOOGs from my local parts supply (about $70 w/ tax, as I recall) and have been quite happy with them. I have had a couple of occasions since installing them to give them a good try-out, the most severe being when I filled the entire wagon full of materials for a new section of fence, including post hole mix. I figure we had loaded about 800 lb. of stuff in the back, plus there were two of us adults. The springs handled this extra weight with ease. Further, because they're variable rate springs, they still offer a decent ride even when unloaded. [Contrary Note:] I recently installed a set of Moog cargo coils on the rear of my 89 765T and while I've been happy with the ride etc. I'm not happy with the sagging rear end they left me with. It sags about 1.5". I've talked with the reps at Moog and they say the cargo coils are for sedans only and do not have an application for wagons. I've ordered a set of IPD overload springs which incidentally list different part #s for 7xx sedans and wagons. RPR also sells Moog cargo coils for sedans only. In speaking with them they've had a lot of complaints of rear end sag when used on wagons [Editor] I installed a set of oversized Scan-Techs (13.5mm instead of 11mm) and they solved my sagging problems. When you replace the springs with heavy duty or "overload" coils, make sure your shocks have damping characteristics that match. Using too heavy a spring with the stock OEM shock may result in underdamping and a bouncier ride. You may have to upgrade to a stiffer shock.

Shock Absorber Notes. [from Import Car Magazine, Mar 03, by Gary Goms]

How does a shop diagnose worn shock absorbers? The answer isn't simple. Many racing teams are now using shock absorber dynamometers to test how well a shock absorber will maintain its effectiveness throughout a long race. But, since most commercial import shops can't afford new shock absorber dynamometers just for testing old shocks, a quick visual check usually reveals most of the symptoms associated with worn shock absorbers.

First, use a tape measure to check the distance from the floor to a common reference point on the body such as the upper lip of the fender well. If a difference in ride height is indicated, the shock absorber may have lost its gas charge, or the vehicle may have a sagging spring. When disconnected from the chassis, a shock absorber with a full gas charge will quickly extend the piston rod. In other failure scenarios, a shock absorber may "stick" up or down due to a broken piston assembly. Next, check for oil leakage around the shaft seal. If the oil leakage looks wet, or covers the length of the shock absorber body, the shocks should be replaced either in axle pairs or at all four wheels.

Rebound recovery tests, unfortunately, are a far more subjective type of shock absorber evaluation. During a rebound test, the suspension is cycled by placing the knee or hands on the front or rear bumper of the vehicle, bouncing the suspension and then observing the recovery rate. In theory, good shock absorbers should dampen spring bounce within one oscillation cycle. In reality, a technician should be very familiar with the suspension characteristics of the nameplate in question. Some auto manufacturers design soft suspensions; others design firm suspensions, depending upon model application.

If a chucking or knocking noise is detected during the rebound recovery test, at least one shock absorber may have a loose piston, a worn piston shaft bushing or worn mounting bushings. When the shock's rebound bumpers are worn or the tires show a mild cupping in the center of the tread , shock absorber fade may be occurring when the shock absorber fluid becomes overheated and loses viscosity during a long trip. When road testing, the most accurate observations are achieved by driving the vehicle over the same stretch of road. Worn shock absorbers will cause the vehicle to nose-dive during braking or roll during cornering maneuvers. Again, the "feel" of worn shock absorbers tends to be a subjective judgment that requires familiarity with the specific vehicle nameplate and application.

How Shock Absorbers Fail. How do shock absorbers fail? In most cases, the piston shaft seal fails and allows the fluid to leak out of the shock's oil reservoir. On high-mileage vehicles, the internal parts such as the piston seal or valving wear out, which alters the dampening characteristics of the shock absorber. Last, the nitrogen charge may leak from the shock absorber, which slightly lowers the suspension height and allows the fluid to foam during normal operating conditions. All of the above failures will, at some point in the shock absorber's service life, cause the shock absorber fluid to become overheated or foam during severe operating conditions or extended trips. Last, the piston itself can become disconnected from the shock absorber shaft. The shaft may then bend, which causes the shock absorber to bind at some point in its travel. Because some pistons are held onto the shaft by a threaded nut, tightening the piston shaft bushings or spinning the piston shaft with an impact tool may loosen the piston-retaining nut. The best alternative is to buy the appropriate tools needed to hold the piston shaft stationary while the retaining nut is being tightened.

Shock Brands. Consensus at Brickboard seems to be:

1. Bilstein HD: great shock, long lasting, very stiff but controlled ride
2. KYB: great shock, not as stiff as Bilstein HD
3. Koni: great shock, adjustable
4. Tokico: great shock, hard to find
5. Boge Pro Gas: great shock, long lasting, ride equivalent to OEM
6. Boge Turbo Gas: great shock, long lasting, stiffer ride than Pro Gas
7. Bilstein Touring: less expensive than HD, questionable quality (see Brickboard archive notes1 and notes2.)

Rear Shock Installation.
Non-Nivomat:
[Inquiry:] I am thinking about replacing rear shocks on my '89 745 Turbo Wagon (non-Nivomat) and would like to know how difficult a job this is [Response: Bill Woesthaus/Warren Bain] **Support both the car and the rear axle.** If you are not supporting the rear axle and it's hanging free, the shock is the suspension travel stop and if you remove the bottom bolt while unsupported, the **axle will fall,** the brake hose will tear and you will have much bigger problems. Take wheels off. Pull the rubber bolt hole cover off the top of the inside wheel well (which is probably covered with dirt). Unscrew the top shock bolt. Then, put PBlaster, wrench and socket (you will need 17 and 18mm sockets) on bottom shock bolt and undo it. Lower the rear axle to relieve the stress on the bolt since the gas in the shock is keeping pressure on it. Guaranteed that this is corroded in place inside the shock bushing: you will probably have to whack this bolt out, or even airchisel the bottom shock mount apart. Wrestle shock

Top and Bottom Rear Shock Bolts

out: the shock mounting bushing sleeves and rubber side bushings are often compressed by the shock mounting bolts and you may have to resort to pounding to remove it. Compress new shock and put it in. Replace the top bolt first then the bottom with antiseize or grease on the bottom bolt to keep it from rusting inside the bushing. It’s a good idea to leave the retainer strap on the shock while you are installing it (you don't have to wrestle with live shock) Possible trouble? Top shock cavity could be too bent in from heavy bolt pressure to allow new shock in easily, or to get old one out!! I ground down shock ears to allow entry. If your holes aren't squashed tight it's a pretty easy job. Torque top and bottom bolts to 65 ft-lbs.[Response: John B] The shocks ARE gas charged and can be difficult to compress and remove...same with the new shocks. IF the new shocks have a wire or strap to keep them compressed, try to install them with the wire or strap unbroken...you clip the retainer device to allow the shocks to expand and hit the stud hole for the top of the shock. Also, the lower control arm that the shock goes into may be tight or loose depending on the brand of shock you buy. If it's loose, make sure you tighten the bolt sufficiently to compress the control arm sides against the shock bushing...or the shock will clunk. If the shock bushing is too long, making the shock impossible to install, just wedge or expand the control arm sidewalls enough to put the new shock in. Jack the back of car up and put it on stands. *Stuck Shock Bolt*: [Gustaf Kalle] To remove an impossibly stuck rear shock bolt, I ended up drilling away the bolt head, and sawing across the bolt on the inside half of the bushing tube. One advice was to try a SawAll (Tiger saw in Europe). Would have been quickest had I been able to lift the car enough. Instead I bought a metal saw blade holder for £1.90 and a Bi-Metal saw blade. This cut the bushing tube in less than 10 min.

Nivomat:

Shocks Differ. [Jerry Warren] The Nivomats on the solid axle cars are smaller (2.5-inches dia.) than those used on Independent rear suspension (3-inches dia.). That's what I found when I checked my 940SE sedan (IRS) and 940SE wagon (solid axle). Removal is similar to the non-Nivomat above. The top bolt is behind the small rubber plug in the frame rail above and forward of the wheel.

Installation. [Tip from Matt W] I've been told that with and Independent rear suspension they just drop out, no need for a spring compressor or any special tools...not always. Yes, in many cars the shock will just drop out through the control arm, and this is what I expected of my volvo, especially since I've been told that by others. I'm not sure if this was because they had 1989 7series, but it's not the same as my 1988 760T. We jacked the car up and unbolted both ends of the shock. This of course was before we bothered to realize that the hole in the bottom of the control arm was nowhere near big enough to let the shock fall out. This hole was just big enough for the shock to rest snugly in there when properly installed. Chiltons said the control arms needed to come off, and that requires two jacks. Afterwards the rear end would need alignment. We said screw it, and just decided to give the shocks to the local shop and let them do it.

[Contrary Advice from JohnB] Maybe, maybe not. Just jack the car up under the shock, use about three long cable ties hooked together to hold the shock compressed, and then jack the car up letting the suspension hang. Take the holding bolts out and remove the shock. The hard way (and I've done it both ways, thank you!) is just to jack the car up and let the suspension hang, remove the holding bolts, and then compress the nivomat by hand, hold it together and remove it before it expands. You don't need to disconnect the trailing arm (I did it once out of frustration but it wasn't necessary the next time) although that's one way. [Confirmation from Gene Stevens] A compressed Nivomat is short enough to wrangle out throught the top of the control arm without unbolting it. Use bailing wire or long Ty-wraps to keep it compressed before it's unbolted, or you can try to jam the bottom up and over.

Broken Upper Mounting Bolt or Stripped Mounting Nut. [Tips from Jason Vincent] I tried to remove the passenger side shock, but promptly broke either the bolt or the welded nut inside the channel behind the top mount. As barbarous as it sounds, the fix (as told by my Volvo specialist) is to use a hole saw to go through the opposite side of the channel. On the passenger side this involves removing part of the exhaust. I used a 1 3/4" hole saw to cut my hole in line with the shock, as high up as was physically possible. The nut is not normally exposed. To expose it the "box section" as I will call it needs to be cut, although on the opposite side of the box, parallel to the upper mount. This process seems barbaric, and it is in some respects, but remember how overbuilt this car is and I really don't think a couple of holes will hurt it. I did go through 2 holesaws and discovered the nut wasn't actually spinning, but the bolt was stripped and jammed into the nut somehow. However, the welded nut can often break loose and spin inside the box channel. I will attempt to extract it and install a helicoil. [Editor] To prevent this, use lots of antiseize on the threads and shaft of both top and bottom shock mounting bolts when reinstalling. *Stripped Nut?* [Jim Bowers] Get a "Heli-Coil" repair kit if you strip the upper shock mount nut. The nut is welded inside the frame and there is no easy access to it. The Helicoil can be installed from the wheel side. Buy the kit at a good auto parts or machine supply store.

Rear Shock Installation: 96+ 960-S90. [Tips from Warren Bain] I replaced the rear shocks on my 965 [S90-V90][1996]. It was pretty easy actually. I thought the IRS would droop too far since I couldn't see any stops for it anywhere. So I jacked the rear up, took off the tire and supported the trailing arm. I took the old one off and put in the new. I attached the top mount but the bottom was tough, since it is new and gas filled it was quite stiff. So I let the trailing arm down. Lo and behold, it went down far enough for me to easily out the lower mount in with no problem. It only took about an hour and while I had the tires off and the car in the air, I tightened all the bolts I could see, size 17mm and 18mm.
If you use Volvo shocks, look for the shock code contained on the plate on top of the radiator, 5th line, 4th character. My 4th line was blank. IE, 031Y35a, 'Y' is the shock code. [Editor] Consensus on Brickboard seems to criticize OEM shocks and recommend aftermarket.

Aftermarket Shocks for S90/V90 Cars. [Eric Seeger] There's finally an aftermarket alternative for our rear shocks! Monroe Sensa-Trac part #5979 is the new (and as far as I can tell, the only) aftermarket alternative for V90 and part #5978 is for S90 sedans. These are replacement for NON-Nivomat rear shocks. Aftermartket Nivomat replacements are available from Monroe as well. I got a pair installed on my wife's V90 tonight, and I can say that they work very well. At Sears, they cost $110 for the pair installed.

Rear Nivomat Conversion. See Volvo 760/780 Nivomat Shock Conversion for complete instructions and illustrations showing the conversion of Nivomats to normal springs and shocks.

Ride Quality and Troubleshooting:

Wheel Nut Loosen/ Tighten Pattern

Re-Torquing Wheel Lug Nuts. [Editor] To re-torque your wheel lug nuts, first loosen them in a star pattern. Place a 19mm socket on your torque wrench along with an extension long enough to allow the wrench handle to clear the fender. Set your torque wrench to 35 ft-lbs and torque the nuts in a star pattern. Start the wrench at a spot so you can smoothly sweep through to the desired torque. Don't use jerky movements. Reset the wrench again to 66 ft-lbs and torque yet again to this final value, again using a star pattern with smooth movements of the wrench.

For more notes on wheel torque, see below.

Wheel Alignment. See Wheel Alignment Adjustment in the Front Suspension section.

Ride Complaints Diagnosis. [Tips from Brake and Front End Magazine, Nov 2001, by Larry Carley] First, you need to inspect for the usual: tire pressure, ride height and suspension components for wear. Today's low profile tires can cause a pull with as little as 4 psi difference from side to side. Tires of the same size but of different manufacture may cause a pull due to rolling resistance or diameter differences. You can't align sagging springs, defective tires, sloppy ball joints or worn bushings. If you have a pull, it's a good idea to swap the front tires left to right to see if the tires are causing the pull. If after swapping the tires the pull is to the same side, the tires are not at fault.

Steering pull can also be caused by incorrect wheel alignment. A vehicle will pull to the side that has the most camber and/or the least caster. Brake pull is an area that can be easily misdiagnosed as a ride control problem. A stuck caliper is the obvious source of this malady. And in most cases, the obvious will need replacement. But sometimes a caliper is replaced and the problem still persists. Remember that a stuck caliper can cause a pull even when the brakes are not applied. An often misdiagnosed cause of pull is a collapsed brake hose. The hose will look OK on the outside, but the inner liner will cause a restriction on the inside. A brake hose problem like this can take two forms. One, it can act like a restriction in the line, and two, it can act like a check valve.

In the first case, the car will pull to the side with the good brake hose upon immediate application of the brakes, but after a second or two, the pull goes away. Because the caliper needs a relatively large volume of fluid to move the piston, the side with the collapsed hose will apply later than the one with the good hose. This is why the pull can be extreme on the initial pedal application, but goes away as the fluid slowly moves the piston. The customer may not relate the problem as a pull because the vehicle may simply feel unstable, as it initially veers to one side and then stops straight.

In the "check valve" situation, fluid will freely flow into the caliper, but will not return to the master cylinder. This can mimic a stuck piston. Check this further by loosening the bleed screw while turning the wheel by hand. If the wheel turns freely after relieving the pressure in the caliper, the caliper is OK. If only one wheel is affected, it's probably the brake hose. To be sure it's not something upstream, reapply the brakes and release, then loosen the hose at the fitting on the body (not at the caliper). If the problem goes away now, the hose is OK. Look at the proportioning valve, master cylinder or ABS system.

Brake pulls from the rear can be differentiated from front pulls by their characteristics. A pull caused by the front brakes is usually severe and tugs on the steering wheel. Rear brake pulls cause the car to drift into the next lane and make the car feel unstable, while having little effect on the steering wheel...

Hard steering (difficulty turning the steering wheel) caused by worn or seized parts is easily masked by power steering-equipped vehicles. A quick test is to turn the steering wheel lock to lock with the front wheels off the ground and the engine turned off while feeling for binding. Disconnecting both outer tie rod ends will allow you to ascertain if the binding is in the left side, right side or steering rack. Certainly power steering problems and cause hard steering also. Low fluid level, a worn pump, or steering rack or box should be investigated. .. Insufficient assist at the wrong time will generate a hard steering complaint from the driver.

Hard or harsh ride can often be caused by overinflated tires. Drivers inflating tires without an air pressure gauge can really go wild with inflation pressures. Check for original size tires. Dropping from a 70 series to a 60 or 50 series tire significantly reduces sidewall height, thereby reducing the ability of the tire to smoothly absorb impacts. Worn struts, shocks or springs can cause a harsh ride as the suspension bottoms out on bumps that it could otherwise handle with aplomb. Worn suspension components also can create a feeling of harshness, particularly upper strut mounting plates, bushings and extremely worn ball joints...

Don’t overlook the possibility that worn upper strut mounts are causing a memory steer condition. This is a condition where excessive friction in the steering or suspension system causes the steering to not want to return to center. Typically, caster will cause the steering wheel to self-center after a turn. If there is too much resistance to the centering force that caster provides, the steering may not fully return to center. Worn strut mounts can cause this friction. If they are severely worn, the suspension spring can actually "wind up." If this happens, the steering may want to return to the side that you last steered it, even if you manually bring the steering wheel back to center. Hence, the name "memory steer"...

Wandering or play in the steering is usually due to worn or loose parts. A bouncy, wallowing ride due to worn shocks or struts is not only nauseating, it can cause loss of steering control in a panic situation and even increase braking distance. While strut rod bushings are common sources of wear causing excessive steering play, don’t overlook control arm bushings, tie rods ends, rack mounts, or steering couplings.... Check for worn or misadjusted wheel bearings or loose wheel lug nuts.

A car that feels unstable while driving but has no excessive free play in the steering may have rear suspension problems. An independent rear suspension has a lot more components to wear out than the good old live axle. Alignment angles that are extremely out of spec can cause instability, especially if the wheels are toed out.

Parts that Affect Tire Wear. [Counterman Magazine, Nov 2002, by Larry Carley]. Uneven or rapid tire wear is often the result of worn steering or suspension parts. Toe wear is the most common type of wear seen on front tires. It produces rapid tread wear that typically leaves a sawtooth or feathered pattern across the tread. If you rub your hand across the tire one way it feels smooth, but it feels rough when you rub it in the opposite direction. Toe wear is caused by toe misalignment, which in turn is usually due to worn tie rod ends in the steering linkage. On vehicles with rack and pinion steering, it can also be caused by worn inner tie rod sockets. Other causes include bent ... bent tie rods. The outer tie rod ends typically experience a lot of wear because they twist and turn with every steering motion, as well as flex back and forth with every gyration of the suspension. The right tie rod end is often the first to wear out because right hand turns tend to be sharper than left hand turns. Their location near the wheels also subjects them to road splash. Over time, water and dirt can seep past the boot seal and contaminate the grease inside. ...

Another type of wear that is often seen on tires is camber wear. This typically produces heavy wear on only one shoulder of a tire (usually the inner shoulder). This is caused by camber misalignment, which in turn can be due to worn or collapsed control arm bushings, worn ball joints, weak sagging springs, a bent steering knuckle or spindle, strut misalignment or damage, or structural damage or misalignment in the engine cradle, subframe or strut tower. When rapid or unusual tire wear is discovered on a vehicle, the steering linkage and suspension should be carefully inspected to determine if any parts are worn or damaged. If everything checks out okay, realigning the wheels should eliminate the problem - unless the vehicle has structural problems in which case additional repairs would be needed.

Tie rod ends can be replaced individually or in pairs. Many technicians prefer to replace tie rods in matched pairs because they know if one has failed, the other is probably nearing the end of its service life, too. Left and right tie rod ends are usually threaded differently, so make sure your customer gets the correct side if only one is being replaced. ... Another often overlooked cause of front toe wear on vehicles is rear axle or wheel misalignment. If the rear wheels are misaligned, it creates a thrust angle that causes the vehicle to lead to one side. The driver has to counter this tendency by steering a little to the opposite side. Thus, an off-center steering wheel is a good clue the vehicle has a rear steer problem possibly due to worn parts. Rear wheel misalignment can be caused by worn suspension control arm bushings, weak springs, or damaged or mislocated suspension parts. On vehicles with independent rear suspensions, rear toe adjustments may be provided to correct rear wheel alignment. But if no factory adjustments are provided, your customer will need some type of aftermarket alignment kit to make the corrections. On front-wheel drive cars and minivans, rear axle shims are often needed to make such corrections.

DON'T FORGET THE SPRINGS Springs may not wear with age, but they do sag and occasionally break. After six or eight years of fighting the forces of gravity, it's not unusual to find springs that are at, or below, minimum ride height specifications. That's why technicians should always measure ride height prior to checking wheel alignment and when investigating steering and handling complaints. Ride height affects wheel alignment, vehicle stability and the suspension's ability to handle normal loads and overloads.

Front End Shimmy Due to Faulty Tires. [David Samuels] Symptom: random shimmy while braking. After replacing rotors, brake components, control rod bushings, and other front end parts I eventually found that the shimmy and vibration problem was more likely to occur on certain types of road surfaces and began to suspect tires. Put it up on jacks and spun the tires, found one of my front rims slightly crooked. May have been from a recent impact. Put those two on the back. This also improved the problem some, but still not cured! Took the car in to a "better" tire shop, with better balancing equipment and had them high speed balance the tires. Again, a noticeable improvement, but not perfect. Finally, in desperation, went back to the tire shop and had the manager look at the tires. He put them on the machine and spun them with the top up. Both front tires could be seen to be out of round even though they were balanced. You could actually watch the surface of the tire moving off kilter. He checked the front rims, found them to be true. However in addition to being out of round, the right front tire was beginning to show some tread separation on the inside. I finally had to break down and buy tires. Now, new tires, properly balanced, tight bearings and new rotors, and my problem is completely gone. My recommendation is to take the car in to a good tire shop with an experienced tech and have your skins really checked out.

Wheel and Tire Balancing. See the FAQ file for a complete description of diagnosis and cure of wheel/tire balance problems. Tire Rack, a major direct tire retailer in the US, has this useful flow chart to help diagnose tire and wheel vibrations. As noted above, tire faults can cause difficult to diagnose vibrations, shimmy, and ride problems.

Wheelbearing Life. [Inquiry:] Readying my daughter's 740 for a long road trip. Bought the vehicle with 112k - it has 120k now. Shows no overt symptoms of bearing wear. No noise. Wheels are tight with little play. Should these bearings be greased/replaced prior to road trip? [Response:] The 700 wheel bearings seem to last a bit longer than those on the 200 series. There are a couple of different types. The early ones were similar to the 200 series and could be expected to last 100K to 200K, perhaps with a cleaning and re-packing at some point. If the bearing still has grease in it and the grease is not burned, I would leave it alone. The later 700s use a slightly different bearing that is installed with preloading. These bearings seem to last even longer. Again, if still have grease and the grease is not burned or hardened, etc. leave them alone.

Alloy Wheel Stuck on Hub. [Inquiry:] In the process of doing a front brake job on my '86 745T, I find myself unable to get the driver's front wheel off....no amount of pulling seems to budge it, and I'm no wimp. [Response:] Loosen the lugnuts some, raise the wheel off the ground and then loosen the lugnuts a bit more...enough to keep the wheel on the hub, but not enough to keep it from moving. (1/8" inch is plenty.) Then *gently* lower the wheel back onto the ground. The weight of the vehicle will break the bond between the wheel and the hub. Then just raise the car up again and remove the wheel as normal.

Wheel and Tire Specifications:

Tire Size. [What are the largest tires I can mount on stock 15" wheels on a 1992 740? The wheels are 15x6".] A very low profile option is 225/50-15. A moderate low profile option is

215/60-15. Both will mount and function with only minor interference (rubbing between the tire and the control arm with the steering turned to full left or full right lock).

Maximum Wheel Sizes.

Wheels:
[Inquiry:] I have a 740 Turbo Wagon with 195/60/R15 tires. I would like to know the maximum size of wheels/tires I can use safely on this car without making any modifications. Does Volvo have any guidelines for max sizes on the 740?
[Response:] On the 700 you should be able to go as high as a 17x8 wheel with a 225/35-18 or 225/40-18 tire. However, this will produce a pretty harsh ride and you will likely experience damage to tires and wheels from normal streeet driving anywhere there might be potholes or pavement damage. I have found that 16x7 or 16x7.5 rims with 225/50-16 are a very nice combination of ride, performance, appearance, and durability. Be sure that any wheels that you buy are the correct offset for the 700 Volvos. TSW makes several wheels that will fit, and there are even optional Volvo sport wheels for the 700 series in 16" and 17" sizes. (very expensive!).
[Response 2:] On my 89 745T with 16 x 7.5 wheels and 225/50ZR16 tires, the front rims come very close to touching the strut spring perches. There is a slight rub on the fender liner at full lock I think my wheels, MMIIs, are only 20 mm offset. 25 mm offset, the standard for 700/900s, would help a bit. Before I bought 17 x 8s, I would test fit them in the fronts. I don't think the rears would be a problem. There seems to be more room back there.
[Response 3:] Actually, 25mm offset (as opposed to 20mm) would bring the inside of your front rims even closer to the struts. The greater the offset, the farther inboard your rims go. I have the Volvo 16 x 6 wheels on my 740 (25mm offset) and they come fairly close to the strut as well. If these were 7.5 wide, I imagine there might be a clearance problem.
[Response 4:] The only figures I have is for the S/V90, but it can take 18 x 8.5" as a max with 225/40R18 as a tire. Don't have the ET value at the moment. Ride comfort is probably gone, but this sort of wheel already needs a suspension kit for maximum effect (handling/cornering), which usually already destroys most of the 'comfort' factor. This sort of wheel/tire combination (anything >= 17 inch) really needs to be used on nice smooth roads and highways. If you have bad pavement where you live, then you should not exceed 16 inch wheels to minimize the chances of damage to the tires and the rims.

Tires:
[Jon Espenschied] Using the stock alloy wheels (15x6), the largest (not widest) tire one can fit on a 700 is 215/70-15. This tire allows ~5mm clearance at rest to the tightest points on the front. However, this size tire will scrape slightly on the front if you hit a bump while turning sharply, and it's good to keep in mind that IRS allows slightly more consistent rear fender clearance to the tire sidewall than solid-axle cars. On non-IRS you may be limited to 205/70-15. The effect of this outsize tire was to (a) raise the height of the car considerably -- nice for my ailing knees, (b) noticeably smooth out the ride and reduce tire noise (c) raise the gas mileage slightly on the freeway while depressing it in the city, (d) produce a significant speedo error, and (e) increase driveline/center bearing vibration under heavy load (increased torque). I ran 215/70R15 Goodyear Intrepid tires on my IRS 760 for 45k miles, and they performed quite nicely. They were recently replaced with 205/65-15s due to worries about stress on the driveline.

Torque Specs on Alloy & Steel Wheels. [Inquiry:] Is there any difference in wheel nut torque specs between steel and alloy wheels? [Response:] There is no difference in the torque requirements for steel or alloy wheels in Volvos. The difference is the studs. The 240s and earlier should be torqued to 85 ft-lbs. The 700/900 should be torqued to 66 ft-lbs, the 850 should be torqued to 81 ft-lbs. [Editor's note: I use anti-seize on each stud to ease nut removal when changing to or from snow tires.]
Torque Values and Procedure:
[Tip from Counterman Magazine] Wheel lug bolts should be tightened by torquing to one-half specified value in a star or criss-cross pattern. The final torquing should be done in the same sequence to the specified value. The bolt threads should be clean and free of rust. While it helps to lubricate the threads with light penetrating oil, never use a lubricant that leaves a heavy oil film or that contains a friction modifier. Friction modifiers reduce the friction between the lug nut and bolt and cause false torque readings. [Inquiry] If I lubricate lug nut threads, does it make it more likely I may overtorque them? [Tip from Bendix] Yes. Torque values listed in shop manuals are almost always meant to be used with clean, dry threads. At Bendix, we recommend against using lubricants on lug nut threads, as do many vehicle manufacturers. We have two reasons:

1. Each lubricant may have a different effect on torque values
2. Heat may cause all but special-purpose lubricants designed for brake applications to melt and run, possibly contaminating pads or shoes and/or rotors or drums.

If you insist on lubricating lug threads, please be sparing and make sure to compensate for the increased torque likely to result. For example, one lubricant manufacturer recommends torquing nuts to only 85 percent of the factory specification when using their nickel-based anti-seize compound on threads.

Anti-Corrosion Advice.[Motor Magazine, Feb 04] If you live in the Corrosion Belt, your wheel lug nuts and wheels may corrode to the hubs, making them virtually impossible to remove. Whe replacing wheels, apply a small dab of common antiseize paste to the threads and then torque the lugnuts to spec. While you're at it, remember to very lightly lube the wheel contact area of a shouldered or tapered wheel fastener. Whatever you do, use a lube that won't run out onto the wheels. Finally, get in the habit of cleaning and lubricating the center opening of a wheel before you reinstall it on the vehicle. A light coat of antiseize paste or sturdy grease prevents corrosion from forming and bonding the wheel opening onto the rotor or axle hub. In snow-and-salt areas, aluminum-alloy wheels are prone to corroding themselves onto the hub. More than once I've watched a desperate technician try to dislodge a frozen aluminum wheel by beating on the inside of the wheel with a dead-blow hammer. The easiest way I know to loosen an aluminum wheel from the hub is to reinstall the wheel nuts or bolts finger-tight. Then lower the vehicle onto the floor, apply the brakes and start the engine. Gently rock the vehicle back and forth by shifting into Reverse and then back into a forward gear. Usually, this bit of fore-and-aft motion is enough to loosen the corroded wheels from the hubs without damaging anything.

Wheel Lug Nut Size. [Inquiry] When I look for lugs there seems to be different thread sizes.

There are some in a catalog that look nice. But what thread size do I order? [Response: Steve Seekins] I believe that the 700/900 series all use a metric lug - 12mm x 1.50 thread. Although close in size to the earlier 200 series, the 200 series use an SAE or US thread. One thing to consider is that the lug wrenches that come with your car have a 19mm socket, and for those of you who use torque sticks with your impact wrench, the proper torque stick has a 19mm socket as well. I have found that many of the aftermarket lugs with 12x1.50 thread require a larger socket. For that reason I usually spend the extra bucks and get the Volvo OEM chrome lugs - they are identical in appearance as the chrome lugs used on the 242GT and 240 turbo models, but with the metric threads, and the chrome seems to be of pretty good quality.

Wheel Interchangeability. [Inquiry] I am looking for a used set of 15 x 6, alloy wheels for my Volvo (91, 740 sedan). I was told by two Volvo dealers that all I need to find are 15" wheels off of any 700 series Volvo from 1982 thru 1992. But various sellers of used wheels have some reference manual called Hollander, and claim that it says I can only use certain years of the 700 series for the wheels to fit a 91, 740. Who is right? [Response: Bob] You can use any Volvo 15" wheel from 81-95 excluding 95 960. [Response: Jim Bowers] With the exceptions of the following, any 700/900 15" wheel will fit. Suspensions on '95 and later 960s and the S/V90 used an identical bolt pattern but a different offset. The 700 series had a 25 mm offset while the 850s and later 960s (95+) have a 43 mm offset. Therefore you will need a 43mm - 25mm = 18 mm spacer to get the offset perfect. Probably won't hurt to be 2 or 3 mm off. This is important for the front steering geometry but probably not critical for the back except for clearance. You will probably have to limit the tire size in order to avoid rubbing the fenders and liners. (Even with stock sizes, 205/55-16 on my 965 I have rubbed the front liners with hard cornering.) [John] Wheels for '95 960 and later model years have a different offset. The offset difference may result in poorer rather than improved handling on your solid axle 940 - it may also adversely impact the wheel bearings.

Wheel Repair:

Wheel Stud Repair. [Inquiry] I went to Walmart to have my tires rotated. In the course of taking the lugs off, they stripped two studs, both on the right side of the car, one on front and one on rear. Can the studs themselves be replaced [Responses: Rob Bareiss/Chip McGrew] Yes. Remove the wheel. Remove the old wheel stud by just giving it a good whack straight in with a hammer. If it doesn't extend far enough through the rotor then you will have to remove the caliper and rotor.Then put the new stud in though the hole in the back. It should come through far enough to place a nut on; tighten until the new stud seats itself. You may need a spacer to get it fully seated. Remove nut and replace the wheel. If you have an abs sensor wheel (looks like a gear with flat cogs) on the front hub you will have to grind one side of the new stud's flange to get it in. You'll have to use a grinding wheel. This wheel is stamped steel and you would destroy it if you try to remove. Then put a nut on the stud and crank on it till the stud seats itself into the hub. You won't have the same problem with the rear since the abs sensor is in the differential.

Alloy Wheels: Damage and Leaks

Damage from Tire Mounting Equipment:

[Tip from L. K. Tucker] I am a former tire store manager. You may be referring to wire spoke or thin spoke wheels as Mags. They may or may not be magnesium, or aluminum. There are also composite types with steel in the center and cast or stamped faces on the outside surface. Mag wheels are made by two general methods: stamping and casting. Cast wheels are thicker because of the possibility of voids and cracks in the casting. Wheels made by the stamping method are usually thinner.
Mag wheels can be damaged by tire equipment. Usually they cannot be BENT. They are cracked. The tire store personel should know when wheels should not be put on machines to change tires. The problem with tire changing machines occurs when the machine pulls the center of the wheel down to hold it for the bead removal arm to sweep the edge of the wheel. If this machine holds too tightly the center is pulled out of position and is warped. All thin spoke or wire wheels must be changed by hand unless the machine is designed to work with those type wheels. Other damage can occur if a cast wheel is too thick at the outside edge, the bead. The sweep arm can damage the appearance by scratching or denting the surface if that area is too thick for the design of the changing machine.
Rather than using a machine, hand-dismount tires and use a radial runout gauge on the bead seat of the wheel. Measure both the radial and lateral runout. If the wheel can be bent (steel in the bead area) check the lateral runout on the front and back. The actual material will determine if the wheel can be bent. Cast wheel damage is usually discovered when the crack opens or the center-plate casting breaks.

Damage from Corrosion:

[Inquiry] The alloy rims in my '93 940 didn't leak when the car was new. Now, I top them off every week and sometimes pressure drops as low as 20 psi. I live in Michigan and road salt is everywhere. Does the wheel bead contact area corrode? [Response: Jim Bowers] If you can see corrosion in the bead area and the clear/paint coating is peeling I think you have nailed the problem. This happened to me with the alloy wheels on my '85 745 after about 6 or 7 years of New England "salt" during the winter. Here in MA they use both Sodium Chloride and Calcium Cloride. When I removed the tires I could see that the corrosion had propagated all the way under the tire bead. It looked like the corrosion was bad enough around the tire valve to leak there also. I had the rims sand blasted to bare metal using a fine abrasive and then had a body shop coat them with an epoxy primer followed by a silver grey paint and clear coat. After that, they never showed corrosion and never leaked air as long as I owned the car. Between the blasting and the paint I think I spent over $40 per wheel. With "hind sight" I should have probably just bought some new steel rims for my winter tires.

Refinishing Wheel Rims. [Inquiry] I recently bought a set of four alloys on Ebay for $100. The wheels are in good working condition, but cosmetically, they leave something to be desired. They have some corrosion on the faces of the wheels and the center caps. I was wondering if anyone had any tips on home refinishing of these wheels. I'm not interested in refinishing them to factory condidtion, I just want to make them more presentable. [Response: Chris Herbst] If those rims are straight, then you still got a good deal. A lot of idiots market those rims, which are almost NEVER in perfect shape, for a small fortune, believing that they are somehow rare! The center caps are worth just as much as the rims if they are in nice condition, because THOSE really degrade over time. Now, how to fix a set of GL rims for $20:

1. Strip all of the LOOSE factory coating off of the rims and sand the edges just enough so the finish isn't still peeling off of the rim at that point. You don't have to be an artist to do this, just do a rough job. Make sure you level any areas where the paint might start to peel like where the clear is chipping, or where there is curb rash (smooth it out a little).
2. Rough up the rest of the rims slightly.
3. Clean all the dirt and debris off of the face of the rim. Make sure you wipe the whole thing (including inside the fins of the wheel) with prep solvent to make sure you start with a VERY clean finish.
4. Buy a few cans of gray primer and silver paint (or aluminum paint looks really nice--a bit brighter). If you can get silver epoxy paint, better still, but I haven't found it, nor have I looked very hard. By the way, the primer makes all the difference in terms of longevity. You can have paint mixed up using the center caps as a match if you need to--easy to take to the paint shop.
5. Prime the rims, then spray the color. Make sure (duh) that you get inside all of the fins. You obviously have to spray from the left and the right to coat them evenly.
6. Clearcoat if you really want to. I have done it but the clearcoat has never made much of a difference.
7. Mount your tires. You're done. The rims look really nice and you'd never know that they are painted unless you get down and really look at them.

I got 175k miles out of ONE paint job on one set I did. I never needed to even touch it up or anything. [Tip from Robert Haire] I've done a bunch of 240 and 700 alloys. I fill interior dings with aluminum filler from an auto paint or auto body store and sand the edges a bit to take out mild curb rash. If the paint is not cracked and really really bad, I just spot prime with two part epoxy (BASF product) and spray with two part acrylic, made up to match by the auto paint store. Avoid stripping the wheels with methylene chloride! Too dangerous. Spray thin coats, avoid sags and you have a nearly new looking wheel. I was told not to clear coat. To spray, I use the pressurized Preval cannisters. A couple for $10 will do a few sets of wheels. The paints, reducer and hardener are rather expensive so it really starts to pay if you have 3-5 sets of alloys to do. [Response: Don Foster] Yep, I agree 1000% — that's how I did mine, except I glass bead-blasted the rims. But also do a thorough and careful cleaning 'n painting job in the tire bead area and where the stem seats. Those rims develop corrosion and pitting, and sometimes this leads to slow leaks. Fill the pits with paint 'n clear coat, and seal the aluminum to stop further corrosion under the bead. [Georege Downs] I'd strip the wheels using a bead blaster, with just enough bead blast to get it clean and uniform. Reason: bead blasting (like shot peening) imparts a residual compressive stress in the surface, which as long as undamaged, gives protection against both fatigue and stress corrosion cracking, since both processes depend on tension in the surface to initiate a crack. Have them use as big a bead as they can consistent with desired appearance and getting into the crevices. [Response: Julio Manalo] I don't know how accessible/ costly it is in your area, but here at home, we have a lot of steel furniture shops that do powder coating for a very reasonable price. This is how OEMs finish aluminum wheels at the factory so you get a factory type finish and your wheels look brand new. Much more durable and shiny than spray paint.

Replacement Wheel Rims. [Tip from Joe Fernandes] Try http://www.aaarims.com/ for a source of Volvo used and refurbished wheel rims. For straightening bent rims, try Saab/Volvo specialist Rim Pro; 1-978-851-6080 See as well http://www.wheels-and-rims.com for new rims at reasonable prices.

Tires:

Snow Tire Sources. [Tip from Lee Levitt] See Pat Greer at http://www.dias.net/~greerent/ for Hakkapellita and Nokian snow tires.

See also http://www.tirerack.com for Tire Rack information and Internet order site.

Exhaust Sensors:

Oxygen Sensor Replacement. See the specific sections on diagnostics in the FAQ Fuel Injection and on replacement in the Sensors files.

EGR Valve. See EGR Valve in Electrical: Sensors, Etc.

Maintenance:

Air Injection Valve

Air Injection Valve. [Inquiry] I noticed a noisy hose in front of the engine of my 1995 940 B230F. The noise goes away when downward pressure is exerted, and air can be felt at the corner junction. What is this thing? [Response] This is the air injection valve, with a one-way check valve (the wider discs) for air injection into the exhaust to heat the catalytic convertor and O2 sensor on cold start and provide sufficient O2 to the catalytic converter so it can do its job. It is used on selected non-turbo engines for pollution control and is controlled by a solenoid. While the connection is still loose, idle the engine and take the time to pull the rubber hose off, and be sure hot exhaust isn't blowing back through the discs...if it is then replacement is in order, else hot gasses will soon burn through other parts. A good cleaning and a bit of black RTV should repair your hose 'for the life of the product'. Usehose clamps on reinstallation.

Exhaust Gases or Manifold Leak.
Exhaust Vapors in Car:
[Inquiry] Getting fumes in the car while idling, not while moving. [Response: Brian Oliver]I've seen two types of reasons for this:

1. Leaking exhaust joint: It could be manifold to head, manifold to pipe, or pipe to cat. I've had all those on various cars, and some others too on FWD cars with "flex pipe"

sections. See also the Turbo section for lots of data.

2. Crack in the front pipe: On our 940, it was in the "crotch" of the Y-joint, and couldn't be seen until the pipe was out and the heat shield ripped off.

If you ever get cold weather, look carefully for little puffs of vapour in suspect locations just after you start the car up on a cold morning. That's how I found the last two.

[Problem:]I own a 1990 740 wagon with the B230F with an exhaust leak at the manifold. Is this a common problem? Do the exhaust manifolds warp easily? [Diagnosis:] The exhaust manifold gaskets on the B230F tend to blow out every once in a while. Mine has a leak next to #1 but since it's not major or real noisy I'm waiting for the rest of it to go or get worse. If you have to change the gasket be prepared to get new bolts/studs and keep a stud extractor handy as they always break off.

Exhaust Manifold Gasket Failure

What Do Leaking Exhaust Gaskets Sound Like? [Chris Wilson] Mine was more of a tut...tut..tut...tut noise but came on during acceleration. [Another] Yeah, tut tut tut ....tick tick tick sorta thing. Really can hear it at around 1500RPm and slightly above starting from a stop.

Detecting Manifold Gasket Leaks. [Tip from Mike McBane] To locate an exhaust manifold or gasket leak, duct tape a shop vac hose onto the exhaust pipe outlet, set it on "blower", apply soapy water to the manifold gasket and turn it on. Bubbles or air leaks will show the location of the cracks or failing gasket.

Exhaust-Like Smell: Leaking Injector Seals. [Inquiry:] I have a problem with my 760 Turbo that my mechanic can't solve: when accelerating hard, with the ac and the fan on, a strong smell of exhaust comes out of the vents. when the fan and the ac are off, there is no smell. Can anybody help with this? The mechanic says that it can not explain why there should be any smell of exhaust coming in, which, by the way, happens also with the recirculation button turned on. [Response: Steve Seekins] I suspect that what you smell is not exhaust, but raw gas. I had this problem on a couple of turbo cars. The source was injector seals. When they get bad on a turbo, they suck air into the manifold at idle and off throttle (whenever the turbo gage is in the vacuum zone). However, under boost, the manifold is pressurized and fuel mist from the injectors is forced out past the injector seals and then gets sucked into the vent system by the intake at the front of the windshield. It is worst under heavy load when manifold pressure is highest and more fuel is being injected, and you only get it when the vent system is operating or the windows are open.
Check at idle with can of spray carb cleaner or unlit propane torch jet. Spray or direct jet at each injector base in turn. Any change in engine rpm indicates leaking seal. Also check intake manifold gasket area and look for combination of bad hose from fuel pressure

regulator and leaking pressure regulator.

Exhaust Replacement: Brands [Editor: Numerous questions about which brands to buy are addressed below.]
[Response 1:] I replaced the exhaust system on my '87 740 Turbo last summer with a Volvo kit. The kit which includes all the hangers and clamps for the car was about $285 and only took me about an hour to install. The kit includes everything from behind the cat.
[Response 2:] I bought the Volvo kit because I have heard that they last longer than the muffler shop kits. Having had a few 240s over the years, I have visited the muffler shops a lot. However, the 240s have so much exhaust plumbing compared to a 740, I would expect the 240 to go through them faster. I figured that at $285, it would cost me about that much to have a muffler shop do the work. Then I will have to deal with the periodic returns to have the system replace under warrantee. Figured it was worth a try.
[Response 3:] I bought a replacement system mfg. by Starla, just received yesterday. All parts made in Sweden. EVERYTHING from the rear of the cat back, including clamps and hangers, was $245 including shipping. Bought from RPR.
[Response: Vladimir Kordac] Stay with Volvo or a quality after-market system. Forget Maremont etc. with their 2yr "lifetime" crap unless you want to eek out a few more years out of the present system! I put in a complete Bosal system recently from down pipe to tail pipe including cat, that went in flawlessly. Total cost was approx. $325. Bosal is supposedly comparable to OEM. We'll see.
[Response: Rob Bareiss] Either the IPD system or the factory Volvo exhaust kit will make you happy. You will also find parts stores which stock "Starla" brand original fit exhaust components. The stuff is great quality. Goes on just like Volvo's. Lasts as long as your originals did, and costs about the same (a bit less). We use a lot of Starla and Volvo brand parts at our shop, and the difference between those, and the "M" or "W" brand junk we throw away is amazing. Get the real stuff, you'll be much happier you spent your money WELL and ONLY ONCE.

[Editor] Consensus seems to be that Volvo OEM is number one in quality, followed by Bosal, then Starla/Walker, then everybody else. Some limited (non-statistically-significant) anecdotal reports about Starla show lighter metal, poor welds or misaligned pipes or hangers.

Catalytic Converter Brands. [Jerry Andersch] I bought a Davico aftermarket catalytic converter from FCPGroton. When I installed it I noticed the construction was not very good: bad welds and a restricted inlet. Five year/50k mile warranty on shell only. The matrix broke up and totally clogged the exhaust system in about six months. I would not buy a Davico product again. Bosal may be a better choice. [Brian King] I purchased a new direct fit Carsound cat from AutohausAZ.com for about $100. The Carsound website had some pretty good info and a search of the forums didn't turn up any negative reviews, so I thought I give their product a try. Other brands are DEC (Diversified Environmental Catalysts) and Walker.

Exhaust Replacement: Procedures.
Tools:

[Jay Simkin/Jeff Pierce] Among the tools you'll need are: (a) a reciprocating saw with a metal blade (in effect a power hacksaw) or an angle grinder with an abrasive wheel, to remove the old system (b) if available, a Dremel is very helpful because it works like a very small angle grinder, allowing you to perform the "fine surgery" when you have to cut through the outside pipe, without cutting through the inside pipe, to remove "slip fit" connections like the ones used on Volvos; (c) socket tools (d) PB Blaster or top quality penetrating oil to help you remove the nuts that connect the catalytic converter to the rest of the system, and that connect the engine pipe to the manifold.

Jacking:
[Tip: WRay] Most folks say to use ramps at the front and stands under the jack points at the rear, but I couldn't find a high quality set locally, so I just jacked up the rear from the differential and used jackstands under the factory jack points. There was plenty of working room because the exhaust on the 740 is so close to the right side of the car, and the cat pipe comes back quite far.

Kits:
[Response: Gary DeFrancesco] (see the section above.) These hack muffler shops are more trouble than they are worth. I have not had the pleasure of getting into the exhaust system of a '89 740, so I don't know what the differences are with the earlier 740s. Assuming the basic design and arrangement is the same, and speaking from experience with my '87 and '88 740Ts, I would go with the Volvo exhaust system. The kit Volvo sells has everything you need behind the cat. It even includes the hangers. My dealer hit me just less than $300 for the kit, and it went in like a dream. It took me less than an hour to do the job. [Another Comment:] Installing the Volvo kit was a dream. All the parts FIT! None of the pipe ends were dented requiring hammering to make them go together. The pipes had smooth curves, not ribbed curves as often found on after market kits. Furthermore, the system is probably better sized for the car which hopefully will result in less trouble for us turbo owners. [Comment: Wray] Fit of the Volvo exhaust kit was superb--nothing banged, rattled, leaked, or buzzed. Only mistake I made was not realizing that the cat pipe clamp is 58 mm, all the rest are a few mm larger. That cost me about 15 minutes to figure out and reinstall some clamps.

Rust and Seized Parts:
[Tip from Brake and Front End Magazine, August 2001] Remove the affected parts using your favorite method. Rusted nuts can often be easily removed by heating them to a glowing red state with a torch before attempting the use of a wrench. Severely rusted nuts and bolts can often be removed by using the "wrong" wrench or socket. A half-inch socket could fit too sloppily on a half-inch nut, but a 12 millimeter socket might be just what that half-inch nut needs. If you have a rusted nut that you need to remove from a good stud, in a catalytic converter for example, that is simply too rusted to come off by any means of turning it, judicious use of the cutting torch can come to the rescue. You can, with some practice, cut a nut off a stud without damaging the threads on the stud. It takes a steady hand and practice,

but it can be done, and quickly. On the easier ones, penetrating oil can still help. It should be noted that there is a big difference in the effectiveness of different penetrating oils. [Editor:] The universal Brickboard consensus is that THE penetrating oil to use is PBlaster.

Pipe Removal:
[WRay] I bought an exhaust pipe cutter ($20, basically a chain with a bunch of tubing cutter wheels on the links and a screw mechanism to tighten around the pipe). Pipe cutter was so much fun, I ended up cutting the old exhaust into very short sections for very easy removal. Used my Dremel tool with reinforced cutoff wheels to buzz through any old mounting clamps or hangers.
[Tip from Brake and Front End Magazine, August 2001] If you need to remove a slip fit joint (one pipe inside another, held with a clamp) without damaging it, it can be done. You'll see a ridge in the outer pipe caused by the clamp. Heating all the way around the pipe in the area of the ridge (until glowing red) should expand and soften the pipe enough that the inner pipe can be removed by twisting and pulling with a chain wrench or large slip joint pliers. If you can afford to damage either the inner or the outer pipe, you can save some time by slitting the unneeded one along the length of the joint with a cutting torch or cut-off tool. Only the torch will work on the inner pipe.

Converter Joint Removal:
[Gary DeFrancesco] To remove the front muffler pipe from the cat. pipe, I put a reinforced cut off wheel on my Dremel tool and slit the muffler pipe just deep enough so as not to cut the cat. pipe. Pried open the slit on the muffler pipe and everything came apart. (Also need to slit the joint behind the front muffler so that it can be separated from the over-the-axle pipe, but here you don't have to be so careful with how deep you cut.) [Another comment] In your case, you have to deal with the muffler pipe being welded to the cat. One approach would be to cut the muffler pipe off several inches down stream from the weld. Then using a die grinder, remove the remains of the muffler pipe from the cat pipe. A Dremel tool will also work, but it will take longer. The first thing to do is slit the muffler pipe open length wise. Then carefully slit the muffler pipe next to the weld to free it from the cat pipe. The idea is to not cut into the cat pipe while doing this. It will take a gentle touch and some time. Once the muffler pipe is off, then the weld can be removed with a grinder wheel. However, if the weld is far enough onto the cat pipe, you may have little or no need to remove the weld bead if the new muffler pipe does not go on the cat pipe as far. This will be a PITA job. But the cost of a new Volvo cat may convince you to get creative. (Don't know what a cat for you car cost, but Volvo wanted over $850 for my '88 740T!)
This leads to another approach to the job. Replace the cat with a good quality after market unit. There are some decent ones out there for reasonable cost. Just make sure it is a direct fit unit and the pipe diameters are not restrictive entering or exiting the cat chamber. With a new cat and the Volvo exhaust kit, you should be able to replace the exhaust system in an hour or two.
[Response: Vladimir Kordac] You'll have a small problem with that welded cat. May have to cut back beyond the weld and use a small adapter piece to mate cat and front muffler (resonator). What kind of shape is the rest of the exhaust? Unlike hunting an electrical problem that may take me hours-years, changing an exhaust is a no-brainer. And results are dramatic. Usually the worst part is getting the old stuff off; however, since I was replacing

everything, I didn't have to mess with cat connections or any
other frozen areas. In the past I would get out the Dremel or rotary cutoff tool to slice through clamps and pipe ends. It would help a great deal to elevate car on all fours.

Header Pipe Replacement. [Editor] When replacing the header pipe, remember that you will need three new bolts and nuts to connect it to the converter behind it. If you need to replace the header, you might consider a new converter to make installation easier: aftermarket units are quite inexpensive. Buy the Volvo OEM manifold-to-header gasket: it is a copper composition and far superior in quality to aftermarket gaskets. You will also need three new copper nuts to bolt the header to the manifold. The two small bolts holding the middle of the pipe to the u-shaped wire brace are 8mmx1.25mm pitch by 30mm. Make sure you use antiseize on all bolt and clamp threads.

Installation:
[Response: Warren Bain] On installation, don't forget the Permatex anti-seize compound on the threads, it makes removal a dream. I use it on all my exhaust systems and the bolts just turn right off without any problems.

Catalytic Converter Diagnosis. [Tip from Fluke Corporation:] Using a Fluke Digital Multimeter with the 80T-IR/E Extended Range Temperature Probe, you can easily and quickly assess catalytic converter efficiency. For this test, first run the engine until the engine is warm and stabilized. (For engines with electric cooling fans, let them cycle a few times prior to the test) Then shut off the engine and disconnect a spark plug wire on one bank of cylinders. (Note for V engines: If there are dual converters, you will need to perform this procedure on each bank of cylinders.
Restart the engine and block the throttle to maintain 1000 RPM with the one cylinder not firing. Measure the inlet temperature of the converter and compare it to the outlet temperature. You should see a differential of 50 degrees F. or more if the converter is working properly. If the temperatures are less than 50 degrees apart, then the converter needs to be replaced. Before replacing a converter, be sure to determine why it may have failed. If it is a very high mileage vehicle, it is probably just expired. If it is low mileage, you should perform a thorough check of the vehicle to determine the cause. For normal engines with a misfiring cylinder at 1000 RPM, you can expect that the temperatures observed will be in the 600 to 900 degrees F. range.
Simple Diagnosis for Plugged Converter. Look for a screw-in pipe plug in the exhaust pipe ahead of the converter. If, when you remove that, the engine's performance improves, it shows there is a restriction in the converter.

Replacement Converters. The cat thread was my doing since I raised the question regarding my '85 740 GLE. To sum up all of the advice I received, replacing the cat should be done if it is indeed in faltering condition--although people seemed to vary in their senses of urgency for having the replacement done. The reason for having it replaced--besides making passing emissions dicey in some states--is that the cone in the converter can come loose and plug the exhaust or can break up into pieces and shoot back through the exhaust into the muffler, etc.

I also called around about aftermarket cats and found one for $100. Herzog-Meier 800-858-6608 sold the VCNA aftermarket for $305 since I'm a IPD customer (you have to tell them this to get the 20% discount!) If you can replace it yourself maybe that would be a good idea (I can forward you the email I received from the car parts place). If you can't then I suggest taking it to Midas or somewhere that specializes in that stuff and replaces them on a regular basis. My Volvo guy was quoting prices of up to $350 installed. Based on some advice from a list member, however, I went to Midas two days ago and had it done in an hour for $208 not including tax. [John Sargent] Original Volvo catalytic convertors are superior to any aftermarket replacement cat. Replacements usually fail emissions testing in a few years. We have four turbo 700s all passing emissions testing and running the original Volvo cat.

[Another Inquiry:] The catalytic converter on my 1989 740GL Wagon needs to be replaced. One shop said that they do not recommend after-market parts, since the performance is never as good as with the manufacturer's parts. Another shop didn't see any problems with using an after-market catalytic converter for about $350, compared to manufacturer's (Volvo's) price of $1300. To me this is a large difference. I am wondering if anyone else has any experience with replacing the catalytic converter [Response: Zee] Euclid Foreign Auto Parts, near Cleveland, OH can sell/ship a decent aftermarket cat. for about $150 (Euclid"s tool-free number: 1-800-837-5110. You must ask for Tina and mention the Brickboard bulletin board for the discount.) I have had a good buying experience with them over Christmas when I ordered a Bosal downpipe (it's the one just in front of the cat. that goes between the cat. and the exhaust manifold). $69 +$10 tax and shipping, sent to my door within two days from Rochester, NY. (I live in PA) What you want to look for when buying any after-market part is that the part meets or exceeds O.E.M. specifications (Original Equipment Manufacturer). You have to ask, or tell parts suppliers you want this, or they can sell you cheap, Asian look-alikes.

Heat Shields. [Tip from Bruce Young] If your heat shields (the metal plates between the exhaust and the body floor panels) are loose or missing, you can replace them with universal aftermarket versions made by Walker (check with NAPA Auto Parts stores).

Exhaust Manifold Studs, Brackets, Front Pipe:

Exhaust Manifold Nuts, Studs, and Gasket Replacement . [See the sections below and Turbo: Broken Turbo Exhaust Stud]

***Removing the Existing Nuts and Studs*:**

Applying Penetrants. [Response 1: Onkel Udo] Spray the studs using penetrating oil repeatedly (PBlaster highly recommended) for the preceding days. When removing the nuts, use a quality six-point socket. One trick for breaking them free is to first tighten them a very slight amount just to get them to "crack", then apply more penetrant and rotate counterclockwise to remove. When you reassemble, use nickel-based high-temperature antiseize compound on the new studs.

Using a Chisel. [Rob Bareiss] If any of the exhaust nuts do not readily break free using your ordinary socket wrench, STOP RIGHT THERE. Do NOT apply a lot of force. Instead, get a hammer (small 2-lb sledge is just right) and a fine chisel. You do not need to split all the way through a nut to loosen it. Just a little work straight into the middle of a flat on the nut is usually all that's needed. Ideally a couple of whacks with the chisel, then the nut spins off by hand. AVOID hitting the stud's threads at all costs.

Using Heat. [Response 2: Don Foster] If the original studs appear "eroded" (rusted away) and you think you can remove them without snapping even one, then new studs would be a cheap investment. I dearly love my oxy-acetylene torch for removing rusted nuts and bolts. Every time I use it, I kiss it. [Another tip] Heat the nut with a Mapp Gas torch and apply beeswax or paraffin wax, which wicks up between threads and eases removal when cold. Use Vice Grip plyers on broken studs. The stud is regular right hand thread, by the way: counterclockwise removes it.

In the Event of a Broken Exhaust Manifold Stud:

A. If the stud has some remnants above the surface: start with low-impact techniques, listed below.

Removal by Tapping and Two-Nuts. [Paul Seminara] Soak with PB Blaster, smack area near thread with hammer, PB Blaster, soak, wipe, heat, PB Blaster, hammer tap. If threads are available, then extract with two nut method (install two nuts tightly, then unscrew the lower nut which jams against the upper). But first tighten a bit, apply more PB Blaster...etc, ... repeat..patience is really the key! If no threads are available you can use locking pliers clamped tightly against the stud.

Removing Broken Studs by Slotting. [George Downs] If the stud is not too tight in the hole you could (with adequate grit protection) use a Dremel Moto-Tool with an abrasive disk (#409), cut a slot in the end of the stud, and remove it with a screwdriver.

Removing Broken Studs and Bolts by Tapping with a Punch. [Tip from Don Foster] Try hitting the stud off-center with a tiny sharp punch and little hammer in a small notch in the stud. Tap lightly and off center. Done properly and carefully, it's surprisingly effective providing the stud isn't bottomed out and jammed in.

Removing Broken Studs Using Tools. A variety of tools may be used depending on access. Most work by wedging against the stud and allowing you to back it out. Sears and many others sell the round locking collar type stud remover; Snap-on has a nice but expensive set of locking collet stud removers, sized by diameter and thread pitch, that use remnants of thread. Assenmacher makes a similar socket-like remover that jams onto the stud and allows you to back it out. See also Broken Stud and Rusted Bolt Extractor for an air tool for similar problems.

Removing Broken Studs With an Electric Welder. [Tip from Gary DeFrancesco] Last spring I removed the head off my '87 745T due to a broken stud. In my case, the stud broke flush with the head, so there was no way to get a wrench on it. Took the head to a head shop and had the machinist replace all the studs, figuring that if one stud is bad, more were ready to let go. The machinist trick to removing the remaining studs was amazingly simple and effective. He hooked up the hot side of his welder to the stud, the ground to the block. Set the welder for about 150 amps., then turned the welder on for 2 seconds. The studs after this treatment are hot to the touch, and the head is a bit warm. But the crud in the threads that makes the stud stick is all burned out. It is the crud that is causing the high electrical resistance. Hence, it is the crud that really heats up and burns off. With the curd burned off, he is able to easily unscrew the stud. He finds better than 90% of stuck studs can be removed this way. And there is no warping of the head since the heat is pretty much contained to the cruddy threads and is only applied briefly. Just one of those welder tricks I have filed away for the day when I get a welder.

Another trick you can use if you have a welder is to select a nut with a hole large enough to pass over the stud. Lay the nut over the stud and then fill the hole with weld metal. Then simply screw the stud out with a wrench. Or butt-weld a piece of welding rod onto the end of the bolt so that you can turn the assembly with pliers. [Jeff Goggin] Using a welder, slowly build up a bead of weld on top of the broken stud, until it clears the surface of the head. Using vice grips, grab the weld and twist out the stud remains. I used an oxymig at the slowest wire feed (basically dropping weld beads onto weld beads), and a medium high setting (110v 30amp welder) - ground clamp to the #1 cam journal. Allowing each bead to cool before adding more material, is the key to getting this right.If the weld breaks before the stud would break free, just keep going at it, rewelding until the stud breaks free. This may take over 6 applications of the weld bead technique. Use a hammer on the top of the bead each time, tempering the bead, which appears to reduce the chances of shearing the bead off the stud. This procedure negates any need for the drill and helicoil procedure in which the biggest problem is getting a straight hole and not drilling through to the water jacket beneath.

B. If the stud is broken off flush with the surface or still won't come out, then you need more extensive work. ***Tales of Caution****.* [Paul Seminara] DO NOT, I REPEAT DO NOT EVEN THINK OF USING AN "EASY OUT" (a reverse-fluted broken bolt extractor). The hardened but brittle extractor can and probably will break off in the hole you drill. Or your hole will be off-center. Then, your available options are reduced to pulling the engine and having a machine shop mill out the extractor/old stud or spending 24 hours and a dozen diamond bits to hog out the broken extractor millimeter by millimeter. It ain't fun! [Editor] If you ignore this advice and break off either an extractor or a drill bit inside the stud remains, then you need to take it to a machine shop for precise drilling or for electro-discharge machining, in which an electrical current is used to melt out the extractor and stud. [Rob Bareiss] If you do break a stud, get ready to pull the head. Don't try to fix exhaust studs in place. [Another caution from Randy Starkie] Personally I haven't had much luck when it comes to drilling out broken exhaust manifold studs. Alignment is critical as you indicated. The hardened stud in a soft aluminum head adds to the difficulty. A machine shop deals with these problems everyday and are actually pretty good at it. They are not always able to deal with them however if a lot of molestation (for lack of a better word) has occurred prior to their attempt. You would have to remove the head to take it to a machine shop. That isn't all bad. While the head is off they can go through it and check for plane, worn guides, replace the seals on the intakes and lap or grind the valves ("valve job"). You would basically have a rebuilt head when finished. [Paul Seminara] Got some diamond bits? Got a right angle reversible drill? Got a moto or air grinder tool? Got the appropriate size left hand cobalt drill bit? Got the appropriate drill and tap? With the above tools you can remove the stud remains. However, centering any hole is critical.

Start with the left hand drill bit (smaller than the stud in question, correct size for stud remover) with the drill in "R". Maybe the stud will come out maybe not. Make sure you follow the stud and don't go outside the envelope. When most is gone, you can try to peel off the remaining stud threads from the existing hole or simply drill the hole to the correct size for the tap. Clean hole. Tap, clean and insert stud. Done. [Editor's Note:] See Alden Corporation's "Drill-Out" power extractor web site for more information on tools and techniques to remove broken or frozen studs: http://www.drill-out.com/ The same caveats apply to these devices as to Easy-outs. *Removing a Stud by Drilling with Diamond Bits*. What I normally do when a punch won't remove a stud is drill it with a diamond drill chucked in a dremel tool. This is fast and is much easier to control than a regular drill. The diamond drill is cheap (~$8 from Truebite - check 800 directory assistance) and since it is coated on its sides, can be used as a burr. However, this requires precision. Grind off the end of the bolt perfectly flat, measure the center exactly, and center-punch it hard enough. After drilling the hole, I use the drill to enlarge the hole until it approaches the diameter of the base circle of the threads. Work your way up slowly. Usually when the walls of the stud are reduced to this thinness, the tension relaxes and it can be walked out with a punch or even a screw driver pushed down the hole. If not, I continue to enlarge the hole until I see the threads. Then I pick the remaining spiral of metal from the hole. *Removing a Stud by Grinding Out With a Dremel*. [Tip from James Dichter] I went to Home Depot and bought a Dremel with the long "hoselike" attachment. I removed the exhaust manifold and turbo. Hang the dremel on the hood and use a dremel drill bit on the end of the hose attachment and drill a holl in the stud. Then use the dremel engraving tool and slowly bore out the hole until you have cut away the entire stud. Now that you have the hole and you've removed most of the threads simply retap the hole with new threads with a tap. Important!!!! When tapping aluminum go very slowly in and out: 1/10th or a turn in and out seemed to do it. (aluminum is soft and tends to blister if you tap a hole too quickly) After you tap the hole or holes insert new exhaust studs, attach the gasket and reassemble. *Removing a Broken Stud by Drilling: General Tips.* [JimL] If a stud breaks off, you can drill it out and retap the hole. Procedure for drilling a stud out is as follows:

- Make sure top of stud is flat or nearly so. If necessary, grind/file the top of the stud flat. With a SHARP centerpunch, carefully punch the stud in the EXACT center. Using a NEW 3/32 or 1/8 bit, carefully drill down through the center of the stud, checking carefully as you go to keep the bit centered. Pull the bit out every so often and cool it in oil as you go. Replace the bit with a new one as it dulls. An alternative: use a left-handed drill bit that rotates in such a way as to apply force to unscrew the old stud while you are drilling the hole. Once you are all the way through, enlarge the hole with the next larger sized bit, increasing by no more than 1/32 or 1/16th inch. Eventually you will have drilled out to the root of the threads. Retap the hole, and install a new stud or use a cap screw (bolt) instead. You may have to drill and tap for the next larger size stud. It is difficult to drill precisely in the center of a small stud. The secret is to go slow, check often, and use SHARP bits. Also using a variable speed drill helps.
- It's not really a difficult process - just tedious.

Removing a Broken Stud with a Right-Angle Drill. [Tip: Bob Mohr] Been there, done that. A right angle drill will work just fine. I'd suggest using a diamond bit in a Dremel rotary tool to put a nice, centered starting "dimple" in the middle of the broken stud to prevent the bit from walking once you start. Taking care to center the bit, drill or punch will save a lot of work later digging out threads from an off-center hole. You shouldn't have to buy a special diamond tipped drill bit. I went down to the local industrial supply and purchased a cobalt bit that went through that old stud like a hot knife through butter. Why cobalt? Normal hardened HSS, or even the TiNi drill bits won't touch that stud!! Have a bottle of cutting oil nearby and squirt a little in the hole every quarter inch or so to cool the bit and flush out the shavings. I ended up drilling it out oversized and installed a helicoil. It worked great.
Another tip if you don't have a right angled drill. I used one of those fiberglass reinforced cutoff wheels in a dremel to reduce the length of my cobalt drill bit. You have to be careful chucking the drill bit, as it's tough to get it in straight. Cutting down the drill bit gives you just enough clearance to get a straight shot at most of the studs with a plain jane 1/4" drill.
Removing Broken Studs by Heating the Head. [Tip from John Sargent] My wife's 86 745T had several broken exhaust studs. I was able to drill and remove all broken studs but one. In order to remove it, I pulled the head and put it in the kitchen oven, at 225 degrees F., for about 45 minutes. When I pulled the head out, it was at about normal operating temperature. The broken stud came out with torque that would not remove it at room temperature. The thermal coefficient of expansion for aluminum is very close to six times that for steel. Now the kitchen smells like an automotive machine shop. If you choose to use this method, I don't recommend locally heating the head, as you might warp it. *Replacing the Studs:* [Dick Riess] Have done it with the 90 degree drill, unfortunately w/o diamond bits and kinda made a mess, but my machine shop friend let me use his Time Cert outfit to fix it. Evidently the Time Cert is used extensively on hopping up the old aluminum VW engines. They just don't come out. So if you mess up the threads, there is still hope. *Replace Studs with Stainless?* [Response: John B] If you break one stud in the process, you might as well replace them all. Almost any stainless alloy is going to be weaker than a good steel alloy...it's only advantage is it's supposed to be proof against corrosion. But you're not a marine environment, so I'd go with stock steel studs. Helicoil the heads if you must, but you'll get higher clamping forces with the stock studs. [Tip from John Sargent] Volvo has a service bulletin to replace the exhaust manifold studs with the new part number. The new ones are supposed to be better, and for

about $2.30 each, not a large expense. Note that turbo studs may differ from non-turbo studs: make sure of your part numbers. *Use of Thread Adhesives.* [Inquiry:] Several of the exhaust studs unscrewed from the head and will need to be reinstalled. Since this is an aluminum head should I use antiseize or some Loctite? Will anything take that heat anyway? [Response: Tom Irwin] I'd get new studs and re-tap the holes. Then I'd use a high heat removable Loctite, designed for dis-similar metals. *Use of AntiSeize.* Coat the new exhaust manifold nuts with high-temperature nickel-based antiseize. *Loose Studs Require Helicoil.* [Tip] If your stud is loose, first get the appropriate tap and try to clean out the hole. Then try to screw a stud or bolt in there and see if it holds. If not, you can reinstall it using a Helicoil. There is plenty of room in the exhaust manifold ear to drill the hole. The holes are .440 except for the locator ear top of port #3. The helicoil that fixes M8 requires a drill diameter .328. You might have to cut the 21/64 bit to get it head on with a standard drill motor without resorting to a right angle drill, but that depends on which stud is stripped. Since the stud is not broken in the hole, drilling and tapping should be effortless. Helicoil (not TimeSert) is the recommended fix per Volvo's manual; it is done all the time and if you drill straight there's nothing to harm surrounding the tapped hole. If you decide to fix without 8mm helicoil, make sure you use a hardened stud or bolt and not all-thread or similar. The turbo engine uses different studs vs. non turbo per parts manual. *Exhaust Stud Nut Re-use?* [Tip from Bob] Do not re-use exhaust manifold nuts; use new Volvo flanged copper nuts. Replace all three exhaust manifold-to-down pipe lock-nuts when replacing the gaskets. These nuts are not to be re-used. [Jim McDonald] Use P/N 94560A080 from McMaster-Carr instead; they're stainless so they won't sieze, and they're locking so they won't loosen. If you use aftermarket nuts, they may not be flanged: a copper washer will help secure the nut and stud.

Removing the Manifold and Replacing the Gaskets. [Tips from Turbobricks, John Sargent, and others] Remove all the manifold nuts and loosen the turbo to down pipe nuts OR loosen the down pipe fixing bolts at the bell housing and transmission, depending on your car. These will be rusted, so use LOTS of penetrating spray for a couple of days before. Use the old trick of first tightening a little, then loosening. Heat often helps. Loosen the two bolts holding the manifold bracing bracket to the side of the block under the manifold. The bracket has one bolt into the manifold, and two into the block. This is hard to find and access. You may have to remove the turbo oil supply and return pipes and the oil filter adapter: if so, use new gaskets and o-rings on re-installation. Loosen the EGR pipe into the back of the manifold, if so equipped: this pulls back about a centimeter, but is invariably rusted. You may also have to release the transmission bracket from the down pipe (and maybe the down pipe at the rear) to gain enough clearance to move the manifold; this too is usually rusted solid. Finally, you may have to push or pull the engine toward the driver's side to clear the exhaust manifold studs: use a jack beneath or a puller on the top engine lift at the thermostat. The exhaust manifold gaskets fit into each manifold runner. Needless to say, you should replace all four. If you look closely at the exhaust manifold gaskets you will notice they are not symmetrical: one side is flatter. If the exhaust gasket are rotated 180 degrees when installed, they will burn out in a month or two. Watch how the old ones were fitted. Or just fit them so they appear to match the ports. Each OEM gasket should be stamped "UT" which means "out"; that side (metal) faces toward the manifold and away from the cylinder head.

Exhaust Manifold Gasket Set

On reinstallation, use high-temperature nickel-based antiseize to make life easier next time around. *Turbo Notes.* When you pull out the manifold/turbo, that's the time to replace the turbo/tube and tube/block gasket and O-ring. Even if you don't pull the entire manifold/turbo out to replace the exhaust gasket (best case) the turbo oil tube is a lot easier to reseal with the manifold loosened (and the two bolts holding it onto the turbo removed). How's your 02 sensor? It's easy to get to with the manifold out. *Painting the Manifold?* [Tip from Tom Irwin] Don't paint your exhaust manifolds, even with hi-temp paint, no matter HOW COOL it looks! The paint burns off under the bolt heads and relieves bolt compression. Almost ALL were under torque spec. [Editor] Probably OK to paint IF you don't paint under the bolt heads. *Gasket Replacement:* See the Engine:Turbo section for more detail. [Tip from John Sargent] If you look closely at the exhaust manifold gaskets you will notice they are not symmetrical. If the exhaust gasket are rotated 180 degrees when installed, they will burn out in a month or two. Look at how the old ones were fitted. The Volvo OEM gaskets have the stamp "UT" (or "out" in English) on the metal side, which goes against the manifold, not the cylinder head. The softer fibre side goes against the cylinder head. The Volvo OEM exhaust gaskets, by the way, are of superb quality. The exhaust manifold gaskets fit into each manifold runner and are located by the studs. Do not use sealer. Needless to say, you should replace all four. Retorque to 10-20 ft lbs (14-27 Nm) for B230F/T, 15 ft-lb (20 Nm) for B234F, 7-11 ft lbs (10-15 Nm) for B280F.

B6304 *Engines.* [Walt Poluszny] The six cylinder engine has six separate gaskets (one for each runner) and Volvo recommends a sealing compound. An effective aftermarket compound is Silkolene 762 available from racing shops. Torque the bolts to 18 ft.lbs. I would re-torque after at least one heating/cooling cycle. There's no gasket between the exhaust manifolds and the head pipe. To remove all bolts, I would soak the bolts with a good penetrant the night before (and again in the morning) and only use a 6 point socket. Volvo uses good bolts, they'll come out fine if you take your time.

Leaks in Manifold to Downpipe Joint. This joint has a small gasket (non-turbo engine) which can fail. To remove it, you must remove the special nuts on the studs. Be careful removing these nuts since the studs may break. [Walt Lear] Spray them down with some PBlaster, drive it and get them hot. Then spray again wherever you are going. Do this for a couple of days. Usually come out like butter.[Inquiry] How do I replace broken studs between the exhaust manifold and the downpipe? (Note: if you have a turbo, see this section.) [Rob Bareiss] If a stud on the manifold breaks, it's not as bad as fixing a stud in the head. You can drill right through the manifold to replace them. The flange is exposed on the top side, so you can drill it out and re-tap for M10, or use any bolt that fits the hole. I'm not recommending that a through-bolt is necessarily the best repair, but it will work, and I've seen cars with that fix for a long time. However, in my experience, apply PB Blaster over the course of a few days before attempting the repair, and the nuts will most likely come off OK. Careful with the rear one, it's a bit more of a challenge to get at. Expect to have to apply a pretty strong force to break these loose. Original nuts are 16mm. Replacements could be 15, 16, or 17. Get new copper M10 nuts from FCP Groton or another supplier before starting this job.

Exhaust Brackets Keep Breaking. [Inquiry:] 've replaced the exhaust bracket about three times during the past 5 months every since I replaced the system. The bracket keeps on breaking/splitting at the same exact point all the time. Does anyone know why this is constantly occurring? [Response: Paul Grimshaw] Check your motor mounts. Bad mounts can put greater torsional strain on the pipes. If they're sagging or twisted, replace both of them. Also suggest changing the tranny mount at the same time. Next, loosen all of the pipe joints, replace your bracket. Now lightly wiggle the pipes to find their (untensioned) resting point. Make sure that no areas of the pipe are touching the chassis. Make sure that at full droop, your 740's rear axle is not hitting the cross-over pipe. Now tighten things up carefully. [Response 2: Dana] Make sure you still have the spacing ring in between the two pipes and that all the exhaust flanges are in place and not stretched out to far. I had a problem with my bracket and clamps loosening up every 1000 miles or so. Turned out the bracket was a manufacturing defect and the clamps I used couldn't hack it. [Norm Cook] On the exhaust downpipe, there's a 1" wide strap that fastens the pipe to bell housing bolt. Mine had cracked all of the way through on both sides of bolt hole so it wasn't holding pipe at all and caused an exhaust rattle. This is important to fix as not having it secured at downpipe would place extra strain on the various exhaust and turbo parts. [Tom Kaylor] I think this could be a design error: I broke three of these. Look for failures here.

Exhaust Manifold Cracks and Repairs. [Inquiry] What would be the best way to repair a 90 + turbo exhaust manifold? It is cracked on the backside where the pipes all intersect (area looks like an "X").[Response: Phil Bradley] It is best to find another uncracked manifold. I was told by my machine shop, which is very good, not to bother welding; it would most likely be a temporary repair. If the crack does not yet go all the way through, it is not leaking yet and you may have some time. In that time, get a better one. The 90+ turbo manifolds are prone to cracking. There is some information at Muggy Welding about welded repairs. But realize that there are cast manifolds that see 1200 degrees and there are cast manifold that see 1800 degrees. Turbo manifolds will more likely be the ones seeing 1800 degrees. According to Muggy Welding, turbo manifolds are problematic. While his rods have worked extremely well on non turbo exhaust manifolds, he has had at least one failure on a turbo manifold.

Repair to Catalytic Converter/Engine Pipe Joint Cracks. [Tom Frisardi] To repair cracks at the converter/engine pipe joint, you do not need to replace the components. Volvo sells the flanges for the converter and engine pipe separately from the converter and pipe, but in "split" form, that is they are split axially and tubes are welded to the outside to enable the two flange halves to be fastened with bolts. This clever fix cost me around $30 vs. over $500 for the converter and engine pipe. My only problem, prior to the repair, was that the flanges and bolts had rusted, enough so that the converter was working free from the pipe, causing an exhaust leak. The converter and pipe are still in acceptable condition. I've put a few hundred miles on it, now, and all's well.

Upgrades:

Stock or Performance Exhaust System? [Dick Riess] The advertising would have you believe that larger cat back exhaust systems are a real help on MPG and performance. My experience on two different cars tends to show no difference except for significantly increased noise levels in the vehicle and outside with the sport system. First car was an 87 740GLE NA. I put a 740 turbo exhaust, cat back. Had to have the cat welded to the first muffler and there are no adaptors. No difference noted except interior noise. Replaced with stock this past weekend. Next car was a 93 940 T which I put the IPD sport exhaust on. The noise level was terrible. No real changes in power or MPG. Gave it to son-in-law for his turbo wagon and replaced mine with stock. Son-in-law took it off his car and sold it. Bottom line: Volvo makes a good exhaust system stock. Unless you get into serious performance issues or like noise, stick with stock and save your money.

Front Fender Replacement. [Qeury] How do I take a front wing off, how many bolts are out of sight etc? [Response: Peter Milne] Apart from the six along the top there are two by the door hinges (open door to get at them) one at bottom of rear portion of wheel arch and two under the side bumper extension. I think they are all 10mm head size. [Editor] The two behind the bumper cover extension may require that it be removed. Use some body sealer on the top of the fender mount to limit vibration and squeeks when reinstalling.

Bumper Cover Removal. [Inquiry] How do I remove the plastic bumper cover? [Editor] These are generally held in place either by plastic rivets on both top and bottom or by inner bolts behind the side extensions. To remove the rivets easily, drill out the center pin and then pry them off. Buy replacements at an auto store or from your dealer. On some bumpers, the rivets are covered by a separate plastic molding which is held in place by five or six spring clips. These are tough to remove: you have to work from below or behind to pry up the small flat insert securing the molding and then pry off the clip. Be careful: the replacement molding is around $180.

Grill Lower Tab Repair. [Tip from Neal Abramson] Part of participating in the Brooklyn parking wars is having your front grill pushed in by some big SUV's rear bumper. As a result the lower mounting tabs are broken & the grill falls out because there is nothing holding the lower half. I found a solution. I screw plastic license plate bolts (available from auto parts stores) in the lower mounting holes & slots in the front lower body panel with the bolt end facing up. I then file down what is left of the broken grill tabs on the bottom of the grill & then drill a hole that is a little bigger than 1/4 inch where the tab used to be. With the bolt end of the license plate fasteners facing up they go into the new holes & you have a good new mounting for your grill without having to replace it.

Rust Locations. For 700/900 series owners, here's where they can rot:

1. *Various Spots*. [UK] Inside the boot, there is a sort of pocket, either side, presumably for carrying water/things etc. This can rot through to the outside world and totally disintegrate. The sill drainage holes get bunged up and the sills rot towards the front of the car (especially where the sill meets the bottom of the front wing). Right underneath where the transmission meets the motor, look to the left and right and you can see the chassis box sections or arms / runners or whatever you call them, they rot from the inside out due to plugged drainage holes probably. Next take up the carpet behind the brake/accelerator, look up a little and there is a seam on the lower bulkhead or firewall and that can rot splendidly. They also go on the inside of the roof where the sun roof slides back. Another nice place to hunt the rust is the A pillar, which can rust quite badly behind the chrome trim, which is, of course pop-riveted on so it is a bastard to put back once off. Apart from that they are not too bad. At least when they are welded up there is something to weld to, which is never the case with a British/French/Italian car. [Note: see comments in "Doors" for reputed seam rust in rear doors.] [DaveM] All the corners of all the box sections can rust: look closely for bubbled underseal in the corners. Look at the mounting points on the rear axle, as there is a narrow gap between this and the inner sill located just forward of either rear wheel . The inner sill rusts.

2. *Frame Rails at Strut Linkage.* [Tip from Stefan, Minnesota] A common place for our 700's to rust is where the strut linkage attaches to the frame rails of the car. I first investigated my '87 740 (Minnesota car with lots of salt) when I found lots of front suspension vibration. It is visible if you turn your wheel and look in the wheel well - the bracket that has 45 degree towards the rear of the car. at that point where it attaches to the frame - the car will rust from the inside out. Your only evidence will be a slightly bubbled undercoating. (as mine was) I took the initative to scrape off the undercoating to find a nice hole there. the more I picked, the more swiss-cheese like it got... As I scraped and peeled back the undercoating - I found a 5" long crack in the frame that was about 1/4" wide and was "spiderwebbing" away from the main crack. The frame was ready to literally rip apart on the next big bump I hit. Totally scary! A welder was able to weld up the crack & re-inforce the frame with cold-rolled steel plates. As I drove the car home - it was totally vibration free.

3.*Fender Guard Joints.* [Chris Herbst, Chicago] A common area for rust on the 700 is where the inner fender guard meets the quarter panel. If the bolt isn't put in, or is loose, then the quarter panel vibrates at speed and scrapes the paint off of the joint area. Make sure the bolt in that area gets fastened properly, but don't seal it since it can trap moisture. [DaveM] There is a seam on the OUTSIDE of the wheel arch exposed to all the elements; water can force the seams apart from the outside. Look up into the wheel arch towards the windscreen and look at the seam which may have started lifting and allowing water into the footwells of the car. This applies to the rear footwells as well.

4. *Door Window Frames.* [Herb Goltz, Ontario] I am seeing plenty of 940s that are rusting at the base of the door window frame on the inside (back edge of front doors above the beltline behind the glass, rear doors in the same place but in front of the glass). It starts in the rolled metal seam, but spreads widely. In some cases, this rust is actually bubbling through to the exterior. It is a strange place to rust. I have scraped mine out carefully and am planning on getting some POR-15 onto all those areas.[Northeastern US] With the rear door closed you cannot see the areas involved. If you consider the door closed, you can see the outside and the inside of the door, the inside with the trim on. When you open the door, please look at what would be called the side or the place where stickers get put, or the mate to the striker plate. Now the Volvo door is really made of 2 major parts. The main part of the door being the bulk of it, and a piece of metal which frames the window and provides the track for the window to be held in place when it is up. It is at the place where this metal frame joins the door where it is welded, and has some manufacturers putty put over it. Another description is to open the door and look at the ends right below the molding that fits below the window. You should see a weld seam there. I have seen cracking/or rust at just the ends of the door toward the rear of the car, and have seen cars that have cracking on both ends on all four doors usually. Poll results on Northeastern cars: >91 940 1 OK> 93 940 2 OK; >93 940 11 BAD; >94 940 2 BAD 1 OK

5. *940 Frame Rails/Firewall Seams.* This last weekend I went shopping for another 945. I saw a nice one, a 94 but was shocked to see RUST on it. So I checked my 94 945 and it had the same rust in the same place. Open hood, look inside on passenger side right where all the brake lines get channeled together heading back to the rear. There is a seam/junction of metals and it was rusting all along there!!!!! Geeeesh, at least my 240's waited 8-9 years before they started to show rust. A sample of 2 isn't great, so check it out. [Tip from Ed Kuczynski] Just bought another 94 945. And while researching found a weakness in the 945's. Look for rust on the firewall in the engine bay, passenger side mainly, along a seam thats fairly low on the firewall. I've seen SEVERAL that have light rust coming from the seams. Also in the engine compartment, again mainly on the passenger side, on the horizontal "frame" members where 2 pieces of metal form a joint. Out of about a dozen 93-95's, most of them had this problem.

6. *Fuel Sender Assembly Top*. [Editor] While the tank itself is plastic, the fuel sender assembly top is steel and is so designed and located that it will definitely rust. See the FAQ notes on preventing this when you remove this unit to replace a fuel pump or hose. A replacement assembly is over $350.

Aluminum Tailgate Corrosion. [Inquiry:] No rust on the 88 745 but the rear tailgate has a small area of bubbled paint around door latch. looks like aluminum tailgate is pitted under the paint. I know aluminum doesn't rust but not sure how to refinish AL? Anyone have suggestions on how to refinish aluminum tailgate and repaint the area? [Response: MikeH] Go to your local auto paint supply house; I used a local chain store called Mateus. Found them in the yellow pages. There is a special, self etching primer made for aluminum. They should know what I'm talking about, if they don't, go to another store. Sand the corrosion to bare metal, clean, prime with the self etching primer and paint. It's been awhile since I have done any painting ie years, but I still had my spray gun. I used lacquor since this was a driveway paint booth and I wanted something that would dry fast before the bugs and other trash settled on the paint. I ended up sanding with fine paper to get the runs and orange peal out but I finally got it right after several tries. They even got very close to matching the silver paint from the paint code!

Rustproofing Products. [Tips from Dave Gayman] As a non-welder, I've put together a stable of substances for beating rust. I'll throw this out to the group for additions, edits, diatribes, etc. I don't have any financial interest in any of the brands, worse luck.
2-part solutions:

- epoxy (any brand, any type except 5-minute, which isn't really strong or waterproof; I prefer marine type at any good boat accessory supplier; silica dust [thickener] can be added to make putty-like goo)

1-part solutions:

- POR-15 paint (http://www.por-15.com; great stuff, takes hours of preparation and dousing with POR's Metal-Ready [zinc sulfate, I think], makes up for lost sheetmetal when you soak fiberglass mat or cloth with it; cures to tough, pliable surface)
- Corrosion-X regular (http://www.corrosionx.com; consistency of salad oil, doubles as very effective penetrating oil; doesn't evaporate)
- Corrosion-X heavy duty (http://www.corrosionx.com; consistency of thin mayonnaise)
- Corrosion-X MaxWax (http://www.corrosionx.com; dries to soft, pliable wax; eventually wears off when used externally, but is good substitute for POR-15 when you can't reach areas for thorough preparation
- NOTE: I order my Corrosion-X stuff on the East coast through:
  Bill Brown, TownDockCX@aol.com, 1-888-746-5679
- Waxoyl Underbody Protector (in the US: http://www.waxoylus.com/; black, strong-smelling mix of solvent, wax, and bitumen [tar] with consistency of pancake syrup; the Brits -- MG, Rover, Triumph owners -- love this stuff; eventually wears off)
- PL polyurethane roof & flashing sealant (http://www.osisealants.com; available at Home Depot; fantastic stuff for gunk-plugging leaky seams, but takes a week or more to fully cure; I doubt this stuff will wear off)
- Polyurethane expanding foam (Home Depot; don't get latex-based type; in one application, this appeared to be slightly susceptible to water, a problem; nice for backing Bondo stuff where gaps and holes would result in several pounds of Bondo inches thick; tender surface, must be finished)
- RTV -- life without silicone seals and adhesives would not be worth living -- GE Silicone II

appears not to give off acetic acid during cure, but I don't know that for sure.

To avoid:

- Ultraviolet-curing Bondo (probably operator error on my part, but seems too thin, and it definitely cannot be applied except in the dark -- any sunlight during application results in scummy, knobby surface)

For POR rust proofing products, check out http://www.por15.com/

Ziebart-Like Spray Application Rust proofs:

[Other Tips:] The Rust-Check Product (only in Canada) is excellent. I recall seeing a promotion recently to have a car done in Toronto for $99. I don't know the exact contents, but it is an oil-type substance that they squirt into the un-seen panels of the car. Holes are drilled in strategic locations, and later filled with rubber/plastic plugs to make this possible. Be prepare for the car exterior to be a bit drippy/greasy for a few days after you get it back from the treatment. Just park it on the lawn instead of in the driveway for few days. [Does not trap moisture like solidifying treatments like Ziebart.] http://www.rustcheck.com/

[Editor:] Much controversy among Canadians on the alt.volvo BBS seems to favor Krown over Rust Check for reasons of quality.

	Actuator in a 940 Remote Entry Malfunction Remote Door Lock Range Extender

Door Operation and Troubleshooting:

Door Hinge/Lock Preventive Maintenance.

Hinge Lubrication. [Inquiry] The driver's door on my wife's 940 has resisted all efforts at lubrication. It continues to make those horrible 'CRACK-CRACK' noises as it moves through the two opening detents. I've squirted lithium grease all over everything, including inside the little grease fitting, but to no avail. [Response] My 'CRACK-CRACK' noise turned out to be produced by the location where the torsion spring passes through the hinge plate that is attached to the body. The minute amount of rotation by the spring in the hinge plate is what was causing the creaking and not the wheels. Squirt some motor oil on top of the torsion spring in such a way that the oil runs toward the hole in the plate that houses the torsion spring. Don't forget the hinges. [Dan R] There are two of those torsion springs on the lower hinge. It is the one you can not see that is causing the noise. It is on the far side of the hinge, and is lubricated from the the bottom. I use lithium grease from a spray can that has a straw over the plastic tube that comes with the can. [Paul Kane] Try Lubriplate. [Dick Riess] If the spring is lifted slightly, it seems to cure the problem. Just use a large screwdriver and raise it a quarter inch or so and problem seems to go away. Good time to lube the hinges and spring also.

Door Lock Lubrication. [Editor] Lock cylinders and lock mechanisms collect dirt in their original grease which hardens over time. To keep them operating, lubricate twice yearly. Do NOT use WD-40 or the like to lube your locks. I use Mobil 1 spray lube (tough to find). CRC makes some superior clear synthetic lubes as does Valvoline. I am not a fan of graphite lubes: I have had frozen locks on GM cars when I've used them and they are messy. Lube the lock cylinders and the inside mechanism using the spray tube on the aerosol can. Spray a little lube inside the lock and then work the key. Use silicone spray on the rubber stripping between the frame and doors. Water can enter the dirt on this strip and freeze, holding the door quite securely shut. Spray it on then wipe off with a rag to remove both excess carrier and any dirt on the weatherstripping. This seems to prolong its life as well.

If, in spite of regular lubrication, your door lock freezes in the winter, use spray isopropyl alcohol in the little "door lock unfreezer" aerosols available at auto stores.

Electric Window and Door Lock Problems. See the FAQ files on Body Glass and Electrical Circuits for more information.

Driver’s Door Won’t Unlock.

Electric Switch Malfunction. [Inquiry:] I can’t unlock the drive’s door from the keylock. I have to go to the passenger side, unlock the passenger side door, reach over and pull up the lock knob on the driver's door, which activates the power door lock system, apparently indicating that the system itself is fine. The system simply won't operate from the external switch on the driver's door. [Response:] The outside driver's keylock should mechanically unlock the drivers door even if the central lock system has failed. If it simply will not unlock the rest of the doors, then the problem is likely either in the switch mounted in the door, the central locking relay, fuse, or wiring between the driver's door and the relay panel.
If the driver's door will not mechanically unlock from the outside, then there is a mechanical problem between the lock cylinder and the lock mechanism or a problem within the lock cylinder itself.
The driver's door switch is actually pretty easy to replace if that is the culprit - just remove the door interior panel and you will find a small rectangular plastic box screwed to the inside of the metal panel near the lock mechanism. There is a rod connected to it from the lock mechanism. If it is bad and you are going to replace it, consider getting the later combined switch and lock motor from a later (~95 or so) 900. The earlier cars have only a switch in this location, but the box looks identical to a lock motor with the exception of a couple of extra wires. This will enable you to later add an alarm system with remote locking if you wish (you will have to run a couple of additional wires for the lock motor to connect it to the alarm system - your car may even be pre-wired for the motor)

Mechanical Link Rod Malfunction. [Inquiry] My driver's door handle is not working. When you press it nothing happens, I have to open it from the inside. [Response: Paul] The door handle may have come off the link rod. You'll need to remove the trim panel, then the screws that secure the handle. There is a plastic piece on the door handle that hooks to the rod. You can remove the plastic piece from the handle by removing the pin that secures it to the handle. Note the position of the plastic piece which can be improperly reversed. Hook the plastic piece to the rod then reattach the piece to the handle.

Door Locks Fail to Lock. [Inquiry:] All of a sudden the function which allows me to lock all doors/ rear wagon hatch has stopped. If you push down on the drivers door lock only the drivers door will lock....BUT after locking all the doors, you can unlock them by the driver's door. Where do I start in diagnosing and curing this ? [Response: John Sargent] Look at two potential faults:

Switch Defect. There is a switch on the push/pull rod the is actauted by the knob on the driver's door. Remove the driver's door panel. Locate this switch and manipulate it by hand. There are one or two screws that secure the switch to the inside of the drivers door. You probably need to adjust the switch.

Relay Fault. There is one Central Locking Relay for both the lock and unlock functions. If the door fails to lock, then the timer circuit for the locking function may be bad. The relay is momentary in action and when you operate the switch manually, the locking coils are only held for less than a second. You need to replace the relay. I have had good luck with used ones. You didn't state what model year of 700 series, but 1986 and later use the same relay and it is located in the Central Electrical Unit in the lower left of the relay block and has a K on it. . For 1983-85 model years, the locking relay is in the driver's door and integral with the switch which controls it.

Door Locks Frozen. [Inquiry] My door locks regularly freeze. How can I prevent this? [Responses: Jay Simkin/Editor/Gord Hull] Spray some high-quality oil into the locks to ensure that water is displaced and they will operate: Valvoline Synpower Spray, CRC, etc. Stay away from graphite powder lock lubricants - the graphite can "pile up" after a while. With your car in the warm garage - or even outside if it is above freezing - insert the straw-like nozzle from the spray lube into the keyway - (open the little door that covers the keyway)- spray a short squirt into the key way - insert your key -and work it back and forth a few times. repeat 2 or 3 times each lock. WD-40 is a mild solvent-based lubricant - it will dissolve any oily build up in the tumblers. Any small amount that drips on the paint can be wiped off. While you are at it - get a light spray lubricant and lube the working/moving parts of the latch whre it catches onto the door-frame. If you do this once or twice a year you should have many trouble free years.

Your locks may be "gummed up" with oil-based lubricants, which get very "sticky", in extreme cold. If a synthetic-based lubricant does not free-up the locks, try to find a Teflon lubricant. An auto supply store should have this item: I do not know of a specific brand, as I have some cans bought years ago. You will need to warm the lock, to liquefy the petroleum-based lubricant, so that it can be displaced by a synthetic lubricant or a teflon-based lubricant. You can warm the lock mechanism with a hair dryer and also be heating the key, and putting it into the lock. When using the hair dryer, be careful with regard to the paint. Keep the hair dryer on "medium". To avoid frozen water from window strip leaks which can drip down and freeze on the lock rods, spray the lubricant into the lock and latch mechanism and rods when you have the door panel off.

Door Handle Fails to Operate. *Symptom:* On my 960, I couldn't open the door. The internal cam actuator was broken and would not operate the wire pull hooked to it to open the door. *Repair:* Instead of buying a new handle or a used one from another 960, I took the plastic cam off a 740 model handle and transplanted it on my unit with the broken cam. I removed the cam by using vice grips to remove the axis pin. I then transplanted the pin and cam into my existing handle, ,reinstalled it back into the car and now it works fine. As it happens, the cam is universal and will fit either right hand or left hand door handles (740, 940 or 960) just by reversing it. If searching in a yard for the cam part, obtain one from a rear door with much less wear. [John Davies] One problem that affects 700 and 900 series cars as they get older is the doorlock failing to latch, or, worse, opening to the first 'safety' position whilst driving along. If this happens, you can often repair this by simply replacing the 'outer' part of the door lock with one from a scrap car. The 'outer' contains return springs, latches etc, and is a sealed unit - it is held on by two 'torx' screws, and can be removed in seconds. The 'inner' part of the lock is located by a screw hidden behind the 'outer' and will therefore stay put during the operation. The 'inner' part of the lock inside the door is less likely to wear through opening and closing the door as the principle strain falls on the 'outer' - if the handles and the key operate the lock properly then the 'inner' part is probably fine. The front and rear 'outers' (although not the inners) are the same, so it is a good idea to take a replacement from the rear of a car as it will have done less work.

Door Contact Switches. See FAQ description of operation and rebuild.

Rear Door Lock Won't Release. [Symptom:'85 760; right rear door will not unlock. Both the power locks or manual will not unlock the door. The knob goes up and down but the door refuses to open.]
[Tip No 1; Requires Door Trim Removal:] I fixed this same problem just yesterday! Remove the trim which holds the speaker and unscrew the locking button, then there is one or 2 screws to be removed (the thing had been messed around with by previous owner so I don't know.) Pull the remaining trim up until it unlatches then pull it outward to remove it. Pull up the locking control as far as it goes then look through the hole so you can see the locking mechanism and watch the little part which moves sideways when you try to lock and unlock it. Then push it towards the inside of the car (you may have to "wriggle" it a bit) while pulling on the lock switch. The door should then unlock and you can open it. Remove the lock with an allen key and detach the control arms and thoroughly lubricate it with some oil/ grease/ or equivalent. You may have to remove the seat by pushing it back hard then pulling it up at each side then sliding it out, in order to remove the door trim. [Tip from Ursula: Requires That You Merely Move the Trim Panel to Access Lock] This is how I got the stuck rear passenger side door open without destroying the panel. First, lower the window. Slide a putty knife between the rubber moulding and the inside door frame and pried it away from the frame -- just enough to open it, but not crack the door panel (which is not as fragile as one might think I came to learn). Pulled the door panel toward the inside enough to see down in there, and I was able to wiggle a metal-hanger-sized bar, located about four inches down from the top of the door frame itself ON THE INSIDE of the door frame that ran vertically from the lock mechanism back to the lock at the end of the door. What was causing the door not to open was that bar had come off of the little rubber inset guide tracks that hold it in a completely vertical position so that it puts enough tension on the release end to unlock the door. VOLVO must have designed it to work within centimeters of proper alignment. Anyway, once I held it completely straight and pushed the door release button on the outside of the door -- VOILA! -- the sound of an opening door! So I just bent the bar inward so that it would sit nicely in the little black rubber guides (there are two of them, spaced about 10 inches or so apart), and the door open and closed and all is right in the world again.

Door Hinges

Spring Broken. [Inquiry] The inverted 'U' spring that holds the door open is broken in my 740.

Has anyone replaced it? [Response: Bob/J. Daigle] The inverted U spring is part of the hinge. You need to replace the hinge. Remove the trim from the driver's side footwell to access the bolts holding the hinge to the frame. Support the door. Unbolt hinge from door and body. Be prepared to spend a little bit getting the alignment of the door right after replacing the hinge. Not too difficult. You may be able to get a used hinge, if lucky, the same color as your car. Try some of the better salvage yards.

Spring Lubrication. [Tip from Todd] The front door hinges on my 1990 wagon kept making noises everytime I would open or shut the doors. I tried everything from oil to some kind of grease and found they would work for a week or two at most. I used Mobil 1 synthetic differential fluid on my door hinges and they have been noise free for about 6 or 7 months. [Editor] The springs are the u-shaped rods that extend up and over, down into a pocket on the pillar. Lubricate the pillar side as well as the small wheels.

Door Replacement and Interchangability. [Tip from Jim Bowers] If you go to your Volvo parts guy, the replacement doors for almost any 4 door 700 will be the same part number. I replaced a driver's door and a right rear door on my '85 when they got rusty. The driver's door came from a '89 and the RR from a '90 as I remember. The driver's door was rusty because some previous owner had damaged the original '85 and put a '82 door on it. You may have to drill a small hole to hold a plastic snap or something. Internal parts such as locks, wires, etc. will likely need to be transferred. Been there, done that!

Door Handles

Door Handle Removal. [Tip from Bob Hoen] I have had the occasion to replace several door handles on 700/900 series vehicles. The tricky part is getting the nut off inside the door while the bolt is spinning in the plastic housing. After trying several different methods, I hit on one that works very well. After removing the outer handle cover,I heat (with a torch) a cheap 1/4 in. drive 10mm socket to the point it will melt into the plastic, and onto the bolt head, the rest of the job is just remove and replace.

960/90 Series. See the FAQ reprint in pdf form for diagrams explaining 960/90 door panel removal and handle repairs.

Interchangeability. [Inquiry] Has anyone fit the 960 paintable doorhandles to a 740 with similar doors? [Response:JLG] You can use 960 door handles on a 740 with no modifications. My friend who is a mechanic at my local dealer is doing this right now. He purchased his from a VOLVO wrecking yard.

Fuel Door:

Fuel Door and Hinge Repair. [Inquiry:] Trying to replace the plastic bracket for the gas tank door. I removed the old one by popping it off with a screwdriver. Not sure if that was the right way to do it. I was told by the parts tech that the new one just pops on. The problem is that is does not attach firmly. Did I do some thing wrong taking the old one off? The four holes are bare metal. Do I need to use some type of adhesive? [Response: Robert Abel] You don't need glue - the spring tension of the bracket holds it in. It is a bit tricky - seems like I had to look at my other Volvo to see how it went in - see if you can see another 940 or 740 somewhere and note how it's assembled.

Removing/Repairing Gas Filler Door Hinge: [Tip from Bill Peyton] The gas door hinge will break if pushed forward. This is usually done by moving around the car with the door open, or by curious children. The repair job can be done completely from the exterior. The black plastic hinge is held in place by four plastic rods. When pushed through the body of the car, they expand four rubber sleeves located on the interior, thereby holding the whole thing in place.

Fuel Door Hinge

Replace as follows:
Open the door, and using a small punch, push the four plastic rods through to the interior of the car. The door will now come out. Note the position of the spring and the hinge. Remove the spring from the old hinge, and either cut or pry our the old hinge. This is a black plastic piece. The ends of the new hinge are tapered to make it easier to insert into the gas door. Clip the spring back into place.
Now for the hard part. You will see on the new hinge four plastic rods. These are held onto the hinge by four small connections, all molded into a single piece. On the other side of the hinge are four plastic “flowers” split into four pieces. You will need to push the plastic rods through the “flowers”, once the “flowers” are pushed through to the interior of the car. Since the rods are not free floating, they tend to break off and fly away unless you hit them squarely. If this happens, put a little taper in the ends, place them back in the hold, and push them through. A punch and a hammer will be essential. Alternatively, you can break the rods off while the piece is off the car, insert them manually, and drive them in again with the punch.
[Inquiry:] Over the winter one of the little pegs on my fuel door hinge broke and now the door is off. I just sent for, and received, a new hinge... and, just looking at it, I can't really tell how it goes on. Are those little plastic posts rivots? Do I put this in with a rivot gun or something? [Response: Rob Abel] it does look confusing at first. If you did not remove your broken hinge, hold the new one up near the broken one so you can get the orientation right. No, you don't need a rivet gun. The connectors are akin to the mollies that you use in your house to hang a picture on wallboard. You position the "pegs" in the holes in the sheet metal, then tap in the smaller driver nails, which expands the connector to hold the hinge firm against the metal. I had the luxury of having another Volvo sitting next to the one on which I was replacing the hinge. Looking at an intact one made the difference for me. Maybe you can find another car and inspect the installation.

Water Problems. [Inquiry] Water collects inside the filler door, in the gasket recesses.

[Response: DanR/Colin Shepherd] I would bet that some debris or mud has blocked the end of the drain tube on the underside of the car.There should be a small drain hole at the bottom of the rubber seal around the filler neck with a 1/4 inch plastic tube pushed into the rubber boot hole draining down to the outside just rearward of the L/H/R wheel. The best way to clear it is to blow it through with an airline from the bottom. If you blow from the top it may push the pipe out of the rubber. If this happens just remove the trim and push the pipe back in.

Trunk/Boot:

Trunk Lock.

Valet Key. My trunk is locked shut: I only have the valet key and can't open it. [Response: Rob Bareiss] Either go to the dealer Parts department with your VIN # in hand, and have them punch out a new key, or, take your valet key to any shop that cuts keys and have them copy that onto the normal key blank. The replacement blanks sold by your typical hardware stores are a full-cut key, not the odd valet key. That will let you into the trunk without getting creative.

Broken or Stuck Lock. [Tips from John Rundle]

740/760 Cars. The secret to entry into a 700 series trunk after the locking mechanism fails (in the locked position .. of course) is two fold. It turns out that the lower locking mechanism is secured to the lower trunk lip with two bolts that are accessible through the fold-down ski-hole in the rear seat with three or four 12" extensions and a 10mm socket. After removing the two bolts the trunk can then be opened with the upper and lower portions still mated and the upper portion of the locking mechanism can then be removed from the trunk by removing three 10mm bolts (only one of them is accessible via the ski-hole as access to the other two is blocked by the closed trunk). When you raise the trunk lid the lower portion of the locking mechanism may bind on the plastic/vinyl trim that covers the lower lip, but a little effort will free it and any damage to the trim is less severe than cutting/drilling the trunk. The upper portion of the locking mechanism is covered by a plastic/vinyl cover/boot .   Which leads to the second method of entry. If this plastic/vinyl cover has been removed you can insert the same three or four 12" extensions (3/8" drive) into the opening on the left side (as you look through the ski-hole) of the upper locking mechanism and release the spring trigger by pressing it towards the right (driver's) side. If the cover/boot has not been removed in advance (as mine was) you will not be able to use this approach.

940/960 Cars. [Tip from Tony Diamond] The usual problem is that the lock control arm, extending from the lock cylinder to the lock itself, has come loose. This is unfortunately covered by the plastic boot trim and is not accessible through the ski hatch opening. You can try two approaches. Easy, risk free: remove the rear seat, climb into the trunk, remove the trim, and repair the lock. Brute Force: A friend with the same car allowed me to dismantle the trim in the trunk to see what was inside. I measured the position of the arm in relation to the rear panel, I then drilled a hole behind the rear number plate and was able to recover the loose end of the control arm with a wire coat hanger and then tugged it open with a pair of long nosed grips. The hole was 25mm and was treated and sealed with a rubber grommet and is unseen under the number plate.

Trunk/Boot Adjustment. [Inquiry] My trunk leaks at the rear window. The trunk lid appears to sit a few mm too high at the front allowing water to pass by the seal. I have read that there is an adjustment on the hinge but I cannot figure out how to access it. [Response: Editor] To adjust the trunk/boot on sedans/saloons:

- Front Edge adjustment: -Remove the seat belt retractor covers and use an Allen wrench to adjust the trunk/boot
- Rear Height adjustment: -Loosen screws to striker plate in rear frame and move it up or down or sideways as required.
- Front Height Adjustment: -Loosen the bolt holding the trunk lid on end of the hinge and move it accordingly

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Trunk/Boot Struts. [Inquiry]My trunk lid will not stay up in winter. [Response: Ed] You need new lid struts. I replaced the struts on my 87 740 in all of five minutes. The rear strut end on the lid has a spring clip on it: use a needle-nose pliers or screwdriver to take it off, then pop it off the ball stud holding it. The front end fits into a notch on the back of the rear seat panel.

Tailgate:

Tailgate Will Not Stay Up: Struts. [Inquiry] My rear hatch will not stay up...almost as if the gas in the 2 arms that hold it up will not provide enough resistance to hold it open. How to repair? [Response: Bob/Rob Bareiss] The two lift struts are the only support and need to be replaced. They are available aftermarket at most auto stores and on line. It is very common for the mounting studs at the body to wear, so be prepared for possible replacement of those as well. They screw out. To replace the struts, prop up the tailgate. Spray a little penetrating oil on the sockets. The strut is held on by a spring clip on the outside of the socket at the end of the strut; once you pry that off it pulls off the ball. A small screwdriver is a good tool for the spring clip. Don't let it fly away and get lost. Just snap the new one on over the ball.

Tailgate Panel Removal. [Inquiry:] My 93 945T has an annoying rattle in the tailgate caused by a missing screw in the brake light bracket. The screw is driven from beneath the bracket. This requires a removal of the entire panel. The lower trim screws are self explanatory, but how does one completely release the upper part? [Response:] This entire assembly has fragile plastic parts. See the section Removing/Repairing Tailgate Panel for complete instructions and for a discussion of a repair kit for loose fasteners.

Rear Tailgate Latch Won't Open.

Lubrication Problems. The problem with the latch is that it takes a lot of moisture from the backdraft. The problem is likely one of two things. In either case you need to remove the back inner panel. carefully remove the rods that connect the electric lock piston (small plastic clip slides sideways) to the outer handle mechanism, and the rod that goes to the lower latch. Now remove the four 12mm nuts that hold the handle from the inside and pull the handle out (you'll need to disconnect the wires for your license plate lights. Now pull the rubber protective seal off the back. Generously lubricate the handle and make sure it's free to return to it's outward resting position, if it stays depressed after you close the gate, the lock will not respond to the electric lock mechanism. while you have it apart, lube the pivoting metal part on the handle to which the electric lock is connected. Reinstall it all and you're all set. I would also consider taking apart the rod that goes through the rear window for your rear wiper. They need greasing every two years or they seize and fry the wiper motor.

Broken Pieces or Stuck Mechanism.
Stuck Due to Cold. [Tom Kaylor] The internal mechanism sometimes sticks from winter cold. Push the outside latch handle all the way forward, then operate the central door locks several times. If the outside latch handle is not returning the mechanism won't engage. Free it up with good penetrating oil.
Broken or Stuck Parts.[John Randle] The symptom was that the latch would operate .. but not far enough to release the locking mechanism so that the tail gate could open. It turned out that a piece of the black plastic guard that goes around the latch had broken off (old age) and lodged under the latch ... I had to remove the trim panel and then disconnect the exterior latch actuator rod as well as the exterior key lock actuator rod inside the tail gate from the latch mechanism. Next I used a 12mm socket with a universal joint to remove two of the 4 bolts holding the latch mechanism to the tail gate and then I used a 12mm offset box wrench to remove the other two bolts. Once that was accomplished I was able to push the tail gate out enough to force the latch open with a common screw driver (compressing the piece of plastic that was lodged in the mechanism) and completely open the tail gate and then remove the latch ... where I then found the stray piece of plastic. Reassembly was straight forward. [Becky Gilbert] Problem: rear tailgate won't latch. You hear the sound of metal meeting metal. The latch has turned too far and is no longer in an open position to accept the bar at the bottom of the rear of the car. Solution: WD-40 and a screwdriver. It takes me a little while to remember which side opens: the hinge is shaped like a C and opens to the right. A little coaxing from inside the right end of the hinge loosens the stuck part and it opens up nicely!! Easy fix and no taking apart of the tailgate!

Loose Rear Latch Handle; Lock Adjustment. [Eric Carlson] Neither the power lock nor the key would unlock my tailgate hatch. Occasionally, I was able to jiggle the lock enough with the key to unlock it, but as soon as I shut the hatch again, it wouldn't unlock. I discovered that the latch handle has to be in the fully returned position (i.e. completely pushed forward towards the hatch) and over the years, the handle didn't quite reset itself. As a result, the lock won't unlock and the key won't turn. If you push the handle towards the hatch and jiggle the key, you can feel the two working against each other. To repair it, remove the inner tailgate panel. Follow the lock assembly inside the tailgate hatch from the lock to the latch - you will see two bars; one is for the unlocking mechanism, the other is for the outside latch handle. If you squeeze the latch from the outside, you will see the latch handle bar move upwards. On the latch handle bar, just behind one of the hatch frame members, you will see a two-piece unit connected by a turnbuckle. With a pair of pliers, rotate the turnbuckle to tighten the rod (effectively shortening the rod and causing the handle mechanism to tighten). One or two complete turns should be sufficient as too much will cause the handle to bind and not open. Be sure to lube everything while you are in there.[Symptom] The outer tailgate latch won't open the gate from outside. I have to crawl over the rear seats and open it from inside. [Jim Weiss] The vertical connecting rod between the lock/handle and the bottom latch has a small fitting in the middle with opposite threads that connects the two parts of the rod. It was easier for me to detach the top end, being careful not to break the plastic retainer clip, and adjust the length by turning the upper rod in the "mini-turnbuckle-like" fitting. It's also a good opportunity to clean and grease the moving parts.

Tailgate Replacement. [Inquiry] Having damaged my wagon's tailgate, how do I remove the old one and install and align the new one correctly? [Response: Paul Golden] I have done this replacement and all it takes is a little patience. Open the hatch, remove the 6 screws for the filler panel, the black piece that runs left and right. Remove the rear interior light: you will see a 1cm space to pry the light on the left side, pull down in an arc to unhook the right side. Remove the wires from light. In the middle of the light pocket you will see a black push pin, turn 1/4 of turn and remove. Using a coin or large flat tip screwdriver, remove the interior panel rivets which screw off, saving the middle ones for last. The connector for the hatch is to the drivers side: disconnect and then remove the torx screw that holds the wire under the black panel you have removed. Gently push the rubber grommet toward the back and pull wiring through the hole. Disconnect the washer hose at hinge. Place some corrugated cardboard under the lip of raised hatch, remove bolt caps. Remove the bottom bolts covered by the rubber flush caps. Pull the lock circlips on the hatch struts, push on the right side, swivel and pull out of the small hole. Now you need another person to hold the hatch while you remove the bolt on helper's side. Remove the bolt on your side and slide the hatch out and up off the hinge. Do the opposite to replace.

Trim:

Inner Door Panel Removal.

740/760/940 Cars. [Tip from Dean et al] Taking off the door panels is a snap after you have done it once. There are only six quick steps to getting the door panel off.

1. Unscrew the door lock stem.
2. Examine the end of the door near latch. In later models, the red warning light lens at the rear of door doubles as a clip, in which case you can gently pry it off; in earlier models, remove both the lens and the clip inside. Remove the bulb. You will see a little black knob on the left wall of the little white box. The little knob is a catch that holds the door on.
3. Turn the plastic screw at the bottom of the door handle "cup" 1/4 turn and remove it.
4. At the top of the spade-style door handle you will see a tiny hole on top of a rubber plug. Insert a piece of sturdy wire, or better yet, a nail and the plug pops out (it is a little tedious to get out.) Then remove the screw you find under the plug.and remove the handle. You may have two screws behind a fake leather panel on the door handle.
5. If you want to remove the switch panel, lift out the whole "cup", levering it carefully past the carpet or leather insert.
6. In '88 models, pull the speaker cover straight out and remove the screw beneath; in '89+ models, slide it forward, off the clips.
7. Use a flat screwdriver to remove the three clips (two in pre-'87 cars) along the bottom horizontal edge of the door (look upwards under the door: if you have the white clips, skip the next sentence.) Slide a thin flat butter knife under the edge of the door panel and slide it up or down until it is stopped by one of the snaps, then gently twist the knife and gently pull on the door panel until it snaps loose. If you have the white door clips, use a screwdriver to lever them downwards.
8. For pre-'87 cars: there are three snap plugs that also hold the inside door panel to the door. Two are in front of the speaker grill (top and bottom), and one about 5 inches below the door edge lamp. Pull out firmly on the bottom of the door and the plugs should unsnap from the door.
9. Now you can grasp the door panel by the sides: lift up and out. Pull out on the bottom of the door panel and push upwards. You must rise high enough to clear the door handle, but keep an eye on the electrical connection that will present itself. As soon as you can, unplug the wiring and lift the door panel completely away from the door/body. As you fit the panel back in you may find that it doesn't seem fully attached along the outer edge. This is where the little black knob mentioned earlier comes in. Look inside the white box and make sure that the knob protrudes into it. Check that the knobs holding the speaker covers are also correctly protruding from their holes in the panel.. You may find it tough to engage all the spring clips along the top edge back into the recess in the door frame. Push to do this.
10. Then reassemble the rest in reverse order.

960 Cars.

1. Pry off the trim around the interior door opener and the cover in the handle recess.
2. Remove screws beneath cover.
3. Pull up window switch control panel.
4. Pry off door warning lamp cover.
5. Use a flat screwdriver to remove the three clips (two in pre-'87 cars) along the bottom horizontal edge of the door (look upwards under the door: lever them downwards).
6. Pull the bottom of the door away from the door frame, then move upwards to loosen the three clips at the top of the door seal. Do not remove these clips.
7. Install in reverse order.

Repairing Vinyl Door Panel Covering.

Tears and Cuts. [Inquiry] How can I repair small tears in the vinyl door panel trim? [Response: Bill] The door panel vinyl on Volvos is very thin and does not lend itself to vinyl repair easily. However, it can be done with an iron on a low heat setting. We've used a product called vinylhyde that you can use to repair the tears. It is sold by detail and interior trim retailers which you can find through Google.

Door Panel Puckering in 93+ 900 Cars. [Inquiry] [Response: Dick Riess] Here in TX we have problems with the top part of the door panel pulling and puckering away from the rubber window sweep. John Howes at http://www.southwestauto.com has a means of repairing. He advertises this service on his web site. [Response: Rob Bareiss] We've seen 960 door panels bunch up on both '95 and '96 cars. Haven't seen it on a 97, but we have only one customer with a 97. We've seen it with both beige and dark grey ones. Volvo will only sell the panels as a set, EXCHANGE! You've got to both spend your $800 AND give them the panels back. If the car's out of warranty, it's best to live with it. Replacement is easy to do, if not easy on the wallet. But even replacement is not a snap: the handle cup, door latch, wood trim, inserts, speakers, EVERYTHING has to be taken apart and fitted to the new panel. Even heat fused plastic parts have to be CUT OFF then screws put in to hold the parts together on the new panels. Speakers must be riveted. See below for tips on repair.

Vinyl Repair Tips:

[Tip from Tom Irwin] I've had tremendous success with a 3M product called "Spray Adhesive #90". Big black can. Remove only the trim you need to to stretch and reposition the material that wrinkled. Peel it back as a far as possible, using care not to rip the foam underneath. When the repair area is exposed and everything else is masked off and protected, apply the adhesive... CAUTION...... If you hold the can too close you will soak and saturated the backing material. A neat trick with 3M #90 is to set the variable nozzle to 'slow' and spray from a distance of at LEAST 10"-12", the farther the better. At this distance, 90% of the carrier solvent evaporates before it hits the material. When sprayed from a good distance, the adhesive lays down in a heavy spider web pattern. Put it on the backing material AND the loose fabric. Let it dry for 1 to 5 minutes. GENTLY tug the creases out of the material and press it firmly with your hand, expelling air bubbles along the way. Put it back together and be sure to tack down any additional loose trim.

[Tip from Dave Stevens] I've had reasonable luck with a DIY fix for this common problem, but it's fairly tedious work. Remove the door panel and take it indoors to work on. Work on a protected surface like a piece of carpet. Carefully unclip the window seal strip from under the top edge. Now, with something like a mildly sharp 3/4" wood chisel, gently open up and pry off the remaining metal retaining strip. Work your way back and forth along the strip on the under side where your handy work won't show. You may need to encourage the top edge a bit, just be careful not to cut into the vinyl or damage the visible part of the top edge (note that very little of this strip is actually exposed from under the window seal, so a little bit of metal wrinkling on the inside edge won't show). Remove any plastic-ware in the area you're working (the door button or the defroster vent). Now for the tricky bit. You need to carefully peel back the vinyl around the wrinkled spots. As the glue isn't all that strong (hence the original problem) it comes away from the wood panel fairly easily. Use a 1200 watt hair dryer (or with care a heat gun on low) to heat the vinyl just enough to let go of the glue. Peel it back slowly. Try not to stretch it. Gently cutting in with a thin knife edge may help. If you start to lift wood chips then you may not be applying enough heat (later scrape off any chips that do get lifted). You'll be peeling back a wide "U" shaped area. Go right back to and slightly around the corners. Go about 3-6" inward of the wrinkles along the top ledge. Stop peeling downward when you hit a defined edge (ie. the ledge corner). Let the vinyl cool. As it does, try to smooth out the ridges of the wrinkles (and any glue ridges on the back side). Note that unecessary heating of the vinyl will only stretch it. Lightly sand or fill any damaged areas of the wood panel that might show through. The lifted area of the vinyl now needs to be properly re-laid, pulling out and smoothing the wrinkles as you go. The excess "puckering" (the original wrinkles) needs to be spread out evenly over the area you've lifted. If it won't spread out enough to avoid further wrinkling then you may want to lift a wider area. There may be limits to how much you can pull and smooth the vinyl without the edges showing, such as at the door lock button and the defroster vent. Practice how much pulling and in which direction to go so as to minimize the wrinkles. Now coat the back side of the vinyl and the panel wood with contact cement. As it's porous, the wood surface will need two thin coats. Be careful not to create a ridge of cement at the back of the lifted area. Let it partially set (this will give you some working ability), carefully lay the vinyl into place, stretching and smoothing as you go. Afterward, press out or use a (pizza) roller to minimize any remaining ridges. Cut off any excess vinyl, replace the trim and you're done. If you've done a good job, any remaining ridge marks will reduce over time especially if you help smooth them out occasionally. In my own experience on front doors, I've been able to do a near-perfect job eliminating wrinkles at the door lock button, but only a half successful job around the defroster vent (but that area really doesn't show that badly anyway).

[Randy Starkie] I made the repair with Weldwood Contact Cement (pint can; brush on). Did it in two steps because of the length of the repair (length of door panel). I removed the two trim/wiper pieces. Pulled the vinyl up into place and clamped it there at a point dividing the job in half. Applied cement to both vinyl and composite door panel, two light coats on the vinyl and three on the panel. After allowing it to dry to the touch I stretched the vinyl out and rolled it into place. I over stretched it some as it was easy to let the vinyl pull itself back into exact alignment even after intial contact. The vinyl wanted to shrink back away from the edge so I used a paint stir stick to clamp it into place using small C-clamps. I did the second half the same way and readjusted the clamps and sticks. I let it set overnight, removed the clamps and reinstalled the panel. Time (and some high interior temperatures) will tell if the fix is permanent. [James Souther] I have used plastic bookbinding tape as an black edge trim on my gray panels by the window, looks factory even though it is not.

Door Armrest Repair. [Tip from Dave Stevens] The elbow area of these door panels has been known to crush under excess and repeated weight. You probably only need to worry about the driver's door. If you have the door panel off, add a stiffener on the back side of the elbow area. I used contact cement to fasten a piece of 3/8" high density fibre board that was cut to fit the area (contact cement goes on the shiny side). Let the glue fully set before firmly pressing into place.

Door Pockets. *Removal.* [Inquiry] How do I remove and install the door pockets at the bottom of the door on the 740? The plastic seems brittle, and I don't want to damage it. [Response: Matt L.] You have to take the entire inner door panel off; the map pocket is screwed on from the back.

Crack Repair. I have a 740 and have developed a crack in the map pocket on the drivers side. I'd like to glue this crack.] I believe it's ABS thermoplastic. [Solution] Remove the pocket by pulling the door panel and unscrewing. Buy some reinforcing material: fibreglass cloth, or my favorite which is hobby shop carbon fibre strip used for model airplanes: the 1/2 inch by .09 inch size is perfect. Buy some plastic-grade epoxy. Roughen the inner surface of the door pocket over the crack, clean with alcohol, apply the epoxy and reinforcing strips. This fixes the crack and materially reinforces the plastic.

760 Pocket Caution. [Norm Cook] I finally got the carpeted map pocket from a 760 installed into my 740 tonight. And guess what--760 map pockets are longer (and not just because it's carpeted) even though the screw holes line up. So when you go to the Volvo shop and look lustfully at those durable carpeted reinforced map pockets for your door panel, ensure you measure it first. I had to elongate about 6 holes and move the panel toward A pillar so it wouldn't bind on B pillar door moulding. It's not really too much of a hassle but it should be reflected in the price.

Handhold Trim Piece Loose. [Inquiry:] Right above the drivers side door, there are two plastic covers, which cover a screw. This piece is loose and driving me crazy. [Response: Rick Klasic] Carefully pry off the 'lid' with a flat screwdriver. Under the lid there is a white plastic clip. Tighten the screw (philips or torx) and replace the lid.

Exterior Door Trim. [Editor] The rubber door moldings in the middle of the doors are adhered using clips in holes: pry off the outer cover using your hands or a spatula (protecting the paint with tape), then remove the inner retainer and clips from the holes. You may need new clips to reinstall, and make sure the paint underneath and at the holes is intact to keep it from rusting. The top rubber wipe moldings are also held in place using clips in holes: protect the paint with tape and pry up using a spatula.

Hood/Bonnet:

Hood Hinge Lubrication. Make sure you regularly spray a light oil (Mobil 1 spray or Superlube) on each hinge pin.

Stuck Hood Release and Cable Adjustment.

Cable Adjustment is Too Loose. How do I adjust the hood release cable? [Response] If your hood will not open, it may be just wear and stretch in the release cable. Fine adjustment of the cable is done inside the car at the adjustment screw just behind the red hood release lever. Coarse adjustment is done at the cable stop at the end of the cable at the hood release mechanism under the hood.

Lubrication to Keep Pins from Sticking. [Editor] When you do your regular chassis lube, clean off the always-dirty hood release pins/springs and re-grease these with a light grease. Spray some brake cleaner in the catch holes while pulling on the hood release cable to move the mechanism, then spray some lubricant to keep the mechanisms on both sides free.

Cable is Broken or Has Come Unattached. [Inquiry:] Anybody knows how to open the hood from outside on a 740, when the cable doesn't work? The latter can no longer be adjusted, and now the hood is stuck closed. Unhooking the handle and pulling the cable itself doesn't work either. [Response: JohnB]. You have to go in from under the bumper, drop the belly pan, long arm up to the cable and pull/flex should release the two locks. Sometimes it helps to have two people, i. e., the springs on the two locks aren't pushing up the hood so while you're pulling on the cable another person lifts up on hood so the hood comes up to the safety latch. Usually pulling the inner wire and holding onto the cable body at the inside the car point works unless the inner wire is broken, in which case you have to access the combined lever to both latches or both latches individually. There are two latches, both cable operated, just outboard of each spring-loaded hood locating pin. If you look at a friend's 7xx you should be able to see where the cable split or lever(s) are). Difficult to describe verbally but once you see one when you have to fix it you never forget it. Take a look at how this works when it is operating normally so you can repair it when it fails. [Tip] If your car has the four-headlamp fitment, you can remove the two inner headlights and work the latches by hand to get the hood open.

Remote Operation:

Door Remote Lock/Unlock and Alarm Operation. [Bob Cavenaugh] If your car came with a remote lock/unlock device, here is how to program it:

Remote. New transmitters (max.4) must be programmed to function with your alarm system. To do this:

- Make sure all doors, hood, trunk/tailgate are closed.
- Turn the ignition on and off 5 times within 10 seconds. On the fifth try, leave the ignition on.
- Press either button on the transmitter.

  NOTE: the first transmitter must be programmed within 15 seconds, the others within 10 second intervals. When the alarm system accepts the codes from each transmitter, the LED on the dash will glow steady for several seconds.
- Switch the ignition off and test the transmitter(s).

Alarm. Since using the remote also sets up tha alarm system, you should know a little about that, too. We managed to set the system off ourselves several times. Embarrassing. If your 960 has the alarm system, there is a red LED in the right side dash speaker grille. The LED will blink when tha alarm is set. Volvo recommends that you not use the transmitter to lock the doors from inside the car. On cars equipped with an alarm, the alarm would be activated and would sound when one of the doors is opened. You should also **not** give the remote fob to a valet parking attandant since it unlocks all the doors and trunk.

Installation of Remote Power Door Lock Actuator in a 740. [How do I install a remote actuator in a 740?] Actually (on US cars) they do have power locks, but the drivers door does not have a power lock solenoid. (i.e. the driver's door is manual, the others are power locks). See the related file for 940 cars with pictures and detailed data.

So you need to find a passenger door power door lock solenoid and linkage (a junk yard is a good source). Reverse the solenoid in the bracket and install in the drivers door. Use the passenger door for a guide, if you need it.
Then you need to provide power to run the new solenoid. You can run news wires into the door from any of the other door lock circuit. I do not have power mirrors on my car, but it has the wiring, of which the wires from where the power mirror switch in the door should be straight over to the passenger door. Tap into the solenoid there and hook up similarly on the drivers door.
For the $29 JC Whitney controller, I installed just above the drivers left foot and tapped into the wires from the switch in the drivers door (that lock and unlock the door) to the solenoid behind the fuses. No need to access the relay, just tap into wires.
I can now lock the doors with the key, the knob on the drivers door, or the little two button remote. Works well. Good range.
[Inquiry:] Is there an *easy* way to add a remote alarm/keyless entry system to an '87 740? The rear doors, passenger door, and liftgate all have solenoids that actuate the locks - but the driver's door is only mechanical. [Response: Anders Persson] When I installed a similar system in my previous 744 GLT 16 Valve -89, I had to add a lock motor to the drivers door. There is such a kit available from Volvo. Article number is 3529 065 for 740, 760 and 780 from 1986 and onwards.

Installation of Remote Power Door Lock Actuator in a 940. See the separate illustrated file from Dick Riess for more detailed information.

Remote Entry Malfunction. [Inquiry:] I'm having to reprogram my remote quite frequently. The batteries are OK. I do not use the remote every day - could this be the cause? [Response: Tony Giverin] The remote fob is not one of Volvos stronger assets!...Even in the best of days the range is from 10-15ft (noted in the manual). Others have found it susceptable to RFI/EMI interference. I myself have found that some days you have to be right on top of the car, other times it works 15ft or more away. Having said that, the frequency of use should make no difference. You say the batteries are OK, I'm suggesting anything under 2.9-2.8v and you can expect trouble. My wife's key fob stopped working altogether recently, I took it apart and cleaned the contact switches with electronic contact cleaner, have not had a problem since. [Peter KL Milne] Every six months or so, I take out the internal batteries in the fob and clean their contacts and contact faces thoroughly, using a PCB eraser. This is enough to keep the about 150 feet range nicely. [Inquiry] Despite best efforts, since disconnecting the car battery I still can't get the fobs to work. I've renewed all batteries. I've done the turn-on-ignition four times and on the fifth turn on press key fob. I've tried pressing the fob eight times. Central locking works fine on key. Status lights are doing a double flash, pause, double flash, pause and so on. What is wrong with this system? [Responses: Peter KL Milne] In another case, one of the sensor loops went open circuit, caused by the bonnet open/shut switch (at the front left-hand of the bonnet opening, very close to the bonnet spring retainer) having gone faulty. This will cause the fob to fail. You might also try reseating the relay.

Remote Door Lock Range Extender. [Tip from Tom Irwin] Are you as fed up as I am when locking/unlocking your brick with the remote clicker and you have to stand 2 inches on top of it and hold your finger to your nose before it unlocks?? Wouldn't it be nice to zap it from 50 feet away and hear the reassuring 'clunk'?? Well, fellas I found the fix! I was into another project today and happened across the central locking transceiver unit which is mounted atop the center of the steering column. It slides right out and one wire harness disconnects easily. Take the unit to a clean bench and remove the 4 screws that hold the case together. Separate the 2 halves. There are 2 PC boards atop one another. The bottom one has all the guts. The top one has 4 wires going to it that terminate at a single grounding trace. THAT IS YOUR ANTENNA ! I swear before the Sages of the BrickBoard...that is what Volvo uses for an antenna.........a 3 inch foil trace buried deep in the bowels of your brick!!

Now the fix... Take a piece of ultra fine sandpaper and remove a spot of the green PCB varnish at the end of that trace. Do this until you see a shiny silver trace peeking through. Find an old DC toy motor and crack it open, remove the armature. The copper windings inside are about a 38 ga. wire. This makes an EXCELLENT antenna. Unwind about 36" and straighten it out. Take one end and hold the last 1/2" to a flame. This will cook off the insulation, it's way too fine to use a stripper.

Using a 20-30 watt soldering iron and rosin solder, attach the bare end of the wire to that cleaned trace. Lay the wire down in the connector cavity and button it back up. Reinstall the unit in the car. Thread this long wire up over the steering column and over to the free loom that passes thru the firewall just next to the Motronic brain. It helps to tape the end to a straightened coat hanger and fish it up in to the engine compartment. Pull it through completely til no slack. See the weather strippping seal that spans the engine bay, just south of the wiper arms? Lift it up from the drivers side and pull it up to the middle of the span... Now lay your wire down inside of it and push the seal back down on the metal stay. This does two things: 1. It makes the job nice and neat 2. It gets your antenna up and out of the cars interior so it does a much better job. The good news? I can pop my locks from 120 feet away!!! HEY! It doesn't take much to get me excited.......... but I know a few of you have mentioned this problem, especially you 850 folks.

Power Windows:

Power Window Preventive Maintenance. See also the information in Electrical: Circuits, Wiring, Relays, Switches

Window Motor

Cleaning and Lubrication. Remove door panel (see Trim section). Using a light grease such as Superlube, grease the sliders on the window jack, and also grease the gears; hit the pivot points in it with good spray lube. There are some bolts which hold the window jack to the door - tighten them. They have been loose, to varying degrees, on every door I have opened thus far. You will be so amazed at how easily the window goes up, you may even be motivated enough to do the passenger side! See the Switch section for preventive maintenance on the window switches. [NA Abdullah] In my case crud, soot, dried grease and the sort practically jammed the regulator gear at the motor. Lack of usage I think also contributed. I find it interesting compared to other makes of car that the Volvo motor will not turn or make any noise if encounters significant resistance. It just stops silently. The moment I unbolted mine from the assembly it was working fine. I have cleaned all regulators since then and not only are my windows working better but I've saved myself a couple of motors.

Tighten Regulator Bolts. [Tip from Art Spon] Here is an ounce of prevention for power window motors and mounts. I have recently had the pleasure of replacing a window motor and regulator. This is not a lot of fun, but a lot of gratification when complete. Anyway, remove your door panels and tighten all four bolts that hold the motor/regulator. This will prevent it moving, torquing and breaking the stupid plastic mounting plate for the regulator. [Editor: I would use Loctite on these since they are subject to vibration.] Also, lube everything up. Mine wasn't expensive ($50) but it could have been prevented.

Window Regulator excl Motor

Problem Diagnosis. [Tips from Darius] To diagnose window problems, start with the switch. When you depress either the window or driver's door switch with the key on position KPII, does the motor operate? If not or if it is quite slow, then the switch is bad. Switches are much more prone to failure than either the motor or regulator. When you depress the switch, can you hear the motor running? If so, your problem is the regulator, not the motor. When the window goes up or down, does it make a clunking noise? Your problem may be the plastic slide clips or loose mounting bolts. If it does not stop appropriately, then the regulator may be worn.

Useful Tools. [Darius] If you need to work on the regulator or motor, buy a small "dentist's mirror" which makes it possible to see into tiny, hidden spaces.

Power Window Problems.

Window Motor Slow. [Symptom:] My 95 960 was recently parked outside in the cold and the next day the right rear window would only go down a few inches and very slowly. After a couple of days it would go down to where it's supposed to go but very slowly and it seems like the motor is struggling. I called the service manager at volvo and he said just to spray some lubricants in the window channels. Well problem is I can't see any channels. I took the door panel off but the inside surface of the door had a cover glued on to it. Is there anyway to lubricate the channels without tearing the cover off. Also does anything else in there need to be lubricated? [Response 1: JT Charger and Gary Heston] The window channels are at both ends of the glass, one towards the front of the car, the other towards the rear of the car. With the window down, spray white lithium grease, a light penetrating oil or silicone spray, down inside the rubber seals, then make the window go up & down several times. [Response 2: H H Hansen] With the window at its lowest point, push the up button and watch the window to see if it tips when it first starts up. If it is you have a loose fastener on the window regulator. I have had this on two different volvos. The plastic water shield to is stuck on with a tack strip: just start at a corner and peel up slowly. Then check for any loose bolts or nuts. [Response 3: Steve Ringlee] Remove the door panel, peel off part of the water shield and lube the window channel and mechanism with spray white lithium grease or Superlube. Replace the water shield, which as noted is glued on with tacky adhesive at the edges.

Switch Failing. See the FAQ section on Power Window Switch repair.

Window Won't Close [Inquiry:] The driver's side window just started not closing flush, causing wind noise. If I open and close it several times it will finally close tight and in alignment and I will not hear or feel the wind. The motor seems to work great and there is no catching, just the window seems to be mis-aligned a little. What caused this and how can I fix it. The noise comes in right at the upper corner above my ear. [Response: Rob Bareiss] Your forward window track has worn to the point that it's not guiding the window straight anymore. You can try putting the window down, taking apart the door, and bending the metal track a bit backwards. It's welded into the door. The other course of attack would be to replace the felt/rubber window guide, which is probably all worn right at the top front inside the door, just below the mirror. Also involves opening up the door panel. There is a little bit of adjustment in the regulators, but not much, and in my experience not enough to always fix this problem. It's almost like the door's too long for the glass. [Response: Tom Irwin] I've found that the Volvo White Teflon Brake lube is DANDY inside the window track. [John Sargent] Take the door panel off. The three 10mm head nuts which hold the electric window regulator may be loose, or will need to be loosened and the fit of the regulator adjusted. The holes in the door are larger than the studs, and allow adjustment. [Steve Irwin] After removing the regulator, I found the center 'pivot' of the "X" to be badly worn. I ended up brazing a 'fender washer' into the support, reaming the hole to fit the old bushing, and reassembling the whole works- this was not an easy fix, and I wouldn't do it again, but it's working great now. I suggest watching that center piviot with a light & mirror while you rock the assembly in the tracks. If you see any slop there, start looking for a servicable replacement. [NA Abdullah] Try removing the door panel and cleaning the regulator, which can become gummed up and will stop the motor.

Window Motor Won't Stop at the Top. [Inquiry] My power window drivers side does not stop at the top anymore. It tries to drive the last 1/4 inch and bends the big geared arm and makes a hell of a "scrunk" noise. I removed door panel and tightened all nuts. I lubricated all moving parts. No change: it is like the stop switch needs adjusting. I could not figure out how the motor knows to stop turning. If this continues it will destroy the gears. [Response: Rob Bareiss] 740 driver's window regulators all have troubles like this. Nothing stops the motor. It just runs into the top stop, and tightens up against the window seal, or if it's bent the arm fouls the motor mounting plate in the regulator. Every one in the junkyards is gone, because they go bad so often. The replacement regulator is better, but doesn't look anything like the original: it's mostly plastic. There are some adjustments possible by sliding the motor and regulator around in the mounting holes in the doors. You should be able to get it to at least seal up fairly well, but sometimes you can't adjust them enough to avoid a gap. Save your $$ for a replacement regulator. [Response: Tim] More than likely you need a new regulator. The gear is worn on the last gear tooth and it is causing the regulator to make a nasty racket & wear out further gears (ie causes a popping sound) - The motor won't stop properly. [Darius] Try to buy an integral motor-regulator unit, which is easier to remove. When changing the regulator, there is no need, btw, to remove the window glass; just use duct tape or something to hold it up when the regulator is removed.

Motor Won't Stop at the Bottom. [Inquiry] The drivers window motor will not turn off when the window is all the way open. The motor cuts out and then back on. [Response: Dick Riess] The stop on the mechanism is most likely broken. What worked for me was to glue a strip of half-inch plastic into the bottom of the door so that the window would bump on it. This takes the place of the metal stop and has worked for at least 4 years. You do need to take off the inner door panel to do this.

Power Window Noise or Movement While Operating*.* [Inquiry] Front power window when going up or down seems to be catching and binding..there is a rubbing type sound..what is the fix for this? [Response: Tom Irwin] Your blue plastic guide blocks in the lateral channel are either very dried out or are broken. Possible the rear channel guide has come loose too. Both are very common failures. Remove the door panel. Once inside, look at the bottom metal piece that the glass settles into. At about mid-position, the two blue plastic guide blocks are clearly visible. They push on over pins and are held with spring clips. Yours may be in pieces already. ANY Volvo dealer will know what "Windows Blocks" are, $10 bux says they have a bucket of them behind the counter. Lube the tracks while you are at it: I've found that the Volvo White Teflon Brake lube is DANDY inside the window track. [Tip: Bill Garland] Just fixed a clunking sound that my 740 driver's side window mechanism made when I closed the window. It occurs just as the window is finishing being closd. I removed the door panel as per the brickboard faq (thanks!) and saw that one of the plastic sliders (shaped like a tuning fork) was broken. Fixed that and greased everything up but the clunk remained. After much pondering I noticed that under the metal clip on one of the sliders that I could see easily was a red plastic washer (p/n 1334889-1) between the clip and the slider. The slider / clip that I had replaced had no washer. It must have disintegrated. So I added a metal washer and Voila! Clunk gone!

Glass Moves Sidewise in Operation**.** [Symptom:]The electric window on the drivers side of my 1990 740 wagon shifts left and right a bit, and when you roll the window up, sometimes it does not fully seat on the back side, and I get a lot of wind noise. To fix it, I roll it down, and roll it back up while pushing the glass towards the back of the car. [Diagnosis:] I think the problem is the plastic roller in a plastic rail (the one which is more or less under the door lock knob).

Power Window Motor Removal.

Diagnosis. [Tip] Before removing the motor you may want to test the leads with a 12 volt source to see if the window moves up or down. If it doesn't then you'll need a new motor and possibly a new switch also. Does the window move with either the front master switch or just the rear or neither? If neither and the motor works with a new 12 volt source then the master switch or less likely the rear switch is at fault. In my case, the motor and the switch failed.

Regulator Removal. [Inquiry:] The plastic plate that the power window motor mounts to was broken in two places...Where can I get a new plastic plate and how much will it be? Also what is the trick to getting it off of the regulator? [Response 1: Bob Haire] You're referring to a large heavy (not heavy duty enough) plastic plate that is the main part of the regulator in some 700s. Everything bolts to this thing. Strangely, on later cars some of these are metal and some are plastic as evidenced by the ones I took off an 87 740. Failure of this assembly is a common problem (due in part to bolts working loose) and Volvo switched to a metal assembly due to the premature decrepitude of the plastic ones.[Response: Sven/Darius] To get the whole thing out, first take the door trim off. Then raise the window to full upright position and secure it there. Unclip the three clips that hold the regulator scissor arms in place. Pop the two bottom regulator retainers out of the plastic sliders that are mounted in the bottom of the window metal strip. You'll break the top lip of the retainer but it will be ok. Unbolt the three or four bolts holding the motor/regulator in place. If you have rivets, drill them out with a 5/32 inch drill bit. With a little cursing and wrestling, the whole thing comes out through the big lower opening. Remove the old motor, bolt it onto the new regulator, reinstall. All should be well without having to remove the window. If you have to remove the window,it is held on to the scissor-like appendage by two clips, facing the outside of the car. Angle it slightly to remove.

Glass:

Window Tinting. I had two cars tinted; my current had tinting from PO when I bought it. If you go for it, do it top-of-the-line, or not at all. None of these jobs have bubbled (all professional), but the one in my 245 is much cheaper material than what I would have spec'ed: it's somewhat dark, and it scratches really easily. Higher-quality films have a higher ratio of visible/UV light transmission: that is, they reject more of the frequencies that heat your car and wreck its insides, while letting you see better. On two cars, I've had titanium film used. It gives the highest UV/vis filtration ratio, looks grey, and is available in three darknesses. Even Sue's car, which has the middle darkness, does not strike the viewer as obviously tinted. When her A/C works, (she has a white 244), the car, even in Florida, can be used as a meat locker. My tan 245, after sitting outside, on a hot, humid day, the A/C can barely keep up. But wagon/paint color make a difference. Also, a good, strong film is a safety feature. I have been emailed that even Volvo's side/rear windows are not laminated, as is required of windscreens here in the US, and of all windows in more advanced countries. A good film will stop bits of glass from flying about.

Removing Tint Film:

[Inquiry] How do I remove old window tint film? [Response: Yvan] Grocery-store ammonia is the solvent for tint removal (but use it outside, preferably on a windy day; very bad fumes). Usually tint will come off in big sheets once you get started. Just take your time. For tint installed below the window rubber trim, remove to within one inch above the rubber line then peel the remaining bit from the window using a razor blade and a syringe filled with ammonia that is deposited in the crack. The ammonia will loosen the film (about 15-20 minutes) and you should be able to peel it up from below the rubber. The remaining adhesive comes off easily with ammonia-based window cleaner and a razor blade. [Tip] See http://www.tintcenter.com/articles/bt_removal.html

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Replacing Window Glass in Track. [Inquiry] How do I put the front drivers window glass back in track. The window has somehow came out of its door hinge side track. Took off panel, but have no ideas on how to get it back in. [Response: Bob] Release the two clips that mount the window to the track, and pull the regulator mountings out of the mounting at the base of the window. Now, tilt the rear edge of the glass upward and front downward till it clears the tracks, re-insert the glass in the track while tilting glass back to horizantal. Once everything is back in place and clips reinstalled, roll the window up all the way and using a large screwdriver, bend the lower portion of the front track rearward to prevent it hapening again. [Tip from Tom F] To fix a loose side window, I had removed the window and the window lift, reinstalled the window into the lift with a little 3M gasket cement, and attempted to put the lift back into the plastic guides. Impossible! It looked different from the Haynes photos. There was nothing to remove or drill out to allow the necessary maneuvering. I removed the window and was able to remove the lift from the window, luckily, because the glue didn't fully cure. First, make sure you mark the location of the lift on the window before you clean all the grime off. Then, the easiest way to reinstall the window is by putting the window into the lift, with the lift installed on the plastic guides. It was a little awkward but I was able to fully seat the window into the lift.

Replacement Windshield. [Notes from Bernard Paulson:] It happened to me a few days ago. Saw that iron rod flying through the air, lifted by the rear tire of the car in front of me, right toward my head. It hit the hood and then went right into and half-way through my windshield. Even the glass shops believed that someone has shot at me. After all, this is L.A. Didn't bother to check with Volvo. Used my brains and connections instead in my attempt to find the most reasonable QUALITY windshield. Interestingly, I found out that the windshields for 88 and up 765s are of a different size than the "regular" 700 windshields (no kidding).

Finally found what I was looking for. A brand new, safety windshield, tinted, with shade, and European E11 seal etched it, certifying it as one that meets toughest European standards (yes, the DO check stuff like that). The parts number is FW575. I paid $145.00 installed plus $8.25 tax, and having paid a total of $153.25, I once again cannot confirm that it is expensive to keep a "Luxury Volvo" on the road.

Replacing Windshield Glass.

Removing the Old Windshield. [Tips (edited) from Zee on replacing windshield glass in 240 series cars; 740 are similar. Note the cautions] As for "special tools" to remove the old glass, I use a length of thin piano wire. You can also use an A or D brass guitar string. Simply remove the chrome trim & rubber gasket combination. The glass "floats" on the buytl-rubber sealant. Slice through the plastic clips along the edge of the window. (Some clips you can pry out using a small screwdriver. Most you can't. Just don't twist the tool, or you'll crack or chip the glass) Insert a strong wire or thin screw driver at the top and bottom of the window, near the centerline. Poke through the sealant, making a pathway for inserting the piano wire. Pass the piano wire in, then across the inside of the glass, then out the opposite hole. Now you have the wire inside the glass, through the sealant, with two ends sticking out, top and bottom, center.
Use vise grips and gloved hands on each of the wire ends or attach the wire ends to pieces of wood. Pull the wire toward you -- from the center of the glass toward the side -- while working the wire back and forth, like you're doing an upper body workout on a ski machine. Repeat on the other half. Go completely around and then some, as it may try to re-stick itself. Pay close attention to what the string is doing inside the car: it can cut into the dash pad or other trim if you are not careful. This method is cheap, reliable and effectively separates the glass from the sticky sealant.
Now, to take out the window, push evenly with gloved hands from inside the car. Begin near the top of the window, and it will naturally stand up for you. When the glass is loose, gently pull it away from the opening. Don't force it or it will crack. There will be places where it is still partially stuck, cut them free with a putty knife or the guitar string. Have an assistant waiting to hold it steady until you come out to help lift it clear of the vehicle, or tilt it forward onto an old blanket laid upon the hood. Any sticky goo on the body work can be removed with carburetor cleaner or acetone.

Preparing the Surface. I removed the thin plastic interior trim piece at the top of the window opening. This piece covers the front of the headliner. It is help in place with 5-6 spring slips which are facing forward. You will get the headliner soiled from your sealant removal, so mask it off. In fact, to avoid getting the sealant goo and particles from falling into the car, I found it useful to mask off the entire window opening from inside using newsprint or craft paper taped to the interior.

I have read where others used acetone to remove old butyl rubber sealant. I found with "pinching" off as much as I could using paper towels, followed with gently "smooshing" using a putty knife, I was able to rub off the rest with a rag or paper towel, and paint thinner. You will not be able to do this if the sealant is urethane, so trim away the old urethane to leave a 1- to 2-mm-thickness on the surface. Do this using a flat razor blade, which will give you a smooth cut and no loose material. You want to provide a fresh, clean surface of urethane on a rust-free substrate for the new urethane to bond to. Remove any rust using a wire brush and a rust-removing primer such as POR-15 Metal Ready. Don't use any Bondo filler on the pinchweld area because it is structurally weaker. Let the urethane sealant fill any gaps. Prime any remaining metal in the 3/4-inch area where the urethane bead is to be located at the edge of the pinchweld with self-etching or epoxy primer; let it dry, then cover it with masking tape. Then coat any rust beyond this using a rust stopping paint, like POR-15 and the correct topcoat. After refinishing, remove the tape to expose the primed-only area where the urethane will go. Prepare this area with a pinchweld primer that's compatible with the urethane windshield adhesive to be used. Use the black pinchweld primer that glass specialists use to enable the new urethane to stick. Don't apply the pinchweld primers until just prior to the glass installation.Apply the primer using a wool or foam applicator. Apply the pinchweld primer only to surfaces where the original trimmed-down urethane bead isn't present. Do not apply it over the top of any existing urethane.

The primer must be fully dry so all solvents are out of it. You don't apply POR-15 or topcoats here because solvents can continue coming out of them for 60 to 90 days, and you'll likely install the glass sooner than that. Another reason is the urethane topcoats are designed to resist chemicals from biting into them, and they may not get proper adhesion.

Installing the New Windshield. Glass shope nowadays use urethane glue to fasten the new window, not least because it adds structural rigidity to the windshield assembly. It comes in tubes, like caulk, and costs about $12 per tube. Buy two tubes. The pinchweld area on the 240 series is nearly 3/4" wide all around the window opening. It's also about 1/2" deep along the outer radius.

One suggestion I received privately from a glass shop pro who saw my installation question here on the RWD forum (check the archives, too!), was that you would be better off to install the clips and install the chrome trim to the glass and install everything as a unit. He said to dry-fit the assembly first, marking the outline of the trim onto the body to aid in centering things for real. It will take a couple of shims along the bottom during the dry-fit. You can use masking tape around the chrome trim such that by carefully slicing it along the outer edge, the excess will remain on the body of the car, giving a perfect outline for centering the assembly. Another idea someone had was to get a couple of those rubber suction cups and an assistant to help position the glass. Evidently you only get one chance to do it right.

The only question I still have is exactly where in the width of the pinchweld do I lay the sealant (either kind) so that it keeps water out of there. On one hand, it seems good to place it along the inside radius of the weld to assure no water penetration behind the glass to the interior. This looks like it would leave a considerable gap between this caulk and the outer radius. (I don't know how much the window flattens out the sealant when it is pressed onto it.) On the other hand, it also seems good to place it along the outer radius, where the weld curves up 90 degrees to meet the body surface. (Looking at this, you'll see what I mean). This troubles me because I am less confident the sealant will adequately fill toward the inside and seal the glass against water penetration. It was not much help to look at the old window for help. Someone had put two more sealants around the edge, while leaving the original Buytl-rubber in place. Before I actually do mine, I plan on stopping off at my local glass shop and asking some questions.

Windshield Leaks: Installation Safety Tip. [Tip from http://www.SouthwestAuto.com] If you have replaced your windshield and have noticed water or air (wind noise) leaks, a serious safety deficiency may exist on your Volvo. In the past some windshield installers have incorrectly used aftermarket butyl tape to reseal or install replacement windshields. This material can fail leaving the windshield no longer securely bonded to the body of the car. In an accident or even an emergency stop any contact with the windshield can cause it to separate from the body of your Volvo. Newer technology urethanes correctly installed using primer on both the glass and body flange, produce a bond as good or better than the original factory installation.

Windshield Trim Strips..

Rubber Edge. [Inquiry] The rubber on my front windshield came loose at least part of it and I pulled on it and then the trim came loose....so I took it all off. My question is can I just replace the rubber trim that was hard and most of it was broken anyway or do I have to replace the metal pieces. I will probably take it to a glass shop to have it done if it is too difficult. [Response: Bob] The metal trim and rubber strip are sold as an assembly and are not available separately. [Response: Rob Bareiss] I would get the windshield replaced with the later style. You won't have to deal with the half-chrome/half-rubber trim stuff anymore. The newer windshields ($10-20 more?) for a 91/92 740 or the 940 should have the black trim glued permanently to the edge of the glass. Should eliminate the troublesome clips and trim pieces. My 88 has maybe 1/2 of the rubber left... I figure it's doing ok for its age. It's due for a windshield this year, I can't stand looking through it any more when the sun is low in the sky. If you need anything for the installation, the windshield shop should be able to tell you, and you can get it either from the dealer (they still sell everything for these cars) or the glass shop if they have it available. Visit the glass installers to see what they recommend, I'm sure they've dealt with every imaginable situation before.

Replacing Trim. [Jay Simkin] You definitely do not have to remove the windshield in order to remove the metal/rubber trim strips. Removing the trim takes "fingertip sensitivity": there is little maneuvering room, and if force is applied, the mounting clips will be broken and the trim strips bent. These trim strips are not cheap. In short, it takes finesse - not brute force - to do this. In terms of tools, you will need a metal putty knife, with the edges "blunted" [Brian Oliver] It's just an exercise in patience. Be very careful when using any metal tool that you don't lever against the windshield itself and crack it. The trim itself is expensive, so try a scrapyard. The rubber-coated steel trim on our 94 940 rusted out very early. I found a 740 Turbo in a scrapyard with the dark grey version of the older s

Attachment Clips. You can get new push-pin style clips at the dealership for so little cost that you don't need to worry about damaging them. I recommend replacing the attachment clips. They usually break when trying to install new trim. The clips and trim on the sides and top of the glass are relatively easy to replace. The clips on the bottom are a bit tricky and if not extremely careful, you can crack the glass. [Erik] To remove these trim strips, lift an end and gently pull or slide it to one side keeping it level to the floor. For side pieces slide them down the windshield towards the ground. Do this outside or in a spacious area so you don't bend the moulding in case you have too little room: it bends very easily. You're bound to break some of the small attachment plastic clips since they get brittle as your car ages.

Vibration Outside the Car: Trim Strip. [Inquiry] I have a 1990 740Gl standard transmission, 174,000kms. Perfect car, EXCEPT for the high speed rattling noise that seems to come from the area around the dash, but outside. It sounds like a new year's eve noisemaker, except the sound is metallic. It occurs only at speeds above 60kms. per hour, and is intermittent- could happen several days in a row, then not for weeks/ It could last a few seconds, or an entire highway trip. Sound can be almost imperceptable, or quite deafening. [Response: Dave Stevens] This is a known problem area for circa-1990 740's addressed in a Volvo TSB. The "official" explanation is that misaligned plastic clips holding the window trim allow the trim to get caught by the wind and vibrate at high speed. You can isolate which piece of trim is the culprit by temporarily covering with a strip of tape to see if the vibration goes away. The passenger side trim seems to be a common area. The "offical" solution is to rotate the rectangular plastic clips a little with a trim tool to improve tension. It might also be a good idea to shoot a little RTV under the clips to hold them in position in case any of the clips have broken fingers.

Replacing Fixed Rear Door Glass. [Tips from Jay Simkin] To replace the small triangular piece of fixed glass in the rear doors, follow these instructions:

Remove the door panel. Put a strip of masking tape along the door and up to the moldings to avoid scratching the paint as you gently pry the trim up. Remove the outside door trim (bottom first then sides then top) with a putty knife bent about 45 degrees a half inch from the edge. Go slowly as it is held by pressure and road grime only. Bending it will annoy you when you try and reinstall it. Unclip the holders of the window to the lift mechinism. Remove the rubber molding that surrounds the rollup window. Remove the rollup window. There is a metal pillar between the fixed and movable windows held by a rivet holding it to the top of the area that the top of the window seats in to when its rolled up. Grind it off with a Dremel tool and with a small punch drive the rivet up into the top of the door. There are one or two bolts or nuts in the door that hold the bottom of the metal pillar. The vertical pillar should now be able to move towards the front of the car releasing the front edge of a big rubber molding that surrounds the fixed window. Gently pull the pillar out. It requires a bit of turning and goofing around but it does come out without bending. Put the molding around the replacement glass and insert it into the area towards the front of the moveable window area. It will just fit as the front area is a tiny bit taller than the back. Go to the hardware store and buy some silicone grease. Otherwise you will spend much time trying to slide the window and molding towards the rear of the car. Unlike regular grease it won't degrade the rubber. Use little and try not to get it anywhere else as it doesn't clean up well. Now just slide it back to its old home. Put it back together. Replace the rivet in the vertical piller once you are sure everything fits nicely. When reassembling the outside trim the top goes first then the sides then the bottom.

Replacing Glass Molding Trim Strips. [Editor] The bright or painted trim strips with rubber seals, located at the bottom of door and body windows, are held on with several molding clips. If the rubber is coming loose, use some adhesive to re-secure it: you do not need to remove the trim strip to do this. Cyanoacrylate superglue works fine. To remove the trim strips, first cut any adhesive at the front of the strip securing it to the body. Then gently pull back the rubber and use a flashlight to locate the clips. Use a putty knife to press down on the clip enough to be able to pull the trim strip away from the body, clip by clip as you move toward the rear. You may need to have a helper lever the strip away from the body, being careful to place a thin strip of wood on the glass to avoid damage. If the rubber is shot, you will need a new molding piece from the dealer: they do not sell the rubber alone.

Water Leaks.

Water leaks can occur from several sources. Loose water shields, clogged cowl drains, and a plugged evaporator drain are covered in the Heating and Air Conditioning section.

Front Footwell Vent Covers. I assumed the 740 had a windshield gasket leaking problem and I had the windshield reset. That did not stop the water leak and wet carpet in the 740. It turns out that it is leaking, as others have reported, from the unused left air intake behind the panel at the driver's foot. This vent panel, a small plastic panel which has an air grille on it, covers a space between the inner and outer fenders. The water directed down from the cowl into this space is supposed to drain through the rocker panel but the rubber gasket on the plug could let it into the footwell. To discover it I ran a great volume of water through the air intake beneath the windshield and sure enough, after 10 minutes a small, but steady trickle of water was coming in. Unfortunately this has rusted the floor through to the outside. WARNING, if you have wet carpets, get it fixed, the floors will rust through in a very short period of time. [Another Inquiry:] The problem is water leaking into the interior in the front footwell areas. The problem only occurred when the car was parked facing uphill. It turned out that runoff from the cowl compartment was directed into the car by a plastic tab on the plastic plates used to close off the footwell airvent openings.(Certain models like European 740's without A/C have fresh air vents in the sides of the front footwells.) After removing the plastic tab in the blanking off plates, the water leak stopped. [Response:] [Gary] Remove right and left front outer kick panels. Remove plastic plug and remove any of the rotten adhesive backed foam seal. Apply silicone sealant to opening and back side of plug. Put plug back in and make sure plug is totally sealed. Then on drivers side pull back rug facing firewall and look up toward windscreen, find the rubber grommet that is supposed to seal water from coming in from just below brake booster area; seal the passenger compartment and engine side of this to stop water from entering and wetting the floor. Disconnect the battery negative terminal. Remove the passenger side kick panel and ECU computer, then the computer cradle. Pull out the plastic body plug and silicone this up like the drivers side. [Another tip] Replace the plug cap for the fresh air intake with p/n 6848804; it comes with a new seal. It is a common problem. Break the old one out and pop the new one in. It should click in. [Tip] If you have a tough time removing this plastic cover or fear breaking it, then don't remove it. It will break. Gently pull it away from the body and clean around it. Then hold it away from the body and fill the gap with silicone sealer. I used 35 year silicone window caulking. Let the plug go back in place, then remove the excess with your finger and make sure the silicone has sealed all way around.

Door Wiring Harness Covers. The wiring harness going from the body to the doors (electric windows, speakers etc.) has rubber protective sleeve. This had split open and since the entry point into the car is several inches lower than that of the door, and once it enters the car it no longer has the this cover, the split acted like an open funnel, and guiding water in. Open your doors and check the cover. Duct tape worked like a charm.

Firewall Grommet Failures. [Darius] Had a significant water leak on the driver's side, floor was all wet. Turns out the water was coming through the hole in the firewall where the hood latch cable goes through. The little black rubber sleeve had slipped out and there was an open hole there. The sleeve was in perfect shape so I coaxed it back in and now my problem is solved.

Other Leak Areas. [Door Wiring Boots] Turns out the culprit was a split boot enclosing the power window, door lock, and speaker wiring. The split allowed water to enter the boot (a surprising amount at that) and was funneled into the car interior. [Cowl Air Intake Seal: Dick Riess] The sealing under the cowl air intake does deteriorate and I have seen leaks there. You need to take off the cowl vent to inspect. Clean and reseal.

Windshield Seal Leaks. You may find a problem in the seal around the windshield that's causing a leak. I'll bet if you pull the trim up, you'll find rust. Ever replace the windshield? [Tip] See Popular Mechanics for information about locating air and water leaks.

Wind Noise: Diagnostic Steps. [Tip from Demian Hurst, Motor Service Magazine, July 2001] For diagnosis of wind noise from such things as body seams or window/door seals, the following steps can be helpful:

- Attach cloth tape to panel seams, molding seams, glass seams, body seams and any other protrusion seam that might create wind noise in the area of concern (see illustration). Road test the vehicle and note any changes in wind noise.
- Remove the strips of tape one at a time. Road test the vehicle after removal of each strip, and again note wind noise.
- When wind noise reappears, replace the last piece of tape that was removed. Remove a different piece of tape. Road test the vehicle again. Keep removing tape strips and road testing until the source area has been isolated.
- Once the problem area has been identified, cut the strip of tape into several pieces and place them back over the area. Remove sections of the strip one at a time, road test and note wind noise. Keep removing tape pieces and road testing until source area has been narrowed down further.
- When the exact source of the wind noise has been isolated, repair as necessary using butyl tape, body sealer or additional weather-stripping.

Mirrors, Defroster:

Rear Window Defrost Wire Repair. [How it works: Jim Holst] Each copper line across the grid is a path for electrical current to flow from one side of the window to the other. As the current flows through the copper line, it generates some heat which drives off the frost or fog. If a copper line is even scratched, the path for the current is broken. No current, no heat on that section. The unbroken sections can still work. Each line is fed current from the vertical strip on one side and grounded on the other.

[Inquiry:] An appropriate question for winter, and old stuff. I've got only two of the defroster wires working in the rear glass of my Volvo. What should I do to get the others back "online"? I appreciate your advice. [Response: Ceferino Lamb] I just fixed mine. Volvo sells an inexpensive kit to fix it (also available from most auto parts places; one is marketed under the Loctite name), but the instructions are incomplete. It's just a little bottle of metalized paint and a brush. Here's what you need:
. that kit
. a DMM (digital multi-meter)
. electrical tape
. razor blade
Look over the wires very closely, with enough light outside to reveal any defects. You're looking for breaks in the wires. If you seen any, fix them with a few coats of the metalized paint. typically, the breaks are often caused by corrosion near the sides, where we don't clean the glass as often. Use the electrical tape to mask off the glass on either side of the wire where you apply the metalized paint.
If you fix all the defects you can see, and that still leaves wires that don't work, break out the DMM and test the resistance in those individual wires. You're looking for areas in the bad wires that are "open" but the fault is not visible. [Response 2: Ross Gunn] Turn on the rear window heater, and with one voltmeter test lead on the heavy strip of conductor at one side of the glass, touch the other lead to the trace that you think has is a break. The voltage will either read 0 or 12V. Move the lead along the trace (towards the other lead if 12V, away from it if 0V) . When the voltage flops over to the opposite reading, you have found the break.

[Rear Defroster Grid Repair Tips from Charles Cramer] I just repaired my rear window defroster on my '87 245 about 2 months ago (I've actually done this on about 4 cars). The job was relatively easy and the repair is working just fine. Here are a few suggestions/comments:

> 1) Often you can identify where the breaks in the grid are simply by turning on the rear defroster when the window is cool and/or damp/humid. Typically, you will see a round, clear patch appear (i.e. defrosted surface) at the breakage point, unless the gap is too wide or a piece of the grid has been damaged/scraped off the glass. What I did was to turn on the rear window defroster, and use a grease pencil (piece of tape, etc.) to mark these gap locations on the OUTSIDE of the glass. If you look closely, you can see the gap (although you may have to use a strong light or flashlight) in the grid. It usually looks lighter than the orangish-brown color of the rest of the grid. If using a voltmeter (analog or digital work just fine) to test for "opens" in the grid , be careful not to scratch the grid with the probe tips! I didn't use the meter method, as all the gaps showed up on close visual inspection.
>
> 2) Make sure that the grid side of the glass is CLEAN before you use the conductive

paint. A good "scrub" with a good quality glass cleaner and a paper towel with some "bite" (those "shop"-type blue paper towels on a roll that you can get at the local auto parts store work well) will ensure that the repair stays put. Don't be afraid to rub fairly forcefully over the grid lines IN THE SAME DIRECTION AS THE LINES (i.e. scrub from the left to the right along the length of the line, and NOT from top to bottom of the rear glass). It's amazing how much crud came off, and the grid definitely clears the frost off the glass faster and more evenly now. If you really want to be sure that the glass and existing trace are grease/oil-free, you can wipe them down with some alcohol. Be sure the window glass is DRY and warm when you go onto the next step. Don't try to do this outside in the cold, because the paint won't dry properly and therefore won't adhere well to the existing grid. [Editor] It might help to remove corrosion by lightly wiping with a fine Scotchbrite nylon pad.

3) The mask that is supplied in the Loctite kit has a gap that is really too wide for the existing grid. If you use it, you end up with a VERY large (wide) repair area, which will be both visibly noticeable and will heat up faster than the rest of the grid (makes for uneven defrosting). I used "invisible" type tape (the opaque type "Scotch" brand or the like, NOT the cello "clear" type tape) to mask off the lines. It sticks to the glass very nicely and you can get it right up to the edges of the grid lines. Don't be bashful about a lot of overhang beyond the gap. It will help you avoid accidentally getting some of the repair "paint" on the glass where you didn't intend it to go. Just make sure that the tape is firmly applied to the glass right up to the grid line, so that any paint can't sneak under the tape. Paint away, as directed in the instructions that come with the kit. As indicated in the instructions, you'll need to peel the tape off the window BEFORE the paint fully dries (actually, once it has just "set"). This is where having extra tape at either side of the repair comes in handy. Start nearest to the grid line at one end of the tape and SLOWLY peel it back and AWAY from the grid line. Repeat for the other side. If the tape breaks, CAREFULLY use a pin or single edged razor blade to lift enough off the glass so that you can peel the rest away. Your repair efforts should yield a nice sharp grid line, that looks (and performs) pretty much like the original. Don't be tempted to turn on the defroster too early - wait the recommended time for the paint to fully cure.

[Tip from James Stoney] I found an item that may be of help in repairing rear window defogger on glass wiring...The CircuitWriter a 7ml pen type unit that allows you to draw the line back in to being....part # S-CCW100P cost is $10.95 from Antique Electronic Supply http://www.tubesandmore.com Also may be available at local electronic supply houses.

Rear Window Defroster Failed. [Inquiry:] Last year my rear defroster worked. This year it doesn't. Switch light comes on and fuse appears good. With radio on AM, turning the switch on causes static. Is there away of checking the heat strips on the window?
[Response:] The static on AM is a good clue -- it says you have arcing somewhere. There's a relay that includes a timing function. Find the relay, pop the plastic cover and resolder the connections. Also check the contacts of the relay itself -- they may be burned. If it is the relay, at worst you'll have to buy a replacement. The resistive strips are all but bulletproof. Check the resistance at the window connections; it should be less than one ohm but not zero and not 10 ohms. Runs on about 10 amps (12/X=10, X<1ohm). Sounds like you may also have a broken

connection somewhere. Check for voltage at one side of the window connections and a ground at the other; the voltage drop across the strip when it's switched on should be 12 volts. Fix appropriately [see above] .

Mirror Motor. [Inquiry] My driver's side rear view mirror does not move when the motor is activated. If you push the buttons, you can hear the motor go, but the mirror only moves back and forth when you push it with your finger. It doesn't stay in place either. [Editor] The electric motor moves the mirror through two small rack gears controlling the X-Y axes of motion. The mirror glass has probably come unfixed from the motor because one or both of the little rack gears have broken. Given the cost of a motor from the dealer, look for a used mirror assembly and install the whole thing instead of replacing just the motor.

Replacement Mirror Glass. [Inquiry:] I stopped in a self serve wash today and broke my mirror glass. [Response: Rob Bareiss] Most windshield shops should be able to replace this glass for you, for 1/2 to 2/3 of the price of the dealer. Of course, if the car's got mirror defrosters, you might be stuck with OEM Volvo. Typically you'll wait 1 day for them to order the glass. Or try an online parts retailer.

Split-View Mirror. [Inquiry]Does the split-view (1/3rd wide angle, 2/3rd flat glass) driver's mirror exists for the 940's? [Response] I just bought one from VLVworld.com. It was the drivers side mirror with the heater element. It is not listed as such on their site, and I was somewhat surprised (and pleased) when it came in, but that is what I received (1/3 wide, 2/3 flat). You may want to email/call them to clarify/confirm.

Mirror Glass and Housing Removal. [Inquiry:] How do I remove the mirror glass on my exterior mirrors?
Earlier Mirror Glass. [Response: Abe Crombie] The mirror comes off by using a vary narrow blade screwdriver and going up through the oblong hole on bottom of mirror and moving the retainer gear to the right. [Editor:] Reinstall by engaging the mounting lugs on the back of the mirror and moving the ring gear to the left.
Later Mirror Glass. [Editor:] Later Mirrors for 940/960/90: I followed instructions in the manual for the later version of the mirror glass without the little gear mechanism in the bottom slot: "pull straight out." After not very much pulling, the mounting gimbal to the mirror motor cracked apart, leaving me now with BOTH a broken mirror heater and a broken mirror motor unit ($$$).
SO: If you have a later 940/960 or 90, here's how to remove the glass correctly. Activate the motor so that one corner of the mirror is way out. Using a flashlight, look inside at the mirror

glass mount. You will see a little conical locator pin with two locking tabs on either side. Each corner of the mount has a similar arrangement. Unlock the two tabs with a narrow screwdriver and pull that corner of the mirror just far enough to keep the tabs slightly disengaged. Move the mirror to the next corner and do the same thing, keeping the tabs just barely disengaged. Do all four corners (which can take patience and dexterity) and gently remove the mirror, removing the heater connectors after you can pull it far enough away. This procedure keeps the fragile circular positioning ring, tied to the motors, intact. To re-install, just re-connect the electricals, line up the locator pins and push the glass back in place until all the tabs lock. A little dab of grease on each tab will help.

940/960 Mirror Glass Locator Pins

Mirror Housing Removal. [Inquiry] The paint on my side view mirrors is starting to chip away so I'm going to paint them the same color as the car I just need to figure out how to take them off first. [Response: Dick] Take door panel off (door panel does not need to be removed if mirror is manual adjust.) Remove triangular portion covering mirror mount if electric and if manual, remove it including flex handle. Unplug cable from mirror if electric. Unscrew 3 8mm (I think) bolts holding mirror. Mirror should be in your hands now.

Heated Mirrors. [Editor:] *Testing Mirrors*. To test the mirror electricals, activate the motor to expose the connectors on the inboard side of the back of the mirror. Use needle-nose pliers to slightly expose the metal connector on each. The blue one is powered when the rear defrost switch is activated: use a voltmeter to test at this point for 12volts and for no resistance on the ground tab (black wire lead.) If it is getting power and the ground is OK, then the glass heater is faulty or the connector is corroded; if not, then the relay or door wiring is bad. Resistance in the mirror itself (between terminals) is around 4 ohms. These mirror connectors easily corrode. It helps to remove them, deoxidize, and reinstall with silicone dielectric grease for protection.
Adding a Heated Mirror Kit. [John Sargent] All 700/900 cars except the 1984 760 have the wiring for heated mirrors.

All you need are the two heated mirror glasses and the switch. The switch for the heated mirrors has two symbols on it; one showing the rear window defroster and the other showing the mirror heater.

At one time, Volvo offered a kit. The heated mirrors are a direct replacement and the replacement switch replaces the existing rear defrost switch. [Editor:] All electric mirrors are heated and the electrical connectors are inside the door panels. It is reported that replacement mirrors from Volvo are all heated.

Maintenance and Adjustment:

Sunroof Preventive Maintenance.

Lubrication. [Editor] Using Mobil 1 Spray Lube, Superlube, or Valvoline Synpower clear spray oils, spray the following:

- Front air deflector hinges and side pivot arm pins.
- Cables within cable channels on the side. Locate these from within the car using a flashlight: they are within the side guides.
- Pivots, levers, and hinges visible from inside the car.

Operate the sunroof to spread the oil and be able to see any spots you missed. Do this once per year.

Sunroof Motor/Crank Preventive Maintenance. For everyone with a sunroof in a 200, 700 and 900: Remove the crank handle and tighten the gear assembly screws. For electric sunroofs remove the cover and tighten the motor mounting screws. They all work loose over time and will cause the drive teeth and/or the drive cables to bind, wear out or get the lid misaligned and then the roof will not close. You might consider using a little Loctite on them to make certain they don't loosen. This little procedure will save you $100's of dollars.

Sunroof Alignment: Won't Retract Properly.

Emergency Retraction. If your electric sunroof will not retract, you can manually close it using a screwdriver. Remove the cover. You will see a large slotted screw, possibly with a ball bearing in the middle of it. Use a screwdriver to depress the bearing and turn the screw to manually operate the roof.

Sunroof Stuck Open: Check Electricals. [Inquiry] The moonroof on my 95' 940 opened tonight and immediately stuck in the ventilation position. The switch makes a clicking sound but the sunroof does not move. The fuse looked fine but I changed it anyway. Any suggestions? [Response: Rob Bareiss] You wouldn't be the first person to have a bad sunroof switch in a 740/940 with a power sunroof. It's likely to be the switch- replacement is pretty straightforward. Get a new one from Volvo, and it comes with a short piece of cable and the connector. How do you tell if it's a common failure item? It'll be IN STOCK at your local dealer (unless they just sold the last one...)

Sunroof Sticks When Closing. [Symptom: I have a 90 740 GLE and noticed that the sunroof is getting stuck when trying to close. I took out the motor, lubed everything and the motor appears to work fine. Also when the sunroof is closed if you look on the outside it doesn't appear to be sitting flush like it should.] [Diagnosis:] If your guides are not broken then you may just be out of adjustment. Adjustment is accomplished by loosening a number of screws, moving the roof and re-tightening. A Haynes or Bentley manual will help you through. If you do need to remove the sunroof there is an easy method. Open the roof to the vent position. Use a screw driver or needle nose pliers to release the springs that hold the sunroof liner to the roof. Push the liner back into the space where the roof would normally retract. This will expose all parts, and adjustment screws. [Response: Rob Abel] Our sunroof in our '93 940 acts goofy at times. Clicks and doesn't move - gets stuck - usually open - have had to close it manually by taking off cover and using screwdriver. On ours it's the switch. I take it out about once every two months, take it apart, clean up the contacts, and it works fine for the next two months. The only manual that will adequately address this is the Volvo factory body manual (Body Fittings: Exterior/ TP 8202201). None of the others do. [Norm Cook] My electric sunroof was binding on the wind flap and keeping it from closing properly. I noticed the sunroof trim had come unglued at front on one side; this was dropping down low enough to bind on the wind flap. Reglueing it fixed the problem.

Electric Sunroof Alignment. [Inquiry] The power sunroof on my '91 940T has stopped functioning, and is stuck all the way "open" (tilted up, rather) and won't go back down. This follows a few weeks of CLICCLICKLCLIK when opened/closed, and some erratic operation.

[Response: Kerry] (Applies to 1986 765) With your sunroof in the vent position you can remove the sunroof liner and check all the bolts on the mechanism and rail to realign the sunroof. To remove the liner:

1. Get a coat hanger and cut out the straight part. Bend the end to form a small hook
2. Pull the edge of the sunroof liner down at the end sticking up (remember your sunroof should be in the vent position)
3. You will see two spring loaded hooks which are attached to the sunroof liner and hooked to the sunroof. These hold the liner in place. They are at the back of the sunroof, one left and one on right.
4. You can unhook them with your coat hanger wire.
5. The sunroof liner can then be slid back out of the way (don't push it to far back)under the roof and above the headliner.

With the liner out of the way you can check all the bolts and screws. You can see the adjustment Allen (some may be Torx or Phillips) screws in the four corners. Adjust these so that leading edge of sunroof is 1 MM lower than car roof.Adjust trailing edge 1 MM higher than car roof. This gives minimum wind noise. When I checked mine, I found two screws VERY loose and one about to fall out. Use some locktite blue on any you have to tighten up.
Then close the roof and hook the springs back on with the help of the coat hanger hook.

The other thing is to remove the cover from the sunroof motor. There is a large screw with a button in the middle on the motor assembly. Turning the screw with a screwdriver will depress the button and allow you to move the sunroof BUT, it also adjusts the stop location for open and closed.

Sunroof Won't Open to Vent Position. [Tips from Ken Dibnah] If you have a 740 with an electric sunroof, when the roof is in the fully closed position you should be able to push the closed switch again and have the rear of the roof pop up to the 'vent' position. If you have a manual roof, after it reaches the closed position you feel a bit of resistance; you then continue moving the crank in the closed direction and the rear of the roof should pop up to the 'vent' position.

If your roof does not move at all, you must NOT pry up the rear edge manually as there are cast tracks at the rear of the panel that hold it in place and you will break, bend, or damage the tracks, roof or the panel.

Most likely it is out of alignment and too tight for the minimal leverage applied by the motor to move it, as well as being thoroughly gunked up. The secret to lack of motion is most likely binding in the up and down motion of the panel. If manual, try moving the crank back and forth, bearing in mind that the first motion the roof makes is that up and down motion at the rear of the panel. If there is resistance to the crank motion immediately, there is 'likely' to not be any damage in the screw mechanism, just binding of the panel in the roof.

If nothing moves as you move the crank towards 'vent', push up gently through that small rectangular opening inside the headliner on the rear of the panel to help it along, by just pushing it free of the roof. The tracks at the rear of the panel move the panel up and down, either to pull it down before retracting or to pop the rear of the panel up for the 'vent' position, and if they are damaged or too gunked up, they will resist opening. The device that is connected to the motor/crank via screw cables slides back and forth in these tracks, raising and lowering the panel, which will not be possible unless you can move the crank/motor. Try to get it high enough to be able to peer inside the roof from the outside to unhook the headliner clips - once you get those, all is revealed and you will be able to see why your roof is not functioning properly.

Re-Aligning the Crank Gears While Aligning the Sunroof. [Inquiry] I removed my crank to try to adjust the position of the sunroof. But the crank no longer clicks to a stop from the crank mechanism pin popping into the hole in the handle. How do I properly time the crank with these cycles?.[Tip from Bob] Start with the roof in the closed position. Remove the crank from the drive gear shaft. Remove the drive gear from the roof. Reinstall the crank, and turn clockwise (vent position) till it stops. Remove the crank and reposition it pointing straight ahead. Now, turn counter clockwise till it locks. Should be 2 revolutions. Reinstall the gear to the roof.

Cable Attachments Loose. [JMars] If you can get the sunroof to open, you can sometimes work from the top down. Remove the metal stock wind deflector and it should reveal the motor driven gear where it engages the cables. There are two rivets on either side that attach the cables that often come loose. Replace them with pop rivets or self tapping screws and use a faucet washer over the gear to keep it inplace. My sun roof was jamming in the rear raised position and I fixed it in this way.

Sunroof Motor and Cable Alignment/Reindexing. [Qeury] My sunroof motor loosened up on the right side and now my panel is off kilter. (passenger side is one inch lower than driver side. I have removed clips and springs per FAQ but the liner will not slide back to reveal mechanicals... does anyone have a secret weapon for adjusting the worm drive when the motor is still in your way. [Tip from John Sargent] The motor (or hand crank) is supposed to move both cables an equal amount. When the motor was loose, it moved one cable without moving the other, and the cables are no longer indexed to each other. After you get one side of the sunroof where it is supposed to be, remove the motor, and look up at the cables. You'll see them on the front and rear of the opening. Then move one cable using a flat blade screwdriver. Watch to see you are moving the side which needs to be re-indexed. When you have adjusted one side to match the other, re-install the motor and try it electrically. With not too much trouble you can get the cables indexed to each other. [Dave Stewart] I loosened the motor again and using it in "out of spec" locations rocked the panel back to true..

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960 Sunroof Adjustment. [Tip from Tom Irwin] Most of the posts I've seen here describe access as through the rear with the roof up in tilt/vent position. Something about unhooking some springs or clips to remove the "push back guard(?)" then push back the headliner panel into the roof....then something about some chingas with a torx screw.

WRONG! Not on this run of 960's anyway.   It took me a while to figure this out, so I hope someone will benefit.   Basically the rear of the roof , when parked, was always about 5mm's below the roof line, while the leading edge was flush. I can hear this at highway speeds.

Don't do anything to the "push back guard", (not necessary) or look for springs or clips, (there aren't any.) Just leave the roof in parked position. Push back the panel was far as it will go without undoing anything. Up on both side of the roof, parallel to the tracks, you will find one per side of black/grey injection molded, plastic strips. Lift the lower edges and they snap right out.

Now there are 4 bolts with an 8mm head. one each at the front and rear of each track, left and right. Loosen each of these 1/2 of a turn. Push up one corner at a time, til it's flush with the roof line, then cinch the corresponding bolt tight. Snap the strips back in place and you are done.

Sunroof Sag and Adjustment.

Adjusting the Sunroof Position:

[Inquiry] Recently I've noticed my sunroof seems to be sagging, and I'm wondering if there is some way to get it sitting straight again? [Tip from Rick Tilghman] There are two adjustable screw brackets that allow you to alter the sitting position of the sunroof (silver coppery color, one on either side in the back to control the angle of the "vent"). It is possible for these screws to become loose with time and allow the sunroof to drop down a bit to the lowest possible sisting position. Fix: vent the sunroof; from the outside undo the two springs that hold the headliner sunroof panel to the sunroof; use a long screwdriver to tighten the adjustment screws down while holding the sunroof at the desired angle.

Repairing Sunroof Support Rods:

[Inquiry] I tried adjusting my sunroof's sitting position, but it is currently maxed out and is STILL sagging below the roofline. Is there some other solution? [Tip from Rick Tilghman] This happened to the sunroof on my 1985 745t. The answer is a bit long, but bear with me and you'll be well informed. The adjustment screws on my sunroof were maxed, and the sunroof was still low. Looking closely I noticed that there was discoloration on the end of the metal bars that the adjustment screws hold the sunroof onto. These two levers, one on either side of the sunroof running parellel to the car's direction, control the venting action and sitting height of the sunroof. When I looked really close I noticed that the discoloration was, in fact, a spot that was supposed to connect the rear and front ends of these rods. Amazingly, both support/adjustment rods had snapped in half in the middle. The flaw: In 700 sunroofs there is a metal bracket on each side with two grooves in it. The front groove is long and closed at both ends. This groove allows a metal pin to slide back and forth, limiting and manipulating the sunroofs vent action. The second groove is closed at the top and open at the bottom, providing secondary (but pivotal) support for the venting mechanism. When the sunroof is up ALL FORCE is applied to the small piece of metal (about 1/4" square) that closes the top of this second groove. This piece of metal is inadequate for the job, and over time the piece breaks from the combination of upward force applied via the levering and downward pull via springs and resistance. Once this piece snaps in two, the back of the sunroof sags down in the resting position due to the lack of support, making it IMPOSSIBLE to get it sitting right ever again. The interesting thing was what I noticed when I examined NEWER Volvos. NONE of the newer volvos sunroof brackets were snapped, and all were in perfect working order. ALL newer volvos utilize a slightly modified design that redistributes the force applied to the metal bracket more evenly between the front and back of the metal bracket. It does this via one major change: In the earlier models there is a metal arm approximately 2" long that reaches to a pin that sits in the aformentioned open ended groove on the rear of the venting arm. In the newer models this arm is replaced with a 5"- 6" piece that reaches past the mechanism to the every back end of the bracket. Additionally, there is a metal bar extending from one side of the sunroof to the other that helps to push the brackets out slightly and keep the pieces oriented properly. This extender has springloaded ends that slip over silver arm extentions from the front groove. Instead of having the springs slip through holes in the little arms of the front grooves (like the older models), the springs in the newer design have plastic o-rings that slip around the metal rods. Because of this and the extender bar, the pull from the springs and general downward is dissipated over the entire arm, eliminating the possibility of breakage. If you notice your sunroof is sagging constantly, and that you can't seem to get it to stay at the height you want, even WITH massive adjustment of the sitting screws, this may be your problem. Open the roof in the vent position and use a flashlight to take a closer look. This problem is apparently limited to earlier production models, but it is possible that later years could experience the same problem if excessive downward force is applied to the sunroof (a luggage carrier comes to mind). Repair: The fix for this is nasty and tedious, but it is doable and inexpensive if you have access to a junkyard. Replace your sunroof supports and mechanics with the newer design from a junker. The sunroof roof itself is only held into place by 6-8 screws, and lifts out once you gain access to these and remove them. You only need to replace the support struts and accompanying components, not the roof itself (but removing it makes it easier to gain access to the elements). Make sure to take ALL the little pieces you take off the junker... many pieces may look similar to ones you have but they are slightly different (so substitution isn't really possible).

Procedure to Remove Sunroof Panel (see also Warren Bain's notes above)

1. Vent the sunroof
2. Release the springs that hold inner headliner/sunroof panel to the outer sunroof panel.
3. Make sure the vent part of the inner sunroof panel is pushed down completely so it is flat.
4. Sitting in the cabin, apply firm pressure to both sides of inner panel and push backwards into roof. The panel should "snap" out of its holders and slide back into the roof completely. Just be careful the vent panel doesn't slip upwards and get caught. Slide it back on its tracks SLOWLY but surely, keeping an eye on it to make sure it the vent is down and that it is properly aligned. The vent can "pop-up on you and get wedged over the metal cross-piece.
5. Look up at the now-exposed inside of the sunroof outer panel. You should see a rod across the middle, the track runners, etc. You should also see a number of brass screws. I think there are four in the front, two on either side in the middle, and two on either side in the back. The last two are the ones that control the sitting position of the sunroof.
6. Remove all the screws.
7. Lift the sunroof panel out of the roof (with care)
8. You now have direct access to the runners and internal sunroof components.

Sunroof Wind Flap.

Adjustment of Height:

[Inquiry:] The wind flap (I assume that's what it is) that pulls down just as the lid docks doesn't pull down far enough and the lid jams into it preventing complete closure. [Response: Dennis Jeong] Tilt the roof up and pull both of the cover flap spring rod loose (it pulls toward the rear of the car). There is one towards each upper corner of the cloth cover . Close the roof and pull the inner cover towards the rear of the car. Check the top of the roof, if it's flush then look at the adjustable catch on the front edge of the roof panel. It should not tightly hold down, there should be a little play. There are four copper colored screw, two per side side. These determine the overall height of the panel and it's fit. Loosen the front catches then adjust the copper screws. Play around with it, you'll figure out how it works. DO NOT FORCE ANYTHING. If you break anything, you'll need to get a used part. The sunroof mechanicals are sold as a unit only. Very expensive.

Vibration and Arm Adjustment:

[Tips from Rick Tilghman] Recently my sunroof flap began to vibrate while driving. Having read other posts from brickers about this annoyance, I thought I'd post my results. While I've disassembled the unit, I've never really thought about the wind flap... it was always just kind of there. Anyway, my first assumption drawn from incidental "looks" at the piece was that the responsibility for anti-rattle lay with the two horizontally mounted springs under the flap (parallel to flap). They just looked weak and responsible. However, when I pulled all the parts I noticed that a cout hanger looking piece of metal was sticking out from under one of the retaining arms connected to the sunroof. I had thought these arms were only responsible for pulling the flap down, but this proved incorrect. After disassembly of the arms it turns out that there is a premolded piece of steel (white metal coat hanger in dimensions) that is curved to bendup into the arm and provide resistance. It also turns out that these pieces and their accompanying brackets aren't stainless, because the whole damned thing was rusting like mad. One of the pre-molded pieces actually snapped as I was playing with it. Anyway, the solution was just to uncouple the retaining arms from the flap (you have to push the flap to a straight up position to do this with it in place), push the arms up out the way, remove the pre-molded resistance piece, bend it appropriately so that it is forcefully "loaded", and reinstall. Once this is completed you may notice your flap riding high and failing toclose properly... generally a side effect of pushing the flap up to get it unhooked and playing with it over time. Just put two blocks under the outside edges of the flap (screw driver handles work well) and gently flex the entire flap down so that its overall shapes doesn't ride quite so high in the middle. Close and open the sunroof after each small flex to make sureyou don't overdo it... you only want it to just clear the sunroof edge. (you could also solve this by altering the bend in the retaining arms themselves, bending them up so the sunroof contacts and drives them down farther earlier, but that metal is a three way piece and much more resistant to general "flexing".) If you need to replace the pre-molded steel first bet is a junkyard brick, second bet is the hardware store (you just need a piece of thin and lightly maleable steel in the appropriate dimensions), final is Volvo (maybe they should be first, but something tells me they don't supply this piece separately). I should also note that the job is slightly easier if you remove the retaining arms entire connection bracket. To do this just loosen the screws that hold teh runner down and gently flex it up about 1/3". The connector can be finnagled out without full removal. End result is an absolutely quiet windflap.

Addition of Plastic Wind Deflector to Roof

[Inquiry] Does anyone have experience with the plex wind deflectors? Does it help the buffeting? Worth the bother? [Responses] It does seem to cut the wind noise. Wind deflector definately worth it!! My 89 740 has one and it makes driving with sunroof open quiet even at 75 mph...well, not silent but quiet.

Sunroof Leaks. [Inquiry:] We just got an 89 740GL, the owner said that the sunroof only leaked when washed with a high pressure spray. This is not the case, it just rained and the headliner is wet. I looked at the seal? if that's the black strip that goes around the whole sunroof, it seemed ok. I'd imagine that the water goes past that seal and into that black gutter type thing on the aft side and drains overboard. I don't have a manual yet so I'm not sure how this is supposed to work.

Drain Holes:

[Response: Tony Stanley] If its a factory fitted sunroof the 'seal' is not to meant to be a perfect seal and the gutter should carry away the water. The chances are the drain is blocked, or the hose is kinked. They drain to the front and rear. The front goes down the A pillars flowing out behind the front wheel, the rear goes out the C pillars and down the rear quarter panel, flowing out behind the wheel. [Don Hodgdon] The drain holes for the front sunroof drains are just below the leading edge of the front door. If you feel under the rocker panel, there is a "D" shaped hole that the water from the sunroof and the fresh air vent (at the base of the windshield) drain to. they can be clogged with undercoating. Water from the sunroof's rear drain holes goes back through plastic tubes, down the C pillars, through the trunk (you have to peel back the carpet on the sides of the trunk to see the hoses) and out through a plastic fitting mounted to the lower quarter panels, hidden on the outside by the rear bumper trim. Debris from the rear window drains clog up the plastic fitting which can flood your trunk and cause the sunroof drains to back up. You can disconnect the hoses and use a shop-vac to clear out any stubborn debris. [Editor] To clear blockages in the tubes, use a long cable with a non-snagging end so you can rotate it within the tube as it is pushed down from the sunroof. Compressed air might either compress the blockage or burst the tubes apart deep with the pillars.

Worn Sunroof Seal Guard:

[Rick Tilghman] Over time the sealing ring around the sunroof's edge becomes worn and frayed, allowing water to leak in regardless of how the roof is seated. The fix is to pull the sunroof panel and replace the sealing ring with a new one. Note: you HAVE to remove the roof to do this since the ring slips off from the bottom. The seal sits on the bottom lip and can be removed by pressing down on it. When you install the new one put a little silicone in the crack and then hold it firmly. This will help make sure the new ring doesn't slide down and dislodge when you vent or move the sunroof.

Sunroof Design Flaw in Earlier Models:

This causes the sunroof to perpetually sag and fail to achieve the solid seal that prevents water from entering the cabin, affecting both the sunroof headliner and the headliner surrounding the sunroof opener. See the Sunroof Sag section for details.

Failing Glass Seal in Glass Sunroof/Moonroof:

[Adam Stevens] In trying to trace a significant water leak from my sunroof, I saw that the water appeared to be getting into the greased 'tracks' that guide the sunroof backwards and forwards (they look like a channel on either side of the sunroof about 2-3 inches from the edge of the sunroof opening and are supposed to catch and get rid of any water that gets past the weather seal around the outside of the glass) and then into the 'guttering' that runs around the outside of the mechanism, thence to the bottom of the plastic corner pieces of the gutter. It seemed a little odd as it was leaking from both sides. It was then that I noticed water between the weather seal and glass on my glass panel. When I removed the glass panel and stood it on its end water dripped out. I pulled the seal off to find that water had been getting under the seal and managing to track around the glass panel thanks to Volvo's crap attempt at sealing the glass to the frame. The sealant was not in the joint for much of the time, but a few mm off which allowed it to act as a nice irrigation channel. The water then reappeared above the guide rails and hence the leak. Had I spotted it before I removed the entire sunroof, I could have undone the 4 bolts holding the glass panel and changed the seal with all other trim and fixtures in place. Alternatively, some silicone sealant would have done the job in minutes. Blast. A few hours job which took me days to trace and fix. [John Seaton] I removed the seal around the glass and had a good look. It seems the glass is bonded onto a metal frame. This bond had gone in places and was letting water through. So with a little time to clean up and reseal then placing the main seal back , no more leaks. [Charles Salley] I used a black silicone trim sealant from my local auto parts store that came with a fine nozzle attachment to force the product into tight areas. I first gently pried back the rubber gasket on the glass side and scraped all the crap off to ensure a good seal, then forced the sealant around the perimeter of the glass. Problem solved.

Manual Sunroof Repair. [Tip from Warren Bain. See also Ken Didnah's sunroof overhaul tips below.] These are the procedures I used to fix my sunroof. Mine would not flip up in the back, in fact one side would not flip up, the other would. The sunroof would retract but would not close without my help. I determined one control mechanism was broken so I bought both, since one was bad, the other might not be far behind, and I didn't want to do this repair twice.
The first and most important step is to determine the extent of your sunroof problem. Will it move at all, will it retract ok and not close, will it flip up in the back? I will not discuss the more involved procedures, cable replacement, sealing strip replacement, cable sleeve replacement or complete removal of the frame. I will also not discuss 140's and 240's since I have only experience with 700's. Some 900's have a moonroof, a glass panel instead of stamped steel,

like my 965, and I will not address them. I will discuss adjustment and control mechanism replacement.
When you have determined the extent of the problem and want to continue, open the sunroof to the ventilation position. From the outside, release the spring clips from the sunroof lining, a pair of needle nose pliers works for this.

- Close the sunroof.
- Pull down on the headliner just forward of the interior lights.
- Pull the sunroof lining back so it is inside the roof.
- Look at the control mechanisms to determine the extent of the repair. Are they ok, are screws missing or are they loose? If the screws are loose, tighten them, if missing, find and replace.
- If the sunroof needs more extensive repair, remove all screws and lift out the sunroof.
- Remove the electric motor or manual crank. Doing this will allow for proper control mechanism centering, a procedure I needed to repeat.
- Replace the mechanisms by removing the two SMALL circlips with a small screwdriver. Do one side at a time so the other can be used for reference.
- Transfer the spring to the new control mechanism and place the new one where the old one was, make sure the small plastic covered tab is in it's slot and on top of the flat metal 'spring'.
- Replace the circlips, again needle nose pliers work here.
- Do the same to the other side.
- Align the control mechanisms with the slots for the small plastic covered tabs, slight back and forth motion works here.
- The control mechanisms should now lay flat and be loose, not tight under tension. The sunroof is supposed to be closed after all.
- You will notice the cranking mechanism is nothing more than a modified worm gear arrangement.
- Make sure the sunroof retracting mounts, up front and to the side, are properly positioned and as far forward as possible.
- Replace the sunroof.
- Replace the screws leaving them loose so the sunroof can be adjusted for height, which will be done now. Do not try to operate the sunroof at this time since it is loose and the liner would be pushed back into the bowels of the car never to see the light of day!
- Adjust the sunroof height by operating the sunroof SLIGHTLY in the rearward position and also in the ventilation position, flipped up in the back.
- Close the sunroof and make adjustments. It should sit down slightly from the roof but there should be no gaps. Make sure the spring clips are installed in the rear edge of the sunroof and the large springs are attached to the large pin on the control mechanism.
- Apply oil or grease to the control mechanism slots which should be an annual event. I found one of mine had dried out grease and was nearly ready to break.
- When you are happy with the positioning of the sunroof, move the liner forward and flip up the sunroof to reattach the clips to the lining.
- Operate the sunroof and enjoy.

See it wasn't that bad! Take your time, have a friend assist, maybe even videotape the entire procedure, just in case.

Sunroof Overhaul. [Tips from Ken Dibnah on stuck sunroofs] Is the roof manual or electric? If it is electric, there may be electrical problems with motor, switches, wires and fuses, which I will not deal with. Will it open? My experience with them is the 'tracks' at the rear of the roof that raise and lower the panel, pot metal I think, break and jam everything up. Also the roof is rarely cleaned or lubricated: if this is done carefully, the only thing to do is to replace worn/broken bits and then adjust the 4 adjusting screws, one at each corner.

You may also have to replace the sealer that lives around the perimeter of the sliding panel, as it may not provide the exact clearance required to allow movement yet still seal.

I will assume it is electric and the motor works (although it may be seized, have faulty microswitches, or need an overhaul - usual motor clean-up with commutator-cleaning and possibly lubrication, although it may have sealed bearings (most likely)). If it does not work, remove the panel that covers it and use the tool that is supplied in the tool kit, inserted in the shaft, to manually move it. Also, when you look at the motor, there is a guarded-by-paint screw that I believe is used to adjust the microswitches, but I have not observed any change when I fiddled with my own. There may be an issue with these switches as to positioning when the motor stops, but bear in mind it is possible to toss the motor and use a crank/manual version from another model.

Do you know how to get at the roof? Open up the rear roof part in the vent position and peer inside. There are 2 clips that are best removed/gripped with needle-nose pliers, unclip them and these will release the head-liner cover from the moving panel. Go back inside the car and push the headliner back in its slot, but not too far in lest it get jammed, as it likes to do; everything is now revealed.

The panel just sits on the tracks in the front, and is actually a loose fit. Most likely you will see that the screw/worm that drives the roof back on either side will be gummed up with old grease/ lube, in typical Volvo fashion; I found that liberal doses of WD40 loosened the goo so it was possible to remove a lot of it. Re-lube was done with spray lithium grease, but beware the close proximity to headliner et al, the grease fairly flies about and careful masking is required.

Sunroof Removal. [Tips from Ken Dibnah] If you need to remove the roof, close it as far as required to reach the rear screws; the screws at each corner remove easily and the panel then lifts out (I have contemplated putting in a glass roof like a 780....hmmmm). Put a blanket on the roof so you have somewhere to set the panel. Taking it off may not be necessary, but it would make it easier to clean all the tracks. I used a dry stick lube on the tracks, but I think something less viscous might help the operation (perhaps the aforementioned lithium grease?), but I would worry about getting it on clothing etc. I have a vague memory of some cables and small springs? I do not have them on my roof, but maybe on an older one? Other car I worked on was a crank-driven roof on an 85 740 GLE, but I think there was no involvement with these cables, except to unclip 'em when the panel came out? If yours doesn't have 'em, forgive my 'old' moment.

If you replace broken tracks/racks, I would replace them in pairs, as whatever shock that has caused the roof to fail may have affected both sides. As I recall, they are involved with split-rings, diabolically small and determined to shoot far under your workbench.

The front of the roof pops up into position only by riding up on the collapsed wind deflector. There are (2?) rubber snubbers that sit under the deflector, only glued in, and frequently these have vanished, therefore not encouraging the roof to finish in the flush position. The rear pops into place by the action of the racks, those that are most likely damaged, and its position is adjusted by the screws that you remove to take off the panel, as well as by the position of the worms when the motor shuts off - you can observe this as the worm should sit in the bottom of the rack, holding it flush, when the motor stops turning.   You can remove all the tracking/guides/ bearing surfaces from the car, just by undoing everything and replacing it in order, but why would you want to? If a worm has broken, perhaps, but cleaning in situ should suffice. With the roof out, your experience should allow you to fix whatever I have neglected to mention. Look for warping, physical damage etc. [Tips from Dan Williams] Removing the sunroof is not as daunting as you might think. There are 8 to 12 screws that hold it in place. First, raise it to the vent position and from the outside, press down on the inner panel to locate the spring clips. They are fairly obvious and easy to access with needle-nose pliers. Back inside, go from vent to 'slide open' mode but only open the sunroof a few inches. Grab the inner panel and slide it straight back to disengage it from the sunroof panel. A quick jerk is required, or the whole panel will move. I used a lightweight mallet - no damage to be done because the fabric was being replaced. Back outside with the panel almost fully extracted remove the screws mentioned above. They can be easily found by looking at the pan for where they protruce. Some of the serews are machine screwsa and some are sheet metal screws. To access the screws on the front will require you to 'spring' the wind deflector open wider than normal. You may have to adjust any slight bend out when you put it all back in. Now just pull the whole assembly out through the top. Place a blanket on the roof in front of the opening to avoid any scratches. I didn't remove the crank mechanism from the rail network, and was able to get it all out and back in, but I believe others recommend removing it before lifting all out. Be carefull with the inner panel. There are some plastic glides that slip over the end of the panel where it moves in the side guides. They can be broke or lost. Alternate solution: Drop the whole pan that holds the sunroof in place. This requires you to remove the four hoses and clips around the perimiter. I have not tried this, but it may actually be easier if you have a second pair of hands. Might be a good idea in your case since you are concerned about the hoses being clogged.

Electric Mechanism:

Removing Sunroof Switch. [Editor] The sunroof switch fails frequently, usually showing intermittent symptoms, because of the high current loads through the switch. See the FAQ section for instructions to remove it.

Electric Sunroof Motor Overhaul.
[Tips on Motor and Cam Follower Overhaul] There have been some comments recently about 740 electric sunroof problems. My experience with my '90 740 GLE follows. Perhaps it may be of use to others.
Problem: occasionally, if the sunroof were opened to either the full back or full tilt position, it would not be possible to move it out of these positions. When pushing the switch, the click if the motor solenoid could be heard, but the motor did not operate. Sometimes, persistence paid off

and the roof would close after a few tries, but on other occasions, the only way to get it to close was to remove the plastic panel covering the motor and with a large common screwdriver turn the drive shaft 1/4 turn in the closed direction (as evidenced by movement of the roof) after which the motor would respond to the switch input.

Diagnosis:

1. Seized sunroof motor. [Colin Shepherd] Wire 12v direct to the motor connections as a first step to isolating the problem before stripping out the micro-switches etc. Mine had a seized drive motor armature bearing and all worked fine when this was freed off.
2. Problem in the switch(es) internal to the motor unit.
   Repair action for microswitches:

Remove the motor as follows:

Remove the two screws holding the plastic cover (2 #10 torx screws)
Cut the headliner as required to get access to the motor - only cut areas that will be covered by the plastic cover. Obviously when the car was built, the motor was installed first and then covered by the headliner.
Remove two small Phillips screws near the rear of the motor housing, 1 10mm nut at the front, and one large Phillips screw that connects the motor ground to the body just in front of the motor (front and rear refer to the ends of the car that have headlights and brakelights respectively).
Withdraw the motor and undo the connector (may be a little easier said than done depending on the amount of slack in the cable)

[Photo courtesy of Mike Ponte] With the motor out of the car, remove the white plastic cover over the switch cam (I'm making up names as I go here). It is held in place by three snap clips and is easy to remove. This will reveal a large (2+ in dia) white plastic cam disk that is driven by the motor/gearbox output gear. On this disk are three cams. There are black plastic cam followers that activate one microswitch each on the top and bottom cams. On the middle of the three cams there is a white plastic follower that moves a plastic leaf that in turn activates both microswitches. The black cam followers had fairly sharp points that rested on the surface of the cam, while the white one had a rather blunt point. My conclusion was that the white one had worn to the point that it no longer activated the microswitches reliably. To overcome this I glued a piece of cardboard (as in cereal box, although others may come up with a preferred method) to the ivory coloured plastic leaf the follower contacts. The cardboard was positioned so that the follower would contact it, thus compensating for the presumed wear to the tip of the follower. I then applied some grease to the surface of the cam with the hope of minimizing further wear and put everything back together.

Result: So far the sunroof has operated 100% reliably. I hope my conclusion about wear to the cam follower was correct and that the roof will continue to work properly.

[Tips on Motor Electrical Overhaul from Pete Gotseff]

Testing:
1) If your motor "clicks" but doesn't move, remove motor cover (2 phillips) and get access to the motor connector (comes in from left side). The blue and red wires at the two prong connector should be +12V or –12V depending on sunroof momentary switch position. If you're getting proper voltage to the motor verify brown ground wire is well grounded (very important!). If I recall correctly an improperly grounded motor will "click" but not move.
2) You will be removing the motor so it would be best to put sunroof in vent or closed position with a screwdriver on the manual override. Either of these two positions will allow the motor and sunroof to be timed correctly when reinstalling the motor.
3) If voltage and ground check out – reconnect connector and unscrew (2 phillips) and unbolt nut (10mm) and let motor hang (not a good idea but what the heck). Now test the motor while electrically connected including the ground. Again, make sure the ground is well grounded. BTW, if the motor moves you will have to retime the motor :-) more on this later. If the motor works normally it is likely your sunroof is binding and you should drop the headliner and dive headfirst into that problem.
4) If motor still just clicks test the motor itself by putting 12V across the actual motor terminals (not the connector) and see if the motor runs smoothly. Reverse polarity to verify both directions.

A properly working motor will rotate (as seen from the bottom and in vent position) CCW about 1 turn to closed, pause, push SR button again and CCW about 8 turns to full open. Not exactly sure about # of turns.

Repair:
If the motor still just clicks then it will likely one of the two microswitches located in the timing gear cover.

1) Pop off the three tabs and carefully rotate the white nylon cover out of the metal motor case leaving the motor wiring connected. This plastic cover contains two microswitches, a selenoid (remember "click") and three small pointed plungers. FYI: These plungers are actuated by the sunroof motor driven timing gear which remains in the case. The timing gear has three alignment points on three levels which correspond to vent, closed and full open. The center point on the middle level is "closed." This will help when you retime the motor.

2) Remove the micoswitch holder pin at the corner (some have a slot to adjust switch position and small retainer clip) and remove the microswitches as a pair (they are soldered together). They can be removed without removing anything else by using a small jewelers screwdriver to

move the microswitch plungers out of the way of the selenoid actuator. Now, use photographic memory or paper to record colors of wires on each switch (you'll be sorry if you don't). Unsolder just one side of the common copper ribbon holding the microswitches together (just one side is good, leave the other side attached to the other switch). Then unsolder the remaining wiring (two black leads) which hold the switches to the selenoid.

3) With switches free test each one for high resistance through the normally closed circuit – the front (blue or red) connections to side terminals. My switch had 63 Ohms across these terminals when they should've been around 1-2 Ohms.

At this point you should find a bad microswitch. You can repair (as below) or replace from a good electronics store (i.e. not Radio Shack) be sure to get a switch with lug terminals not spade type. Spade type will not fit when placing switches back into the cover.

4) Now open switch case by carefully drilling out one side of two small metal retaining rivets. Punch rivets through with small screwdriver. Open case carefully to avoid spring, switch assembly from flying behind/over/under workbench. Sand contacts lightly with sandpaper. Reassemble case and epoxy switch case cover (you'll never do this again). Resolder switches and reassemble them into the cover.

5) Turn the motor manually with a screwdriver to ensure the three level plunger in the cover will fall somewhere between the three timing points on the timing gear. But don't align the gear points directly with the three level plunger – they will interfere when putting the cover back on. Replace the cover which contains the microswitches and selenoid onto the motor case.

6) I suppose now would be a good time to bench test the motor. If no 12V supply is available (I use an old Sun computer power supply) test in the car (see below).

Retiming motor (electrically installed in car):
1) Make sure motor is electrically connected to sunroof connector and ground. Now, run motor CW (as seen from below) until it stops, push on momentary switch again. If no movement then motor is in vent position.
2) If sunroof is in vent position motor can be reinstalled. If sunroof is in closed position push sunroof button to rotate the motor CCW to the closed position. Now the motor can be reinstalled. This may take some trial and error but if the motor is working correctly you'll figure it out eventually – HeHe.

Sunroof Won't Stop at Close: Motor Defective. [Inquiry:] My sunroof will not stop in the closed position and therfore the user must get out and look at the roof to make sure it is closed properly. The local dealer says the "stop" mechanism in the motor has failed and the only solution is to replace the motor or live with the nuisance. [Editor: see overhaul notes above. An overhaul is labor intensive and a new motor might be a better choice] [Response: Rob Bareiss] Replace the motor or live with it. You might get lucky and find a good one in a junkyard. If that fails locally, try calling the used parts suppliers who advertise at the Brickboard. They have more nationwide connections. I will bet that they won't guarantee one of those motors once it's out of their sight. Alternately you can bite the bullet and buy the $300 motor new from your friendly local dealer. Seems to be happening to a lot of '88's lately. Can't guess why except they're about the right age to fail, and they're among the earliest cars to have this unit.

Electric Sunroof Motor Needs to Be Zeroed. [Tip from Jim Urban] Don't know if you are aware of this, but: to zero out the power motor:

1. Disconnect the motor from the gears.
2. Hold the motor in your hand and run the motor rearwards to the stop position (4-5 secs).
3. Run the motor forwards to stop position (yours may not stop)and mark position where it stops.
4. Run motor forwards again (should go to vent position).
5. Run motor forward (1-2 secs). It should close from vent postion. Mark where it stops.

If motor doesn't stop in same position, adjust it using a screwdriver. Adjust it between the two stop marks.

6. Put the control arms in the neutral position (the little wing on the arm is in the notch in the rail.
7. Install the motor. If the motor won't line up, move the control arm forward on one side (1-2mm). Still a problem? Move that arm back to neutral position and try it on the other side.

Your gears are working, so I think this will work. If not, I can't help.

Sunroof: Replace Motor with Crank. [Inquiry:] My sunroof motor has died and I do not want to spend $400-500 to replace with a new Volvo motor. Can a manual sunroof crank device replace an existing sunroof motor? How extensive is it to perform, or is it a square peg into a round hole... Do you know of a good aftermarket manual crank or motor unit available? [Response: W. Bain] I have a manual crank in my '86 744Ti and it is blissful. My 965 has an electric motor. Go to the junkyard and find a donor with a manual cover and crank and remove the handle, the gear mechanism, the plastic trim and ALL screws. Make sure the sunroof itself sits in the roof properly, i.e. flat and level, while fully and properly closed . Remove the power motor and tape up the wires. Swap the manual for the power parts. The crank mechanism needs to be centered properly, otherwise it will need to be re-centered.

Sunroof: Replace Crank with Motor. [Tips from George Holmer] To convert your manual sunroof to a electric one and enjoy the luxury of a smooth, button operated opening and closing of the sunroof, simply do as follows: At a breakers yard, find a sunroof motor, a motor cover colour matched to your headlining and a switch matching your dash style. Get as much wire as possible. Once home, remove the sunroof rank handle and then the cover to expose the mechanism. Remove the mechanism too and replace with motor, this is a direct fit. Now, you have to wire it in. Remove the trim bit that goes along the top of the windshield and also the mirror, the sun visors and the sun visor clips. Finally, remove the grab handles and trim behind the grab handles on one side to expose the screw fixing the A pillar trim which you then also remove and the panel underneath the steering column above the driver's feet. First, ground the sunroof motor by attaching the black wire to one of the sunroof bolts. The pull the red and blue wire to the switch which you have fitted in a spare switch socket and attach red to red and blue to blue. Finally, wire the black switch wire to an grounding point and the blue/yellow wire to a power supply, preferably the fuse which according to your fuse board is the one for the power sunroof. Now re-connect the ground lead on the battery and test sunroof.

Headliner:

Sunroof Headliner Replacement. [Tip from Chris Mullet] When I replaced my sunroof headliner, I left the sunroof in place, but dropped the back end of the pan (over the back seat) and slid the sunroof headliner panel out the back. I had to remove or loosen all the screws out of the pan except for the ones across the front which kept everything in its proper location. That way, I didn't have to do a bunch of re-adjusting of the sunroof itself when reassembling. Worked slick. [Editor] There is a Volvo TSB (83910, August 1994) describing a procedure to replace the headliner on the sunroof and the inner panel. [Rick Tilghman] Let me just say that you want to use 1/8" headliner EVERYWHERE, not just on the sunroof. Don't listen to what anyone else tells you... trust me and ask for 1/8" material. If the store you go to (a fabric store) doesn't have it have them order a new roll. The reason for this is that the headliner must go under various edges around the car (including under that plastic edge at the sunroof opening) and the 1/4" is too thick to fit. Also, the 1/4" material is much heavier and will pull off the headliner backing board over time faster than the 1/8".)

[Tip from Lawrence] With the sunroof in the vent position, release the springs so the sunroof will lay flat (you will need to use needle nose pliers to reach underneath to release the spring, the spring holds the sunroof headliner to the sunroof). Then from inside or outside the car(wherever you can get a good bite) give the sunroof headliner a shove(a mighty shove) to the rear. It's held by two clips in the front. The headliner will release from these two clips when you push it back. A shove will release. But you can't baby it. Pull, shove, whatever. Once you push the sunroof headliner out of the way, you can reach everything else.

Removing the Sunroof Pan to Replace the Headliner. [Dave Rogers] If your car has a sunroof, replacing the headliner is more difficult. It is frankly best to remove the sunroof assembly. When I did my headliner, I removed the pan in which the sunroof is mounted:

- Loosen the hose clamps from the drain hoses and remove the hoses.
- Remove the screws from the front of the pan. Remove the sunroof motor (at the front of the sunroof pan). Remove the screws from the sides of the pan.
- The pan can be removed at this point. (I do have a wagon, so it is easy)
- The next steps I took once the pan is removed, but could probably be done with the pan in place, which might be easier for a sedan.
- Move the sunroof to the 'all the way open' position. (not just popped up)
- Remove the 4 screws from the front cable casing (this covers the cable that moves the sunroof back and forth. The cover has something like plumbers putty to waterproof it, so you might want to have some putty on hand.
- Remove the 5 or 6 screws from the side brackets on each side.
- The sunroof assembly should come out now. Pull the whole assembly toward the front of the car and out the sunroof hole.

- To remove the sunroof from the assembly: pull the sunroof toward the back of the assembly so that the tabs on the back of the sunroof slide out of the tracks. Twist the sunroof so that the front tabs slide out of the tracks. You should now have a track assembly and the sunroof. Put the tracks aside.
- Pull up on the back of the sunroof which exposes the clips that hold the sunroof in place. Pull on these to remove the headliner from the exterior part of the sunroof. At the front of the sunroof are two clips that the headliner into. Slip the headliner off of the exterior. You should now have the interior and exterior parts of the sunroof. Replacing the fabric should be easy from here on out.

Replacing the sunroof is the opposite of install, just make sure that the rear of the sunroof assembly mounts into the holes at the rear of the sunroof pan. In all this took me about 2 hours to do.

VolvoGuard Car Alarm Remote Operation. [Editor] For tips on operation, see the FAQ File. Repairs are complicated and require the OEM Manual for tracing wiring and components.

Hood Lubrication. [Tip from Andrew] My 940 had a bent down spot at the back edge of the hood. My mechanic informed me that he sees a lot of 940's with this problem, as the hood starts catching on the cowl …and bends it. The solution: lubricate all the hood hinge pivot points. It loosens up the movement and eliminates the tendency for the hood to try to move back against the cowl when opening. [Editor] Volvo recommends engine oil for this, although a good spray lube will work just as well.

Jack Points. When jacking the car using a floor or bottle jack, place a pad under the jack points so as not to bend them. [JohnB] If they do become bent, use a big screwdriver, a drive pin or cold chisel to open the flanges of the jack point...after that a flat piece of strap iron maybe 3/16" thick and what, 20-30mm wide (same as your jack) can be driven down the channel to open it up.

Wagon Third Seat.

*Buying a Third Seat. [*Inquiry] I am seeing 3rd seats for sale on e-bay and the sellers claim the seats will fit 740/760/940/960 regardless of year. My Volvo dealer says this is not correct. Can anybody tell me who is right? How do I ensure I am getting a seat that fits my 1994 940 wagon? Anything else I should be wary of buying a 3rd seat used? Are they difficult to install? [Response: Jim Bowers] They will physically fit. Be sure to get ALL the fittings, hardware, belts etc. The colors won't match perfectly unless you get "matching year" color codes. [Response: Kevin Walsh] I installed a 3rd seat in my '91 945 SE last week, paying $225 on ebay for ENTIRE seat with seatbelts and all hardware. The only trim I'll need is the side trim where seatbelts poke through side panel trim. The trim on car before was a fake "air vent" looking thing. the 3rd seat piece is just square trim with no "vents" so belt can pass through. As far as installation, it's a no-brainer. The seatback has two spring loaded side pivots at hinge, just put one side in and pry other in with screwdriver and line up with hole. The spring loaded pivot will "pop" into place at pivot. The seatbottom just bolts in; make sure you get nut backing plates for seat bottom side attachments. The seatbelts have "knockouts" where threaded mount attachment point is. I would look for a seat out of a 940 just because it's newer but 740/940 seats should be identical with the exception of fabric colors. [George Downs] Seats from 245s and 855s will not fit but any seat from any 745, 945 or V90 will fit.

Fitting the Third Seat. [George Holmer/Kevin Prowse] You will need a 1/4" drive T30 Torx head socket to remove the rear seat catches (T30 screwdriver was no good because the screws were in very tight), as well as a 16mm socket with ratchet and extension. See

Third Seat Installation for an illustrated guide.

1. Fit seatbelts (end bracket in pre-drilled hole in wheel arch, cut the carpet and on passenger side the plastic trim panel, middle bracket in hole just behind C-pillar and the roller behind the trim panel for the C-pillar on top of wheel arch)
2. Fit buckles in pre-drilled hole inside the spare wheel well
3. Fit seat in spare wheel well (tube at the base of the back rest in holes in brackets and the rear of the well. Fittings at the front of the cushion fits on the side of the well, where it will be apparent when you have the seat in place).

A Few Tips for Installation. [Kevin Prowse]

- You have to remove and later replace various pieces of the interior plastic trim in the back. Easy to break one of the clips or crack the trim, so go slow and cautious. Once you have them off and can see where all the clips etc are located. it is easy to get them back on/off again.
- You have to remove some plastic plugs inserted into threaded holes in the back of the wheel wells (to attach seatbelt catches) and in the back of the spare tire well (to attach another seatbelt catch). You will probably find these impossible to pull out. All I could do was pinch off tiny fragments of plastic with my pliers but the plugs were staying put. Figured it out in the end - used a drill bit slightly smaller than the bolts, in a hand drill and just slowly drilled them out (careful not to damage the screw threads though). Alternatively, according to Jeff Pierce, you can just push these plugs through.
- Volvo supplies "self locking" bolts for the attachment of the various parts of the seat belts (7 bolts altogether). These are very much like brake caliper mounting bolts, and like them are probably not supposed to be re-used. As far as I can tell, they are just good high strength bolts with a dab of red threadlocking compound on the threads (locktite or a similar product no doubt). If you are installing a used seat, and choose not to buy new bolts from Volvo, you should at least clean up the threads and apply some fresh thread-locking compound before installing these bolts.
- You have to somehow push in a spring loaded pin in the base of the seat and get it lined up with a bracket in the back of the spare wheel well. The pin then pops out into a hole in the bracket. Volvo suggest a pipe wrench, but I didn't have one with a wide enough jaw opening. Tried levering it in with a screwdriver and a tire iron, but they kept slipping off. I ended up using a 10" locking pliers, adjusted the jaws till they just fit over the end of the pin, clamped them together, which pushed the pin about halfway in, then carefully screwed in the adjuster on the end of the locking pliers using a pair of regular pliers, this pulled the jaws of the locking pliers all the way in, and therefore pulled the pin all the way into the seat base and it was easy to push the seat into place.
- Altogether the installation took me about 5 hours going real slow with frequent

coffee breaks.

Folding the Third Seat. Pull the bottom of the seat from the center up towards you and push down. It should go flat, then on the top push the two black brackets on the side inward and the seat should bend towards you. Seat back will fold toward rear of car on top of the seat bottom. Grab the arm rest handles and gently pull towards you and push down, they should also fold down flat. Once down you should be able to replace the floor paneling over it. Stow seat belts in clips on side provided for this purpose.

Wagon Load Cover. [Inquiry] How does one fit the load cover in the rear of the wagon? [Peter K.L. Milnes] The pillar is not pre-drilled. The brackets are marked left & right to match up with the slope of the pillar. The load cover part of the bracket (part with square hole in) should be horizontal. Drill the holes in the pillar trim so that the tubes just pass through. Then you fit the bracket screws through the tubes into the metal of the pillar. The brackets should be low down and sufficiently in-board to allow them to be squeezed slightly outwards when fitting/removing the load cover. This is usually done by locating one side into its bracket then pushing that bracket outwards with the load cover and springing the other end into its bracket. The brackets should have the correct screws with them.

Wagon Dog Guard. [Inquiry] How do I install the dog guard in the rear of my estate? [Responses:Ian Junor/Ian Cook] There are captive nuts hidden in the roof (behind removable but fragile cutouts in the plastic trim above the windows.) You will need to locate these and cut access. The access will eventually be hidden by the mounting plate, but keep it as small as possible. You will also need to fit two lock down clips to the back of the rear seat. You will need to work out the best position for these to keep the guard held down tight with no rattles. Drill carefully. The guard will also require two clips attached to the upper framework of the side window. Again this will be a question of best estimate for location and take the usual driling precautions to avoid drill bit slide.

Wagon Tool Kit. [Norm Cook] My tool kit, fastened to right rear cargo panel, kept falling out/over. I assumed the square plastic opening holding the plastic anchor screw had broken off. Turns out it wasn't broken. To fix I put a ~1/8" chunk of plastic on the bottom lip where the tool kit sits. This pushes the whole assy up enough so the plastic anchor will securely grab the top side of the square opening. [John Sargent] The square opening is supposed to have a nylon piece snapped into it. The nylon piece provides a nice socket for the pin to lock into. The nylon piece is Volvo part number 1224832.

Trailer Hitch. [Inquiry:] I am considering installing a trailer hitch on my 1996 960 wagon. Has anyone used an alternative to the Volvo hitch kit and if so how successfully and approximate cost.

Volvo Hitch:

[Response: Jim Bowers] I advocate the hitch kit from Volvo. It just bolts in place and is so complete with instructions etc. you can DIY in less than an hour. It even includes a stick-on template to trim the lower plastic trim below the bumper if needed. It utilizes nuts already welded into place on the frame rails. The "tow hook" is removed on that side and those bolt holes are used. While it may cost a few $ more than an aftermarket one, it is the best and is rated for the car's maximum tow rating. The receiver insert can be ordered with either a 2' or 1 7/8' ball. It can be changed later to any size desired.
Again the most reliable electrical connections will be obtained by ordering the kits from your friendly Volvo parts guy. The wire kit is quite expensive but in comparing the work it required to get my '85 working with Radio Shack parts to using the kit on my '96 I would do the Volvo kit again in a second. The Volvo kit comes with complete instructions and the wiring job was an easy one evening job. (All the bulb warning features still work correctly and the '96 has a trailor light indicator in the dash. Similar to directional indicators.) [Comment: W.T. Bostick] The only problem I've found with the Volvo hitch is that it's an odd-ball size of receiver(rectangular tubing instead of square) , so bike racks ect. that use a standard reciever size will have to be modified (cut off the receiver insert tubing from the rack and weld on the Volvo-size tubing). I believe the it's the same height as a standard reciever just wider so you might get away with some sort of shim though.

Others:

[Response: Wormy J] Go to U-Haul, their hitch is the same as IPD both made by Drawtite. It was about $140 installed. They my let you have it for less if you bolt it in (six bolts). As far as wiring just run a wire from the relay to the rear for the brake lights. Use wire diagram to hook it upstream of relay. The other lights do not run thru the relay so you can tap into them at the rear. [Editor:] IPD now sells a wiring kit to integrate the Volvo wiring with standard US trailer wiring: five wires to four. [Nathan Babcock] I had ordered a Class II Reese hitch (with free drawbar) from Hitchfinder.com. It was $120.00, but shipping was a bit more than the $116.00 Drawtite at eTrailer.com. However the free drawbar ($20.00 value) makes the Reese hitch a better value than the Drawtite. Plus the Reese has optional weight distributing and the exact same tow specs (3500 lbs, 350 lbs tounge weight). This is a NICE hitch, heavy, *well* made. The free drawbar is also nice, solid piece of steel, exactly like the $20.00 model offered at eTrailer, but painted black. Aside from the drawbar and pin, the kit included seven heavy duty 19mm head, 30mm long hex bolts with washers and supplemental lock washers (one extra). In short, they give you everything but the thread lock and the wrench to install it.

Interchangeability: The sedan and wagon hitches are interchangeable.

Installation. [Jim Bowers/Paul Wittenbraker] The hitch has five holes on each side. Two of these match up to the built-in nuts that hold the tow hook on one side. Two more that are closest to the receiver match up with more built-in nuts. The two rearmost bolts on each side go all the way through the hitch, with a small 2-hole plate between their heads and the hitch. Use Loctite Blue to secure the threads.

Trailer Lights Wiring.
Using the Volvo Wiring Package:
You can purchase from Volvo a wiring package that will integrate the five wire Volvo taillight wiring to standard four-light US trailers. The installation is simple with good instructions.

Using an Aftermarket Wiring Packages:

IPD sells an aftermarket trailer wiring kit for US$38, but requires that you get some connectors, an inline fuse, 12 gauge wiring, and that you run power directly from the battery.
[Tips from SomeGuy in Maryland] This is being posted to provide a reference to others who want info on installing the DrawTite ModuLite system in a 700 series wagon. I found little detailed info in archives before I did mine and thought this might be helpful.

The ModuLite system isolates the trailer wiring from the car's lighting system, enabling the "light out" circuit to remain functional. The system takes power directly from the car's battery and uses the car's lighting for signal only.

I obtained an in-line, water-resistant blade, type fuse holder rated for 30 amps from Radio Shack. The ModuLite instructions recommend using 12 AWG wire from the battery, so there is a hefty splice involving 10 and 12 AWG to be done up front by the battery. I also used a 3/8" ring connector to attach to the battery pos terminal. Splicing the 10 AWG to the ring terminal is a job also, I slit and opened up the ferrule on the ring terminal, soldered the wire to the lug, then soldered a small piece of copper banding around the opened ferrule. I've always been told you shouldn't trust solder for a mechanical connection.

I'll assume anyone reading this far knows how to remove the underdash trim on the driver's side. If not, I know this is out there in archive. To route the wire to the rear, there is a triple nipple grommet just below and outboard of the brake booster that only uses two of the nipples. From inside the car, pierce the spare nipple to the outside, then run the12 AWG power wire through the nipple from the inside of the car. Snake the wire along the driver's side outside edge of the car. The driver's door interior trim pulls up but, as always when dealing with plastic, be careful not to pull too hard too fast.

To route the power feed further, you're going to need to remove more interior trim. The FIRST piece you want to pull is the one directly outboard of the back seat, I believe it would be called the C pillar. You'll need a TORX screwdriver bit to remove the bracket that holds the seatback in place. There are three TORX bolts holding it, one is hidden by the rubber cushion. Then remove the seat belt anchor bolt. (Why is this a Standard sized bolt instead of metric? I dunno.) Remove the Phillips head screw in the top section and the piece will pull out, starting from the TOP and pulling up and out. Then you're ready to pull the trim under the cargo section window. NOTE: if you don't pull the C pillar trim off first, you WILL break fasteners holding this piece in place. Once the obvious fasteners are removed, this piece is removed by pushing it FORWARD. (Don't ask me how I learned this.) Remove the cargo section rear conrner trim pieces and you have access to everywhere you need. I usedlots of tie-wraps and ended up with an installation that looks very professional, if not factory.

From here, follow the instructions for wiring that come with the ModuLite system. Everything works fine and I have an installation that took all day to install, but looks the way I think it should.

If you're planning on this job, give yourself several hours to do it right. You'll probably save at least 1-2 hours of head scratching by reading this message, but skills vary so plan for at least an afternoon.

Converter and Power Source for Trailer Lights.

[Inquiry] I recently installed a Volvo trailer hitch on my 1994 960 sedan. I ordered the wiring harness kit from Volvo. I also ordered a convertor, part #1189936-6. The instructions that came with the wiring harness do not mention the convertor. Do I need to install this convertor? What does it do? [Response: David Hunter] The bulb-out sensor will not carry the added current required by the trailer lights. The converter has a separate power source to the battery. It acts like a relay taking its signals from your existing wiring and passing the power to the trailer. It can also look after the incompatibility that exists between some cars and trailers that have a 4 wire or 5 wire system. Don't buy the converter at the dealer. Go to any auto parts store, much cheaper.

Trailer-Towing Tips. [Tips from John Shrout] As one who has towed a camper extensively (coast to coast & then some) behind my '87 745, I would like to weigh into the discussion.
First: A 745 makes a GREAT tow vehicle -IF:
1) You put on a good hitch. The Volvo dealer installed hitch is terrific.

2) You install a good trans oil cooler, which you need to do to reach the 3300 lb. capacity.
3) You don't exceed the weight limit. There are reasons for limits.
4) Put electric brakes on the trailer if over 1000 lbs. and a brake controller on the brick.
5) Don't tow in overdrive.
6) Don't forget that the weight limit includes passengers and stuff inside the brick itself.

Had the local Volvo dealer (a good one) install factory hitch and trans cooler. Had trailer dealer install electric brake controller. Had to remove the black plastic skirting (wrong word, I know) to make room for the hitch. Total cost in 1992 was about $1K for everything. With this setup I towed a 1600 lb. Coleman pop-up camper around Virginia , including the mountains until we got stationed in California. Towed the camper behind the brick all the way across the country. We took the southern route, so the mountains weren't too bad, but I made up for it later towing the trailer a number of times into some 7-8K and better mountains while we lived in Southern CA. Never a problem. I serviced the trans every year or so just to ensure the fluid wasn't burnt. If I was equipping the car again today, I would install a trans temp gauge. With the electric brakes on the trailer, stopping distances weren't much worse than without, so we never had that panicky feeling, even in Los Angeles traffic. I bought some cheap but effective trailering mirrors that strapped onto the regular mirrors. They vibrated some, but worked well enough for safety. Started trailering with about 85K miles on the brick, it now has 211K. Same tranny, still going strong.

Just do your trailering smart and listen to the experts. Most of the rules for this sort of thing have been written in someone else's blood. As John Wayne said, "Life is tough; it's tougher when you're stupid."

Long-Distance Car Towing Hints. [Inquiry] I plan on towing my '85 740 behind my Jeep using one of those U-Haul dollies that go under the front wheels. The trip will be about 1,000 miles. Are there any precautions I should take, or is it a matter of putting it in neutral and driving off? [Response: Don FosterJohn Sargent/Chris Herbst/] Disconnect the driveshaft at the differential. Why? Because your tranny (tailshaft bearings) are lubricated by splash (if a standard) or ATF circulated by the pump (if an automatic). Neither splashing nor pumping occurs if the input shaft of the tranny isn't spinning. The tailshaft bearing will run dry after about 20 miles, or so. Disconnect at the rear axle flange using 15 and 17 mm wrenches. Pull the rear half of the driveshaft out of the sliding spline instead of trying to wire it up out of the way since when it's disconnected from the rear, it can just slide out of the center splined section. The AW 71 drive shaft should be indexed, but if not, make sure you mark it so you can re-assemble correctly. See the FAQ discussion on driveshaft balance and alignment. You might also disconnect the

electronic speedo/odo pickup on the rear of the differential if so equipped.
An alternative is to back the car onto the dolly, lock the steering wheel, and drag it on the front wheels. Don't overlook the need for registration, insurance, visible license plates, visible tail 'n direction lights, and all that.

Auxiliary Fuel Tank. [Tip from Will] The 22 litre auxiliary boot/trunk tank can only be fitted to 700 series and only on sedans. This option was never introduced in the North American market. There isn't enough room to fit them on wagon's and I've yet to hear / see a 900 series sedan with them. They came as standard equipment on all Australian delivered models (and possibly for some other markets too) while for most other market it's an optional equipment. I have seen a photo of an US-spec 740 or 760 Turbodiesel with the auxiliary trunk tank on eBay. They do take up a bit of your trunk space when installed. The auxiliary tank has its own fuel tank sender, and this sender is wired in series with the main tank sender. A small clip / screw behind the fuel gauge needs to be removed to change the tank reading from 60L to 82L (clip for VDO instrument cluser and screw for Yazaki instrument cluster). Since the auxiliary fuel tank sits above the main fuel tank, the auxiliary tank is only filled when the fuel quantity exceeds 60 litres. A known common problem with the auxiliary fuel tank installation is the connecting hose between the two tanks. They are connected by an L-shaped rubber hose under the car, behind the main fuel tank. This L-shaped rubber hose deteriorates over time and will crack, causing fuel leaks and spills. Any experienced Volvo mechanic on the 700 series will be aware of this problem and the general practice is to replace this hose every 5 years or so. [Report from Bishop] When I took the secondary boot/trunk tank off to get to my fuel sender/pump today, I found rust on both parts of the underside on the small tank, and a much larger amount on the sill area under the right of where the tank was sitting. The rust was not visible until I lifted the tank up.

Spoiler. *Trunk Supports.* [Inquiry] I have a rear deck spoiler that I will be installing on my 90 740 sedan. Does Volvo offer heavier duty trunk shocks for cars with spoilers? [Evan] Volvo PN 1394650.

Roof Rack Loose. [Inquiry] The luggage rack on my 1990 740 wagon is loose. I have tried to tighten the bolts but they just turn and don't tighten. It seems like the nuts the bolts fit into are not there any more. Anyone have a fix for this problem?

Fastener Details. [Editor] The fasteners holding the roof rack in place consist of round rubber sleeves with fixed brass nut inserts, into which is screwed a 6mmx1.25 pitch screw. These are difficult but not impossible to replace or repair. If you can't get the screw to insert into the nut, be careful: you can strip the soft brass thread. Use oil to lubricate the threads of the screw and try again, remembering that the nut inside can become canted. To remove the fastener assembly, insert the screw about four turns into the nut, then push down on the screw to pop the nut out of the bottom of the rubber sleeve while leaving the screw head on top. Then pull up carefully on the edges of the sleeve and remove the assembly. To reinsert the fastener, insert the screw four turns into the nut, push the nut all the way through the sleeve so it is showing on the bottom, then push the rubber sleeve back into the roof hole. A little penetrating oil on the rubber will help. You will probably have to use a screwdriver to push the bulged portion of the sleeve beneath the roof: tape the hole first to avoid scratches. Once the rubber sleeve is in place, pull up on the screw head using pliers to pull the nut back in place inside the sleeve. If the nut turns endlessly inside the rubber, a little superglue applied VERY carefully inside may secure it: DON'T get the adhesive on the threads. A hypodermic syringe makes a good applicator. And don't use Loctite when replacing the screws: this is guaranteed to make the nut turn inside the rubber.

Often, the rubber sleeves will tear. The only fix is a new sleeve from your dealer. My advice is unless you have a good reason to remove the rack, leave it alone.

Homemade Roof Rack Construction. See the FAQ file for more detailed instructions.

Rear Spoiler Removal. [Inquiry] I have a 740 sedan with a Volvo rear spoiler on the trunk lid. I want to take it off. I took the clips off the sides but the thing won't come off. Am I missing something? [Response:] usually it is held by double sided tape or screwed in place: look under the trunk/boot. Remove the screws attaching the side clips. Then carefully break the tape bond with a thin putty knife to remove the spoiler; or unbolt it from under the lid. Use citrus-based or 3M spray adhesive remover to remove tape remnants and polish with cleaner/wax.

License Plate Holder. [Inquiry] I need to put a license plate on the front bumber. The bumper has 2 holes. How do I do this? [Response: Kane/Steve] There is an "H"-shaped holder with studs to mount the plate that bolts in to the bumper using those two holes. Get one (along with the two bolts and the four metric stud cap nuts) either at the dealer or from a junkyard. This makes installing the license plate easy, with no additional holes to be drilled.

Cupholders.

Volvo OEM Cupholders. [Editor] EBay frequently has used examples of the Volvo OEM cupholder/armrest with two slide-out trays in front and back for cups. Try Swedish Engineering and VolvoWorld too. If you bid on one, make sure it has the hinge assembly attached: the cupholder hinge is more robust than one on the standard box lid. If you find one and it is the wrong color, buy some Plastikote Vinyl Color spray from an auto parts store (Advance Auto carries a good selection) and re-spray the correct color. You will also need a new front latch: the cupholder uses a blade and requires Volvo p/n 9134157-8 "Lock catch for armrest (alternate 1: 20 x 19mm)" which fits in place of the lid's magnetic catch. Costs about $5. To remove it, rotate 45 degrees.

OEM Cupholder Not Secured. [Tip from Jason Knauer] I have a 940 with the OEM cupholder armrest. The slide-out holders began ejecting during hard stops and accelerations, gradually escalating from an occasional nuisance to constant annoyance. The holders are meant to stay place simply by friction within the internal tracks, but years of use had worn them to the point that they moved freely under any vehicular force. To solve this, I used four 0.5" square fabric (not "hook") pieces from a pack of stick-on Velcro squares. Pull each cupholder tray fully out. Stick the Velcro squares on the top surface of the cupholder tray immediately in front of where it enters the armrest. Problem solved! The fabric adds enough drag to the trays to prevent them from sliding on their own, even when slid out partway (great when you only want to use one cupholder!)

Aftermarket Cupholders. See http://www.husco.com/ for an aftermarket center console cupholder assembly of fine quality. [Tip from Chris Mullet] I've installed both the Husco and Volvo cup holders in two different cars.

- Husco:
  - Requires drilling the existing arm rest.
  - Quite durable (metal cup tray).
  - Slides forward for greater comfort as an armrest.
  - Only one tray with two cup holders for front seat - None for rear seat.
  - Looks somewhat "aftermarket".
- Volvo:
  - Looks like it belongs there.
  - Dual trays - two cups for front passengers, two for rear.
  - Flimsy (plastic) trays.

[Editor] You can also purchase one of the small cupholder units that either insert into air vents or are held, with a rubber strap, by the window glass. For the latter, discard the strap, cut off the slot on the top so as to flatten the back, and adhere it to the door using 3M body trim tape.

Installing a Ford Taurus Cupholder Above the Radio. [Tip from] I've sucessfully mounted a 1/2 DIN-sized cupholder in my 940 suitable for cups and some (but not all) small cans / bottles. This is similar to the cup/coinholder mounting in a 760 / 960 which has been previously posted. Source of the cupholder was a Ford Taurus. Caveat: if you can't use a chisel, hacksaw, dremel etc and convince yourself you know what to do - don't start. To do this:

Installing a Taurus Cupholder Above the Radio

- cut to remove the coinholder
- remove the console 1 1/2 DIN opening / rack
- remove 1/2 mm each side of the console opening (the small lip) to allow the headunit fascia to be recessed into the opening
- trim side of cupholder to allow it to be recessed
- assemble mounting cupholder first. The headunit mounting frame should locate and fix this in place. Screw the frame to the base of the opening / rack

All trimming is to the sides of components which are recessed and not visible.

Coin Holder. [Tip from Will] Volvo makes a coin holder that fits directly into your ashtray. Part number is 9166785, should still be available from the dealer. Makes it easier to get coins out, but only holds a few coins.

Plastic Glue That Works. [Tip from Carl Krall] When I was looking at my smithereened handbrake cover I remembered that I'd bought some plastic cement called PowerPoxy Plastic Bonder. It comes in one of those syringes, which I hate because it never comes out evenly although it looks like it should. Anyway, my cover is now elbow-worthy again, although I did break the tiny joint that goes under the handbrake while putting it back. I sanded the joint and glued it again with a strip of metal (folded-over farmer's helper) behind it for morale, and did it while it was in place so the agony of installation didn't have to be repeated. The stuff really stinks, and you've got maybe 5 minutes to use it once you mix it, so be ready and make a small batch. It's set in about 15 minutes, but I wait a day before I unclamp it or move it. Buy it at Builder's Square, and likely Lowes and Home Depot. The info number on the package is 800.248.7699, answers 8-4, M-F.

Converting Incandescent Lamps to LEDs. [Procedure from Jon Belmont]. I've finally finished (after about 4 months) converting the interior lights of my C70 over to red LEDs. I know that this is the 700 series forum, but I was asked to do a write up when I finished the job so that it could go in the 700/900 faq. With that in mind, the write up below is more of a general overview without getting into the nitty gritty... it's a good heads up for some of the issues ANY car owner might face if undertaking a conversion like this.

C70 LED Instrument Panel

Conversion of incandescent interior lights to LEDs. For the last few months, I’ve been going through the process of converting the interior lights of my ’99 C70 coupe over to red LEDs. As I’ve been talking about this process on the brickboard and with friends, many people have asked me about some of the problems I’ve run into and about how it went in general. I decided to do a write up on everything I went though, starting with a primer on some of the differences between LEDs and incandescent lights, then covering how those differences affected my conversion.

First of all, LEDs usually operate in the 1.7 to 3.5 volt range (depending on color, make sure you check first!), and the incandescent bulbs in my Volvo run on a full 12 volts. They also draw substantially less amperage, so you can run several LEDs off of a circuit that was used for only one incandescent bulb. Next to consider is that incandescent bulbs illuminate in a 180-degree range. In other words, if you look at a bulb from the top, it puts out just as much light as it does out to the sides. LEDs don’t work that way… they illuminate in a cone shaped pattern that varies in width from 10 to 75 degrees. Usually, the wide angle LEDs are not as bright as the narrow high intensity ones. There are a few other specs for LEDs that you must look at when you decide which ones to use. Luminous intensity, which is measured in millicads (mcd), shows how bright an LED is. Also, the actual color of an LED is indicated by its wavelength, measured in nanometers (nm). Make sure that you have the same wavelength for all of your different LEDs. There are many different shapes of LEDs like oval, cylindrical, square, and rectangular. The lenses are clear or colored, transparent or diffused. The LED shape and lens type usually correspond to the viewing angle. Certain “surface mount” LEDs have wide viewing angles and are fairly bright, but they are EXTREMELY small and difficult to mount. Finally, there are “direct replacement” LEDs that are designed to replace incandescent bulbs. They may have a built in resistor so that they can operate at 12 volts, and some even have the proper mounting base (like a flange or screw base) that allows them to “plug and play” in place of incandescents.

The easiest bulbs to replace were the ones in a “direct lighting” situation, where the LED faces directly at the item being illuminated or there is Lucite light piping to direct the light properly. The switches for the foglights, sunroof, windows, door locks, courtesy lamps, headlights, and seat heaters all had incandescent bulbs that mounted into plastic twist-in bases. These were the easiest to replace; I just had to unwrap the leads of the lamps to free them from the bases and replace them with 12 volt T-1 (3mm) LEDs. In a couple cases, I had to bend the LED 90 degrees to point at the back of the switch you’re illuminating (remember what I said above about viewing angle… some of the bulbs were mounted perpendicular to the switch). In the radio, the LEDs were soldered to the circuit board but Lucite directed the light to the back of the faceplate. They were easy to desolder and replace with the same kind of 12 volt T-1 LEDs (once I dissected the radio, that is). I had to angle the LEDs that illuminated the radio display so that there were no bright and dim spots, but it was relatively simple.

Speedometer LED Circuit

Speedometer LEDs

The items that were harder to convert were the climate control and the instrument cluster. The faceplates of those items were not directly lit by light bulbs, but were illuminated more indirectly using backlighting through the sides of the bulbs. Had I just swapped them out for LEDs, there would have been very bright and very dim spots. I had to use several more LEDs (a couple hundred) than there originally were light bulbs (seven!) to get the light distributed evenly. For the instrument cluster, I literally used hundreds of LEDs mounted to a blank breadboard and packed them in as close together as possible to ensure even light distribution. I also used a dremel to sand down the tops of the LEDs to try to diffuse the light (they were transparent) more evenly.

In situations where more than one LED is used to replace a light bulb, you can join them together in parallel and run them off of the connection for one light bulb. I also used lots of 2 volt LEDs and joined them together in series in groups of 6 (2 volts X 6 LEDs = 12 volts draw) so that I didn’t need an in line resistor. Also keep in mind that some of the lights (such as the ones in the door and window switches) are already LEDs. Some of those look different (i.e. the anode and the cathode are reversed) and may already have a built in resistor so check that stuff with a multimeter to avoid messing something up. In summary, it was a LOT of work and entailed many obstacles I didn't anticipate. I ended up using about fifty of the 12 volt, T-1 LEDs for the switches and the radio and some of the climate control. I used about a dozen surface mount LEDs soldered in series to small wires to illuminate the rest of the climate control. Finally, I used almost 350 super bright LEDs wired together and mounted on breadboard to directly backlight the instrument panel, odometer, and trip computer. I got all my LEDs from eled.com. Great selection, quick shipping, and good prices for bulk discount. It was worth it and a learned a lot during the process, but make sure you do your homework before you get into it! I was able to finish the job as a result of sheer stubbornness more than anything else. You can see from the pictures some of what I went through.

Engine Block Heater. [Tips from Jay Dymond] To assist in cold weather starts, you can install a block coolant heater or an inline hose heater, along with a battery blanket. I highly recommend a battery blanket. They are cheap (about $20.00 Cdn) and really help sub-zero starts. If you want the block heater, installing a new NAPA block heater is not difficult. It goes in the rearmost frost plug on the exhaust side (passenger side), next to the engine coolant drain cock. It's a bear to reach unless you are working from under the car. The frost plugs are metal discs, roughly 2.5 inches in diameter (from memory)along each side of the block. There are 3 or 4 of them on each side. Only one is appropriate for the block heater, due to interior engine casting obstructions and the potential effectiveness of the heater. The frost plugs are often thought of as a design feature that the car manufacturer used to ensure a frozen block would pop these things out rather than cracking the block. In fact, they are simply casting points from the engine casting. If you are installing the block heater yourself, jack the car up; block it up with jack stands after removing the passenger side front wheel. This makes it much easier to gain access to the area under the manifold and work under the car. Drain your coolant from the engine petcock (you will probably want new antifreeze anyway, if you are winterizing your car, right?). Attach a plastic hose to the petcock and use a bucket to catch all the coolant. Get it all, it's poisonous to little furry critters like my doggy. Take a hefty screw driver or pointy type drift and a good sized beater stick and commence to beat on the frost plug till it is driven out. DO NOT MARK UP, SCORE OR MUTILATE THE LIP (or surround) THAT THE PLUG SITS IN OR YOU WILL NOT GET THE FROST PLUG TO SEAL. It can take a while to get the plug out, but all of a sudden it will drop out. I had all but given out when it popped out onto the floor. You can also try to puncture the plug and pry it out, but again, be sure not to damage the surround. It helps if you have really cleaned the surround on the block, and lubricated the o-ring on the block heater. Clean up the lip of the hole with a rag, getting all dirt and grunge out of the way; you want a very clean seal. Insert the heater, with a bit of non-petroleum based lube on the rubber o-ring. I used dielectric grease and it seemed to work well. Dino-oil type grease is not a good thing on rubber. As I recall, the heater element winds up pointing up about 11:00

oclock, but I may be wrong on that. At any rate, you will find it only fits well one way. Tighten the puppy up according to the instructions you get with the thing. As I remember, mine tightened with an Allen wrench. Don't be a gorilla and overtighten it; it is a brass assembly and as such distorts/strips easily. The block heater will seat itself as you tighten the center bolt. Tightening the center bolt pulls the heater into the recessed surround, just like a drywall reinforcement used to hang heavy pictures or objects in a home. I have never heard of one falling out, unless someone has made like a gorilla and overtightened it to the extent the bolt has broken. If that happens I can only presume that after a while the block heater would be pushed out by coolant pressure (what is it, 12 psi?). There is no need to overtighten things. Just tighten it up so the heater is snug and partially recessed in the surround, and test for leaks. Route your cord to the front of the car appropriately (away from hot items) and tie in position with plastic ties. Tighten up the petcock, refill the engine with 50/50 antifreeze/water, put rad cap on, and start the engine. Check for leaks. If all is well, shut 'er down, put the front wheel on, and remove from jack stands. If you plug the heater in now (you didn't try out the heater when it was not installed, did you?.. a bad thing), you should hear it hissing and burping after a few minutes of current. Start the car up again. After you have brought the car up to temp, shut it off and let it cool down again. Check your coolant level again and adjust accordingly. Another good idea is to smear some dielectric grease on the contacts of the block heater, as this area does eventually corrode if you are in salty country. The same principle of installation holds for all 4 cyl Volvo engines. Our 6304 in the 960 however uses a pricey bolt-on heater attached to the side of the block.

Body Care, Paint, Waxes Etc.

[FAQ Home]

Body Care and Waxes. Hagman's or Sonax products, I prefer Hagman's. I machine-polished my car for 6 months ago and waxed it with Hagman's wax and the water still pearls. I've tested Turtle, Simoniz, Maquire and so on but Hagmans is still the best. When I worked in a Recond-garage we used Sonax but that was before Hagman's new products, here in Sweden Hagman's gets the highest test-score in all car-mags.

PURE CARNAUBA WAX! Accept no substitute. As for removing the fine scratches, try a product called "Fill n' Glaze" from 3M. Available at most automotive paint supply stores. Pricey, but good! Pink in color. WARNING: Always follow the Fill n'Glaze treatment with the above mentioned Carnauba Wax. Your paint is left unprotected without it!

Rain Dance is a decent wax, as is Mother's. I have tried all the silicone polishes and only one has seemed to perform as claimed. That's Finish 2001 by Turtle Wax.

Car Care Appearance Products. [Tip] See http://www.carcareonline.com/index.html

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Touch-Up Paint Source. For the last 5 years I have been touching up vehicles for auto dealerships. What I have done is put together a touch-up system for your car using all the tools

and supplies I used at the dealerships. This is a basecoat/clearcoat system like the factory uses. I custom mix the paint for your car using your paint code so it is a great match. I can match any year vehicle. 1,000's sold----will ship anywhere. For more info go to: http://www.ultimatetouchup.com
For information on color codes, see http://www.vlvworld.com/colorcod.html

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Paint Chip Repair. [Inquiry:] I have a paint chip in the front of the hood. It appears to be down to the metal and about 1mm in size. What's the best way to repair this?

Chip Preparation. [Tip from Jim Powell] Use a jeweler's loupe to see the chip clearly. Take a dental pick and scrape any loose debris, rust or dirt out of the chip. A roughened surface will help the touchup paint adhere better. After the bottom and sides of the hole are cleaned and the sides are reasonably perpendicular, clean the area several times with grease and wax remover. (3M Adhesive Remover or PrepSolv). Do a final cleaning with several applications of Isopropyl alcohol.

Chip Repainting. [Tip from Cavalier Forum at Yahoo] When touching up the car and I don't have a lot of paint chips to fix, I dig out one of my dissecting needles, dip just the very tip into the paint, then touch the tip to the chip area. That is also a very accurate way to do touch up and does not use a normally hard-to-get hypo with fine needle tip.   A dissecting needle is basically a largish steel needle stuck into the end of a plastic rod whose diameter is typically that of a pencil and length is about 5 inches. You can find them in hobbycraft stores that sell model paints and tools like pin drills. You can make your own substitute for a dissecting needle painting tip by using a paperclip. Straighten the paperclip out. Take a needlenose flat-faced pliers (or any pliers with a flat crushing surface) and mush the end of the paperclip down. It now looks like the end of a tiny bladed screwdriver (which is what I use for tightening screws in my glasses when desperate). Use the pliers to chomp at it until you have a reasonable tip on the end of the paperclip. That is your new recyclable painting needle.

If you don't have a hypo, you can substitute a dissecting needle. If you don't have one of those, you can substitute a homemade paperclip painting tip (and feel proud that you are related to MacGyver who invents things on the fly). If you have no paperclip, you can always take a sliver of wood. I've taken wooden doweling and sharpened it in my pencil sharpener (the small manual ones) to a tip before and used those.
Really, the hypo method is better when you have a TON of paint chips to do. If you only have ten or twenty chips, you might as well use a metal tip....

The above methods are cheaper than using an expensive artist brush (the sables can run $10 each) unless you use one of those cheap wal-mart "artist" brushes and clip most of the hairs off.   [Response 2:] Airbrushing can make very good repairs. Getting an airbrush and a small hobbyist compressor (like for painting plastic models) works OK. A little practice and you can make extremely good repairs. I do it all the time. The secret is getting the build up in the chip even with the surrounding surface by several applications of paint and wet sanding/polishing level.

Chip Repair Buffing. The Langka product works well to buff the bubble of new paint down to the level of surrounding paint for an invisible repair. Buy it at IPD for about US$20.

Paint Scratch Repair. [Tip from Steve Ringlee] It's getting cold out here in subtropical Iowa, so I thought it opportune to do the last detailing of the season and repair the paint scratches in my 944, the result of careless nitwits in the supermarket parking lots. I had read somewhere about using a hypodermic syringe to lay in a thin bead of paint right in the scratch. After getting my flu shot I just asked the doc for the needle, explaining that I needed it for my car. He was a little skeptical, but knowing me to be the straight arrow I am he said "OK, you didn't get it from me" and I was on my way.

The touchup paint from Volvo is really for filling chips, so it has to be thinned with lacquer thinner to work with this technique. I mixed a small quantity to a watery consistency in a small bottle, then sucked it up into the needle. Make sure you mix it well, else the metallic particles will settle out. Use denatured alcohol to clean the paint of wax, silicones, etc. Then practice on a hard surface to get the flow right: too much pressure on the syringe and it comes out too quickly. Lay in a very small bead of paint right in the crack with gentle pressure on the syringe.

My first attempt resulted in too much paint in the crack, which I left on the car until it dried. Then I used very fine auto wet sandpaper (more than 600 grit!) to sand it flush with the surface, and oversprayed with a little clear coat. This in turn required more sanding and polishing until it was smooth. Not the best, but it was OK.

My second scratch filling went better and I just filled the crack with enough paint to cover it without requiring sanding or clearcoating. I then emptied the paint back into the bottle and used a brush to fill in a larger ding. The thinned paint works vastly better than the stock touchup paint and I will follow this technique in the future. Clean the syringe with lacquer thinner and keep it for your next scratch or maybe one rousing bash with the local druggies. Some of our local high school crew would, I am sure, inject the paint just to see what would happen.

Black Window Trim Renewal. [Tip] Repainting the trim really improves the look of an old Brick and I've found it's as durable as the original trim finish. The trim around the windows is actually polished/painted stainless steel. If you have just a chip in the paint less than 3/8" or so, use Dupli-color touch up paint in the bottle #sf-104 flat black. Prep/clean the chip with mineral spirits, then denatured alcohol, and apply the paint in light coats to build. When dry after a day or so, carefully level if necessary with a small piece of 800 wet/dry paper, then polish and wax to blend. If you need to restore the window trims, try repainting them with SEM Trim Black, an aerosol paint you can find at body and paint supply shops. On my trim I've not had a lot of peeling or chipping ... just wear. I clean the trim with Prep-all degreaser (also available at auto paint supply stores) then lightly sand the trim with a 1200 grit wet/dry sand paper. You may have to do more agressive sanding if the surface has a lot of peeling-you may also need to prime the trim after heavy sanding.Then clean it with Pre-pall one last time... mask the windows, doors and roof (using masking tape and panels of newspaper.) Give the trim at least two light top coats of Trim Black. Wait for the paint to become tacky, at least one hour, and remove the masking. [Editor] This works well for faded windshield wiper arms, too. In my case, I used

Duplicolor Trim Black.

Bumper and Trim Color Renewal. [Inquiry] My black bumpers are looking grey and washed out. What can I use to restore them?

Wax Remover. [Rob Bareiss] First try wax removers, sometimes called a prep solvent, which is used for detailing a car or preparing it for new paint. One professional product is called "PrepSol" but you can also use bug and tar removers. Apply it to a rag, not the car. Should work like a charm to remove graying wax on black bumpers and trim.

Paint Respray. [Response: Chris Herbst] In my experience, there is no substitute for spraying the trim with the proper trim paint. The extra expense for trim paint is not a bad stretch when you consider it lasts longer. You can use the stuff for bumpers, trim, whatever. I've been using a SEM product (Superior Restoration Products) in the shop recently. It is easy to work with and does a good job. If you want to paint bumpers, buy the chemical that lets you etch into the material, and holds paint better. It gives a great finish and the end result is BLACK bumpers (or gray, whatever you want or have) that stay exactly the way you want them to stay, for quite a long time. I have also used flat black paint (good quality is a little better) for some trim painting. The thing I've found with that is, if you don't prep the surface appropriately, it gives bad fish eyes and can start to chip badly in a few years. After a lot of miles with front end trim painted, I can say that the trim paint is a good extra investment. [Tip from Bryan] Duplicolor makes a spray bumper re-coat: http://www.duplicolor.com/products/bumper.html [Response: DZ] I've tried the products IPD sells (Forever Black-longer lasting & Black Again-temporary)and they are not worth the effort.

Painted Bumper Cover Repair. [Inquiry:] My 1997 960 with the plastic body color bumper has a dent in it. Short of replacing the bumper($700), is ther any thing I can do to repair it ? Is there a filler or body putty that would fill in the dent? [Response: Leon Tong] The following procedure is described in the Volvo factory manual on paintwork repairs:

A small ridge may appear in the bumper cover following a low-speed collision. This can be repaired by heating the cover and pressing the material Heat bumper cover with a hot-air gun to soften the damaged area. The bumper cover is sufficiently soft when light pressure with a wooden spatula produces a small mark in the plastic. A suitable distance between the hot air gun and bumper is 12 cm. The distance can vary depending on the type of gun. Start with a greater distance and reduce if required. It may be difficult to heat large areas. Divide the work into sections. Note! paintwork will be damaged by excessive temperature. Work carefully and be aware of changes in the paintwork caused by excessive temperature. Place a wet blanket over the heated area and press out the damage with a wooden block. Keep pressure applied until the bumper has cooled (about 2 min). Use compressed air to accelerate cooling. Repeat procedure until the damage has been completely repaired. Some areas of the bumper may require repeated treatment." Now, I haven't tried this myself, so I can't vouch for it. And since you've got a dent, you'd be working from the inside. But it seems like it's worth a shot if the alternative is patching and re-spraying.

Front Spoiler Repainting . [Inquiry:] My (white) '89 740 still has excellent paint but the front spoiler could use fixing. Has many nicks and scratches and would look a lot better if repainted. Has anyone painted this piece with any luck?
[Response: Nathaniel] The front spoiler is a breeze to paint. But before I continue with the process let's talk about the paint itself.
The paint is nothing special . . . use the same paint that is used for the car. [Important Tip from JohnB] You DO need to add a flexible additive to both the primer and the color/clear coat paints. Also, get your viscosity right, fisheye additive in high humidity, etc., etc. The reason the old stuff cracked off is cuz it wasn't flexible enough to take the movement in the spoiler. Any automotive paint supply shop should be able to sell you a can of the additive. [Nathaniel's Comments Continued:] A good recommendation is to use PPG. What your going to need to be armed with is the color code # for your car. You'll find this code # on a little plate inside your engine compartment (I'm going to avoid telling you where it's located because it varies from year-to-year). Just look around at the various plates containing important information about your car and you'll find it. Mine is located above the passenger side headlight cluster. It's cleary notated "color code". Use this # to ensure that the paint color matches
the rest of the car. If worst comes to worst contact your local Volvo parts dealer and they will be able to tell you the color code. It's on your car though and will be a 3 digit #.
Once you have this # look in your yellow pages for any shops that specialize in auto body paints and supplies. These places are not AutoZone, NAPA, etc. The most that you're going to get from those places is a spray can of white that resembles the car color and, in the end, will look like s*$t. Because the spoiler is such a big part of the front end of the 740 your probably going to want it to look just as nice as the rest of the car. Given that, get yourself a pint of base coat white and the necessary mixtures that will make up your clear coat. This may sound daunting but it's not hard. [Tip from Brain Oliver] Here in Ottawa I can get spray cans custom mixed to match the colour code of the car. Very good paint and very easy to use, and no, it's not a big automotive department store that does this, it's a car paint store. Try "automobile body shop - equipment and supplies" in your yellow pages and choose one with hours that suggest they welcome the retail do-it-yourself customer. [Nathaniel Continued] Once you talk to the boys at PPG you'll understand what I'm saying; they'll give you everything you need and will be able to answer your questions. [Editors Note: PPG is one brand, but you can find others including DuPont, Sikkens etc.]
No need for a fancy sprayer either. You should be able to purchase, at the paint store, a sprayer that has a glass bottle with measuring marks on it that also contains a canister of propellent. Once together, this spray painter works just like a spray can. The only difference is that you measure and mix the contents according to PPG's standards and blow on the paint. Once done painting, clean out the bottle and use the same glass bottle to mix the clear coat. BTW, buy a couple canisters of propellent.
As far as prepping the spoiler . . . no need to pull it off the bumper. Just mask off the the spoiler from the rest of the bumper and car, clean the surfaces to be painted. Once clean sand to rough the surface, clean again, sand with a finer grit paper to smooth out any major imperfections, and clean again. Prime with a light colored primer, atleast 2 coats, and allow to dry.

Blow on 2-3 coats of base paint then follow up with 2-3 coats of clear coat. Allow to cure, about 24 hours, before washing. Once the paint job is dry you will be able to drive the car. Total cost? Should run you no more than $60. Time involved? No more than 5 hours. Incidentally, you will not use all the paint you buy. Be sure to save what is left over for future touch-ups on the spoiler, the paint is not cheap.

Best of luck, it's not a tough job. Done correctly it'll add new life to the front end of your 740. But remember, the spoiler is plastic and is therefore flexible. The next curb you come against is likely to stress the paint job thereby creating cracks which will lead to future touch-ups. So watch out!!

Painting Black Bumpers. [Inquiry] Has anyone had any luck painting the bumpers on a 90 or newer-style black bumper? I saw a 740 with color-keyed bumpers the same color as my car and it looked awesome. [Response: Ringlee/Herbst] It's done regularly. Diligent degreasing and dewaxing using commercial solvents and cleaners (3M makes a range of good products) is essential. Use abrasive cleanser (e.g., Comet) with a green kitchen scrub pad until the oxidized rubber stops coming off. Fill all the dings in using JB weld. Then use the wax & grease remover on the bumper. Spray the bumper with a can of plastic bumper prep: it's like a midcoat for paint on plastic bumpers, and helps to offset the effects of oils from the plastic working their way out and flaking the paint. Be prepared, it's not a cheap can... expect $30 or so for it, no kidding. Use a flex additive pre-mixed in the paint to keep it from cracking on the flexible bumper. Use good quality products and for a project like this, shop at an actual body supply/paint shop. That's where spending a few extra dollars for the materials pays off tenfold in having to re-do it in three months. And three months after that. And so on. When you have the color keyed paint mixed, specify that it is for a bumper and they'll mix it differently. To make the match correct you have to clearcoat it unless it's a flat color that is basecoat-only. Either that or make sure you specify single stage paint. [Scott Cook] I painted my front bumper and found it much easier than I had thought, and the results looked much better than I had thought they would. I used DupliColor bumper paint, flat black, and their Adhesion Promoter (primer) that helps the paint stick better. Back in mid-March I painted a small patch on the front bumper with the DupliColor stuff to see how it would look and how it would hold up. Very good looks and no sign of fading, peeling, fish-eyeing, etc. It even withstood love-bug season here in Florida, with the attendant vigorous scrubbing, etc. daily at times. Masking took me more than 5 minutes, about 15 to 20 or so. On my 1991 745T, I took out the grille, and the trim panels under/inboard of the headlights. With that stuff off of the car you can easily mask off the stuff you want to keep clean and still paint far enough back that the paint covers the bumper all the way under the trim and grille when you replace them. If you are going to be thorough and paint the narrow back "end" of the bumper, where the bumper ends at the front bottom of the front wheel well, mask off the tire and wheel and, in any case, mask the wheel well at least half way back, just in case you have a spasm or something while you are spraying. Mask up well over the "top" of the areas you have masked. In other words, wrap the paper up over the top of the fenders and front of the car into the engine compartment. Position the paper and crease/fold/tape it so that you can spray to the very back edge of the bumper, under the headlights, turn/marker lights, and fenders. I chose to mask off the egg-crate grille under the bumper because it is originally a semi-glossy black on my car and was in good condition. Wanted to preserve the contrast. Wash, scrub and let the bumper **thoroughly** dry. Make sure everything around it is bone dry too. Water drops on wet paint will look awful. Pre-clean/prep with bug and tar remover, according to directions on the Adhesion

Promoter can. And make sure you don't get trapped in a closed space with the fumes from that stuff. After inhaling too much Adhesion Promoter, I left the garage side door open while spraying paint and the variable breeze had no effect on the application of the paint. [Garry Mawhinney] I kept all the trim on the car and just spent a lot of time with masking tape and newspapers. After careful prep work, I used a can of SEM Plastic/Leather Prep (part number 38353) then follow up with SEM Trim Paint (Charcoal Metallic part number 39033). They are both less than $10 per can at my local auto body supply shop. The difference is amazing and the key is prep work.

Roof Rack Repainting. [Inquiry] My black roof rack's paint has begun to peel. I'm looking for suggestions as to what paint I ought to use for repainting it. [Response: Chris Herbst] I'd just cover the roof and paint it with black epoxy paint (matte finish). That's what I use to match trim pieces. It gives a fantastic finish and lasts for a long time. In fact, only stone hits will really peel that stuff off, if you prep the surface right (all contaminants gone). Once it starts peeling, you're looking at more than a one-time repair. You'll probably be touching up once a year.

How to Remove Pinstripes from Paint. [Inquiry:] Can any one recommend the safe way to remove pinstriping from the side of my 760 GLE? [Response:] I've done this twice.

1. go to a detail shop (they'll use some type of a "turpentine" substance to remove it.
2. go to an industrial paint supply store and get a special pad that fits on the end of a drill. You can "blast it off" safely--never tried this.
3. buy some 3M Adhesive Remover and plastic "razor" blades; soak the tape and scape it off.
4. use a blow drier to heat it up and it'll peel off a lot easier.
5. use cleaner wax to get rid of any excess residue.

Depending on the age of the paint and the stripe, you might find a paint line where the tape was.

100K Badge Mounting. [Inquiry:] I sent off and just received my 100,000 mile badge from Volvo. It's a very nice looking badge with sticky tape for mounting it. My question is, where are these normally mounted, and how well do they stay when you mount them? My first thought is to mount it outside so that it's visible to drivers of lesser vehicles, but I don't know how well it would stay. If you've mounted one before please let me know where and how well it worked. [Response:] I've got a 100 and 200K badge that I mounted to the grille of the car in the upper left hand corner (looking at the front of the car). Clean the grill with Windex or rubbing alcohol to remove any dirt/contaminants. Stick the badge squarely on the grill...press on firmly. I've had mine for a number of years and they're still solidly stuck, even through torrential southern thunderstorms and heat to a Northwest winter.

Rubber Trim Preservative. [Tip from Zee] For good rubber reconditioning (not mere cosmetic gloss) check into:

"Trim Re-Nu" by Auto Tech 1-800-545-8624

Silicone-free. Requires sun to activate it! Then it blocks UV damage. About $12-20 for a 8oz. bottle. Will treat two cars, because you use it sparingly. Should do great for under-hood rubber, too! Ask around at wholesale paint suppliers to the autobody trade. [Editor:] Try also 303 Aerospace Preservative at http://www.303-products.com If you live in a cold area subject to freezing, try treating your door gaskets with silicone spray to keep them lubricated.

Painting Your Own Car. [Editor] As with many things, preparation is 90% of the job: successive sanding and repair is labor intensive but yields a much better end result. Consider doing all this work yourself, then having a paint shop do the final spraying. For further information, visit: http://www.autobodystore.com/

Seat Electricals:

Seat Heater Functional Diagnosis.
Basic Troublsehooting:
How to troubleshoot the seat heaters:
1. Are fuses good?
2. Check seat heater switches to ensure they are good and the lamps light up. Contacts may require cleaning, since they are in an area that accumulates dirt and debris.
3. If your car has leather seats, it will have a relay. Cars with cloth seats (probably only GL and base models) may lack a relay and have the thermostat direct in line with the heater elements. The relay may have come loose, or it may suffer from internal solder breaks. Remove, re-solder, and reinstall.
4. Remove seat cover and trace continuity on seat heater harness. Sometimes the connectors to the thermostat break, sometimes the wires to the element break right at the edge of the element. There are often breaks in the harness that develop over the years. It seems to be much more common to have a problem with the wiring than with the thermostat. I've found the connection often becomes loose right at the thermostat--I actually resorted to soldering one thermostat in place--no more problems! Repair breaks with soldering. Simple way to test the thermostat is to check continuity after placing the 'stat in the refrigerator for awhile.
5. If Steps 3 or 4 show the seat heater to be ready for retirement, replace with a new seat heater. Cost will be around $100. Repeat process whenever seat heater malfunctions, or every five years, whichever comes first. (Seat heaters commonly start to fail around the five-year mark).

Connectors:
[Response:] My seat heater didn't work, so I decided to remove the cover (by removing the side clips from the seat) to the bottom section of the seat (the part you sit on). While inspecting the warmer unit, I noticed that one of the connectors attached to the thermostat (mounted in the middle of the heater unit) had come loose. I have since heard from others that this is a fairly common problem among Volvo seat heaters. After reattaching the connector (and making the connection more permanent) the seat toasted my bum like a charm. [Note: your seat may not have this thermostat, which is used only on normal-output seats. High-output have integral relay-thermostats.]
[Response:] Seldom is a non operational seat heater due to a broken element. 90% of the time it is a break at the spade connectors at the stress point near the thermostat. The thermo itself may fail or you may have no voltage to the connector under the seat. Test for continuity with a meter through the under-seat connector when ambient temperature is below 50 deg F with seat heater switch off or under seat connector unplugged. Seat heater thermo is accessible with seat installed. It is pretty obvious how to replace the thermo. If you disconnect the thermo you can use the ohmeter to check the continuity through the back cushion.

Relays:
The seat heater relay/thermostats are under each seat, and can be unclipped from the spring wires and removed. The usual relay-death syndrome, i.e. broken solder joints, is the culprit. Just re-flow the solder and your bum will heat up once again... Note that relays can differ by model year and by seat style (leather or cloth).

Removing the Cover to Access the In-Line Thermostat and Seat Heaters:
If you move the seat fully forward and incline the back to its most upright position you can see how the upholstery is attached for the bottom cover. It's simply a spring loaded bar. Pull it out of the two side attaching holes. Recline the seat fully back and then pull the detached end through the fold between the seat back and bottom, then gently pull it over the bottom to reveal the seat heater webbing. Slide the webbing out gently and you will see the thermostat, a conical spring-like device. For the seat back heater, you must use a heavy wire cutter on the wire clips that hold the upholstery in order to access the back heater web, otherwise removal is similar. I used heavy-duty plastic wire ties to replace the cut wire clips to refasten the seatback upholstery. Installation is the reverse of above. The only difficult part of the operation is getting that spring loaded bar back into the attaching holes under the seat. For more detail, see the seat foam replacement section.

Seat Heaters Over-Heat. [Inquiry:] I have a problem with my driver's side heated seat. Last winter it basically cooked my ass. It got so hot that I had to pull over and get out the car and then get it shut off with the switch. If I turn it on it comes up to temperature immediately almost and it gets super hot. Its almost like the element is right at the leather on the bottom seat. Now the thing doesn't work at all and I'm not sure how to proceed. The switch lights up and appears to be allright. I guess its either a bad thermostat or element. I'm not sure where any of these parts are located. [Response 1:] had the same thing too. The problem (in my case, anyway) is the relays. They are under each seat, and can be unclipped and removed. The usual relay-death-syndrome, i.e. broken solder joints, is the culprit. Just re-flow the solder and your bum will heat up once again. [Response 2:] It could be that the relay or the thermostat that controls them has a problem.

Seat Heater Switches. *Dirty Contacts.* Examined the switches for the electric seat heaters. Both sides had stopped working within the past year, and I had assumed the seat wires had failed. Surprise! Neither switch functioned; the contacts were dirty. It's a bugger to get the switch apart, but it's a simple hi-amp contact that's easy to clean. This is probably a common failure mode. *Lamps Burned Out.* [DaveM] The bulb in the switch is part of the circuit when the switch is activated. It completes the circuit and whilst lit also allows power to the heater pads. Therefore, no light? No heated seat. A trip to the Scrappies soon put it right: change the switch.

Seat Heater Switch Removal. [Inquiry:] Any advice on how to remove the seat-warmer switches? The little orange "heater-on" indicator light is burned out, and I need to get at the switch for the purpose of replacing the indicator bulb. {Response: JohnB] On my 90 they're just clipped into the center console. I remove the screws under the parking brake handle and up comes the center panel and a bunch of wire harnesses. Carefully pop the harness connector off the switch and pop the switch out for replacement or repair.

Power Seat Diagnostic Trouble Codes. [Editor] The power seat system incorporates an On-Board Diagnostic subsystem used for fault tracing and repair. Diagnostic Trouble Mode (DTM) 1 is used to read stored fault codes. DTM 4 is used to calibrate the seat if control modules, motors, potentiometers, drive cables or other components are removed. The OBD systems vary by model and model year: in 740 and many 940 cars, they require a cable connection between the seat connector and the OBD Diagnostic Link Connector (DLC) box in the engine compartment above the left wheel well. 960 and 1994-95 940 cars can read the codes directly by inserting the OBD selector pigtail into DLC box "B" position 6. Press the button in box "A" once to select DTM 1 and read out the codes. Erase codes by pressing the button for at least five seconds, wait until the LEDs light up, then press again for at least five seconds. After releasing the button, press it again to obtain code "1-1-1", indicating codes have been erased. If you have a problem requiring use of the OBD system, buy the Volvo OEM Service Manual TP 8501201 "Power Seat" for complete diagnostic and repair information, especially if you must re-calibrate the seats. If you can't get a flashing LED, see No Code.

Power Seat Motor Failure.

***Caution.* Disconnect the negative battery terminal in order not to set off the air bag . There is a sensor under the seat.**

Won't Travel in One Direction. [Inquiry:] In my 960, the passenger side 8-way powered seat works in all directions except down in front. [Response: Mike Froebel] You have a dirty switch. I have had good luck carefully prying out the rocker part - the part you move with your fingers. Pry that plastic out from the front or rear. Once again, be careful, there is 6 small parts in every switch. Clean all electrical contacts by scraping with a dull knife, and get all the sandwich crumbs out. Grease the 2 balls (also helps to hold everything together) and snap it back in place. You may also have a broken solder joint where the bottom of the switch is soldered to the circiut board. You have to take the assembly out to do this. There are 2 bolts holding it in from the bottom. Either way you should be able to fix it for no money.

Seat Back Jammed. [Tip from Don Willson:] On a trip last week the seat back quit working on one side. So I clipped the hog rings at the bottom of the seat and pulled the upholstry up like pulling off a sweater until I could get to the flexible cables. After quite a bit of investigating I figured that the motor and gear boxes were OK. I finally decided that the flexible shaft inside the housing to the inner gear box was too short and had slipped out of the gear box toward the motor end. Since I could not stretch the cable I shortened the housing about 3/8 inch and reassembled it and it works fine.To synchronize both gear boxes leave one unconnected and move the other side back and forth until it is about in the middle of the travel with the other side not moving, then reconnect the loose side.

Cable Failure on One Side. [Inquiry] My drivers power seat will not move forward or backward on one of the rails. This causes the seat to twist rather than move forward/backward. [Response: DanR/Bob] The same motor drives both sides via cables from each end; these in turn move each side of the seat. What happened on my seat was that the inner cable's end had rounded out on one side or has pulled back inside the sheath. The cables are round except for the last few inches where they are square. The square ends fit into the motor shaft and the gear on the track gear box. It seemed that the inner cable should have been longer than it was as just the last 1/8 inch was making it into the gear housing on the track. Many folks have repaired this by making the outer sheathing shorter to get more of the inner cable to seat into the gear housing. I didn't see any way of getting the metal sheath off the cable without destroying the ends. So I left it alone, all I did was insert 1/4 inch piece of round steel in the inside of the motor shaft to push the cable through the sheath further into the gear housing. [Tip] Cut off a finishing nail to a length of about 1/4", squareish on both ends. Drop it into the center hole where the cable fits into the motor; put the cable back in and reinstall everything.

Diagnostics. [Fred Morefield] You first need to figure out which cable is inoperative. To do this, run the seat forwards and backwards and see which side is moving and which is stationary (faulty). Then run the seat up as high as it will go so you can see under it and follow the cables from the motors to their respective servos. When you find the cable that runs to the dead servo grab it in hand and run the seat forwards or backwards and make sure that you feel the cable spinning in the sheath. IF it does then at this point you can usually get it to operate by pushing that cable one way or the other and getting it to engage. Doing this will allow you to move the seat all the way one way or the other which will facilitate accessing the bolts to remove the seat.

960 Cable Removal, *Repair, and Reinstallation* [Jay Simkin]

1. Remove the seat from the car.
2. Position the seat bottom-up on supports (with towel or blanket to protect the upholstery), such that the leading edge of the seat is closest to you. The "leading edge" is that which is against the back of the driver's or passenger's knees, and thus the edge closest to the windshield, when the seat is installed.
3. Find the seat motors, a three-unit cluster, mounted towards the seat's leading edge.
4. To the right of the motor cluster, you will see a black steel bracket, with a “D” shaped hole in it. The round side of the “D” faces the seat's leading edge .
5. On the underside of that bracket, on the left side of it (i.e., the side closest to the motor cluster) you will find six, 8-mm, hex head, self-tapping screws. These six screws secure the bracket to the motor housings.
6. Use 1/4" socket tools. You will need an 8mm socket, a 4" or 6" spring flex shaft, and a ratchet. Starting from the screw closest to the seat's leading edge, remove these screws. You can insert the spring flex shaft through the “D” shaped hole to access some of the screws. Note: there is no need to touch the screws at the other end of the black steel

bracket, that closest to the seat track.

7. When you remove the screws, you will notice a slight gap (3/16", 3-4 mm) opens up between the bracket edge, and the studs on the motor housings, from which you removed the screws mentioned in (E). Do not be concerned. You will close this gap, when you re-install the screws.
8. You can now remove the drive cable end from any of the three motors, by pulling the black plastic cable housing straight towards the “D” shaped hole in the steel bracket. The end of the drive cable is not secured to the motor housing by a set-screw. You will see that at the motor end of the drive cable, the bright metal cable housing is slightly flared. This flare in the cable housing allows the black steel bracket to snug the end of the drive cable housing, into the motor housing opening, when the bracket’s 6 mounting screws are tightened.
9. Once the motor-end of the drive cable has been removed, you can remove the other end, from the track drive gear mechanism, beside the seat track. You can then replace the cable.
10. In some cases, you can restore function, by pulling the drive cable out of the black plastic housing and reversing the cable, i.e., inserting the end that was closest to the motor, so that it goes into the track drive gear mechanism. This may be worth trying, if the end of the drive cable, that was closest to the motor, is slightly rounded or worn, and if the end, that was closest to the seat drive mechanism, is not rounded or worn. While a slight rounding may stop the motor from turning the drive cable, slight rounding or wear does not seem similarly to affect the drive cable’s capacity to turn the track drive gear. [Kevin Kazanjian] I have fixed many seat cables on 800-900 volvos and have found that using a small pair of vise grips, you can lightly clip onto metal collar, with cable removed, and heat with a lighter. When the metal heats up, it will slide off the sheath. Clip off a small amount of sheath, reheat metal retainer and slide back onto sheath. You will see the plastic slightly ooze out around crimp holes in retainer. It will not come apart
11. Once you have installed a new drive cable assembly, or reversed the drive cable in its housing, you should test the new assembly.
12. *Testing and Reinstallation:*
    a. Using your hand, push the end of the track drive cable, into the motor housing, and hold it firmly in place. Use the seat switch to activate the motor. If the tracks (normally bolted to the floor) move smoothly and completely, forwards and backwards, you’ve restored the seat to good working order. You may want to lubricate the tracks with a spray grease (e.g., white lithium). If the seat tracks do not move smoothly and completely, forwards and backwards, check the tracks to ensure they’re free of obstructions (e.g., coins, dirt, debris, etc.) and not bent or otherwise damaged. Clear any obstructions, and re-test. If the tracks are bent, or teeth broken, the tracks will need to be replaced.
    b. Reinsert screws into the holes at either end of the black steel bracket, and tighten them “snug”. REMEMBER: these screws are going into plastic, so brute force will strip the hole!!! Tighten the two end screws alternately (rather than doing one completely, and then the other). This alternate tightening will gently and evenly draw the steel bracket towards the motor cluster, pushing the ends of the drive cable housings into the motor housing openings. The four middle screws need not be re-inserted at this point.
    c. Re-test any repaired drive mechanism, to ensure it still works through its full range of movement. If it still does so, insert and tighten the remaining four hex head screws. Go GENTLY: these screws are going into plastic studs on the motors, so it is easy to strip a hole.
    d. Re-install the seat in the car.

960/90 Seat Motor Failure. [Inquiry] My 960 driver seat front back motor works with the switch but only the left track moves. The right (inner) track is stopped. It seems to be clear but it is stopped. Is there a fix that someone has performed? [Response: Peter Rhyins] This is a common problem with 960 seats. Volvo considers this an adjustment, and has a service bulletin to do the procedure which requires re-connecting the shaft which has stripped off (see above).

Seat Alignment. Unfortunately, once you've re-connected the motor shaft the seat needs to be realigned so that both rails move forward and backward evenly, and to prevent further damage to the motor which can fail if this re-alignment isn't done.

Manual Non-Computerized Seat Alignment:

1. [Jay Simkin] First remove the drive cable from its opening in the seat track drive motor (the middle one in the cluster).
2. Supply power to the seat, from a 12-volt battery (or portable 12-volt source) through leads with insulated (red and black flexible plastic), spring-loaded alligator clamps. The wire from the positive pole of the battery/source should go to the spade terminal, for the red wire on the grey connector and the wire from the negative pole of the battery/source should go to spade terminal for the black wire on the grey connector.
3. On a passenger-side powered seat - which does not have “memory” - use a carpenter’s steel framing square (16"x24"). Place the short leg of the square along the outer edge of one of the tracks, with the long leg extending parallel with the leading edge of the seat, until it (the long leg of the carpenter’s

square) extends past the track on the other side of the seat.
4. Use the seat switch to advance the powered track, until it just touches the edge of the carpenter's square. Both seat tracks are now aligned.

Computer-Controlled Seat Alignment:

On a powered driver's seat - with memory and its own seat computer - you may need to take the seat to a Volvo dealer, to get the tracks re-aligned, if the method set forth above, does not restore synchronous track movement. The alignment can only be done with a Volvo diagnostic computer that can detect the stepper motor current while driving both rails to their end stops. If they aren't both at the exact same place, you'll have problems.

Re-Setting Seat Position When the Switch Has Failed [Jay Simkin]

This is a work-around to be used to move the seat when the seat switch unit has failed. This work-around allows power to be supplied to the seat motors so that the seat can be moved.

- The seat should be removed from the car. WARNING: Before removing the driver's seat from the car, the SRS System must be de-activated. To do this, remove the battery negative cable clamp from the terminal, and put the terminal in a plastic bag. This will prevent accidental airbag deployment. The airbag sensor is mounted on the floor pan, under the driver's seat. An accidental airbag deployment can be lethal at close quarters.

  Put the seat on a flat surface. Under the seat, you will see the three seat motors, mounted next to each other. Atop the black steel motor mounting bracket, there's a black plastic connector - secured to the motor mounting bracket with a yellow plastic circular clip. This connector attaches the wires from the seat switch cluster to the motors. This black plastic connector houses six wires, white-black, yellow-green, and blue-violet. These wire pairs drive the seat motor, that control front-to-back, seat bottom tilt, and seat height. To change the direction of movement, reverse the red/black wires from the battery or portable 12-volt source. Thus, if red to white / black to black moves the mechanism in the direction opposite that you wish it to move, connect red to black and black to white, to reverse the direction.

  Seat-back angle is governed by a separately-mounted, in-seat motor. It is powered by a separate yellow-green wire pair. Here, too, motor direction (and so seat angle) is changed by reversing the wires. Here are the wire pairs

  [Red = + (positive)
  Black = - (negative)]
  Motion Front-to-back - To move seat forwards (towards dash): Red to Purple// Black to Blue
  Seat Tilt - To tilt seat downwards (towards floor): Red toWhite // Black to Black
  Seat Height - To raise seat (towards roof): Red to Green //Black to Yellow
  Seat Back Angle - To bring seat upright (straight up): Red to Yellow //Black to Green

  To reverse these movements, reverse the wire sequences set forth above.

  Reconnect the black connector, and secure it to the motor mounting bracket, with the yellow plastic clip. Re-connect the two-wire seat back angle control motor, by inserting the male into the female connector.

Power Seat Switch Cluster Removal and Repair.
Cleaning and Accessing Switches. [Inquiry] My seat is stuck, I assuming its in the switch cluster, any tricks to removing and replacing it? [Response: John] Assuming it's a switch problem (could be checked with a test light), it's possible that dirt, soda, moisture, etc has corroded or gummed up the 'stop' switch contacts. Try spraying electrical contact cleaner (via radio shack or wherever) directly onto the switch assembly from the top while moving the stop switch on/off. I've often had good

"luck" doing that but worst case scenario is that your switch assembly (called a power seat controller) is NG. They're not cheap, over $150. [Response] There are two bolts that hold it in from underneath, which can be difficult to get to if you can't raise the seat. I was able to fix an intermittent problem by re-soldering the connections on the circuit board.

Wiring Harness. [Further Inquiry:] I got a new switch. Its easy to get the switch out, the tricky part is the harness, and the front seat cushion, Anyone know how to remove the cushion? the harness disappears under the carpet, any ideas where and how much of the carpet to lift up? Why Volvo decided to have a 24 inch harness on this switch has got me, you would think a connector could have been built into the switch housing, and tie right into the main harness. [Response: Bob] You can pull up the front part of the cushion. The front part of the seat cover is attached by a rail going side to side. Usually has a clip in the center. Remove the center clip, grab the center part of the seat cover where it wraps around the seat frame, bend the rail out in the center so it will come out of its holes on each end. Then you will find an S hook attaching the cushion to the frame about 6 inches from the front. 1 hook on each side. The wiring plugs in near the outer seat mounting bolt. There is a plastic cover attached with 1 screw at the front of the left adjustment rail. Remove screw and cover, pull up the carpet slightly and you find the 3 connectors for the switch. One connector may not match, as they changed them. If so, you can either order the plug and terminals at the dealer or splice color for color.

Electrical Problems. [Inquiry] None of the power controls are currently working on the seat. Since there are separate switches for the forward/backward and tilt functions, I'm pretty sure it's not the switch. I also checked the fuse, and that's not it either. One person at the local dealership suggested that there is a relay that might be at fault, the fellow at the parts department claimed there was no such relay. What do I do now? [Response: Steve] There is a separate 25A fuse for each front seat. The relay was mounted on the switch board on the non-memory type seat used to '92, and often had cracked solder joints on the switch board. Memory seats have a separate control unit.

Power Seat Switch Repair. [Inquiry:] The seat adjustment switches on my 760 do not work unless I push on the bottom of the circuit board. When I do this, I hear a click (like a relay connecting) and then they all work. I will re-solder the connections on the bottom of the board, but I can't figure out how to get the board out of the plastic case, so I can get at the other side. Does anyone know how to get the board out of the plastic cover? [Response: Craig Henrikson] Remove the cover over the rear seatback gear unit and then take out the phillips head screw at the rear of the plastic "pod" that holds the switch assembly. There is also a similar screw at the front of the "pod" that is not easy to get at but a good offset screwdriver should do the job. Both of these screws go into the seat frame. On the bottom of the "pod" there are 2 bolts that hold the switch assembly in place. Remove these and you and pull the switch assembly up -- this should give you limited access to the PC board. You can them resolder to your heart's content. If this doesn't give you enough room then remove the seat (4 bolts - push to rear and lift) and you can then cut some of the cable ties under the seat to loosen things up. NB -- The switch assembly is a single unit with multiple solder points to the PC board -- if you need to repair a switch GENTLY pry up on the switch actuator and you will have access to the interior of the switch. All the PC board wiring is on the bottom of the board. My major problem has been the on/off "STOP" switch -- it is easily bypassed by soldering a short wire between the 2 board connections toward the rear of the stop switch section of the board. Note that there are 2 relays on the board and you can't get at them if they are defective but you can probably bypass them if you are daring!

Seat Mechanicals:

Seats Interchangeable?

Front Seats? [Inquiry:] Are the driver and passenger seats interchangeable in 74x, 76x, and 940 cars? [Response:] The short answer is sort of yes. The front seats use the same symmetric components mounted differently for left and right seats. The basic frame is ambidextrous. The lumbar support can be swapped around from left to right side (of course, the upholstery will have the hole for the lumbar adjust knob on the wrong side), as can the seat belt anchors, reels etc. The part that's not as trivial is the seat track and associated height adjustment. Earlier models, I think 88 and older, have left-right asymmetric tracks, though it looks like with a little bit of metal smithing that can be taken care of. 89 and newer cars (I think) have more symmetric looking tracks, though I couldn't guarantee that a left seat will bolt directly into the right spot. Generally, only the left driver's seat came with height adjustment, and typically only manual, except for some 760 and 780 cars. Therefore, I'm not sure that the height adjustment mechanism transfers to the passenger side easily (i.e. the mechanism is symmetric), though I could be wrong. Power seat mechanisms can, as far as I have been able to tell, be moved from left to right as long as the bottom of the tracks is symmetric, which I believe happened in 88. As far as the difference between older, asymmetric tracks and newer symmetric-looking tracks, the front outer track mount differs slightly between 87 and 88, but if the car itself is 88 or newer (accepting newer tracks), the older style track mount can be modified very easily to fit the newer body. If an 88 seat is to go into an older body, the 88 track needs an additional piece of hardware, and I doubt you can buy that piece separately, so it would help to have an old donor seat. Power seat electrical connectors may differ among models and years, which can be easily rewired. See the discussion below for more details on installing power seats in a manual seat car.

700/940 versus 960/90? [Inquiry] I have a line on some great front seats from a 1993 960. Will they bolt in to my 1990 760? Both cars have power seats. [Response: Bob] Yes.

240 versus 740? [Inquiry] Can I use 240 seats in a 740 or vice versa? [Response] No: they have completely different configurations.

Rear Seats? [Inquiry] Are the 700 and 900 rear seats interchangeable? [Warren Bain] The sedan rear seat back cushion will be too high. The rear of the 944 is higher than the 744. I know this from personal experience: I replaced my 744T interior with one from a 944. Everything else except the headliner and the padding surrounding the two small rear side windows will fit.

Wagon Seats.

Squeek in Seat Latch. [Inquiry:] I have a 92 960 Wagon with 91K miles. It has an annoying squeak that appears as though it's coming from the roof pillar (right behind the backseat no the driver's side). It squeaks when going over bumps. [Response: Lance Schumacher] I had a similar problem on mine. It turned out to be the latches for the folding middle seat. I put some Vaseline on all the contact points and the squeak disappeared.

Release Lever Repair. [Inquiry] How do I fix the release lever on the fold down rear seat? Mine has snapped off/out completely. [Response] Note to all 745 owners----the backrest release mechanism is fragile, with several small brittle plastic parts involved. Be gentle when operating it. You don't want to have to do this job, which is difficult. First I had to figure out how to get the latch to release in order to remove the back rest. It turns out you have to pull one of the control rods and push the other at the same time. Once it can be lowered, you have to depress a spring loaded pivot pin at the on the outboard side, and perhaps unbolt the hinge assembly at the center. With the backrest out of the car, you have to skin it, and dismantle it completely to install the replacement parts. If you can find at the junkyard a matching backrest with a working mechanism you can swap, that makes the job go a lot quicker.

Seat Removal.

Front Seats.

Safety Caution. [JohnB] **Disconnect your battery negative cable before removing the front seats or working around the crash sensor under the driver's seat.** The air bag wiring harness is fairly safe, but it's possible to nick one and/or inject a static charge and fire off the airbag. It's also possible to drop something on the crash sensor and do the same. Nearly every safety note on airbag equipped cars says to disconnect the battery and wait 20 minutes before messing around where the airbag can be tripped. It goes without saying that you should NOT work around or under the airbag or crash sensor with the key in the ignition and the radio on. If your sensor does go off, the combined cost (new) of a replacement air bag and sensor is more than $2,000.

[Tips: Jay] To remove the front seats in the 700/900 series:

1. Unscrew the side seat pocket. Unbolt the seatbelt retractor from the seat (reinstall at 35 ft-lbs). See the caveats in the SRS section about removal of the retraction mechanism.
2. Unscrew the plastic cover to the outboard front corner bolt.
3. Disconnect the wire harness connectors located near the outboard front corner of the seat track.
4. Pop off plastic covers to 2 rear bolts holding the seat down. There's 2 ways to do this (at least in my car): either push down and slide away from the seat, or take a pocket knife and wedge the edges of the plastic thing.
5. Unbolt 4 bolts (reinstall at 35 ft-lbs)
6. Get in the back seat, bend over, and with one hand near the base of the seat and the other near the shoulder area (for balance), slide the seat all the way back; then push forward a bit (.25 inches). You may need to lever the rear of the seat track up over the back detent. Then pull/tilt the rear of the seat up. It's much easier on your back if you have a

helper to maneuver the seat out with out tearing up your door panels etc. What you're looking for is trying to get a lug out of the keyhole shaped cutout on the floor of the car. If you didn't get it the first time, slide the chair forward or backward slightly and pull up again.

7. Once it's out of the lug, put the seat in the most upright position (seatback 90 degrees to the seat) and take the seat out of the front door. I did this standing right outside the front door (pretend it's the driver side). My left hand grabs the bottom front underside of the seat. My right hand holds either the headrest or shoulder area. Then lift and take out. Try not to mess up your back.

   Reinstallation:

   Re-install the seat in the car by aligning the studs on the seat track bottoms with the holes in the seat pan. When the seat is flat on the floor, move the seat, until the holes at the end of the seat tracks match the holes in the floor pan. Insert the seat bolts and set the threads into the holes, by turning the bolts by hand, counter-clockwise, for one full turn. You should hear/feel a slight “click”, when the thread on the bolt engages the thread in the hole . Hand tighten as much as possible, and then torque to 33 pound/feet (45 nM). Hand tighten and then torque the seat belt anchor bolt to 33 pound/feet (45nM).

Rear Seats. [Tom Irwin]

1. Remove Rear Seat Bottom Cushion--About 6 inches in from either side, on the leading edge are latches that hold by way of foam compression. With the palm of your hand, PUSH IN...Then DOWN, Then lift up and away, both sides.
2. Remove Rear Center Headrest--Extend upwards...lift and unsnap lower section of plastic cover. Then remove 2 phillips trim screws on upper part of plastic cover..really have to pull up on the headrest as you do this..set plastic cover aside...Remove 3 bolts w/10mm heads...withdraw center headrest.
3. Remove Seat Backs--Find metal tabs at right and left lower corners, bend slightly upwards and pull lower part of seat backs outward. Lower the center armrest to about 45 degrees. Push up on seat back until upper corner tabs/slots come free, pull entire seat back ass'y forward over and away from center armest. CAUTION.. feed 3 seatbelt straps carefully over seat back as you withdraw it from car.
4. Remove 2 Remaining Headrests--Take out 2 bolts w/ 10mm heads, each side, remove reinforcement plates, withdraw headrests and set aside. Remove 3, T-25 screws that secure Rear Deck Panel.

Seat Tracks. **See Safety Caution Above**. [Inquiry] When I disassembled the passenger seat to fix / lube the seat rails 2 ball bearings fell out when I slid the rails off the bottom of the seat assembly. I didn't see where the came from and re-assembled the rails without them, but now the seat wobbles a little from side to side and front to back. Anybody know where they came from ? How to re-assemble this (non Electric) seat? [Response: John Hibbert] I have the same problem with my 93 945. The tracks are very successful at collecting Aussie sand, resulting in jammed runners. In attempting to clean the runners I ended up with ball bearings and rods and no idea where they came from. After much thought I reluctantly had to admit failure and posted to Brickboard. Gregg Stade very kindly posted a detailed reply, however I've been too busy to follow his advice. It goes as follows- 'I think there should be 2 rods and 4 ball bearings per side. Note how the tracks are positioned.......... Now to the small pieces. I think what I did was lay the rods and bearings in the grooves on top of the track rail still attached to the seat and then gently slid the removed track on, over them. The order of the pieces is as follows: bearing, rod, bearing near the front and then another series of bearing, rod, bearing near the rear of the same track. While sliding the removable track on you'll probably need to temporarily hold the pieces from sliding out of position until the track is completely on. It may take a couple of goes to get it right. You'll know you have it right when the removable track will slide very easy on the fixed track.'

Seat Track Extenders. [Editor] Both Volvo and http://www.seatextenders.com/ offer seat track extenders to increase distance from the steering wheel.

Seat Back Removal.
Removing the Seatback:
See Safety Caution above. Remove the seat for ease of access. To separate the seat back and the bottom, remove the 4 bolts that point their heads inside, under the rear of the seat bottom. To open both the seat back and the bottom, you will have to bend/cut the small wire clips that hold together the rods at the end of the upholstery. You can try to reuse these clips at reassembly, but I usually just use those plastic ties used found at automotive stores in a multitude of colors. For the bottom, the upholstery is also held on the side of the seat by small hooks protruding from the frame. These should be easy to

deal with. There is also a bigger metal clip on both sides that has to be forced off. After removing all these, you should be able to peel the upholstery back after unhooking the metal rod at the back end. There is also a metal rod held down with some clips at the center of the seat. For the seat back, you have to remove the small plastic panels on the sides of the seat (right side this means removing the knob for rake adjustment first by turning the locking ring inside it). You should also remove the lumbar support knob: just turn it CCW till it comes out, then the base should just come off. As for the above mentioned plastic panels, the bottoms snaps out, and then you push upward to unhook it (it's pretty tricky and I have broke some, I hope I remember correctly the setup!). Once you removed these plastic panels, you'll discover similar small hooks as on the seat bottom. After unhooking those, you should be able to pull up on the seat cover and get the job done. This is a great opportunity to repair a broken lumbar support mechanism!

Removing Seatback Cover. [Tip from Herb Goltz] Removing the back is easier than the seat bottom. Recline the seatback as far as it will go-- the first set of hogrings are at the bottom-- I think there are 3. Cut them with a pair of heavy wire cutters. It will also help to remove the plastic covers over either gearbox on the sides (probably a big phillips). Roll the cover up like a sweater. You will encounter 2 hogrings internally at some of the pleats in the seat. Cut them too and keep rolling. In order to get the headrest off you will need to feel for the vertically oriented rods from the back of the seat. The headrest is held in place by plastic retainer springs. Press in very firmly at the base of the rods while a helper pulls upward on the headrest. It is a little tricky to figure out exactly where you need to press, but you will get it to come out eventually. Then you can just pull the cover off. While it is off you can also fix broken seat heater elements and repair the lumbar support if it needs fixing.
To replace the cover, use nylon cable ties instead of the hogrings. The seat covers have metal rods sewn in that you need to capture with the nylon ties the same way the hogrings used to. If you are expecting heavy use, you could use 2 at each point. I trim off the remaining ends with wire cutters.

Lumbar Support Repair. **See Safety Caution above.** [Inquiry] am hoping that someone can provide me with careful step-by-step instructions and tips on how to replace the lumbar support mechanism in both my front leather seats.

[Response: Bob/John Hibbert/Rodrigo Silva] I had the same problem with my 93 945. The most common failure is a broken adjustment bracket screw: the large white screw in the photo which separates from its square end support piece on the other side of the adjuster. IPD sells a rebuild kit for US$65 that contains all needed parts. The following are the steps I followed:

Broken Lumbar Support Bracket Screw

1. Remove bottom section of the rear seat behind the one you wish to repair. In the wagon it simply clips out. This gives better access and enables front seat to recline further.
2. Recline the front seat as far back as it will go. This will reveal 3 wire hog ties used to keep the extension of the backrest's front and rear covers together, thus preventing the entire backrest seat cover from slipping. Cut these with a pair of pliers and remove the remnants. Replace them with plastic ties on reassembly.
3. Return seat to the upright position.
4. Remove the lumbar support knob by turning it anti-clockwise. You will feel it turn more freely when it disengages from the internal thread. By pulling it firmly it will now come away. Also remove the trim bezel. It simply pulls away. The larger knob, the rake adjustment knob does not need to come out.
5. In the bottom edge of the front and rear faces of the seat cover where the rings were, you will see two metal rods going the width of the seat inside a pocket. Remove these rods.
6. Tilt the seat to enable the front section of the seat cover to be pulled through to the front.
7. Now commence pulling the seat cover up as though you were removing an article of clothing over your head by turning it inside out from the bottom. About 6 inches up you will feel some resistance. On both sides in the back, there are 2 elastic straps with hooks attached to the frame. Tilt the seat as far forward as you can and by getting down in the rear passenger footwell you should be able to unhook these with needle nose pliers and it will enable the seat cover to be pulled up high enough to reveal the lumbar assembly. You don't have to remove the cover completely, just 8 or 10 inches until you see the lumbar bracket.

8. Disconnect the strap that stretches across the back of the padding. When tensioned it shapes the seat. This is done by putting pressure on the two clips.
9. Move to the outside of the seat again. Get your T-25 torx screwdriver from the Volvo tool set. Three screws can be found rearward from the knob you have removed. They hold the lumbar assembly in place. To access them you will need to gently push padding out of the way and maybe slide the seat to give room to work.
10. Remove the mechanism from its internal location. The problem will now be obvious and most likely be a break in the plastic bolt-like fixture. It has a hollow rectangular head. Mine was broken through this head. This head has a pin passing through it.
11. You now have two options- install the rebuild kit for $65US -or repair by placing a 10mm bolt through the centre of the adjuster to tie it together and strengthen it.

Lumbar Assembly Screws

Repair:

1. To repair you will need - a 75mm x 10mm cup head bolt, an electric drill, drill bits from 11mm downward, hacksaw or grinder and file, and a small nail or pin.
2. Remove the pin that passes through the head of the plastic bolt by tapping with a rod of smaller diameter. This enables the broken bolt to be removed.
3. Drill an 11mm hole through the centre of the hollow rectangular section of the plastic bolt. It needs only be wide enough to enable the 10mm bolt to snuggly slide through the centre.The head of the bolt should be at the rectangular end.
4. Fit the broken section back together and carefully align the drill so it passes through the plastic casing, then the bolt and then through the plastic casing on the other side. This is to enable the pin you removed to locate in its original place and at the same time pass through the bolt.
5. Once again check that the plastic bolt is together as it should be. Drill a hole the diameter of the small nail or pin you plan to use, through the non threaded end section of the plastic bolt. This hole must go through the plastic, steel bolt and plastic to enable the pin to locate snuggly. It keeps the plastic bolt together and enables it to be wound in and out without breaking.
6. Cut bolt so that it finishes flush with the plastic end. File pin so that it also is flush. The cup head at the other end doesn't have to finish flush.
7. Proceed with cover installation below.

Rebuild with Kit:

1. Remove the anchorage point on the left side (this is the side that has the knob, and the side that actually moves to tension the lumbar strap). There are three screws hidden under the hard styrofoam on the rear side of the backrest and the soft cushion on the front side of the backrest. Gently pull apart these two pieces to access the three screws. The IPD kit also provides new screws.
2. Once the mechanical piece is installed, place the strap in the clips that are provided for it. The metal tabs on the strap should pop into place on the adjuster mechanism. The other side should be similar but the only annoying thing is the center console may get in the way.

Seat Cover Reinstallation:

1. Pull the seat cover down and over the rear section and the front section so as to cover the seat again. be sure to massage the foam into its proper place so as not to have any funny looking bulges anywhere. Once the cover is all the way down, and you have the flaps of fabric in the front and rear of the seat, recline the seat backward little by little, and stuff the rear flap of fabric throught the area where the seat cushion and the back rest meet, so as to have it protrude through that area once the seat is completely reclined.
2. If using zip ties to resecure the cover, put the end of the zip tie through the old metal ring hole on both pieces of fabric. Patience with a little tugging to pull the fabric through a little more is the basic idea. Once you have the zip tie through, you can cut the end with wire cutters. Reassemble. .

Front Seat Bottom Foam Replacement (Editor: this has been edited for 700/900 cars, which have different seat construction from 240 series.)   [Tips from Paul Seminara]
1) **See Safety Caution above.** Remove seat from car by unscrewing the four bolts securing each corner of the tracks. The front outboard bolt is covered by a plastic molding which is unscrewed. The rear screws are covered with a plastic surround;

pry outwards gently on the sides and pull them out. Unplug the seat heater and power seat connections at the front corner. Unscrew the side of the plastic pocket. Remove the seat belt at the side seat frame.
Pull the entire seat assembly, including tracks, back as far as it will go. Lever up the rear tracks over the metal detent if they catch at the back. Then move the entire assembly forward five millimeters to locate the locking keys with the removal holes. Pull upwards to unlock the seat. This may take some rocking and moving. Each track has a locking pin in the middle of the track, securing it to the body structure.
2) Study/memorize seat covering at front and back, seat springs, wire grid, wiring, foam and upholstery for ease of reassembly, damage and possibly for need of more parts than you have on hand. Study the seat heater wiring and unplug the underseat connections to the heaters. Do one seat at a time so you have the other at hand as a model.
3) The 700/900 front bottom cushion is held on to the frame by two spring steel bars inserted into the covering flaps at front and back, and two wire clips in the front. The bars are inserted into the end of the covering material, fit into holes in the side frames, and are clipped to the seat bars with round spring clips. To remove them, first pull off the round clips, then bend the bars until they pop out of the seat frames at the sides. Pull the bars out of the material (if they will come easily) and push the rear material forward under the seat back.
The wire clips are clipped from the side frames into the second-from-the-front hog ring positions under the seat foam. Use needle nose pliers to pull these out from the cushion bar. The bottom cushion then pulls away from the frame. Watch out for the seat heater wiring: don't yank it out when pulling off the cushion.
4) You will see two hog rings beneath at the back, holding the rear of the seat heater in position to the bottom wire grid. Remove these.
5) At minimum you will need new foam. (You may find good used foam in a wrecker. Good luck. It may stink.) Get the best VCOA discount you can from a Volvo dealer or go to a reseller (IPD, RPR, Borton, Verrigni. Editor's note: around $150 for the bottom cushion from Volvo with VCOA discount). Study the foam and the side stiffener rods. The covering material is secured to the foam with hog rings at each side, tied into stiffening rods molded into the bottom of the foam.
6) You may be missing springs. Some of the well stocked hardware stores sell almost perfect matches (in some cases better springs).
7) You may need a new wire support grid, which you can buy from RPR or Borton's. You may also need a seat heater, but don’t buy one until you open the seat up. It may be repairable. Mine was - the connector to the thermostat was broken - I soldered the wire to a new spade connector and the thing works great.
8) Remove the five hog rings on each side that hold the seat covering to the cushion. They make special pliers for these but an assortment of wire cutters/pliers/vise grips/super grabbers will work. [Tip from Jake Fournier:] I pushed the end of a closed needle-nose pliers into the ring and opened the pliers to force open the hogrings; wear eye protection - one of those sharp little buggers nearly got me!
9) Remove the spring steel slide bar through front upholstery holder strip. (A thin piece of steel about the thickness and width of a hack saw blade). It pops right out and slides out of the fabric/leather.
10) Now peel back the front of the upholstery carefully to expose the foam.
11) You will see two hog rings holding the seat heater to the front of the foam cushion. Remove these rings.
12) Now the fabric/leather should peel all the way back to expose the seat heater grid. And the foam should come out of the covering.
13) Your seat heater is held to the middle of the foam by two hog rings in the slot in the middle. Remove these rings. If your seat heater wasn’t working replace it/ trouble shoot it now.
14) Clean all the dirt and foam bits out of the seat frame and power seat mechanism with rags and compressed air. Clean the fabric upholstery cover at this time: laundry or dry clean.
15) Clean and lubricate the seat tracks and the power mechanisms. Examine the side metal frames at the top where the hidden fabric part of the cover rests: if there are any burrs, remove them with a file and cover the edges with electrical tape to keep from cutting the fabric.
17) If the grid is shot or you are missing springs time to attack that now. I simply cut the center wires out of the grid, since I had to replace it anyway. (No need to stretch the springs to remove a bad grid!!). You may need help stretching the springs back, the last couple require some arm/wrist strength.
18) If the side felt upholstery is torn above the securing holes, take it to an upholstery shop and have them stitch in a reinforcing canvas strip so that it can be re-used.
19) Position the seat heater. Secure it with two hog rings at the front, two in the middle slot (tied to the wire stiffener), and two at the back underneath (tied to the bottom wire grid.) The electrical connection wires hang free.
20) Re-attach the seat cover at each fabric hole to the side seat foam stiffener. Don't bother with hog rings: use a heavy-duty tie wrap (not the cheapie kind) per hole. Pull them tight while pulling the fabric covering down over the foam, and push the square lock inward into the foam so it does not rest on the seat frame. These ties/rings hold the covering on the foam. There are five to each side.
21) Place the covered cushion back on the frame. Pull the back fabric flap through (beneath the back cushion), insert the spring bar, wrap around the rear seat frame bar, and insert the sides of the spring bar into the holes in the side frames. Insert the rear round clip into the carpet spring bar and then clip it onto the rear seat frame bar to secure both the cover rear flap and the carpet.
22) Insert the wire clips into the seat cushion stiffener rods at hog ring position two from the front. Using needle nose pliers,

pull these so they are reinserted into the side frames of the seat.
23) Insert the spring bar into the front flap, wrap around the front bar, and insert the bar ends into the holes at the seat frame sides. This holds the front of the cushion onto the frame and tensions the covering. Add the round spring clips to secure the bar.
24) Clean and treat leather with Lexol.
25) Plug the seat heater connections back together.
26) Reinstall the seat in the car and plug the seat heater in. Re-torque the seat bolts and the seat belt to 35 ft-lbs.
27) Adjust the seat and enjoy!!!!

Seat Pocket Mount Repair. [Tips from Bill VanOrden] To repair the plastic side pocket at the base of your seat -which tends to break at the mounting points- you will need:

Seat Pocket Mount Repair

- Solvent alcohol
- JB Weld Epoxy, fast or slow (Loctite Quick Epoxy can also be used)
- Machine screw approximately 19mm long, same diameter and pitch as the original attaching bolt, see drawing to determine length.
- Nut to fit the above bolt
- Metal bushing or piece of copper tubing to fit the above bolt, about 8-10mm shorter than the bolt. Length is not critical as long as it does not project out of the well in the pocket. Use the drawing for reference.
- Solvent weld or MEK to repair pocket
- Small piece of 3/32" to 1/8" thick ABS plastic sheet

Remove the seat pocket from the car and clean the area around the broken mount with solvent alcohol. If you use isopropyl from the drug store make sure it has no oils in it, many times "rubbing alcohol" has mineral oil added to it and this defeats its use as a cleaner. Remove and clean the part of the pocket still attached to the seat. Re- attach this to the seat pocket using solvent weld, do NOT glue!! The trick to solvent welding is to get both pieces very clean and hold them together. Then touch a modeler's paint brush wet with solvent to the joint. If you have enough (but NOT too much) solvent on the brush it will wick into the joint and very soon a small bead of plastic will ooze out of the joint. If you have too much solvent on the brush it will run all over and mar the surface of the plastic. This technique can be used to repair cracks in most of the 740 interior panels, I have about a 1/2 pint in my car already! Set aside for 1/2 hour. Weld (using your now perfected solvent welding skills) the small piece of plastic sheet into place. Set aside again for 1/2 hour. Drill the hole in the attaching well through the newly attached piece of plastic. Scuff the outside of the bushing with sandpaper or a file to make the epoxy adhere to it. Bolt this bushing into place using the nut and bolt. The length of the bolt has to allow it to project about 7mm out of the repaired seat pocket and the length of the bushing is such that the head of the bolt is still below the surface of the well opening. See the diagram! Carefully mix the epoxy and pour it around the bushing and fill to almost the top of the bushing. Do NOT fill past the bushing!! Set this whole mess aside in such a way that the epoxy is even and level in the opening, watch it for a minute or so to make sure you have it setting level. When fully set up (overnight in warm area even if you used fast set epoxy) remove the nut and install using the bolt used to hold the bushing into place.

More Headroom Via Lower Seat Cushion. [Inquiry:] I'm suffering from a lack of headroom in my '88 760. I've heard of a TSB about lowering the front seats to gain about 1" to 1.5". My local dealer does not know about it. Can anyone help me identify it, or even better, tell me what it says and whether it's a DIY kind of job? [Response: Paul Wright] Volvo service bulletin for US and Canada markets TP 31127/1 (English); 09/88; Body Interior, states that "From model year 1991, the seat frame springs can be lowered approx. 10-15 mm (about 1/2 inch) to provide increased headroom." The drawing on the service bulletin shows that there are two sets of mounting holes in the seat bottom frame, where the six springs under the cushion hook into the seat frame. The bulletin suggests hooking the springs into the lower series of six holes. I believe there is only one set of mounting holes cut into the pre-1991 seat bottom frames, but it should be possible to drill out some new ones about 1/2" lower, and get the same headroom advantage as is already available on the post-1991 seats.

Headrest Removal.

Seat Headrest

Front Headrest Removal. [Note 1:]It's a game of blind-man-buff... there is actually a hook/latch holding the two rods.. you have to press down firmly at the back of the seat about 6 inches below the top of the back to release them. [Andrew] Just below the headrest on the back - just where the fabric can be pressed in -toward one side (about three-four inches from the side edge) I found/felt a wire lever (seemed to have a small loop/circle at the end). It was horizontal mainly - from the side. Worked my fingers and pressed it - released the headrest.It does require some pressure. [Jay Simkin] As you face the back of the seat, you will see there is a rear seat pocket. About nine inches above the top edge of the seat pocket, there is a line of stitching, which runs from right to left, about 5" below the top of the seat (there are also lines of stitching, that run down towards the top edge of the seat pocket). About one inch above the top line of stitching, there is an angled area, where the fabric is stretched, so that the central part of the seatback forms a recessed panel. About 1.5" above the top line of stitching, you will feel - when you press gently forward (i.e., as if you were going to press your finger through the seat, to the front surface [that closest to the steering wheel]) the edge of a frame. Using your index finger, press gently but firmly forward, directly below where the "foot" of the headrest joins the seat, right below the frame and about 1 1/2" to the "inside" of the angled seam. When you have pressed your index finger 1 - 1 1/2" forward, you should feel something springy. It will move forward, as you press on it. This is the headrest catch release lever. The front edge of the steel headrest post has a notch in it. The headrest catch locks into that notch. When you press forward on the headrest catch release lever, you disengage the catch from the notch. It is sometimes helpful to push down on the headrest, push the headrest catch release lever forward, and then pull up on the headrest, to disengage the headrest catch from its notch on the headrest post. You should free each side of the headrest, by lifting each side 1/2", before trying to pull the headrest out of the seat. To re-install the headrest, simply align the posts with the holes, and push the headrest downwards. It will automatically lock into place.

Sedan/Saloon Rear Headrest Removal. First remove the rear seat back. The headrests are accessible once the seat back comes out.

Wagon/Estate Rear Headrest Removal. [Jay Simkin] Begin by setting out the terms of reference, so that you can quickly identify the items, to which I refer. 940/960 wagon back seats have a small section (on the passenger side of the car, US/Canada models; driver side of the car, UK/Japan and similar models) and a large section. The small section has a single headrest. The large section has an outer headrest (closest to the door) and an inner headrest (in the center of the car, next to the inner edge of the small section). The large section's inner headrest is part of the infant booster seat. I presume you want to remove the outer headrests, i.e., those closest to the rear doors, rather than the headrest of the infant booster seat. (a) Uing the flexible vinyl loops, release the catch for each lower seat section and rotate it upwards and forwards, so that the seating surface is against the back of the front passenger seats. (b) Using the release lever on the outer upper corner of the each seat back section, press the lever rearwards (towards the back of the car) and release the seat back. Push the seat back forwards and downwards, so that the rearward-facing surface of the seat ends up flat, and facing the roof of the car. (c) Lift the flat, rectangular carpeted panels, immediately behind the seat sections. There is slight spring tension on them. (d) Immediately in front of the hinge, for the flat rectangular panels noted in (c), above, you will see a 10mm hex nut, that holds to the floor, a black plastic anchor. This anchor is attached to a galvanized metal section, that goes up into the seat back. This galvanized section is part of the mechanism, that pulls down the headrest, so that the top edge of the headrest is flush with the top of the seat back, when the seat back section is pushed forward. (If this were not done, a protruding headrest would stop the seat back section from rotating fully forward, thus preventing the creation of a flat floor in the load space). (e) Remove this 10mm hex nut (using a 6" extension bar and a ratchet handle will speed this work). There is no spring tension on this hex nut. Remove the black plastic anchor from the stud (which stud is welded to the car's floor). Replace the hex nut on the stud (to keep the hex nut from getting lost). (f) Gently grip the galvanized section and rotate it 45 degrees (in either direction). Pull gently on it - rearwards - until it comes free of the headrest post. With the seatback full forward, you will have room to remove the galvanized section and the plastic tube attached to it. Do not remove the wire springs from this mechanism. (g) Set aside the galvanized section. Rotate the seat back section rearwards and so upwards, by about 45 degrees. Firmly grasp the headrest and slowly pull it out of the seat. Take the galvanized section and place it on the longer of the headrest posts. Slide it on at a 45 degree angle, and then rotate it, to lock it into position on the headrest shaft (this will keep the galvanized section from getting lost, and ensure you can replace the headrests easily, when you no longer need to the booster seats). (h) Place the headrest units in a plastic bag, and store in a cool, dry place. This will prevent mildew from damaging the fabric/leather, and keep the foam cushioning from drying out.

Seat Covers:

Vinyl Repair. I found that a clear PVC solvent adhesive does a real functional job on repairing tears in vinyl upholstery. It's sold in tubes at Walmart for $3. Called "Tear Repair". Call 800 248-Poxy

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Leather Seat Repair. [Inquiry:] The carpool has taken its toll on the mothership (wife drives the car). What is a good option to get the front seats recovered, as the local guy says that he only has vinyl (yuk). or do i have to buy the whole seat from the junkman? New leather covers are available from the dealer at about 1300 bucks for each seat. [Response:] I had a '90 760 wagon with ruined seats as well. Instead of doing the dealer rape, I took it to a local auto upholstery shop. They took a good look at what needed to be done, and suggested they replace the panels in the seats that were either worn, cracked or torn. They replaced the panels, and then redyed the whole seat to its original color. This was done to both front seats, and the dye was put on the whole interior. They also put in a brand new headliner for me, and fixed a few nick nicks around the interior. The whole job cost me $500. I think that might work for you instead of bending over at the dealer. [Response 2:] The driver's seat on my '92 940 has some cracking in the leather so I took it to a local upholstery shop that is well respected around here. As we discussed the options for proper repair, he told me he gets all his replacement leather from a supplier who dyes the leather to match what's already in the car--He clips a small sample from under the seat to use for color match. This upholstery shop then sews up the replacements.

[Tip from Gennaro Lopez] I've taken off many a 240 seat and repaired the upholstery (shoe repair shop does wonders with the leather). Now I'm gonna tackle the wife's 740 sedan. Passenger's seat has a rip in the middle of the seat. If I can remove the leather skin, I'll take it to Guiseppo at the shoe repair place and he'll sew a thin piece of leather to it for about $5.

Seat Cushion and Skin Removal. [Inquiry:] Are the methods for removing the seat & seat skins similar between the 740 and the 240? Any hints to avoid trouble? [Response: Bob] There is a bar going through the upholstery front and rear, similar to 240. You should remove the seat pocket- 1 screw on rear, spring loaded retainer on front. Looking from under pocket, you will see a hole with a spring and round plastic thing. Stick a screwdriver in and press the retainer toward the seat, and gently jiggle the pocket upward. Then you will find a steel hook about 4-6 inches from the front of the seat cushion. Push the hook toward the center of the seat and unhook from seat frame. Pretty straight forward. I usually leave seat bolted down. However, if you decide to remove it, after unbolting all 4 corners. you have to slide seat back a bit and then lift. There are slots in the floor with holes (key shaped). Not too difficult.

Color Issues. If you have color problems due to scratches, etc., try a local art supply store and look for those solvent-based permanent art markers that come in a myriad of colors. There is usually a good match in color to be found (although watch color density: the lighter densities work better). Use the marker to color in the scratches, etc. and reduce the color contrast. If you need to re-dye areas of the seats, the dye used in detail shops is from Fitzgerald's (http://www.fitzgeraldsrestoration.com/)and they can be reached at 800 582 3326. The seats do look good. Of course I'm still going to get some Lexol and treat them to keep them looking good. [Tip] Here's a commercial site with a great deal of useful information about leather repair: http://www.leathermagic.com/

[Tip from John Acampora] All of the guys on my Mercedes list swear by Leatherique http://www.leatherique.com. They have stuff to repair cracked dashes and re-dye/maintain leather.
[Editor:] I rebuilt three seats with the Leatherique products, including leather fill for cracks, Rejuvenator Oil, Pristine Clean, and custom-matched dye (send a small swatch cut from the matching vinyl beneath the seat). The results were

spectacular. The total cost for all the seats in my 940 was $120 and I had extra product left over.

Seat Cover Sources. [Tip from Dick] You should contact Marathon Seat Covers. They make fabulous seat covers and at reasonable prices. Even can get different grades at different prices. Have used them for years. Can get them at 800 735 2769 or they have a web site which is http://www.marathonseatcovers.com Have used their 200 and 700 series covers and the fit couldn't be better, they look like original equipment even with a klutz like me mounting them.

Seat Map Pocket Repair. How do I fix the map pockets on the back of the front seats. The elastic bands are completely stretched out so that the pockets do not rest agains the seat? [Response: Bruce S.] I bought elastic strips from a craft store. I then cut small slits across the channel that holds the old elastic inside the the map pocket, about 2 inches from each corner. Cut the old elastic, but leave enough of a stub to work with on each side. Now using small safety pins, pin the new elastic to one of the old stubs. Now pin the other end to the old piece and use it to pull the new through the channel. Now experiment with how tight to pull the new, and safety pin it to the other stub and cut off the extra. Then push everything back through the small slits and its as good as new with only the small slits on the inside of the pocket. I think I used a single edge razor blade to cut the slits.

Upgrade:

Wagon/Estate Third Seat Installation. See the scanned OEM manual instructions thanks to Kris Carlson.

Installing Power Seats in a Manual Seat Car. See Jay Simkin's discussion for complete instructions.

Instrument Panel and Dash:

Heater Control Trim Removal. [Tip: Peter Gotseff] Start from outboard side (right side) rock up and down and pull gently to unclip the upper and lower right side panel clips. Now grasp panel firmly and pull out and left to unclip the big center spring clip holding panel to the dash panel cutout. It often feels like its sure to break but hasn't yet.

Headlight/Fog Light Switch Trim Removal [Tip: Peter Gotseff] As with the Heater Control Panel there is a large and stubborn spring clip. You must start from the outboard side (left side) and either pulling by hand or prying slightly with a flatbladed screwdriver unclip the clip and remove the panel. Don't start near the steering wheel since the panel has plastic clips that slide behind the dash cutout .. and they will break if pried too hard.

Wood Trim Removal. [Dan Ray] In 760/960/90 cars, there may be a wood trim surrounding the instrument cluster or the switches on either side of the steering wheel. This will have to be removed in order to remove the cluster. It may not be for the faint hearted. Go slow and never force anything, the wood trim clips are in the very center of each piece, so that is were you want to concentrate your force. I used a small screw driver for the initial prying, then used my fingers for the heavy pulling. It might be easier during first time removal to undo the knee bolsters to gain access from below, in case something falls in. It seems that all the dash parts are sort of lightly glued together with a combination of dirt, grime that sticks together with time, and cleaning detergents.

960 Panel Trim Screws

There is one steel tension clip that holds each piece of the wood trim, one clip for each side of the steering wheel. They pull straight out. With the wood trim the switches pull out too, and the light bulbs that light up the switch tops. Every thing must be disconnected from the switches. Don't worry about what goes where, each plug is unique.

[Dave Hunter] The wood trim is also held in place by tabs that need to be released. I accessed the tabs by removing the panels under the dash and reaching up to depress them. They're not easy to see, but you'll need to feel around for them and look with a flashlight. I think I may have even had to remove the metal bar by the knee bolster to get better access (don't remember). If I recall one set of tabs is near the headlight switch. To remove the trim piece on the right of the steering wheel, slide out the radio, remove ashtray, carefully pry up and backwards to pop out the cover at the shifter. This will expose 2 torx screws which hold the bottom of the large trim piece. Remove 'em. There are 2 metal springy things one on each side where the radio was. Spring them inwards (towards center)with a screw driver while gently pulling on the large trim piece. The bottom of it will now be free and the top will easily release as you move up towards the switches. You will have to unplug a few wires as you go such ashtray lights etc. The ECC is then easily removed, just take out 4 torx screws

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Dashboard Crack Repair. [Inquiry:] I just noticed a hairline crack in my dashboard. It starts where the metal leaves the windshield and is heading toward the air vents. Its tiny, only an inch long, but having owned Volvo's before I want to catch it before it starts looking like the Grand Canyon. [Response: Zee] While I had the broken windshield out of my project, I used GE Silicone II as a filler for the 1/8 - 1/4" wide cracks it has. I believe this will remain flexible and yet be tenacious enough to stick to the edges of these cracks as they expand & contract. In former attempts with my '78 244DL, I tried one of those fill 'n color match vinyl repair kits. It did not adhere well to the edges of the crack. So, the crack kept spreading and this material could not restrain it.

If I wanted to preserve what I could on a nice car like yours, I believe what I would try if the GE Silicone II caulk as a filler and adhesive, then use the color agent from one of these vinyl repair kits to help blend the repair site.

One tip: Before applying the silicone caulk, mask the area either side of the crack so you keep the caulk down in the opening, not spread out over good vinyl. The GE product tends to dry clear, but shiny. If your crack is narrow, you may get away without needing to use the "texturizing" procedure of the vinyl repair kit (heating the repair while pressing a grained material over the patch.)

[John Sargent] The good upholstery shops have upholstery dye that is sprayed from a paint gun. The dashboard on our VW Dasher was replaced with a wrecking yard unit which was the wrong color. I took it to a friend of mine who has an upholstery shop and had it sprayed black. The 2 small, fine cracks did not propagate further in the next ten years. These dashboards are notorious for terrible cracking. [Sean Corron] I used paintable silicone to fill the cracks - reasoning that it was flexible enough to hold up to the weather changes and had good adhesive qualities - and painted the whole mess with Krylon Fusion. It actually came out quite good for an $8 fix, even now, 6 months later, it looks far better than before I got to it. Fusion, with proper preparation, sticks extremely well to plastic and vinyl. BUT, the silicone handled the weather changes better than I'd hoped...when it got good and hot, the silicone expanded and rose above the level of the crack. So, no cracks, but seams where they were.

Dash Covers for Cracked Vinyl Dash Panels. [Inquiry] I've been looking at a nice 1990 740 Turbo. The only thing that bothers me about the car is that it has a severely cracked dash. Is this common in the 740's? Is it difficult to replace, or not worth the bother? [Response 1: Landon Sheely] From what I have read in this group over the past year and my experience with my '88 744, I have been able to gather the following: This is a very common problem. (Mine has done it in three places to date.) According to popular thought, there seems to be some correlation between using the "Armor All" branded product and the cracking. (FWIW, I used it on mine) I have seen a number of folks in the group warn against Armor All and recommend the use of another, more beneficial product. (Meguiar's) You can obtain a replacement dash from Volvo, but it is prohibitively expensive. The most popular fix I have heard of is the installation of a dash cap. As soon as I can get the time, I will probably end up purchasing and installing one myself. Available from IPD (http://www.ipdusa.com) for around $100.

[Response 2:] J.C. Whitney carries them for some Volvos http://www.jcwhitneyusa.com/ Also the following company carries a wide assortment, but a bit more than RPR at about $99 http://www.dashboards.com/ IPD also carries them, $99 for your car

[Response 3:] The consensus on dash caps was that they last not. The mechanical forces exerted on a cap by the fissures under it are irresistible with the passage of many moons. IPD or others, dash caps are ultimately doomed to buckle and/or crack verily even unto themselves. What works instead is to buy one of those arguably tacky tight-loop carpet dash covers as soon as you buy the car. Keep thy dash cover on and thy dash will crack not. It it's already cracked, cover it and the cracks will recoil from thy sight.

Visor Repair.

Hinge. Is the visor hinge repairable? [Editor] Not really. It is a one-piece unit that generally fails at the horizontal hinge. This hinge consists of a horizontal plastic rod extending into a hidden spring steel holder. It fails by cracking inside the holder and is not repairable. High OEM cost will force you to use a recycled unit from a breaker yard. To remove the visor, determine whether you have an electrical unit with an illuminated vanity mirror. If not, just unscrew the visor at the hinge and install the new one. If it is illuminated, first remove the A-pillar trim panel. Pull the vanity lamp fuse (if equipped), unscrew the visor and pull it down enough to expose the wire to the vanity lamp. Cut this about two inches below the hinge. Remove the old visor. Insert the wire for the new visor into the hinge hole and splice it into the old wires using butt-end crimp connectors and heat-shrink tubing insulation. Install the visor, then the trim panel.

Vanity Light. [Tips from John B] The vanity light wire pair goes down the right A-pillar and is connected to a chassis connector right behind the glove box. The same chassis connector supplies the glovebox light power and ground. In many models, the visor lamp is controlled by a mercury switch. Test the mercury switch in the vanity mirror (if so equipped) is bad by grounding the lower (visor down) set of contacts; if the lights go on, the mercury switch has failed. Later models don't use the mercury switch; they have a weighted switch. Earlier models have an on-off switch that may fail.

Glove Box

Removal. [Tips from Matt Cary] The glovebox is held in place by two screws and two nuts. The two screws are hidden under little 1-inch square trim pieces that you see when the glovebox door is opened. These trim pieces are easily removed with a small flat-blade screwdriver. Then you can remove the two phillips screws. The two nuts are hidden at the bottom of the glovebox... you have to look up from the passenger floor to see them. There's one on each side (10 mm). With the fasteners removed, the glovebox slides out easily. [Rick Faltersack] On my 87 740, I found an additional glove box fastener. To the right of center, near the latch mechanism and under a black plastic cover, there was a white plastic body fastener which is rotated with the screw slot to remove.

Door Closed and Won't Open. [Inquiry]The glove box on my 940 turbo is stuck. The knob will turn and the resistance of the return spring is felt. However, the door catches do not release and the door will not open. Using the ignition key in the lock does not do anything. [Response: Jay Simkin] I'm pretty sure I know what happened to your lock. At the back of the lock body, on one edge, there is an aluminum stud, shaped like a capital letter D. The rounded edge fits into a recess in the locking bar, which is made of plastic. When the key is turned, the lock body rotates, and pulls the locking bar downwards. That allows the angled lip of the locking bar to disengage from the latch, and enables you to open the door. The aluminum stud has broken-off from the lock body. As a result, when the lock body turns, there is nothing to pull down the spring-loaded locking bar. It will not disengage from the latch.

Before anything can be done, you will need to open the glove box. That can be done by taking a 1" wide rigid blade putty knife, and gently inserting it between the top of the glove box door, and the under edge of the glove box opening. You will need to press downwards, gently but firmly. You are using the "give" in the door, to press it down far enough, so that the locking bar will clear the latch. When that happens, the door will open. If you own a Dremel Moto-tool, are handy with it, have miniature drill bits (Nos. 60-80), and have some experience taking locks apart and re-assembling, them, you can repair the lock. If not, then you should go to a salvage yard, and remove a lock from a glove box, to which lock the salvage yard owner has a key. You can install this lock in place of your broken lock. If the salvage yard owner does not have the key, you can take the VIN from the vehicle, and get the key code from Volvo. With the key code, a locksmith can make a key. You can install that lock in your car. You will need two keys: a door/ignition key, and a glove box key. If the salvage yard owner does not have a key to the glove box lock, you can take the lock to a locksmith, and ask them to re-key it, so that it matches your door/ignition key.

760 Glove Box Trim. To remove the horizontal trim with the chrome that runs from the far right passenger (LHD) side of dash, under the right vent, above the glove box, and around the curve of the dash under the two center vents in an 89 760, remove one or two screws, accessible at the top of the map compartment, which hold two tabs on the back side of the trim.

Panel Vent Removal. See Heating and Air Conditioning.

Headliner:

Headliner Tips-DIY?. *Repair the Headliner Yourself or Have a Shop Replace It?*

- Headliner Board alone NEW will cost around $ 850.00 that price (does not include Sunroof Insert)
- 1/8" Material IS A MUST; don't let anyone suggest 1/4" since your car is designed for 1/8"
- Knowledge of Your Sunroof is a Must.
- Call the Volvo dealer nearest youand ask the SERVICE MANAGER for the names of the Trim Shop (Upholstery Shop) they use.

While they may be referred by the Volvo dealer, it's still your responsibility to check them out. Remember to insist on the 1/8th inch material . Most Upholstery Shops don't always use the 1/8th inch material because most of their headliner work is domestic vehicles using 1/4". You want them to use new, first run material. not blems, not over runs, and not their old stock that has been sitting on their shelf for the past few years.

Headliner replacement for sedans or wagons usually costs around $ 325.00 which includes the sunroof panel and a full service to the sunroof. I would also recommend you have your sunroof seal replaced at the same time This costs around $ 80.00 and will minimize the water flow into the sunroof carriage. This will extend the life of the new headliner.

Repair It With Adhesives? I, like all other 8+ year old 740 owners, had the same problem with my headliner coming apart. Adhesives will NOT hold it up, even temporarily, since the layer of disintegrated foam that remains attached to the headliner board will continue to flake off and not provide anything for the adhesive to stick to (believe me, I tried!!).

Repair It with Pins? [Sean] I fixed my 91 sedan headliner with spiral push pins from Walmart. They have a clear head and a wire spiral sticking out of them. You twist them in. I used two or three packages to fix the area above the passenger seat where the liner was coming down. I spaced them apart evenly side to side and ended up with an upholstered pattern look. Several pins broke while pushing them into the liner, but they came back out easily enough. For about $5 and 10 minutes of your time this is certainly well worth considering. They are almost invisible.

Headliner Replacement. [Editor] See the excellent illustrated article on Do-It-Yourself Headliner Replacement from DIYNetwork.Com, which summarizes an episode of Weekend Mechanic. This has been edited to include Brickboard tips from Volvo owners and is included in the FAQ at Headliner Replacement.

[Tips from David Jeff who ignored the above and bravely did the headliners in three 740s on his own] [Editor's note: the Volvo OEM Body Fittings, Exterior technical manual has an excellent series of illustrations and procedures for those interested in DIY headliner repair or replacement.] I will gladly share my headliner experiences. My family fleet of Volvos (6) is made up of '85 to '88 740s and 760s. I don't buy Volvos until they are 10 years old and beyond 100,000 miles; but, I've concluded that all 700 series headliners regardless of care or climate, will sag before 10 years of service. Sagging generally starts in the domed section of the headliner over the backseat passengers. The foam usually initially stays glued to the headliner board. The fabric just separates from the foam. The weight of the sagging fabric and busy young hands in the back seat pulling at the sagging fabric quickly accelerate the process.
If upholstery pins or small screws can be carefully installed to better secure the fabric to the board, I think the sagging process can be slowed down significantly. However, the only long term solution is to remove the headliner board from the car and glue new headliner fabric. I've done 3 - 700 sedans. Last year I priced a replacement board at the local Volvo dealer. I remember something like $350? (parts only - not installed) Local upholstery shops that advertised headliners as low as $99 were in the $450 range for my Volvo. Thus my decision to replace it myself.

Material:

[Rick Tilghman] Let me just say that you want to use 1/8" headliner EVERYWHERE, not just on the sunroof. Don't listen to what anyone else tells you... trust me and ask for 1/8" material. If the store you go to (a fabric store) doesn't have it have them order a new roll. The reason for this is that the headliner must go under various edges around the car (including under that plastic edge at the sunroof opening) and the 1/4" is too thick to fit. Also, the 1/4" material is much heavier and will pull off the headliner backing board over time faster than the 1/8".) [David] I bought three yards of new 1/8 inch foam-backed headliner fabric at an auto interior supply store for $7 per yard. I've read on SB that most fabric is thicker than that used by Volvo. I have discovered several headliner suppliers on the internet: Anthony's Upholstery Shop in Tampa Florida ; Gilbreath Upholstery Supply in Des Moines, Iowa (http://www.upholsterysupply.com); and "Heads Up', from HeadsUp Industries in Florida (305) 472-3300. Also see http://www.ipdusa.com/ for 700/900 headliner kits. I have not done any business with either. I think Anthony's has 1/8" fabric. 3M makes a spray glue ("3M General Trim Adhesive - Clear Part No. 051135-08088") made specifically for this purpose. I've found it at WalMart cheaper than the auto interior supply store. You'll need two cans for the boards and a third for the sunroof.

Removing the Headliner from the Car:

[David] To begin, I think you need to completely remove the headliner board from the car. I'm not sure what the board is made of. It's fragile and somewhat brittle. It's not particleboard. It's not fiberglass. It is some kind of molded pressboard with a brown wax paper glued to the top side. The board is secured on plastic strips above the windshield and the back window. At the rear there is a square plastic fastener about 1" from the edge in the middle of the back window. Plastic trim pieces screw in above the doors holding the sides and a plastic molded trim strip secures it to the sunroof opening. The electric sunroof motor cover, the dome light and the sunvisors and rearview mirror secure the rest. To remove the sunroof headliner or the sunroof pan and sunroof assembly, see the FAQ section in Body-Sunroof. I recommend removing both front seats and the entire backseat (the upper half obstructs removal of the trim pieces around the rear side windows). Remove the trim (8 pieces, 4 each side) the visors, the mirror and the sunroof trim. Don't forget the fastener at the back. With a helper, attempt to carefully lower it and pass it through the passenger front door (biggest hole) or, if you have time and ambition, through the back window which you must remove. Without excellent help and great luck, you will break the board where the rear view mirror attaches and along both sides of the sunroof opening. [Tip from Lawrence] The only way I could get mine out was to bend it. Just pick a spot that won't be noticeable when it's back in the car. Bend a bare minimum, just enough to get it out. Try not to break (you may have to crease it). But even if it breaks, it will be easier to fix the one crack and not a jigsaw puzzle of broken pieces. [Jim Egelston]What helped me was that the car I bought spent most of its life in a garage and is a Northwest car. I think the cooler climate here might have kept the headliner board from baking and becoming brittle, as opposed to a southern car. My car does have a sunroof, but I had no breaks anywhere. I did have to bow the board slightly to get the corner to clear the door opening. Having two helpers was important.

Repairing the Headliner Board:

Once out of the car; it's time to repair the board and prepare it for re-gluing new headliner material. Coarse sandpaper will quickly remove the foam and dried glue. Sanding and painting should be all that is required for most boards. Some present greater challenges and require more patience. My first board was busted up before I even tried to get it out. I laid the pieces out on a flat table. I used wooden yardsticks and paint stirrers for support on the top side of the board. The yardsticks ran from front to back providing additional support to the board along the sides of the sunroof opening. More support may be needed around the rearview mirror and sun visors. Drilling holes and securing the boards with flathead machine screws are excellent in re-establishing the headliner board. Carpet seam tape also does great to secure this extra reinforcing. Also, try fibreglass mesh and compound to repair breaks. [Tip from Bill] Any repairs to mend cracks in the board should only be done from the back side of the board. If you use tape or any type of strapping on the front side this will show through the finish when completed and installed. After sanding down the bottom side getting it ready to reglue; I used yellow mesh sheet rock tape (real sheetrock men use paper tape. This is the stuff sold for those of us with less sheetrock savy) Anyway, this mesh tape provides a great foundation for bondo. I used bondo to re-construct the board. I sanded the bondo smooth. Duct tape can be used to redefine the edges of the board. Then I painted the board with latex paint just to be sure my new headliner fabric would have a good surface to stick well so it wouldn't sag again in a few years. Hopefully, you won't have to totally rebuild your board. But, I still prefer this over $350. [Tip from Chris] Use duct tape to repair the board. It works. The headliner board does not bear any weight so there really is no need to make it very strong. The material will hold it together, the duct tape will do the same as well. [Tip from Dan Williams] I bit the bullet when I did mine and made it a two piece assembly. I cut laterally across the liner at about 4 inches behind the light assembly. I put a couple of velcro fasteners to help hold the 'center' in place on reassembly, but not sure it was necessary. I wrapped the fabric over both edges at this point and the seam is not very obtrusive. Afterall it is a 16 year old car, and I believe that this looks better than some random wrinkles from bending or breaking the backer board on reassembly. My mechanic also reminded me to be very cautious with the opening where the lamp mounts. If it gets buggered up, the light will forever be falling out. I believe you can repair the backer board by gluing it back together with paper on each side, ala paper mache.

Glueing and Installing Fabric:

The glue is sprayed uniformly on both the fabric and the board. It sets 1 to 3 minutes. Follow the directions on the can! You get one good chance to place the fabric where you want it. I cut the fabric 6" longer than the board. I then fold the fabric in 3 sections - no cutouts for sunroof. I glue one section at a time. I get my helper and start at the rear being sure to totally anchor the molded section allowing headroom for the backseat. After doing all 3 sections, trim to 1" around edge and flip over and spray glue to secure. For the sunroof opening - cutout leaving 6" fabric to secure to the roof opening in the sunroof frame. (The first time, I neatly trimmed to the board and figured out I didn't leave enough fabric after I got it back in the car.) [Fabric Installation Tip from Ira Eisenberg] Here is a tip passed along by an auto upholsterer. Assuming you have the backer board out of the car and nicely cleaned up, run one pass of adhesive along the backer board midline.....one end to the other..... and then one pass on the new headliner material along its midline. Glue headliner to backer board. Then fold one half ofthe headliner material back from edge to glued midline, spray adhesive on half the backer board and the folded back part of the headliner. You may want to place clean paper around the headliner edge between the two layers before spraying adhesive so it doesnt get on the other half of the headliner which is facing up. Then, roll the headliner back onto the backer board starting at the midline. Slow and steady, light pressure with your hands, and it should lay down flat and smooth. Then repeat for the other half. Let the glue dry for a day before you reinstall into the car.

Installing the New Headliner:

[Chris/Jamie] I put the board back in the car through the front passenger side of my sedan, the same way I took it out. I moved the seat as far back as possible, and lowered the back as far down as possible. It does go in without taking the seats out. Try real hard to get the new headliner board back on the roof without breaking it. When you are hanging the board, don't support the weight of the board with your fingertips or you'll have indentions all over. They'll go away evenutally, but they aren't pretty.

Replacing a headliner takes me most of a weekend. The sunroof is a project all by itself. I've done one sunroof. The 1st headliner job I did was a little over a year ago. There is no evidence of any sagging.

Headliner Cleaning. [How to clean headliner without destroying it.] The majority view was that I shouldn't attempt it and that it would probably dissolve the glue and make the headliner fall down. Since it was really dirty (dust, various spots and water marks), I bravely decided to give it a try nevertheless. Remember that this was done to a 1987 780, with a beige velvet-like headliner. It may not work for other cars and, for all I know, there may be a much better way. Anyway, this worked.

Gently brush with a soft (clothes) brush to remove as much dust as possible
Spray a little "Fabulous" brand carpet cleaner ($1 at the local dollar shop - this is not in a spray but in one of these pump devices - I guess other types of carpet cleaner like Resolve would work also but I didn't try) onto headliner. It will not foam (actually you will not even see it, so don't go overboard and drench it)
Leave for 3 minutes
Work in gently with a slightly moist synthetic sponge. This should create a little white foam.
Gently wipe off foam and clean sponge in clear water. Press sponge so that it is nearly dry. Wipe off more foam etc until no foam is left.
Let dry (make sure that the sun visors are down to let air ventilate).
If some dirt is left, leave to dry for a few days and repeat.
Make sure to be gentle and to use little water.

For ideas on interior trim cleaning, see the FAQ Section. For tips on removing tobacco smells, see the FAQ section in Preventive Maintenance.

Trim:

Storage Tray Under Radio. To remove the storage tray under the radio in order to access the relays, remove the snap-on cover over the cigarette lighter with your fingernail or a small screwdriver. Remove the two philips screws securing the storage box: one of these is angled in. Remove the storage box by gently tugging on the left side, pulling it and the cigar lighter wire out from the console.

Center Console.

Center Console Tray Removal. To remove the center console box:

- Pry up the screw cover in the bottom of the storage box and remove both screws.
- Remove both screws in the bottom of the handbrake tray and the plastic trim cover in the handbrake slot.
- Pull the console back, being careful to disconnect wiring to the seat heater switches and lamps.

Center Console Removal. To remove the entire center console:

- From the back seat, remove the ashtray
- Using two small flat-head screwdrivers, pry up the two clips at the bottom of the ashtray holder assembly; remove the assembly.
- From the front driver's seat, remove the fuse cover in front of the shifter knob.
- Raise the emergency brake handle and remove the two screws found under where the emergency brake handle was sitting.
- Partially lower the emergency brake handle.
- Remove the metal clip found under the fuse panel that helps locate the central piece of the console. Caution: don't drop this!
- Stepping on the brake pedal, move the shifter out of park, to neutral.
- Very carefully lift the black center portion of the console and slide it forward into the fuse area (be gentle!) There may be two clips on the front portion of the back colored piece of the central console, or they may be locating nubs.
- Put the vehicle in park, and feel free to move about the cabin.Open the storage compartment on the upper part of the central console.
- Locate the small panel at the bottom of the compartment, toward the back.Using a small flat-head screwdriver, push the clip under the forwardmost slot toward the back, and gently remove the cover.
- Remove the two screws found under the cover.
- Gently remove the center console, being careful to remove the wires and fasten seatbelt

panel from the back of the console.

Consider vacuuming before reassembly, or at least retrieving all the loose change. If you are replacing your emergency brake cable, you will need to pry up the top metal tang that holds the locator pin in place.

Center Console Footwell Side Panels. To remove the footwell side panels on each side of the radio (so as to expose the innards of the center console and radio/fuse box):

- Remove the ashtray and fuse box cover.
- Pull back the center console tray (see above) to expose the two screws fixing the footwell side panels.
- Peel back the carpet at the front bottom corner of the panel to expose another screw.
- Remove the radio and radio box. Remove the two side screws holding the panel inside the radio compartment. Unfix the metal strut at the bottom rear of the fuse panel holding the two side panels together.
- Pull the panel out.

Interior Trim Panel Removal Notes. {Editor} To remove various panels, follow these instructions:

A-Pillar Trim Covers. Pry off the grab bar screw hole covers (driver's side) by pushing down on the cover while prying up with a screwdriver slightly inserted under the bottom of the plastic cover. The cover snaps onto an underlying plastic holder. On the passenger side, remove the trim strip in the grab handle and unscrew the handle. In both cases, remove the screws holding the top molding piece in place, then move this aside and remove the hidden screw holding the A-pillar molding at the top. Things interlock, so don't force it too much. Slide your fingers down behind the A-pillar molding to pop off first one and then two metal clips. Then pull the unit up and back to slide it off the remaining trim fastener at the bottom of the A-pillar. Push back the rubber defrost duct and pull straight back to remove the bottom of the molding from the flat trim spring holder at the very bottom of the panel. To reinstall, make sure all wiring is stuck to the pillar with putty, then reinstall as the reverse of the above. You will probably have to remove the bottom panel fastener to place it correctly and reinstall it. Warning: it is wider than Ford or GM fasteners, so if you break it pay close attention to the diameter of the replacement. Note: there may be a bottom hidden screw near the kick panel.

Door Top Panels. [Rick Tilghman] The panels above the windows are held on by the screws for the handles. You have to remove the trim in the middle of the handles to expose the screws underneath (there are two of them on each handle).

Window and Headliner Trim Panels. You have to start in the back with the tower panels (at least in the wagon) and work your way up to the front. The panels are generally an overlapping system, with the front pieces on the bottom and the rear pieces on the very top.

Climate Control Trim Surround. [Note from Pat Dwyer] The plastic trim piece that goes around the heat-A/C control switches and goes leftward , ending at the left edge of the ignition slot, is difficult to pry out, and probably fragile, but it did NOT break under my ministrations. I used a knife blade to pry the plastic 'somewhat' loose, all the way around, but it felt like it was stuck somewhere...and it was: just to the right of the rear window defrost switch, where the plastic trim piece meets the vertical console, there is a spring-tensioned clip holding the whole trim piece in place, and it will take some wiggling and jiggling and cussing to pop the plastic off, but it does come off, and all in one piece if you do it right!

Headlamp Switch Trim Surround. [Bob/John Shatzer] On 740/940 cars, pull the headlamp knob off and gently pry the trim from the left side. On 960 cars with wood trim, remove the narrow dash trim just above the headlamp switch trim surround and be very careful of the wood veneer on the surround.

Kickpanels and Side Trim under Driver and Passenger Dashboards. To remove the front trim panels where your feet are extended on either side of the front seats: remove the large plastic body fixing plugs holding the kick panel to the upper instrument panel. Pull down on the rear edge of the kick panel and maneuver this backwards: some foam will be in the way and the panel itself is mounted in two guides on each side on the left side and in one guide and next to the blower housing on the right. Remove the panel. To remove the side trim at the bottom of the A-pillar, unscrew the front two sill trim screws using a Torx driver. Carefully maneuver the side trim out from under the sill trim, then pull back gently to remove. The top of the side trim is inserted under the A-pillar trim: bend this slightly to remove. On reinstallation of the right side trim, make sure the plastic catch on the side trim engages the metal frame attached to the ECU mounting frame.

Door Panel Removal. The door panels are very easy to remove after you've done it once.
1. Later Cars. [Tip: Peter Gotseff] These instructions are primarily for 85 and newer 700 models w/ one piece door panel i.e. w/o a door strap, mine is an '89. Remember don't force too much or you'll break trim clips

Remove plastic screw at the bottom of the door handle "cup" 1/4 turn and lift out the whole "cup". The p/w switches can be removed now by removing their cover plate. This always seems awkward but push the carpet cover back and remove the p/w switch cover up and forward.
Pry speaker cover off by sliding forward only. There are two trim clips beneath the forward edge of the speaker cover which help hold the door panel on.
Unscrew lock knob.
Unclip the three white door panel base clips with a small flathead screwdriver. These are located at the bottom of the plastic door panel (look up at the bottom of the panel.) They are removed by inserting blade and prying straight down to completely remove the clip

(Haynes manual has a figure for this, 11.7)
Remove the red edge marker light lens by inserting flat screwdriver or knife and prying straight out. The lens cover also acts as a clip.
Remove entire panel as one by pulling out on the bottom of the door panel and pushing upwards making sure to free the p/w switch assembly at the same time. Watch out for the speaker and marker lamp electrical wires inside: disconnect these as you raise the panel.

2. Notes on Earlier Cars. (<=1988 model) Pull the speaker cover straight out. There may be a screw under the speaker cover; remove this if you see it. Remove the plastic screws beneath the door handle. There's another hidden clip behind the red "door open" warning light lens on the aft edge of the panel; in later model cars the clip is integral with the red lens. This is a good time to R&R the window switches and lube the power window mechanism: see the "glass" and "switch" sections of this guide for that.

Sedan Rear Deck Panel/Package Shelf Removal. [Editor]

- Remove Center Mount Stop Lamp: Push up on locking tab beneath, pull entire stop lamp assembly toward front of car.
- Remove Rear Seat Bottom Cushion--About 6 inches in from either side, on the leading edge are latches that hold by way of foam compression. With the palm of your hand, PUSH IN...Then DOWN, Then lift up and away, both sides.
- Remove Rear Center Headrest--Extend upwards...lift and unsnap lower section of plastic cover. Then remove 2 phillips trim screws on upper part of plastic cover..really have to pull up on the headrest as you do this..set plastic cover aside...Remove 3 bolts w/10mm heads...withdraw center headrest.
- Remove Seat Backs--Find metal tabs at right and left lower corners, bend slightly upwards and pull lower part of seat backs outward. Lower the center armrest to about 45 degrees. Push up on seat back until upper corner tabs/slots come free, pull entire seat back ass'y forward over and away from center armest. CAUTION.. feed 3 seatbelt straps carefully over seat back as you withdraw it from car.
- Remove 2 Remaining Headrests--Take out 2 bolts w/ 10mm heads, each side, remove reinforcement plates, withdraw headrests and set aside. Remove 3, T-25 screws that secure Rear Deck Panel.
- Remove Deck Panel--CAUTION Feed 3 seatbelt straps sideways and CAREFULLY out of the plastic grommets. The right and left grommet/'wing' extensions are VERY weak and will break. Be careful when withdrawing Rear Deck Panel from car: the side molded extensions are likewise very weak and may break if they contact the car frame.
- Remove Insulating Pad--Just lift it up and away.
- Remove Speakers.

Wagon/Estate Tailgate & Trim Panel Removal and Access. [Tips from Bill Peyton]

Removing/Repairing Tailgate Panel.

[Tips from John Hibbert] The following applies to a 93 940 wagon, and I would think, to all 700 & 900 wagons. You will need a small to medium flathead screwdriver & a torx screwdriver found in Volvo tool kits. A CAUTION before you start. When steps 1 to 4 are completed it will be time to remove the trim. This MUST be done by sliding the complete trim including the brake light upwards to disengage the 4 fragile plastic tabs that secure the trim at the top. Failure to slide upwards will cause them to break.

Step 1. Open the tailgate fully.
Step 2. Remove the plastic surround which is part of the housing for the lever which opens the tailgate from the inside. This surround is held by 9 shallow 1"(2.5cm) long plastic lugs. The centre of these lugs is found at- TOP EDGE ie edge closest to glass. (3 lugs in total). One lug can be found 2 3/4" (6cm) in from each side. The third lug is in the middle, 6"(15cm) from the edge.

> SIDES: One lug on each side 1 1/2" (3.5cm) down from each top corner.
> BOTTOM: (4 lugs in total) One lug can be found 1 1/2" (3.5cm) in from each side. The other 2 are to be found 4 3/4" (11.5cm) in from each side.

Start at the top right corner by sliding the flathead screwdriver between the carpet trim and the plastic surround 2 3/4" from the side. Push the screwdriver in firmly and gently twist at the same time. You will feel the lug come free. Repeat this process at the centre of each lug. (measurements given are the centres). The surround will come free. It is fragile; if it breaks, a replacement may be had for about US$11.

Step 3. Move to the bottom of the tailgate. With a 1/4 turn the 4 plastic fasteners can be removed.

Step 4. With the plastic surround removed in step 2, this has revealed 2 torx head screws. Remove them. The only thing holding the complete trim to the door now are the four fragile plastic tabs at the top. DO NOT PULL THE TOP OF THE PANEL. These four fasteners hold the top of the panel at the bottom of the window and fit into slots where the open side faces the top of the door. The trim panel is slid upwards to disengage these fasteners. Before sliding the trim up, you must support the trim while you disconnect a power supply connector on the right hand side. This can be done with one hand. Then slide the whole panel toward the top of the door, working the fasteners out of their slots. This is the only way you will remove this panel without breaking the panel itself. The trim is very light and will now come away.

With the trim removed it is a good opportunity to apply LocTite to the 3 screws that hold the wiper motor in place. They have a tendency to work loose. You will also find a small phillips head screw between the opening lever and the latching mechanism at the bottom of the tailgate. This can work loose. Tighten but do not overtighten. As it is housed in plastic, Loc Tite is not recommended. A spray of lithium grease to moving parts is also a good idea.

Step 5. On reassembly do not forget the need to reconnect the power supply to the window heater.

Repairing Loose Tailgate Plastic Panel:

[Rob Bareiss] There is a repair kit available for all Volvo 700/900/850/V70 plastic hatch trim panels, since they ALL are doomed to come loose at the holes securing the body fasteners. The kit runs about $20 and replaces the inside corner plastic with little metal reinforcing tabs. Try any of the Brickboard advertisers for this kit. It's not really a Volvo part number- it's aftermarket, in response to large demand for it. [Another Approach] You can also cut two wooden battens about 1 inch X 2 inches x 5 inches and screw them into the inside of the tailgate interior either side of the wiper pivot point at the centre. Attach each of the two pieces of wood directly into the tailgate (just below the window line and between where the 2 clips normally fit on either side). Use 4 metal self-tapping screws to hold the wooden battens to the tailgate (having first drilled 2 small holes into each of the wooden battens and then use the battens as guides to drill into the tailgate's internal frame). The tailgate is aluminium and is easy to drill into with a small hand-held manual drill (careful you don't use a power drill which may go through the outer panel of the tailgate!) With the 2 battens secured, reinstall the plastic trim panel and refit the 2 torx screws in the centre. Then drill 4 small holes (2 on either side) through the top of the trim panel so that the 4 screws are screwed down through the holes in the panel and into the 2 wooden battens to securely hold the panel and keep it from rattling.

Removing/Repairing Left Cargo Area Trim Panel.

This is the panel behind which is the gas filler tube. Note that there is not much reason to remove this panel, as the filler cap hinge can be repaired from the outside. This must be why it is so hard to remove!
Remove as follows:
Remove the left cover on the cargo area floor. Remove the plastic oval piece on the D pillar. Pry it out gently. Work the upper trim piece away from its clips. You can pull this out and nothing should break. Remove the three screws holding the aluminum trim piece on top of the tail gate gasket.
Fold the left hand passenger seat forward to expose the seat latch. Using a Torx screw, REMOVE the lower front Torx screw. Slide the rubber piece off of the seat latch and REMOVE the rear screw. Now LOOSEN but do not REMOVE top front Torx screw. This should loosen this panel sufficiently.
Remove the fasteners holding the front, and the rear of the panel. Turn 90 degrees with a flat head screwdriver.
Now the fun begins. Pull the panel by the seat out and behind this at the front of the panel we are removing. You should see a white fastener. Pry this out with a screwdriver, needle nose pliers, or both. You will probably need to replace this fastener, as it is very brittle. Once this is out, slide the panel forward, working the three remaining clips out of the slots minded into the panel. You will need about an inch of movement. You may need to pull the bottom out to clear the gas pipe, etc. But, this panel will break if you pull up, or out. You can only slide this forward!

Removing Rear Floor Panels for Access to Fuel Tank and Pre-Pump:

[Tip from Rick] The access panel is underneath the first of the three panels for the back/boot area. The way to get it out is:

1. put the middle seats down
2. lift up the spring loaded backers on those seats
3. push the springs up and just unlatch them from the flaps
4. push the flaps back and unscrew the three bolts holding the panel down
5. lift the panel up about 10 degrees, until the metal tabs are over the bolts that stick up, and then PULL the panel towards you. The panel is secondarily attached to the floor via two tongues that slip into brackets fixed to the floor. The unit will just slide towards you and can then be put aside. On the right under this panel you will see a square metal panel with 4 bolts. Undo the bolts and use a screwdriver to just prop the panel up. it should just come right out.
6. Directly beneath you will find the primary pump

Cupholders. [How do I add cupholders to my 7xx/9xx car?] [Solution 1:] I think I got the same cupholder, also from Caldor. A black plastic ring with a multitude of little "fingers" inside that grip the can or bottle or cup. I peeled the double sided tape off, opened the glove compartment, and stuck the cupholder to the inside of my glove compartment door, on the left side closest to the driver. The glove compartment door still closes if you're careful where you place the cupholder. This worked fine on my 1992 940GL.

[Solution 2:] I found an adjustable cup holder that is designed to mount on a flat horizontal surface. I then used plastic zip-ties to secure it to the e-brake handle in the center consol (each if these cars were auto trans equipped and using the e-brake was a rarity anyway). If you do it right, when the e-brake is down (off) the cup holder edges will be resting on the consol and be level and stable. Of course, you would have to remove the cup when pulling the e-brake (minor inconvenience for me). A bit of compromise here if you use your e-brake much, but this has been well worth it for me.

[Solution 3:] Use one of the generic cupholders with the strap through the top, designed to be held by the window glass. Discard the strap, cut the top off and round the edges with a file, and secure to the driver's door panel with 3M trim adhesive tape.

[Solution 4:] Buy a Husco Trac-Top armrest/cupholder combination for around $70. See http://www.husco.com/

Plastic Trim Reinforcement. [Tip from Allen Hendry] Plastic interior parts do break and crack. For weak areas(i.e. console tops, door pockets, etc.), or areas that have already developed cracks but are still intact, use a combination of expired plastic credit cards and five minute epoxy to repair/reinforce such areas. Just cut the card to fit the area, apply the two part epoxy according to directions, push the cutout repair piece behind the area you need to reinforce in a manner so that it does not show, and let it cure. You're done, and the area is now much stronger than before. I probably have about six square feet of such material in my old 300k 740 -- but the plastic still looks good! [Editor] For door pocket reinforcement, use the same technique but substitute the carbon-fibre reinforced plastic strips used to build model airplane wings. [Adhesive Tip from Don Prociuk] I have found that because so much of the car is ABS plastic you can use the ABS solvent that the plumbers use to join pipes. It sets solid and water does not bother it. It also works well to replace the lens covers on the tail lights.

Armorall on Trim. I decided to wean myself from Armorall after reading the BMW digest FAQ on leather and Vinyl care which severely criticizes its use. I have just started using Summit Industries' Vinylex. They're the same cats who make Lexol leather cleaner and conditioner. What I noticed was how it smells exactly like BRAND NEW VINYL.

Carpets:

Carpet Removal. [Editor] Carpets come in three pieces: front left and right and rear.

Front Carpets. To remove the front carpets for cleaning or replacement, move the seats all the way back, remove the kick panels on both sides, remove the covers to the front outboard seat tracks and the door sill protectors, and pull each side carpet out. You may need to remove the front seat bolts if the carpet is notched around them.

Rear Carpet. To remove the rear carpets, move both front seats all the way forward and remove the seat cushion. Remove the center console and tilt this forward on its front edge. Pry off the seat track covers by opening both front tangs and pulling back. Remove all four rear seat bolts. Unscrew the door sill protector trim. Gently pull the carpet out of the car. Installation can be a little tricky and may require removal or loosening of trim pieces to push the carpet edges back in place and of the front seat bolts to slip the carpet back under the rear rails. See tips in the seat section regarding how the seat track keys are mounted in the body if you move the seat tracks.

Carpet Cleaning. Once removed, the carpets can be easily vacuumed and shampooed. I use a hose to blast dirt out: it works very well. If you have odors in the undercarpet pads, clean them and use Febreze to absorb odors.

Replacement Carpet Source. I found the web address of a company that sells molded replacement carpet for Volvos. $225 + $24.50 for shipping for a kit for my 740 seem reasonable for all new carpet. http://www.salesco.com

[Tip from Greg McNair] Get your carpet from ACC Carpets in Anniston AL....www.accmats.com or call them at 1-800-352-8216. I JUST installed my carpet from them, $175 delivered to my door. Very nice carpet, molded fairly well. Plan on spending at least 5 hrs doing this yourself, not including "pull out time". I ordered the Sandalwood color for mine, took 2 days to make it, and 3 more to get it to my house. Despite a couple of mistakes I made around the shifter area, it looks factory new, and surprised the heck out of my local Volvo dealer. This is one piece, not 2 like the factory setup. If you aren't sure of the color, let them send you color samples free....any color you want. I am very pleased and will recommend them to anyone.

Water Leaks. [Dave Stevens] Most water leaks result from clogged air conditioning evaporator drains, leaves in the cowl screen, or leaking side vent panel gaskets. Before you tear apart your interior, first try to find the A/C drain grommet in the firewall, poke it clear, suction it out. If you're chasing a wet carpet problem like I was, then rather than methodically following the water leak back to its source, start with a quick and easy check like this. Excess moisture in the A/C condenser cavity will also lead to mold and associated odors which can be difficult to eliminate. Other tips are in the FAQ Heating section.

Radio and Speakers:

Radio Code Input. [Inquiry:] After replacing my car batteries my factory stereo will not turn on. It displays EEEEEE message. Can you please help me fix this? [Reply: Steve Ringlee/Rob Bareiss/Mike Heaton/Bob] You need to enter your four or six-digit radio anti-theft code after you turn the radio on. The unit will display “Code” or "rpt", after which you punch the four digits. If the unit won't accept the correct code (you have three tries before it chokes and displays “Eeeeee”) then turn the radio on, leave the ignition key at KP I for two hours(or go for a drive) to reset the unit and try again after two to four hours. On the CR-814 radio or SR-7145 radio/ equalizer/cassette deckj, you have to enter a 6-digit code, then push the "aut" button after entering the code. The "aut" button is the upper button just to the right of the "3" button. To unlock the CR-814 radio, it has to remained connected and turned on for just one hour, during which time the code shows "OFF". The SR-7145 has to remain connected and turned off for 24 hours. If you've lost the code, see below.

Radio Code Lost. [Problem: Lost radio security code.] [Response: Bob] Codes are available from your local Volvo dealer if you have the car's VIN or the radio serial number. When a dealer replaces a radio, they are supposed to update the Volvo data base with the new radio code, but most seldom do this. If you don't have the VIN of the donor car, you must supply the dealer with radio model and serial numbers. Pull the radio and look for the serial and model number pasted on top. To remove it, follow this link.They may ask for proof of ownership before they give you the code. They should do it for free. While they are on the computer, ask them also to get your key code #'s if you don't know those. They could come in handy some day.

Radio Removal. [Inquiry] Does anyone know how to remove the radio from the dash of the 940 Turbo Wagon?

Earlier Radios. [Response 1: George Chow/Mike Gambone] To get the CR-814 out (and nearly all decks from the 7x0 and early 940), pull out the two knobs on each side. Pull off the knobs, and the rings behind the knobs (the AM-FM adjuster and the loudness control switch rings). To the outside of each of the shafts, in the unit, are metal spring tabs. Use a flashlight to see them. Use two very thin screwdrivers to hook each tab and lever towards the middle of the radio. This releases the spring locks, and the unit will slide out. You have to pull out while you lever the screwdrivers toward the center. Beware of the trim piece: don't flex it too much else it will break, nor should you use the trim piece to pull the radio out:: it's held by four tiny tabs at the corners, which will certainly break. Note as well that the top of the radio has two flat springs that act to dampen vibrations. They may hang up on the trim surround: just flatten them with a thin putty knife blade. [Tips from Jeff Pierce] If you still can't remove the radio, try this:

- Get some reasonably strong metal wire. I use the 14 gauge copper ground wire from Romex electrical cable. The chrome spring wires from the thick black paper clips also work: just bend them into shape. Or an old bicycle spoke.
- Cut 2 8"-10" pieces
- Bend one tip -- at about 1/4" to 1/2" in -- of each of them at least 90-degrees (100-110 degrees is even better)
- Remove the knobs and outer rings on both sides of the radio face.
- Insert the bent ends of the wires into the tabs.
- Pull toward the center of the radio, and then out. The unit should come right out. Watch out for the flat springs on the radio top: use a putty knife to compress these.

[Response 2: Red Fox] If it is the SC-810 radio, the vertical bars on front plate are the releases. Push them in with a screwdriver and they will pop out, then pull them out a little farther and this releases the radio to slide out. Note: If you don't know the security code for the radio, do not unplug it.

Later 940/960 Radios. The later 940 radios (CR-915) have two narrow slots on either side of the faceplate. Look inside these with a flashlight and you will see a flat metal spring. Insert a screwdriver into each slot and lever the spring inwards toward the center of the radio, then pull the chassis out. The cautions about trim pieces and flat springs above apply here too. Do NOT jam a scrwdriver into the hole as far as it will go: you will bend the spring clip and make it very difficult to remove the radio. [John Marshall] To remove the CR905, firstly pull the unit forward (very slight amount only is possible), by putting some fingers in the cassette opening; this moves the tip of the spring clip away very slightly from the side of the housing and helps in getting the screwdriver tip behind it. Using 2 very thin-shafted flat tipped screwdivers, put these into the slot openings each side of the stereo, angling the drivers at 30-45 degress inwards (handles towards each other) The screwdrivers need only go into the slots approx 1/4 of an inch, and their tips have to be pushed outwards against each side ot the stereo console housing as much as possible, so they slip behind the tip of each spring clip. When they have bottomed out, the screwdriver handles can be straightened out, away from each other, to bend the clips in against the radio chassis. It helps to have an assistant with their hand in the cassette slot gently pulling outwards on the unit at the same time, and voila, the unit releases. With one person, it is possible to release one clip on one side, and then the release the second clip whilst using the spare hand to pull the stereo out via fingers in the cassette opening.

Radio Light Bulb Replacement. *LCD Bulbs.* [Tip from Colin Roberts :applies to UK cars] I posted a msg here some time ago about my radio LCD display not being lit up, seems other people had similar probs, all the buttons were lit, but not the lcd, i have now stripped the radio down and found out how to replace the lights, Well, no one could help me, so out came the radio! All that is behind the display is 2 capless bulbs (12v.) Here is the method for those of you that are good with a soldering iron and can do very fine work.
First obtain 2 or more 12v very tiny capless bulbs, these are about 4mm long with just wires coming out from the bulb, (i have these as I work for a company that used lots of different types of bulbs) Remove the top and lower panels, and also the facia panel , (after removing all the knobs and tape button). Disconnect the 2 plugs from the tape unit, then remove the 2 bulbs (could have yellow wires on) from the front of the tape unit. Remove the tape unit complete, on the front main inner panel there are 3 screws that have to be removed, this allows you to pull the panel out from the chassis, (not too far though) on the back of the pcb there is a black plastic panel, this has to be eased away from the pcb as well. NOTE : the pcb will only come out about 1/2 inch as it is connected to the main pcb by 2 ribbon cables, DO NOT OVER STRETCH! Now for the tricky bit, look at the lcd display, it has a box round it, this has 4 tabs holding it to the pcb, carefuly prise the tabs up and then remove the box, and you will see the 2 bulbs !
It is a bit of a job to desolder the bulbs, but it can be done and fresh bulbs fitted, the old bulbs will have a green rubber cover on them which should be put onto the new bulbs before they are fitted. If you feel that it is a bit too tricky to replace these bulbs, I would think that a local radio repair shop could do it, if the radio was stripped down right up to the point when you can see the old bulbs, all he would have to do is de-solder the old bulbs and fit new ones, then you could re-assemble the radio yourself.   PS: If you took the radio to a local repairer, not stripped down, he would probably say it could not be done as it needs special bulbs. But I now know better!

940 92 Radio Bulbs Burned Out. [Inquiry] A couple of the microbulbs that light up the facepate of the radio have burned out. I replaced with 12 volt bulbs (required some soldering) and they work but are too dim. Have learned that they should be 6 volt microbulbs. [Bob Kraushaar] Radioshack.com has what you are looking for: Miniature Lamps, 6 Volts Catalog # 272-1140 for $1.29

960 96 Radio Bulbs Burned Out [Tip] Today I took on the challenge to open my SC-815 to replace the burnt light bulbs in my 96 960. Every single bulb was out and it became especially irratating when the LCD light went out last night. I read through brickboards list of posts regarding replacing the bulbs and found the suggestions to go to Radio Shack. However, I passed by Southwest Automotive repair and asked one of guys over there, 1) if they sold replacement (button) bulbs, or 2) if they had a suggestion where I could find them... To my suprise, he suggested the HONDA dealer [Volvo dealer does not sell 'em] where each bulb (bracket/socket included) is sold for $1.50 each. No need to remove any glue or any winding. Simple remove the old, and insert in the new. The honda socket is just a little smaller. However it fits perfectly. You'll need to use the blue rubber bulb covers from the old bulbs because the honda dealer bulbs are clear.

Radio Static in 740. [740 has radio static on the AM band; how do I fix it?] [Solution 1:] I use to install car stereos and one way I used to get rid of the "audio tach" was to clean the terminals on the alternator. If your Volvo has a separate voltage regulator, unplug the regulator and twist the wire bus one or two times. So it looks like a rope. This will screw with the RF radiation that the alternator makes. Make sure you clean the contacts and put some dielectric grease on them prior to connection. Make sure you DISCONNECT THE BATTERY before starting or you could fry the regulator. If anyone has questions about stereos problems, feel free to e-mail me KEITHPOND@aol.com

[Solution 2:] Regarding Kirk's recent AM radio static in his '90 740, I had an identical problem. I have no idea what precipitated this, but I had been doing the normal "tuneup" items like replacing cap and rotor, plugs, etc. The only real before-after delta was some body work which required re-aligning the front driver's door hinges, and I suspect that the body guys mucked around the wiring harnesses in the process. I ended up ameliorating (not fixing) the problem with the following:

- antenna filter from Radio Shack on the antenna lead behind the radio
- power filter (also RS) behind the radio
- additional radio chassis ground from the back of the radio to the chassis on the left side of the passenger footwell; this is just a wire, two lock washers and two screws.
- follow a Volvo TSB about the same problem and solder an additional antenna housing ground from the antenna bottom tube (inside the car, where the telescoping tubes go up through the body) to the body of the car using a wire, screw and lockwasher.

Radio Cassette Flashes “Head”. [Inquiry:] Shortly after we bought the 745 this past June, I noticed the word 'HEAD' flashing on the stereo when a cassette was playing. [Response:]As I recall, this "head" indicator is connected with a timer built into the stereo. After 20 hours of tape playing, the player indicates a cleaning is in order. The timer must be reset manually. All you have to do is press the right right hand tuner button while the tape is playing and hold it in until the "head" indicator resets itself.

Radio FM Section Failed. [Tip from L.K. Tucker] I finally took the covers off a pushbuton Volvo radio. The problem with no FM in most alll Volvo radios is probably an ignition noise suppressor diode package in the antenna circuit. (Failed shorted) A fifty cent part. From the schematic symbol silk screened on the circuit board it is a switching diode pair. Removal brings the FM back as long as the engine is off. The spark plug pulses suppress the gain control circuits and the radio won't work well on the road without this diode package.
The part id is AG 20 and the name is TAIYO. I think any small voltage switching diodes can be wired to replace this part. I have down loaded Mouser and ordered Digikey but not located a close replacement. Does anyone have a supplier for this particular part? A radio repair parts site emailed me that Clarion, California is the US supplier for Volvo radio and Robert Bosch, Chicago is the US company for Blaupunkt.

Amplifier Failing; Location? [Inquiry] I have a 1992 960 and it has a problem with the amplifier circuit. When I try to put a fuse where the amp circuit is - fuse 32 I believe - it fries instantly. Does anyone know what this can possibly be? Or where the amp is located? [Response: Jeff Wickersham] Your amp has probably short circuited somehow and crossed a soldered positive lead with a ground. The amp is located above the drivers side knee panel, to the left of the steering wheel. There are two bolts holding it to a securing point, and a Bosch relay or something is attached to the amp itself. The amp has a rectangular connector which connects it with power and the speaker wires, and a din cable coming from the radio. Disconnect the amp, then turn the key to acc and put a new fuse in. If the fuse blows the problem is in the wiring, if not, it is in the amp somewhere. You can find a used amp for a reasonable price.

Radio Wiring Color Reference. Your Volvo uses unique non-DIN connectors in the radio and amplifier. To wire an aftermarket audio system correctly, you should have a good wiring diagram (the OEM Volvo wiring diagram book is the gold standard). Always test wires to make sure they are correct. To check hot, ignition, lights, dimmer, use a test light or voltmeter. To check speakers use test radio. To check speaker polarity (assuming you don't have a polarity tester): Touch (for a very short period of time) one wire to the positive side of a 1.5-volt battery (any size), and the other wire to the negative side. If speaker "pops out", then polarity is correct. If speaker "pops in" then polarity is reversed. Make sure that the wires you are going to check for speakers do not have any power.

Adding an Aftermarket Radio. [Mike Heaton] To replace your radio, you'll need a new radio and a kit / harness. You may also need a mounting kit. You can add a new radio without a new harness but go ahead and pick one up as it makes life much simpler, especially if you ever want to put the factory radio back in. Which kit / harness? To find out which kit and harness works on your car, go to http://www.crutchfield.com. Enter your cars information, then add any head unit to your cart and proceed to checkout. At that point the right kit and harness will be added to your cart, you can click on them to see them. You can buy them from Crutchfield for $20 each plus shipping, or for $15 or so from a local stereo installer. If you buy from the installer make sure the harness looks like the one from Crutchfield. Behind the radio there will be a wiring clip and a round plug. The round plug contains the speaker wires which goes to the amp and then to the speakers, and the wiring clip will contain the remainder of the wires. Your harness will have two clips, one of which will go into this clip behind the radio, the other of which will connect to the clip that is in the amp. So, find the amp (a silver box ~ 1" x 4"x 4", with silver vents all around, located just behind the dash above the driver's left knee), it will have a clip in it plus the same round plug you saw in the back of the radio. Undo the clip and connect the harness clip to it. You may need to add wire extenders to get the wires from the harness (the speaker wires) back up to the back of the radio. The amp will be disconnected (by-passed) at this point. Connect the other half of the harness to the clip behind the radio, connect all of the appropriate wires and put the radio in with the kit. For my '93 945T, the harness was a Metra model 70-1120. This is the same harness as is used by the 240 series; it is different than the harness used by the '93 960.

CD Player.

Adding an Aftermarket CD to Volvo OEM Head Unit. [Editor] Your OEM stereo unit is made by Alpine. The only proven CD changer that works with these Volvo/Alpine OEM head units is the CHM-S620/630 series. Whatever add-on CD changer you buy, make sure that it is compatible with the M-bus electronic data bus used by your factory radio. For more information about system compatibilities, see the following links:

http://www.discountcarstereo.com/oem/oemchangers.htm
http://www.autotoys.com

See also the following links to understand more about integrating CD players with Volvo radios:

http://www.installer.com/
http://www.stinger-aamp.com
http://www.blitzsafe.com/

Adapter Needed to Integrate Aftermarket CD with OEM Head Unit. [Inquiry:] What adapter do I need to add an aftermarket CD player to my 91-95 Volvo 700/900? You need the VOLALP adapter from one of the peripheral interface companies (who also selll kits for '96 and newer Volvos that need the digital converters):

Stinger Electronics   http://www.stinger-aamp.com

The retailers listed above carry this part along with cables and other parts. Caution:[RJK] Be careful which adapter you get. There are 2 versions of the VOLALP adapter, one with DMX & one without. I was warned by the local Hi-fi Buys installer against using the DMX type adapter in the 700/900 series. It can ruin your day as well as the components. The adapter without DMX may be had through the retailers above who are supplied by Peripheral Electronics. [From Blitzsafe] Volvo radios with CD changer controls from 1991-1995 can interface using a VOL/ALP V.1 with Alpine changers S600, S601, S611, S620, S630 (S604, S614, and S634 require Alpine adapter KCA-130B.) This interface is designed to plug directly into the Volvo radio and to the aftermarket CD changer cable (not to the factory cable if prewired)

Cable Needed. Adding an aftermarket changer in a car with the Volvo OEM cable will require a new cable: Volvo thoughtfully made the ends reversed to prevent exactly this situation. Buy an Alpine-compatible cable and install it with the VOLALP adapter at the front, near the radio.

Where to Mount It? In a sedan, mount the CD changer horizontally under the rear package shelf in the trunk/boot by screwing the mounting bracket to the metal frame on one side. In a wagon/ estate, mount it vertically in a rear side compartment under the removable floor board. These units really do not fit in the glove box or under the seats.

Routing the Cable. [Tip from Paul/Peter] I ran the CD changer cable from the radio to the trunk down the right side sills of my car. It's a simple matter of popping off the door sill plates and running the wires under them and around the B & C pillar trim. It's a pretty quick job. [Chris Herbst] It's much easier to route the cable around the sides than to bring it down under the center console. Pick either side: the only harder thing about the left side is the driver's side knee bolster for the SRS system. Other than that it is pretty easy. Also don't mess with the wires for the seat belts (92 and up models) as they can cause an SRS light.

CD Errors and Malfunctions. [Inquiry] What does "E01" designate on my CR-814 (trunk mounted) 6 disc changer? Tape and radio are working fine, but can't get the CD player to even pop out discs. [Response: Brandon] Take a look inside and see that all the CD's have gone completely into the cartridge. It's usually disk 1 that doesn't go all the way in. Use a very small screw driver to get that disk in so you can pull the cartridge out. [Response: Brian] When I had that code, the eject button on the changer didn't work. You can use a credit card to eject the cartridge - slide it under the cartridge and it will pop out. Empty out the CDs & put the cartridge back in, then use the credit card to eject again... any more CDs show up in the cartridge? The other thing I did was spray contact cleaner on the cable end & socket at the back of the changer. Has been working great since I did this 2 months ago. [Rob Bareiss] If the factory CD changer has a disc jammed inside, look on the front of the case for a very small hole, below where the cartridge slides in (on the inner part, inside the door) into which you can insert a paper clip or other stiff wire to release the changer mechanism. If this doesn't do it, I'd recommend going to a shop that sells Alpine units- the Volvo unit is an Alpine 6-disc and they would have the best chance of getting it open for you with the least damage. [Scott Pilkington] With the ignition off, pop the CD holder unit out, and reach in and turn the disc inside the player a few turns with my fingers. When I power the car back up, the disc always has ejected.

Theft Concerns. [Tip from Chris Herbst] Some moron broke into my mom's car last night. I went to check it out--the usual damage. Passenger side window broken, CD player torn out of the dash. The SMART thing I did when I replaced the stereo was, I didn't bolt it to anything. I just put it into the dash with the aftermarket install faceplate and left it sitting in there. I have done that kind of installation a million times. Never, EVER bolt your stereo into the dash in the hopes that it will save it from thieves. They will hack the dash before they give up on the stereo. One stereo gone, one window broken--but that's where it stopped. Other than a little inconvenience and about $150, the problem was minimal.

Speaker Removal. [Tip from Tom Irwin. Applies to 960 and in some cases 940]

Front Dash Speakers:

> Use a thin blade to lift up the edge of the plastic strip at the bottom of the grill. Rock it side-to-side...it pops out. Remove 2 T-25 screws that hold bezel in place...remove bezel by lifting slightly and withdrawing towards you. Speakers are held by a slot at the top and 2 trim fasteners at the bottom. Use a pen or slim screwdriver to push the center pins down on these fasteners, then lift the outer edges up with a screwdriver. NOTE (to reuse these clips, once removed, push the center pins back up and out of the clip, squeeze the expanding portion of the clip and they are ready for reuse.) Slide the speakers out DONE!

Rear Deck Speakers:

- Remove Center Mount Stop Lamp: Push up on locking tab beneath, pull entire stop lamp assembly toward front of car.
- Remove Rear Seat Bottom Cushion--About 6 inches in from either side, on the leading edge are latches that hold by way of foam compression. With the palm of your hand, PUSH IN...Then DOWN, Then lift up and away, both sides.
- Remove Rear Center Headrest--Extend upwards...lift and unsnap lower section of plastic cover. Then remove 2 phillips trim screws on upper part of plastic cover..really have to pull up on the headrest as you do this..set plastic cover aside...Remove 3 bolts w/10mm heads...withdraw center headrest.
- Remove Seat Backs--Find metal tabs at right and left lower corners, bend slightly upwards and pull lower part of seat backs outward. Lower the center armrest to about 45 degrees. Push up on seat back until upper corner tabs/slots come free, pull entire seat back ass'y forward over and away from center armest. CAUTION.. feed 3 seatbelt straps carefully over seat back as you withdraw it from car.
- Remove 2 Remaining Headrests--Take out 2 bolts w/ 10mm heads, each side, remove reinforcement plates, withdraw headrests and set aside. Remove 3, T-25 screws that secure Rear Deck Panel.
- Remove Deck Panel--CAUTION Feed 3 seatbelt straps sideways and CAREFULLY out of the plastic grommets. The right and left grommet/'wing' extensions are VERY weak and will break. Be careful when withdrawing Rear Deck Panel from car: the side molded extensions are likewise very weak and may break if they contact the car frame.
- Remove Insulating Pad--Just lift it up and away.
  Remove Speakers-- 2 Screws 2 Slots each No sweat. New 6"x9"'s fit the hole perfectly w/o mods..BUT, the screw holes don't line up. (Euro Spec) A Drill w/Right angle attachment would be nice...or drill from underside, in the trunk.

- Electrical Connections-- I used the Factory Wiring Diagram. GENERALLY the wire with Black Stripe is Negative. BUT DON'T TRUST THAT!! Check it out for YOUR CAR SPECIFICALLY. Lastly, I recommend using a layer of double sided mounting tape (or Equivalent) where the speaker frames rest against metal. Keeps everything nice and tight and eliminates source of squeaks and rattles.

Door Speakers:

> Push the plastic speaker cover forward to pop it off the posts holding it on. The 5-1/4 inch speakers are riveted into the door panels. Drill out the rivets to remove the speaker. Replace either with new rivets or screws and nuts with Loctite to prevention loosening. Inspect the harness to make sure the insulation is intact as it passes through the door post.

Speaker Installation. Crutchfield has an on-line "what fits my car?" application to help you purchase the appropriate sizes. Note that door speakers are shallow and that only those less than two inches deep will fit. Installation is the reverse of removal noted above.

Antenna:

Antenna Won't Fully Retract. I futzed with both power antennas on my 740's, and have come to the conclusion that the mast must be kept meticulously clean, otherwise it will may not fully retract. So, whenever I tank up the car with fuel, I grab a paper towel, wet it, and run it up and down the mast a few times. Also, it took a lot of cycling of the mast(s) to get them completely cleaned of years of accumulated pukey. I used WD40/Liquid Wrench/ other similar spray lubes on either a paper towel or shop rag. Then commenced to cycling the mast(s) and rubbing (Imagine what the neighbors were thinking: some sort of fetish, rubbing your mast with a rag...!) But, it worked. Usually, I wipe them down/clean them about once a week as a part of the routine carwash/vacuum. [Editor] My favorite antenna lube is one of the mountain bike wax-based chain lubes, such as Pedro's Ice Wax. Works great.

[Another note:] I have also seen it recommended (in the Popular Mechanics Auto Column) that after you clean off your antenna mast that you get a piece of waxed kitchen paper (such as Cut-Rite) and rub it on your mast. The paraffin off the paper keeps the mast "slippery".

[Another note:] I had little success in getting my 780 antenna to retract completely, despite numerous attempts of all sorts. The PO had had the mast replaced (after it was broken off because it didn't retract completely...) but he never got it to work right before or after the replacement. I have now solved the problem and, since I understand it is a fairly common one, here are the steps (usual disclaimer - this is for extreme cases):
1. Make sure that the mast is not in any way bent. Check by putting something straight (such as a ruler) against the mast and turn it - do not trust your eyes.
2. Remove all the grease from inside the main assembly (the black thing inside the car) - the

grease prevents proper grip on the mast's "tail" and isn't necessary to lubricate a mainly nylon mechanism.
2. Cut off whatever is not useful from the mast's nylon "tail" (about 2 inches in my case). This is a simple way to reduce drag. To find out how much you can cut off, extend the antenna completely (I did that by turning on the radio and disconnecting the antenna in extended position). Check 5 times before you cut!!!
3. Keep cleaning the mast. I have taken to wiping it off every other day or so with a dry tissue and there is still a little dirt coming out (even though I cleaned it frequently both before and during opening up the whole thing...).

Upon reassembly the antenna retracted completely most of the time. Now, a few weeks later, It retracts 100% of the time. At this point, I am not using any lubricant when I clean the mast. I will of course have to in due course, but an excess of lubrication seems to create problems.*Leaving the Antenna In the Up Position.* [Inquiry] I would like to disconnect a wire or in some way disable the power antenna when it is in the UP position so it will be up all the time. Can this be done? [Chris Mooney] With the antenna fully extended (radio powered on), disconnect the 3-wire connector in the trunk/boot which powers the antenna motor.

Antenna Replacement.

Antenna Mast Basics:

The mast and the nylon line come in one unit - about 20 bucks or so, so don't bother trying to fix the existing one. The mast is attached to a nylon cog line that rewinds down into a housing attached to the motor. When the line breaks, the end can remain in the housing, in which case you need to loosen the unit to open the housing enough to get the piece out. The nylon cog has gear teeth on one side: these teeth face the front of the car and are gripped by the rotating gear inside the motor case.

Antenna Mast

Removing the Mast:

[Kenric Tam] To remove the old mast, turn off your radio to retract the antenna as far as possible. Undo the fixing nut at the antenna base on the fender or roof top and remove it by pulling it up and over the retracted antenna. Then have someone turn on the radio to raise the antenna and while you hear the motor going, pull up on the extending mast to remove both the mast and nylon cog line. You can do this by yourself too if you're quick enough to run back and forth. Once you get it out, remove the small metal retainer sleeve at the bottom of the old mast for use with the new one.

Compare the old mast with the new one. If the nylon cog line is shorter on the old one, you've got plastic cog left in the motor assembly and you mayl have to open the motor case and pull it out (see instructions below.) Don't cut the new line to match the old one unless you KNOW it is too long. First try removing the interior panels to get to the bottom of the antenna tube and removing what's left of the nylon/plastic cable. If this does not work, you have to remove the power unit.

Inserting the New Mast:

The insertion part is a bit easier. Make sure you have inserted the little metal sleeve from the old mast onto the bottom of the new mast. Then, with the radio "on" and the teeth of the cable facing the front of the car (not left, right or back) feed it in while turning the radio "off", trying not to rotate it. It may take a couple of tries to get the feel of the end of the cable going through the tubing and hitting the spool of the power unit. You know you're there if your assistant turns off the radio, with you pushing gently down on the plastic cog cable, and the cable gets grabbed by the spool. Once it is, (watch out the mast doesn't whip around and get you), insert the mast as it is winding up. Then tighten the mast nut and cyle the radio power 5 times or so. It will eventually take up the slack it detects, and you're done. This part is really only five to fifteen minutes, even for a mechanical klutz. Lubricate it afterwards.

Mast Won't Catch in Motor:
[Editor] If you can't get the motor to catch the mast end, it's probably because of accumulated dirt and grease in the motor takeup reel. Remove the antenna motor from the car (see instructions below) and degrease the takeup reel. Don't overlube your antenna to avoid similar problems. Clean the exposed section of the mast regularly (like every oil change) using a rag moistened in WD-40.

Piece of Old Antenna Caught in Motor:
[Inquiry] While trying to insert the antenna mast the motor seemed to stop with about 3-4 inches left over. Do I need to trim the white part or is there something obstructing it in the motor?
[Response: Dave Stevens] A broken piece of the old tail gear is likely still caught in the drive mechanism. If you compare the length of the tail gear on the old and new masts you should see the difference. You'll need to open the gear case at the motor to pick it out (see below)

Mast Stuck and Won't Come Out: Removing the Motor Unit

Power Antenna Motor Removal

[Inquiry] I can't get the mast out of the holder. I think it is bent: if I pull it, the fattest tube (the last one) only comes out about 4 inches, and then it gets stuck. [Response I too had trouble getting the mast out, and so resorted to taking out the whole unit from the car, and opening up the motor. It sounds scary but it is not a big deal. The inside of the unit is basically a plastic basket or spool, that simply grabs the teeth of the cable. Disconnect the wiring, antenna cable, and the big nut on the body which is holding the unit. Unbolt the motor in the trunk. The bracket that holds the antenna motor can fall through the holes in the sheet metal, if you are not careful. [This necessitates fishing it out from between the molding and body and then figuring out how to get it back into the holes. Putting in the lower one first, then rotating the threads until the upper stud is in the hole will do the trick. Avoid this issue by putting the nuts back onto the threads, so that they don't fall back out.] Disassemble carefully, keeping all parts in order, by removing the central nut from the round takeup device. There is a silicone gasket, so try not to pry it. No need to remove the motor itself. There is one snap ring inside holding the takeup reel on the main shaft. Remove this reel (the large gear) and degrease it, along with the circular mast storage reel above it, the small guide rotor, and the input shaft. Carefully lube the shaft and reassemble. Then follow the instructions above for reinserting the antenna mast.

Antenna Rack Comes Out. [Inquiry] I was cleaning and lubricating the antenna on my '91 740 sedan as a part of routine maintenance when I got distracted and the radio got turned on or off - I don't recall which. But it caused the plastic strip that pushes the power antenna up to come completely out of the tube. I assume this goes down into some sprocket or geared wheel of some sort. I tried to simply place it back into the tube but it doesn't grab or do anything. I also turned the unit on hoping it would grab and re-feed itself but nothing worked that way either. The plastic piece I am referring to is has notched teeth on it just like a timing belt. The end, strangely has no metal piece or any special shape to it that would connect with any part down in the tube in any special way. It just is a certain length of plastic with these notches in it, that feed into something. There must be some kind of gear down in the tube? Or is there a hole that I am missing and need to get in back into?
[Response 1: Rick] You're on the right track (no pun intended). Turn the radio on and push the plastic feed into the hole until it stops, then turn on the off and it will feed it self into the gear box. If it doesn't work then take the cover off the box and hand feed it. [Response 2: Tom Irwin] Rick is completely correct. The length of nylon track goes through a couple of guideways on the way down, so don't be shy about giving it a gentle push to ensure the track is in the gearmotor assembly before switching off radio and engaging retractor motor. Only one more thing to mention, if it doesn't work at first...change the orientation of the track/gear/teeth. That is, if it doesn't grab right with the teeth facing the back of the car...then turn the assembly 180 degrees around so the teeth face the front of the car. Then, turn the radio off and the retractor motor should grab it up right away and pull it back down the hole.

Power Antenna Rebuild? [Inquiry:] The power antenna on my '89 760 is stuck in the fortunately) up position. The motor still cycles on and off, but the antenna doesn't move. There's some play (up and down) in the antenna, and before it stopped moving it sounded like a gear in the unit was trying to engage but couldn't. The unit (in the trunk) looks sealed. I haven't removed it - yet. Can I rebuild it? [Response 1: Michael Pardee] The power antenna unit can be opened, but the usual failure mode is the breakage of a plastic "caterpillar" track which changes the rotary motion to an extend/retract motion. Repair is probably hopeless. [Response 2: RLS] Volvo sells a replacement mast, including the nylon caterpillar, which can be (carefully) wound back into the motor/gear housing. It costs about forty bucks. I replaced my antenna, which would only extend about 2/3 of maximum, with a $9.95 permanent mast purchased at AutoZone.

Warning Lights Flickering: Bad Alternator Brushes	**Accessories:** Adding a Warning Lamp for Loss of Engine Coolant Adding Accessories and Wiring Them Through the Firewall

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"Service Engine" Light Reset in Various Models.

740 Pre-89 and 760 1987. [Procedure:] There is a reset button on the back side of the instrument cluster. It is located on the back side about where the 80 mph reading is. You may be able to get your hand up from the bottom to press the reset by first removing the lower kneepad. You can also remove the two outer lower screws on the instrument cluster and gently pull out the instrument panel enough to get your hand behind to press the reset button. Remove each small plastic cover to expose the mounting screws. The speed nuts into which these two are screwed sometimes fall off, down into the dash area. There is just enough slack in the harness to allow pulling the assembly over the steering column to get at the reset button. Press the button nearly flush with the back of the cluster for proper reset. A lot of people just remove the service bulb on this model to avoid the trouble of having to reset light every 5000 miles. N.B.: 740's with SRS do not have service reminder lamps in these vintages.
740/940 1989-1995, 760 1988-1990, 960/90 through 2000 . On these cars there is a small black, circular rubber plug in the clear plastic of the instrument cluster. Carefully remove the plug ... then take a very small phillips screw driver or even a nail and push in the re-set pin just behind the hole in the clear plastic. The button will click. Replace the plug and the service light is re-set. The later 960/90 series cars have 10k service intervals. Don't let your dealer tell you that you need a "scan tool" to reset this lamp: they are referring to the "check engine" lamp, not the "service engine" lamp.

Cluster Removal:

***Caution:** Before you remove the cluster, disconnect the battery negative so that any contact between the rear of the cluster and the metal surround will not result in a short and a fried circuit board.*

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740 Instrument Cluster Removal. It's very simple. Place the turn signal and wiper stalks in the down position. Take a super slim screwdriver and remove the small plastic cap surrounding the small clock set knob on the left and the cap surrounding the dash light dimmer on the right. Under each of these is a phillips screw. Remove and pull the whole cluster out. Don't even need to remove the steering wheel. If it 's the first time out, the wiring will be held in tight behind the dash by plastic ties. You can cut these ties which will afford you enough room to twist the cluster around and replace any bulbs etc, or mark each electrical plug and unplug enough of them to give you the room you need.

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760 Instrument Cluster Removal. [Inquiry:] I can not figure out how to get the instrument cluster out of my 89 760. It looks like all of the trim around the dash switches has to come off, then take a couple of screws out on top of the dash insert. I can't seem to make anything move. [Response: Chris Ascoli] I found out the hard way. Besides the two screws in the upper black insert, there are I believe 3-4 more screws hiding behind the air vents, one per vent. Take each air vent and push the top all the way into the dash as if you want to shoot the air up at the ceiling of the car. Once you do this, you should be able to see the screw in the upper portion of the plastic JUST behind the top of the vent. It's kind of tricky to get at, but you should be able to squeeze a Phillips head in there and remove them. Forget to do this and you'll hear a Crrrrrraaaack of the plastic housing surrounding the temp controls, etc. As you can imagine, that's how I found the screws. Chilton's did a fantastic job of NOT telling me about them. Thank God I didn't break it enough so that it hung away from the dash when reinstalled.

Once you get the vent screws, just pry with a little force and it should come out. But if it seems to hold up somewhere, check for any other screws at the binding point. The vent ones are definitely key though.

Pushing the Flat Spring to Remove the 940 Cluster

940 Instrument Cluster Removal. [Inquiry:] How do I remove the instrument cluster in my 940? [Responses: Abe Crombie and IanB] Disconnect battery negative and place the turn signal and wiper stalks in the down position. We got it out with a small screwdriver which will go through the slots in the side of the plastic bezel. You will feel a spring clip as you push into slot. Hold the screwdriver at an angle as shown in the photo. Push the clip hard while pulling toward you with the shank of driver; the clips are attached to the dash and are also robust, not easy to damage. The surround is alloy and is held by the cluster screws. There are lugs cast into the sides of the surround onto which the clips lock. Do one side only, it should come out easily once you get one to let go. One clip each side, nothing else holds it in. After you get it out remove the cluster by taking out (4) Torx screws and it's out. If it's turbo you have a gauge hose to disconnect at a joint about 8 or 10 inches from gauge. The latter is easier to do with the kickpanel above brake removed. Before you replace the bezel, grease the spring clips and the lugs to make future removal easier. To replace the bezel simply push it in and the clips lock onto the lugs.

Difficulties? This bezel can be tough to remove. Some tips: [Chuck Lee] I took off the knee pad and worked the left clip from underneath the dash. Get the left clip free, pull the bezel out a little and the right clip releases easily. More stuff to take off but a lot less cussing. [Paul Larson] When I looked through the vent opening, I saw the steel clip moving, being pushed by the screwdriver....problem is, the screw holding the clip assembly to the alloy surround was just a tad too long to allow the clip to completely clear the retaining ears on the bezel....it limited its travel. I removed the vent and ground off the screw tip (no easy task through the vent hole) and then looped bailing wire around the clip and pulled.....finally, the bezel came free. The clips were twisted on the alloy surround, causing them to be canted way far into the centerline, making it even more cantankerous to release. That bezel would have never come out without going through the vent opening and grinding that screw.

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960 Instrument Cluster Removal. [Inquiry] I'd like to pull my 960 instrument panel. See the 940 information above for basic removal. The 960's fancier dash has what looks like a one piece plastic trim panel that covers everything above the wood strip (with the switches). I suspect that there are retainers somewhere, but I don't want to risk breaking the plastic by prying where I shouldn't. Possibly the wood trim comes off first to expose fasteners for the upper panel? Anyone have the right steps to get the instrument cluster out? [Response: Tom Irwin] That is a very tricky job. Especially if you have that wood crap all over it. It is almost impossible not to break one of those strips. As much as I hate to say it in a DIY forum, you might want to have a specialist or *ugh* dealer look at this. Check for super glue repairs when you get it back too. [Editor] Volvo OEM manual is invaluable here, showing locations of screws, etc. They also warn you that the wood laminate strips are "extremely delicate", so beware. See the FAQ Section for details.

Lamps and Switches:

Replacing Instrument Cluster Lamps. [Inquiry:] How I can replace bulbs behind the clocks (speedometer etc.) [Response: Peter James] Remove the instrument panel assembly per the notes above. It will be limited by the wiring harness plugs and the hose for the boost gauge. I usually disconnect the hose which gives you enough space to get your fingers in to turn the lamp holders and remove/replace the bulbs. You can disconnect the wiring plugs but I don't bother, I put a mirror up on the top of the dash against the windscreen with bluetack and work from the drivers seat.

Changing Warning Lamp Bulbs. [Editor] These 1.2W 12V "grain of wheat" bulbs come in two kinds: presoldered into the integrated black socket, or replaceable separately from the socket, which can be removed from the panel by unscrewing half a turn. The former are expensive (US $12 at the dealer). [Greg Mustang] I easily found the bulbs themselves without the holder for under 1$ each. If you have good soldering skills and good tools, you can do as I did:

- Mount the assembly on a vise. Using minipliers pull off the assembly's prongs (they are pressed in). Rip out the old bulb and discard.

- On the new bulb, straighten out the two leads. Take a strand of wire from a stranded copper wire and lengthen (solder) the bulb's leads about a cm or two each.
- Insert the bulb in the old socket, sticking the wires out the end.
- Press in the old socket's prongs.
- Solder the lengthened leads to the sides of the prongs where the old ones were. You need good soldering skills and a smaller iron or you will melt away the black holder.

I did five bulbs in a matter of 10 minutes max. ...and saved myself 60 "dealer" bucks. Good for another ten years.

Changing Panel Illumination Colors:

The dash illumination bulbs themselves are #94, a common bulb used in most dashes, and you can get several colors. I have changed mine all to red. Some of the switches use a very small bulb that I could not find colored; for these I purchased some heat resistent colored film used for theater lighting from which I made small straw shaped covers for each bulb. I do a lot of night highway driving and I find the red lighting in the dash much easier on the eyes while still making the guages very visible, rather than just dimming the standard green/blue color.

*960/90 Cluster, Panel, and Interior Lamps.*Here are some part numbers for the interior bulbs for 960 cars, courtesy of Jon at Borton Volvo. 800-328-7114.

- 30710781 glovebox bulb with socket US$6.80 ea
- 9130288 rear ashtray/center console bulb with socket (blue tint on bulb). One bulb lights up both areas. $5.74 ea.
- 9130294 gearselector bulb w/socket and wires. The bulb can be replaced separately from the socket. $12.30 ea.
- 3523962 front ashtray with connector & socket $13.55 ea.
- 9148906 bulb for dash switches w/long holder (sunroof, foglight) $4.02 ea. Some switches take more than 1 bulb.
- 9148908 bulb for dash switches w/short holder (defroster, hazard light). I think these may also be good for radio bulbs. $4.02 ea. Some switches take more than 1 bulb.

These I got from local autoparts store:

- 2721 bulbs for ECC. Four bulbs
- 158 bulbs for instrument cluster. Four bulbs. I'd recomend bending the contacts on the base of the bulb socket a little bit so as to make a better connection with the circuit board.

Replacing Switch Panel Lamps. [Editor] Each instrument switch (fog lamps, antenna, rear defroster, etc.) has either an integral 1.2W miniature bulb or a 1.2W bulb in a holder, transmitting light through a small lightguide. Carefully remove the trim surround panel, starting at the heater control in the case of the right hand trim, to access the switches from the rear. On the left, you will have to remove the headlight switch knob and the nut beneath to remove the

trim. To access the bulb, gently pry the plastic molding that surrounds the switches and the headlamp switch. Start prying by the left vent and work your way towards the steering column. The lamps are plugged into the top of the switch unit. Pull out the old bulb and replace with the new one. There is no need to remove the switches.
These bulbs are NOT available from anyone other than Volvo, so plan on either visiting the dealer or calling a mail order Volvo supplier for the correct bulbs. Several applications exist, so make sure you get the right one.

Replacing Heater Control Unit Lamp. [Tip from John] Remove the trim surrounding the heater/AC control unit, then just take the 4 screws out of the unit and pull it out of the dash. In the back on top there is hole where the light bulb assembly twists into place. Replacing the bulb is easy.

Replacing Glove Box Lamp. [Inquiry] I've been trying to replace the bulb in my glove compartment for quite some time now and have been unsuccessful. I've tried opening up the little plasic casing. How do I do this? [Response: Dick Riess] You need to remove teh glove box. There are 2 screws and a couple of nuts holding the entire box in. Once you remove it the light is easily accessible.

Center Console Lamp Replacement. [Inquiry:] Does anyone know how to replace the light that illuminates the inside of the center console and the rear ashtray? I can't figure out how to get in there. [Response: John R] The plastic panel on the rear of the centre console clips out, but it is very hard to pull out, feels like it will break. It has two mounting tabs at the bottom. Try removing ashtray and then gently prying these tabs back, while pulling around bottom of the panel. Once this panel is removed you can gain access to lights (also gives you access to the handbrake adjustment).

Shift Indicator Bulb Replacement. Shift Indicator Lamp. [Inquiry:] How does one replace the bulb that illuminates the gear selector letters? [Tips from Remi Kwan and Dick Riess]

1. The shift light is an Osram #2721 "grain of wheat" bulbs fitting into a separate base, available at most auto parts stores.
2. Remove ashtray, fuse-relay cover
3. Pry out plastic L-shaped knockout plate at the base of the hand brake.
4. Undo two torx screws on plastic cover under the hand brake.
5. Remove metal clip, revealed by 3, near the front of the shift cover.
6. The plastic cover from the shift gate all the way back to the hand brake as one piece. You'll need to push forward a bit, to remove it from the hand brake end, then pull back to remove from the shift lever. You can twist it so you don't have to disconnect the seat heater wiring. But be careful with the bulb connection for the seat heater switches, under the plastic cover, on the right hand side. You might want to just disconnect it and

reconnect when done.

7. The light is deep down on the left (drivers) side of the gear shift, under the shift gate and under the N indicator, with two wires going to it. Reach your hand down the side and under and feel for the two wires.
8. With a long needle nose plier or your fingers gently pull down on the wires to remove the light socket, which is held in place by friction. There is enough wire to bring the socket out far enough to easily replace the lamp.
9. Make sure the bulb works as you do not want to repeat the job.
10. Reinstall in reverse order. The fun part it to reinsert the bulb holder: it is harder putting the socket back in than taking it out.. A long curved needlenose pliers works best.

[Note:] Your shift indicator black plastic may be attached by 2 screws on the top and bottom of the shifter. Remove these and the black plastic indicator and you'll have easy access to the shift indicator bulb.

Removing Headlamp Switch. [Inquiry] On the leftmost dash panel, the knob for the headlights is creating problems for me. How can I remove the knob from the panel without breaking it? [Response: Bob] The knob just pulls off. If the panel the switch mounts to has to come out, gently pry from the left side.

Removing Sunroof Switch. [Tip from Jay Simkin/Jim Holst] To remove the sunroof switch (which fails because of high currents to the motor) you will need to pull the fascia trim on the passenger side of the steering wheel. Start at the end farthest from the steering wheel surrounding the climate control unit and work toward the steering column. Use a plastic putty knife to GENTLY pry the narrow frame that surrounds the climate control unit loose. Don't start at the steering column or you'll break the plastic there. There is a fairly stout metal clip on the back of the trim about half-way toward the steering wheel. Use the plastic putty knife and insert the blade at the bottom at a 45 degree angle. Push down on the handle and the clip will start to release. A little more pressure and the clip will release. Once that is free, lift the section that goes around the ignition. The sunroof switch has an electrical connector which you must disconnect. The switch is held into the fascia by plastic clips on the side of the switch. Press those inward to release the switch. This is a good time to check and replace any of the light bulbs which illuminate the switches in the fascia.

Turn Signal and Wiper Stalks.

Stalk Screw Locations

Replacing Turn Signal or Wiper Stalks. [Photos

Courtesy of Jurgen Winkelvoss] [Tip from Editor] My kid's 940 cruise control died and I traced it to a broken wire in the turn signal stalk. The Volvo manual instructs you to remove the air bag and steering wheel to replace the stalks, a nightmare if there ever was one. After looking carefully at the assembly, here's an easier way to do it:

Short T-25 Bit

1. Buy a small Torx T-25 bit and, using a very hard hacksaw blade (I used a diamond-coated blade for tile) cut the shank end down to just fit inside a narrow 1/4 inch box-end or ignition wrench. Tape or glue the bit into the wrench.
2. Disconnect the battery to disable the air bags.
3. Remove the top and bottom covers of the stalk assemblies by removing the four screws forward of the steering wheel. The bottom cover takes some maneuvering to clear the stalks. Remove the driver kick panel, the knee bolster cover, and the knee bolster under the steering wheel.
4. Using your special tool, remove the two screws holding the stalk to the steering wheel assembly. Your tool will be just short enough to fit between the stalk screw and the back of the steering wheel or front of the housing. Use a magnet to remove the screws so you don't drop them into the assembly.
5. Disconnect the electrical connector at the front of the stalk and then, in the case of the turn signal stalk, disconnect the cruise control wire under the dash. Snake this up so it can be pulled out.
6. Pull the stalk out and replace the new one in inverse order.
7. Torque the knee bolster screws to 5.8 ft-lb and button it up.

Turn Signal Return Repair. [Tip from Tom McGowan] Problem: a turn signal that would not return to center position on a 940. After removing the stalk, I found that the turn signal would return OK when the white plastic piece was stroked by hand, but not when mounted on the steering column. The white plastic piece on the turn signal that returns it to neutral position is at an angle to the steering column and is stroked by a segment of the steering wheel. My fix was to cut two pieces of a third of a thin metal washer, glue them (Shoe Goop does a good job) to the back of the turn signal on the steering wheel side of the brass inserts, and then remount the turn signal. This changes the angle of the white plastic piece to be closer to a right angle to the steering wheel and steering column, and effectively lengthens the white plastic piece giving it more stroke. This solved the problem

Caution: Spring Inside Box

Turn Signal Contact Repair. [Procedure from Jurgen Winkelvoss] Once the stalk has been removed, lever the cover off at the points shown in the photo. CAUTION: There is a small spring and button contact at the inside center which must not be lost, so be careful in separating the pieces. Remove the contact and spring. Using polishing paste and a small foam swab, remove dirt and oxides from the brush surfaces. Note the contact wear path on the brush surfaces and clean this carefully, removing particles and dirt from the surrounding area. Make sure the brush tracks are not damaged. Reassemble, including the small center spring and contact, and reinstall.

Note Contact Path on Brush

Turn Signal Contacts

Dome Lamp. *Vacuum Temperature Sensor.* [Inquiry] The dome light in my [940 SE/760/960] makes an irritating sound (hissing / whooshing) when I am cruising but backs off when I accelerate. [Response: Alex/Jeff] There is a vacuum-powered air temperature sensor in the dome lamp assembly which draws air across the sensor and sends an electrical air temperature signal to the ECC climate control unit. Vacuum is limited by a check valve on top of the intake manifold, which has failed. Replace the check valve.

Troubleshooting:

Warning Lights Flickering: Bad Alternator Brushes. [Inquiry:] We just replaced our battery because as we drove the warning lights were constantly flickering on and off (plus sometimes we had to jumpstart the car to start it). Now the car starts fine but the warning lights continue to flicker. Any idea on what could be the problem? [Response: Russell Smith] Check the brushes in the voltage regulator. Most likely they are worn out, causing the idiot lights to flicker and preventing the battery from charging adequately.

Gauges or Warning Lights Stop Working Intermittently, Alternator Fails: Failing Flex Circuit Connections. Has anyone experienced a situation where all the gauges in the binnacle act as if they are not getting any power? 2. Has anyone experience a situation similar to 1. above, but where the gauges seem to take turns taking a swan dive? [Response:] Have seen this problem on a 85 / 740 turbo. I took out the instrument cluster and tightened every screw and connector I could get at and this fixed the problem. Talking to a Volvo mechanic, he said there is also likely that a ground is bad on the computer module situated near the passenger side, side wall. [Response 2:] For what it's worth, my '90 745 had the gauge problem intermittently. Drove me crazy, and the dealer "tightened the grounds" four times, each with a positive effect for a short while. They did give up, saying it was mostly likely a cracked p.c. board in the dash, which would fail as it flexed. Wouldn't know without pulling the dash.You can replace this flexible board by purchasing both a replacement board ($200) and the twenty or so new cadmium-plated screws from the dealer, the latter to eliminate any oxidized screws at connections. Pull the panel, marking connectors on the back, and then gently pull off each outer connector receptacle by unlocking the tabs. Unscrew all the screws, replace the flex board with new screws, and reassemble. [Andrew Woods] I've had an intermittent fuel guage, warning lights, and a jumpy tach, as well as an alternator that would not work till I revved the engine up past 2k rpm's, all due to faulty connections on the instrument cluster. I always thought it was bad connections where the wires connect to the cluster but I found out that it was bad solder joints that were cracking and losing conductivity. I resoldered all the connections and found at least 3 that where cracked where the solder was actually supposed to bond to the wires. The solder joints had cracked and were so loose that I could actually poke the piece of wire coming through the solder and see it move. The solder was still connected to the PCB, but not to the wire. After resoldering these, now my fuel gauge, my warning lights, and my alternator now work when I turn the car on and my tach is no longer jumpy. For anyone else having problems I suggest you try this

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Temperature Gauge Fluctuates. [Inquiry:] I just noticed my heat gauge flutters from the left to middle (not into the hot Zone) . There does not seem to be any pattern to this, smooth roads or bumpy, acceleration or slowing , whatever. It looks normal for a while, and then starts getting the jitters. [Response: Steve Ringlee] To test your gauge, get an appropriate resistor from an electronics store (preferably with a 5W or above rating +/-5% tolerance), solder an alligator clip to one end and a quick disconnect connector to the other. Pull your gauge temperature sensor connector from the sensor (the one under number two cylinder intake manifold on B230F engines) and insert the quick disconnect into the half of the connector wired to the gauge (not ground). I recall that out of the panel this wire is yellow-white. Check your wiring diagram to confirm this. Attach the alligator clip to ground and turn on the ignition. Your gauge should read in the hot end if it works. If it doesn't, then either the gauge or the wiring harness to the gauge is faulty. Clean wiring connectors with electronics connection cleaner (such as DeOxIt) and test again. If it reads correctly, then the sensor is bad.

Coolant temperature gauge sensor resistor ratings for 7XX/94X cars are:

Cars from 82-86: 87 ohms to get a 90C reading at the gauge (range: 217 ohms +/- 35 ohms at 60C/140F to 67 ohms +/- 15 ohms at 100C/212F)
Cars from 87-93: 206 ohms to get a 90C reading at the gauge (range: 560 ohms at 60C/140F to 153 ohms at 100C/212F)

Cars from 94 on: 75 ohms to get a 90C reading at the gauge (range: 780 ohms at 20C/68F to 75 ohms at 90C/194F)

Temperature Gauge Sticks. [Tip: Dave Wilson] One of the problems that affected my '89 TD Estate has been a sticking temperature guage. I, probably like many others was suspicious of the electrical connections and all relevant ones were cleaned and checked. Finally some three months ago I stripped the instrument cluster down even further in order to examine the guages and lubricate their bearings. These are heavily damped guages. A few small drops of an extremely light instrument oil was applied to the accessible bearing part of these gauges under their pointers, and there has been no recurrence of the problem in the intervening months.

Fuel Gauge Fluctuates or Fails to Work. [Inquiry] The fuel gauge on my 940 fluctuates up and down and sometimes responds to a whack on the dash board. The gauge has seen numerous attempted repairs over the past year, including the total replacement of the gauge itself. It slowly got to the point of not responding even to vigorous whackage upon the dash board. How to fix?

Diagnosis. To isolate the fault, obtain a 68-ohm resistor. Disconnect battery negative, insert the resistor between the sender connector near the tank and ground, reconnect battery negative, and turn on the ignition. The gauge should read the value noted. If it does, then your sensor of faulty. If it does not, then your fault is in the wiring from the tank to the gauge, the gauge itself, or (for 1982-1984 cars only) in the voltage stabilizer at the panel.

Year	Gauge Indictation Using 68 Ohm Test Resistor	Sensor Resistance Range	Notes
1982-1984	Gauge should read 3/4 full	Lever-type fuel gauge	If temp gauge is also incorrect, then voltage stabilizer is faulty
1984-1992	Tubular-type fuel gauge with: 60-litre tank: left side of pointer should touch red part of gauge 80-litre	Empty tank: 0-ohms LED "low gas" lit: 10-18 ohms Full tank: 280 ohms	Supply voltage comes from temp gauge. Insert test resistor between gray-white lead at gauge side and ground. Measure sensor resistance between ground and gray-white lead at sensor side.

	tank: right side of pointer should touch red part of gauge		
1993 +	Non-tubular type fuel gauge with: 60 litre tank: 1/4 tank full 80 litre tank: 1/5 tank full	Empty tank: 131ohms LED "low gas" lit: 113 ohms Full tank: 2 ohms	Measure resistance between brown and gray-white sensor leads at sensor side.

1. Fuel Sender Unit Failure. [Tip from Dave Stevens] For the 940's, the early symptoms are a fuel tank gauge that appears to stick, often reading too high. Then it progresses to the point where it won't always go below a certain point or above a certain point. Driving over bumps or filling the tank will often cause the gauge to jump and read more correctly. Eventually the problem gets so bad the gauge will rarely move. No matter how bad it gets, you can probably still get it to move if you take a mallet and carefully pound the top of the tank around the sending unit (under the access plate). I would say that is the ultimate diagnostic for this particular problem. Based on reports here, the problem did show up on a few cars during the warranty period, but is now starting to show up more and more as these vehicles age. The problem likely correlates better with mileage and rough road usage. Quite simply, the fuel level sending unit in the tank is shot. Specifically, the internal sliding contacts are totally worn out. This only affects the sending units in the later 940's with the enlarged ~73 litre tank. It is fundamentally different from the earlier 900's and 700's with the ~60 litre standard tank or the ~80 litre expanded tank. It's about 1.5" longer and uses a different pre-pump attachment. Additionally, the resistance values probably don't match so a different or modified gauge is likely required (probably just a resistor or jumper wire). The 940 also needs the maximum sender resistance to correspond to the proper tank level as it triggers a bright low fuel LED on the dash. It's an expensive problem to fix. It almost goes without saying that you can't get the little contact strip worth only a few cents. You need the whole sending unit. Apparently Volvo only sells the sending unit with the entire tank pickup assembly including the pre-pump for approximately US$500. There are two alternatives: Find a working used sending unit and have it installed, or fix it yourself.

Repair of Sender Unit. To do the latter, remove the tank sending unit, remove the sender barrel (fast, high heat de-soldering), crack it open without damaging anything (non-trivial), carefully slide out the float assembly with the worn contacts, repair the contacts, put it all back together. If you're lucky it will still work. Hints on cracking it open around the mid-seam: warm it for a little flexibility in hot water; try to wiggle the halves and *slightly* push in the tabs to break the friction bond of the inside lip; crack it open by holding each end and firmly pressing the mid-section over a protected edge with the little notch in the seam facing toward you (it's much like cracking an egg; it takes a lot of strength, just be prepared to stop quickly once it separates so you don't bend the internal rods; it sounds awful when it finally comes apart). Once the guts are exposed, you'll easily see that one or both contact fingers on the float have jagged ends where they used to have wide pads that would slide up and down the resistance coils (you can even see this before you start by looking into an open hole -see quiz below). These pads were too thin and have simply worn off. Your job is to figure out how to re-build these pads. (Our Don Foster would totally love this challenge.) Carefully crimping on a tiny strip of very thin nickle plated sheet metal (scavenged out of some old broken toy or electronic item) is what I used. The tricky bit is to make sure the pads are solidly attached, do not have sharp edges, aren't too big and can still move freely with light outward pressure. If the resistance coil rods are handled the coil wire may become loose and will cause binding. If this happens, carefully re-wrap the coil back and forth a number of times to eliminate the loose area (hint: follow the original coil marks when doing this; carefully fold over any excess wire at the top only). You'll need to make sure the little contact frame doesn't get bent out of shape. It must be able to slide up and down without binding (hint: tweak it carefully to restore proper contact; the rods have notches at the ends for alignment in the sleeve holes; doesn't matter which rod is in which hole; the float assembly only installs one way so that the contacts fit all the way up into the head area). Re-assemble and visually test the sender sleeve unit by immersing it in a pail of water. Clean and dry before final assembly and installing. [Dan Ray] After experiencing years of intermittent fuel gauge operation in my 960, I pulled the sending unit including the whole pre-pump stalk from the tank. I cut the wires to the sender and removed it from the stalk. Pulling it apart, it was apparent that the problem is in the sender. There is a thin shiny stainless steel metal conductor that resides on the float and makes contact to the wound wire (rheostat). The metal contact had a film or sludge that was grey, almost like a powdered metal that was very difficult wipe away. Also after almost 300k miles the points of contact had worn a groove into both contact edges. I bent the conductor so the contact point was at a slightly different area. Reassembled the unit, soldered the wires, added a little shrink tubing and after reinstallation, the guage works flawlessly.

2. Failed Fuel Gauge. [Tip] I had a similar problem on my '96 960, noticed it right after I pulled the car out of a 3month storage, read empty so I went to fill up and the tank was already full. Gauge was steady but would never read correctly and not once would go to full position. Tried testing the Fuel gauge by jumping the connector in the trunk, located on drivers side, it responded as expected and went to full position on several tries. Pulled fuel sender and found no problems testing on the bench. Then went back to the car and re-ran the same test on fuel gauge, this time it went only 3/4 the way. Put sender back in car and changed out the gauge which was the problem. Sending unit appears well built and quite unlikely to go bad, which is good because its a bear to R&R. Electronics are all inside the gas gauge and that's where my problem was.

3. Poor Instrument Panel Contacts. [Response: Tom Irwin] My friend who is a Master Volvo Tech told me that usually the comb connector in the back needs to be re-crimped. After I did that 3 times he told me that if the re-crimp doesn't fix it, then it is in the electrical interface between the 3 screws that hold the gauge in place, with the flexible PCB sandwiched in between. The flex PCB, while very environmentally friendly to manufacture, easily deforms and becomes brittle with time. Ask ANYONE who has a 240 with tail light problems about these little beauties. In addition, the retainer/conductor screws are supposed to be cadmium plated. But cadmium is bad-bad for the environment. So the 3 little screws are coated with some other shit that blooms into galvanic corrosion after a while even though they 'look' ok. I wire brushed them, straightened the pcb and hit em with DeOxIt. That repair actually lasted the longest: about 3 days. There is only one permanent repair in this case: the screws must be soldered. My buddy tells me to lay a small amount of solder, very quickly and VERY carefully to the contact points under each screw. Use a light iron with temp control. Try to hold ~700 degrees f. Use a normal 60/40 rosin core solder. Be very careful not to melt the plastic substrate as you heat up. I like to keep a can of electronic freeze spray to douse the hot spots immediately after flowing a bead of solder. In a pinch, a can of 'compressed air' turned upside down will achieve the same thing. Solder all 3 screws to the PCB traces and you are done. No more fuel gauge problems.

Speedometer Failures.

Diagnosis: Speedometer Head, Wiring, or Sender Unit? How to tell if the fault lies with the sending sensor on the rear axle, the wiring to the speedo, or the speedo itself:

> *Sensor Test.* [Peter KL Milne] The sensor is bolted on the rear face of the differential behind the Panhard rod with a tied-on electrical connector. It senses the rotation of a toothed ring attached to the crown wheel inside the differential. The twisted pair wires from the sensor (one Brown (740) or Brown/White (940) and the other Green/White) are shielded right into the boot area. Inside the boot area where the filler pipe comes up to the filler opening, they route through a little sealed plastic box at the rear of the wheel arch thence to the large A-pillar connector at the front of the driver's door and then to the back of the instrument panel. These in turn route into the panel through a small four pin connector behind the speedometer (740) or the larger passenger side A-connector (940) at the rear of the instrument panel which carries these two wires into the speedo. These connectors may work loose. You can test the sensor and wiring at this panel connector. [Tip] I had a dead speedo and odometer. Using my digital volt meter, I switched it to 10 volts AC range. I had a friend hold the leads where the wires go into the speedometer. I drove up to approximately 15mph, and as I did, the needle smoothly moved up towards 1 volt. As I slowed down, the voltage dropped smoothly as well. As far as I can tell, this means that the pulse generator in the rear end is working fine, as is the wiring that comes from it. If I had known this beforehand, it would have saved me major headaches. Now I can just concentrate on getting the speedometer fixed. [Editor] Make sure that there is no corrosion at the rear sensor connector. If there is, spray with electronic deoxidizer and clean it. [W Jepsen] After my speedo failed, I tried testing the sensor signals with an oscilloscope. They appeared fine. After installing a new speedo which failed to fix the problem, I installed a used sender and wire pigtail from Revolvostore ($30). That did the trick. Seems that the sender can show up with an oscilloscope test but not a good enough signal to power the speedometer.

Wiring Test. [Editor] Test continuity in the two sensor wires from the connector behind the panel to the sensor connector on the rear axle using a continuity tester and a long wire. Test ground at the panel and the sensor in the Brown or Brown/ White wire by using a continuity tester at both the sensor connector and the panel. If ground is bad, look for corrosion at the left A-post body ground plane. Needless to say, the Volvo OEM wiring diagram manual helps considerably in locating these wires.

Speedometer Failure: Capacitors. [Tip from Anders] Symptoms: Speedo dead, odometer functioning. Fault: Shorted 220 uF capacitor inside speedo. How to repair: 1. Remove instrument panel 2. Remove speedo, four screws on the back side and a flat cable connector 3. Carefully peel off the meter needle and remove the speedo background (glued) 4. unsolder capacitor and replace. 5. Assembly is reverse of disassembly. [Tip from Rick Borth of Overseas Speedometer] 1991-1992 740/940/960 speedometers also frequently fluctuate or fail because the electrolyte from the capacitors near the chips leaks on one or both chips....causing the chip to malfunction. We replace the capacitors, clean the board and it usually works again. Procedure is tedious, but have successfully completed 50-75 repairs without incident.

Speedometer Repairs. [Note on rebuilder:] Palo Alto (CA) Speedometer Service(http://www.paspeedo.com) : (415) 323-0243. I have yet to use their services, but they were recommended by a local shop here in Boise as the best in the business. I called them last summer, contemplating sending my wife's speedo in for repair, but I haven't gotten around to it yet. The price they quoted was around $90, just to fix the odometer. [Another:] just had my electric speedo/odo repaired. know this is a common problem so thought I'd pass along the shop's name and number.

A+ Emissions and Speedometer Repairs (Chris (904) 642-8120); 3122 #9 Leon Road ; Jacksonville, FL 32246 He's a straight shooter and keeps a clean shop. Does lots of Volvo speedo work through the mail. [Another referral:] I wanted to pass on contact information for a company I found here in Austin that works on Volvo (and other makes) speedometers. Its called Overseas Speedometer and you can get their contact information at www.speedometer.com . I just dropped off my speedometer to get re-calibrated for my V8 conversion and to get the odometer working again. A couple of Volvo shops around here gave him a good reference so I thought I'd pass it on. [Tom Kaylor] I had mine rebuilt for $100 by www.speedometer.com and it now works fine. [Jay Simkin] To have the mileage re-set, send the speedometer to APT Instruments International, Inc; 9632 Humboldt Ave S;Bloomington, MN 55431; Tel: 952-881-7095.
http://www.gaugeguys.com/Repairs/speedos.htm

Odometer Failure. See below.

Speedometer Fluctuates. [Inquiry:] My wife’s 1991 740 sedan speedometer needle simply drops to zero (as if someone pulled a socket from the wall) At this moment the odometer and trip odo also quit. Very occasionally, when driving, at highway speeds, the speedometer needle will jump back up to the correct speed, and the odometer starts working, but usually after a 1/2 mile or about 40 seconds, the needle falls back to zero and the odometer quits. Other times everything works fine for hundreds of miles. Often when starting the car after is has been parked, odometer and speedometer never work at all. [Response 1: Don Foster] Check the connection at the speedo sensor. It's in the differential cover, about 3" above the filler plug. Be sure it's mechanically secure, and check the contacts (both sensor and connector) for signs of corrosion or oxidation. As much as possible, examine the harness for any signs of a break or tear, or for signs the wire might have been cut. If it's not wiring, then it's either the sensor or the speedometer head (which is electronic). Possibly, the power supplied to the speedo head where it's mounted in the dash cluster is intermittent. [Response: Pat Hannon] The speedometer in my 745 with 160K has been jumping around a little on the highway. The cruise control would try to follow the erratic speedometer, then disengage. I suspected a broken wire at the sending unit. What I found was a burnt wire at the sending unit. The wire had grounded out on Volvo's safety wire. I suspect that the safety wire slowly eat throught the insulation on the wiring, causing it to ground out. The plug was melted and an inch or so of insulation on the green stripe wire. Make sure the safety wire is not cutting into the two wires on the sending unit at the back of your rear end. [Response: Scott] Check the instrument cluster grounds under the dash and in the right footwell. In 88 there were some 700 series cars that would register up to 60 mph while sitting still and the grounding problem was the cause.

Speedometer Calibration. One of the benefits of the new millennium is that it has become reasonably cheap to check your speedometer using a GPS. If you don't own one, I'm sure that your neighbor does! When I checked my speedo against the GPS (Garmin Streetpilot) it revealed that the speedo read 10% too high. I.e., 110 km/h on the speedo was only 100 km/h in reality. In order to verify this, I checked the speed against the odometer. At a certain speed, 1 km takes a certain number of seconds to pass. Example: 1 km @ 60 km/h takes 60 seconds. This test also showed a 10% difference between indicated speed and true speed (assuming that the odo is more accurate). Having this much of an error, I felt very motivated to investigate the possibility of a calibration. Since the speedos of the 700 series are electronic, another approach than replacing an internal driver wheel had to be found. By doing a lot of reasearch on the Internet I found that in most cars it actually could be done, merely by a change of a resistor. The speedo itself is build around the ubiquitous ITT UAF2115 chip (A datasheet could be found here: http://heneghan.members.beeb.net/audi/uaf2115_1ds.pdf). And the resistor to be changed is the one that is connected to pin 4. Enough theory!

How to calibrate:

1. Remove the instrument cluster as shown in the FAQ, i.e. remove the plastic covers and unscrew the two screws.
2. When the cluster is removed, open it by removing a number of philips screws on the rear side. Notice that the silver colored screws are longer than the golden ones so make sure that you where they belong upon reassembly.
3. Remove the speedo by unscrewing four screws on the plastic circuit board side. Two of the screws are also holding two connectors. Do not mix them!
4. Carefully remove the meter needle by turning it counter clockwise while pulling. After that remove the "number plate" which is glued onto the meter. Don't worry, you will probably

not need more glue to reattach it, it is quite sticky!

5. Unscrew the three small screws which now should be visible. After that, the meter core should come lose.
6. Unscrew the two screws on each side of the the step motor (silvery thing, 3 cm diameter) and the circuit board should come lose.
7. Locate the resistor shown in the picture. Heat up your soldering iron, this is the little buggar that is to be replaced!
8. Replace the resistor. In my meter, the value of the original resistor was 51 ohm. In order to decrease the speedo reading by 10%, I increased the value of this one with 10%, i.e. 56 ohm. Of course, you should increase the value with the same amount as your error. I double checked this by hooking it up to a signal generator, but that is not necessary unless the error is REALLY big. It is of course possible to use a potentiometer instead of a fixed resistor, but I prefer resistors since the do not change that much over time.

Resistor Location in Speedometer

9. Reassembly is almost the reverse of the assembly. It could be tricky to realign the meter needle, but I did it by rotating it counter clockwise until it rested at 20 km/h (as it did from the beginning).
10. Buy a bottle of beer.
11. Test drive your car and enjoy an extremely accurate speedo reading!
12. Drink the beer! And my result? The GPS and speedo now read the same within 1 km/h at all speeds up to 130 km/h (didn't test at higher speeds)!

Odometer Failure.

Odometer Gear Failure Mode

Engine Service Reset Button. Often the "engine service" light reset button can make the trip odometer gears stick. Punch this several times to free it up.

Repairing Non-Working Odometer. [Tip from Mark] At some point during your 700/900 series Volvo’s life, its odometer may cease to function. I believe the gears jam or break due to people resetting the odometers while the car is moving. If only the odometer (cumulative mileage and trip) has stopped and the speedometer still works properly, do not fret. An easy and cheap solution is readily available. What has happened with your odometer is the gears that turn number barrels have become jammed. The usual culprit, according to the owner of speedometer shop I spoke with, is the set of gears that operate the service reminder light decided to be stubborn and constipate the entire odometer show. Because the guy in at the speedometer shop was so confident about what caused the problem and how easy it was to fix I decided I would try to save my self a few bucks. I got quotes ranging from $95 to $220 to fix the odometer if I removed the gauge cluster from the car and brought it to them. I ended up fixing the jammed odometer for less than 2 dollars. Here is how I did it:

1. Remove the gauge cluster from the dashboard. Directions to remove the trim panel to access the screws holding the gauge cluster in place can be found in the 700\900 FAQ. If your car is a turbo I strongly suggest cutting the vacuum line to the boost gauge 3 to 4 inches from where the tube connects to the rear of the gauge cluster. These small hoses harden over the years and I was terrified that I would break the hose nipple off trying to remove the vacuum tube. I went to the local parts house and purchased a package of barbed vacuum hose connectors for less than 2 bucks to reattach the cut hose. This way I did not have to worry about doing any expensive and troublesome damage to the boost gauge.
2. Once the cluster has been removed locate the five or six screws that hold the clear bezel to the front of the gauge cluster. The screws that hold the bezel on are the biggest ones on the back of the cluster. If you try this please take a moment to study the panel before removing screws. In addition to removing the screws, you will have to unclip or detach a couple of small plastic parts around the edge of the cluster. I wish I could be more specific but it has been a while since I fixed mine. It is not difficult. You just want to take the time to be careful and attentive to details. Once the clear bezel has been removed, use the eraser end of a pencil, or some other object that will not scratch the number barrels of the odometer, to carefully advance the odometer past the point where it has stuck. See below if you need to replace the gear. Reassemble and drive happy.

Replacing Odometer. I have found a solution: at the pick and pull I can get an instrument cluster for very cheap (10-25% of the repair estimates). I just unscrew 8 screws at the back of the board and remove the cowl and lens. Then take 4 screws out of the white speedo housing to pull it free. This can be transplanted easily into your recipient cluster and even a slightly different 1990 model works well in the 86 cluster after removing the service reminder reset cable that the later ones come with. Who needs that function anyway? To reset the mileage to your correct (but by now estimated) figure is also trivial once you remove the small white electric motor that drives the odometer, and slide the pin holding the small exposed gears. The odometer digits now rotate freely. No cheating at this point. Most of the speed-odometers are the r9800 variant but compatibility is something to check for in the replacement. Apparently, this number keys it to the rear end properly. This is also a swell time to throw in a large tach if you can get one.

Replacement Gears and Parts. Your odometer is mechanical. See http://www.odometergears.com/ for parts and supplies.[Another Tip] VDO in Winchester, VA, and other places advertise. Get a copy of Hemmings motor news, you will find them in there. [Editor] IPD now sells for $50 a complete odometer repair kit along with a DVD showing the repair procedure.

Tachometer Failure. [Dan Ray] My tach sometimes registered zero at idle or would bounce around, always at idle. I pulled the instrument cluster, unscrewed the tach, cleaned the contacts with a spray electronics cleaner and shot a little silicon at moving parts. Next, I cleaned the mounting points to the circuit board. The mounting screws are the electical pathways from the circuit board to the guages. The copper in the board where the guages mount seemed too dark in color, not corroded but not real coppery either. After reassembly, tThe tach works as it should. I assume the resistance from the board to the gauge was the problem. [Editor] Try Caig Labs DeOxIt or ProGold(now available at Radio Shack), useful for deoxidizing and cleaning contacts. You might also replace the small cadmium connector screws securing connectors to the flex board.

Electric Clock Repair. The Clock Works; (Automotive Clock Repair & Quartz Conversions - Most Service Completed Within 24 hours) at 1745 Meta Lake Rd., Eagle River, WI 54521-8531Contact: Jerry Magayne Voice or Fax: (715) 479-5759 E-mail: clockworks@juno.com
See also: http://www.speedometer.com/

Windshield Wipers Operate When Horn Is Pressed. [Inquiry] [Response: Chris Mullet] Besides checking your chassis grounds at the front of the car, it can happen that the steering column-to-dash structure anchor bolts start working loose, causing a flaky ground and resulting in the "horn honking causes wipers to wipe" problem.

Bulb Failure Sensor Lamp Won't Go Out. [Inquiry:] My left low beam failed, and my bulb failure warning light dutifully advised me of the need to replace the bulb. I replaced the left low beam, and all the lights on the car work now. But, my warning light is still on, though it goes out when I flip to high beams. Anyone know a fix for this? [Response:] The bulb failure sensor works on current flow. If the bulbs are miss matched, say a Wagner bulb on the left and a Sylvania on the right, chances are they have different resistances. This causes different current flows to each bulb and the light on the dash will come on. You may just want to change the other headlight and hope that stops it, or live with it. Also, corrosion in the connectors in the circuit that the head lights are on can cause the indicator light to come on. It can be very frustrating, and I know many people that have pulled the little bulb out of the dash. [Editor] The bulb-out relay is very sensitive to differential current flows due to corroded bulb bases, different lamps, same brand but different countries of origin, etc. Make sure the bulbs are identical. Watch out that your brake lights are still operating as well: if the relay fails, the brake lamps won't work.

Speedometer Relay and ABS Lamp. [Inquiry:] I recently brought my 1987 Volvo 760 GLE with 200,000 miles in for repair after I noticed that the speedometer, odometer and cruise control stopped functioning. The car does have ABS and the ABS dashboard light also went on full-time just about the same time as the speedo/odometer/cc went out. [Response: Zippy] The speedometer converter is a relay looking device that is under the left side kick panel (under dash piece) that has its own fuse mounted to the top of it. You hadn't recently jump started your car's battery have you? Done incorrectly it is very common for this hidden fuse to blow, rendering ABS and the speedometer inoperative. This only happens on the older ABS cars.

See also ABS Lamp Lights After Start-up

White Switch Markings Fading. [Inquiry] Every time I clean and detail the interior, the white markings on controls (i.e. horn icons on horn buttons, white line on headlight switch, cruise control button "off" and "resume") slowly fade. I tried different kind of weak cleaners and even watered-down Windex but the "ink" is very soluble. It's worse with Armorall. [Response] On recessed markings you can buy paint sticks and rub new paint into them. Simply take a cloth and buff off the excess. [Response: Phil] I found the same and now just use water on a rag to clean most controls. You can re-do notched or recessed markings and such with something like a toothpick and "Wite-Out". (Do it in yellow or orange or green for a custom look!) I think the cigarette pictogram on the lighter looks better if it's not re-done.

Ambient Air Temperature Gauge.

Bulb Replacement. [Dave Stevens] To remove the illumination bulb for the ambient temperature sensor, remove the instrument panel. The OEM Volvo (yes, dealer only!) bulb sits on top of the gauge unit pointing down. If you don't want to pull the panel, you can still get the bulb out by reaching up behind. There isn't a lot of room above the unit and you have to pull the kick panel and other impediments. The bulb has a blue plastic square back end that can be undone with 1/4 turn of an 8mm open end wrench once you have access to the left back side of the instrument cluster. Lift the old bulb out, pop the new one in and while pushing the bulb down in the socket turn it back 1/4 turn to seat it.

Gauge Reads Too High. [Inquiry] The outside temperature gauge is reading up to 10 degrees hotter than the actual ambient temperature after the car heats up.[Response: Tim/Editor] Sensor resides in a hole on the driver's side of the under-bumper air intake. It comes loose easily and is probably hanging next to the radiator. Pop it back in place, using a little silicone to hold it there.

Accessories:

Adding a Warning Lamp for Loss of Engine Coolant. See Loss of Coolant Sensor for Volvo 740/940 Cars for more information as to how to add this sensor and warning lamp.

Adding Accessories and Wiring Them Through the Firewall. See Running Wires From Engine Compartment to the Cabin for wiring tips.

Electrical: SRS Air Bag & Seatbelts

SRS Cautions. Before touching your SRS system or any of its components, be sure you know what you are doing by reading the Volvo OEM SRS manual which is available from Volvo Technical Literature. In addition, switch the ignition "off" and disconnect the battery negative lead before doing any work on the system. Do not pound or tap anywhere near the SRS crash sensor (for example, while under the car) if the ignition is "on" even if you are not working on the SRS system. Do not use an electrical welding unit on the car without disconnecting the battery negative lead. Do not under any circumstance use an ohmmeter or live electrical measurement instrument to measure resistance in the airbag/seat tensioner or wiring while these components are connected, as this may cause them to activate. You are highly advised to leave any repairs to trained dealer personnel who know what they are doing.

SRS Onboard Diagnostic Codes: 1992 and Prior Cars

[Tip: Bob] There are three possible locations for SRS test point. In 1992+ cars with two diagnostic test socket boxes (box "A" has the probe, the test button, and the LED readout lamp) at the left strut tower, socket 5 in box "B" is SRS. Accessing code and resetting is same as for check engine light.

In earlier cars, the test location is the fusebox behind ash tray. There are 4 fuse holders across the front of the fuse box, some of these do not have fuses. The second from left would be SRS test point. It has a terminal on one side only. You plug in to this socket and ground it to read/ reset code. [Jeffrey Davis] Use an 18 - 22 gauge solid wire with 1/4 to 1/2 inch of insulation stripped from the ends. Insert the end of the jumper you made into the test point opening so it is gripped by the clip inside. Arrange the wire so you can touch the other end of it to the grounded metal ring of the cigarette lighter. Turn the ignition on so the dash warning lights are on and wait 15 seconds. Ground the test terminal for 2 full seconds. The SRS light will flash immediately when the connection is first broken. This is not a fault code. The light will then flash one to ten times for the code (see table below). The light will then come back on. Without turning the key off, clear the fault codes. Ground the test terminal three times for at least 0.25 seconds each time all within a period of 1.5 to 5 seconds. It will probably take several tries to get the rhythm. The lamp will go out for 4 seconds, re-light for 3 seconds, and then go out. If the light does not stay out, then there is still a fault present and you will need to go further in to it. [Jay Simkin] Always read the codes three times before resetting them. Often they will not reset after just one, or even two readings. If you still have SRS trouble codes, try this as a last resort. Disconnect the negative battery terminal clamp. Let the car sit for 1/2 hour. Reconnect the negative terminal clamp and drive the car. Do this three times. If the SRS light re-sets, fine. If not, it is time to replace the SRS sensor.

In 780 cars, the test point for the SRS OBD system is not in the front row of fuse sockets nor in the engine compartment, but rather is a brown/black wire with a female spade connector, located in the vicinity of the fuse panel or behind the radio. Reading codes is done the same way as above by grounding the wire.

Code	Fault	Corrective Actions
1	Fault in crash sensor	Check all electrical connections and/or replace crash sensor.

2	Fault in standby power unit or in wiring between unit and sensor	Check all electrical connections between unit and crash sensor. Replace standby power unit. Replace crash sensor.
3*	Test terminal or SRS warning light lead is shorted to battery + or to ground. Symptom: warning light continuously on or always off. (*SRS light will always be on or will not activate)	Check at test terminal connector for short circuit to battery + or ground. Check wiring harness and connectors
4	Air bag assembly resistance low	Check wiring, contact reel, and connectors for short circuits. Measure resistance of contact reel. Replace air bag module
5	Air bag assembly resistance high	Check gas generator connector. Check wiring and contact reel for open circuit. Replace air bag module.
6	Not used	
7	Not used	
8	Air bag or wiring shorted to battery positive +	a. Check wiring and connectors for shorts. b. Check wiring and contact reel. Measure circuit resistance. c. Replace crash sensor.
9	Air bag assembly shorted to ground -.	a. Check for grounded gas generator wiring. b. Check wiring and contact ree for short to ground. Measure circuit resistance. c. Replace air bag module.
10	Mercury switch in sensor shorted, or closed for more than one minute. Lead to seat belt tensioner shorted to ground or battery positive.	a. Ensure that crash sensor is correctly installed. b. Replace crash sensor. c. 780: Check seat belt tensioner wiring.
11**	BOTH seat belt tensioners disconnected (no code if only one connected). (**780 only. Car must be started twice to enable code 11 to be displayed.)	a. Ensure both tensioners are connected. b. Check common wiring harness. c. Replace crash sensor.

SRS Onboard Diagnostic Codes: 1993+ Cars. Later 940 and 960 cars have an onboard diagnostic system for the Supplemental Restraint System that both monitors the system and stores any fault codes for later diagnosis. Faults can occur in components such as airbags, seat belt tensioners, and the sensor unit or in their associated wiring circuits. A fault is indicated by the SRS lamp in the instrument panel, which remains "on" until the fault has been remedied and the OBD system cleared.

SRS Codes. Per Jay Simkin, 9 out of 10 times some fluke makes the SRS code lamp go on, and once it is reset it never comes on again. There is always a chance that the system has a weak component (maybe the backup power capacitor) that may have been affected by an electrical glitch. Could have just been a very hard jolt that set it off. Make sure you follow the instructions carefully, including reading the codes at least three times, to properly reset the system.

A. To read faults, refer to the OBD diagnostic output boxes on the front of the driver's side strut tower. You will find two, labelled "A" and "B". Box "A" has the probe, the test button, and the LED readout.

1. Remove the selector lead from the side of "A" and insert it into terminal 5 of output box "B".
2. Turn the ignition "on" to key position II.
3. Wait about ten seconds.Press the button on box "A". Keep it pressed for about 1 second.
4. Read off the LED flashes. Codes have three digits: A-B-C. If code 1-1-1 is read, there are no stored fault codes. If a code other than 1-1-1 is obtained, write it down and press the button again to see if there are more. When the first code recurs, all codes have been read. If you can't obtain any flashing light, see No Codes.
5. [Jay Simkin] Always read the codes three times before resetting them. Often they will not reset after just one, or even two readings.

Code	Fault
1-1-1	OK: No faults detected in the OBD system
1-1-2	Internal fault in the sensor unit
1-2-7	SRS lamp, short circuit or break in circuit
2-1-1	Steering wheel module, short circuit in wiring
2-1-2	Steering wheel module, break in wiring
2-1-3	Steering wheel module, short circuit to ground
2-1-4	Steering wheel module, short circuit to +12V

2-2-1	Passenger module, short circuit in wiring
2-2-2	Passenger module, break in wiring
2-2-3	Passenger module, short circuit to ground
2-2-4	Passenger module, short circuit to +12V
2-3-1	Seat belt tensioner left, short circuit in wiring
2-3-2	Seat belt tensioner left, break in wiring
2-3-3	Seat belt tensioner left, short circuit to ground
2-3-4	Seat belt tensioner left, short circuit to +12V
2-4-1	Seat belt tensioner right, short circuit in wiring
2-4-2	Seat belt tensioner right, break in wiring
2-4-3	Seat belt tensioner right, short circuit to ground
2-4-4	Seat belt tensioner right, short circuit to +12V
No code	SRS lamp in the instrument cluster does not light
No code	Fault in diagnostic output

B. To clear fault codes other than 1-1-2 (indicating a crash sensor fault, which must not be cleared but rather returned to the dealer):

1. Remember to read the codes three times before clearing.
2. Remove the selector lead from the side of "A" and insert it into terminal 5 of output box "B".
3. Turn the ignition "on" to key position II.
4. Press the button on box "A". Keep it pressed for at least 5 seconds.
5. Release the button. The LED lights.
6. Press the button again when the LED lights and keep it pressed for at least 5 seconds.
7. The codes are now cleared.

To check whether codes are cleared, repeat procedure A above. If codes remain, then the fault persists and must be repaired.

[Jay Simkin] If you still have SRS trouble codes, try this as a last resort. Disconnect the negative battery terminal clamp. Let the car sit for 1/2 hour. Reconnect the negative terminal clamp and drive the car. Do this three times. If the SRS light re-sets, fine. If not, it is time to replace the SRS sensor and the power module.

"Bad" Crash Sensor and Wiring Connector Faults. How do you know the sensor is really bad? On my 91 240, the SRS light came on while driving indicating a fault in the system. I bought the factory SRS service manual which said that the trouble code showed a bad airbag or wiring from the crash sensor to the airbag. I then bought the test resistor which substitutes for the air bag to see if the SRS light would go out. Because the air bag and all the associated wiring checked good, the manual said the crash sensor is bad but only by elimination. After learning that a new sensor listed for $960, I studied the wiring diagram for the SRS system and discovered that the power for the SRS light comes from the dashboard not the SRS system which turns the light out when no fault codes are stored. So if there were no power to the system the light would stay on. I cleaned the contacts of the yellow or orange connector, where there was power, which is under the carpet of the transmission tunnel driver's side. I then cleared the trouble codes (see below) and everything checked out fine. That was over a year ago and the light reacts normally. The manual did not mention this as a possible cause. I hope this explanation will help you and others with "bad" sensors.

[More on this problem from Jeffrey Davis:] A common problem is corrosion of the contacts on the yellow or orange power connector for the crash sensor under the carpet on the transmission tunnel. If the procedure to reset the fault codes doesn't work, make sure the contacts are clean and then try to clear the codes again. If the SRS light comes back on, the problem is probably another component or even low battery voltage. Faults must be cleared for the light to go out.

Replacing SRS Crash Sensor Control Unit. [Query] I have entrusted my 1991 740 Turbo to a Volvo dealer to diagnose the SRS warning light. The service rep wants me to authorize replacement of the SRS control unit at a cost of $1500 (!), adding that the unit is 'mine' once the protective packaging is opened, regardless of the condition of the original. Given this policy, is it possible to determine if a SRS control unit is bad short of swapping parts? [Response] Buy a used unit from a boneyard. For about $100-150, you can purchase the sensor/control unit and power supply box, install it, and be off and running. Just make sure that the donor car did not have its air bags deployed: the crash sensor is a one-use-only device.

Air Bag Lifetime. [Query:] Airbag-SRS needs a check after 10 years. [Response:Bob] Volvo's intent for the 10 year SRS service (as indicated on the sticker) was to replace the air bag and check the system for faults via the SRS diagnostic conector. The bag replacement interval was extended to 15 years (Volvo Service Bulletin 88-0001 April 2003) . "According to the owners manual the airbag must be replaced after 10 years. Tests have shown that the service life can be extended to 15 years. Further tests have indicated that the service life of driver s airbags, manufactured between 1987 and 1992 which are 15 years old can be increased to 20 years. For driver's and passenger airbags manufactured between 1993 and 1996, the service life can be extended to 15 years. The airbag system has self-diagnostics. This means that the only check required is to ensure that the warning lamp is working and no diagnostic trouble code (DTC) is stored. The warning lamp indicates if a diagnostic trouble (DTC) is stored."
If the SRS light comes on with key in run position and goes out after approximately 10 seconds or at engine start, all is well. .

Seat Belt Mechanism Repair.

Seat Belt Won't Release. [Tip from Dick Riess] When my seat belt would not release, I squirted WD-40 down the mouth of the buckle receiver and now it works perfectly, in fact better than previously. Never have seen lubrication of this even suggested and I know a lot of receivers have been replaced. Perhaps they just need a squirt of lube. [Editor: try Superlube or Mobil 1 Spray for non-staining lubes].

Seat Belt Won't Fasten. [Query:] The driver's side safety belt on my 1990 740 will not fasten. It slides in the fastener/buckle but does not click and the holder will not latch to hold the metal tip in the buckle. When looking in the buckle, I can see some kind of red plastic device which I can move around but can't get out. Anybody had this problem before and know how to fix it? [Response: Alan Carlo] I had a similar problem on the passenger belt. I took it out of the car and disassambled the plastic cover. It is glued/sonic welded together so I had to cut/pry it apart. Once the cover was off I found a lot of junk in the mechanism. Carefully disassemble, clean and lightly lube the mechanism and test it before re-gluing the cover together. If memory serves there is a plastic slide and spring in there. It is clear how it works once the cover is off.

Seat Belt Retraction Reset. [Query] I removed the front passenger seat. When I was ready to reinstall the seat belt reel unit located on the bottom of the seat it wouldnt give me any slack. I could feed it more belt but it wouldn't give any back. After playing with it for too long I decided that I would just get a different seat belt from the junkyard. As soon as I removed the belt off another 740 it did the same thing. Is there any kind of reset? [Response: Don foster] You must hold the spool in exactly the same orientation as when it's mounted. Otherwise the internal latch locks it up. It can be a royal pita. [Response: Art Benstein] Hold the retractor perfectly level and steady while you pull out the belt. The spool locks when a weight senses inertial change. [Response: John Randstrom] You must duplicate the angle that the seat belt assembly is mounted to the seat frame before the belt will unspool. I took me quite a few positions before it freed up. After this experience I always pull out some slack and put a large safety pin through the webbing that prevents the excess from being drawn into the belt assembly before unbolting it from the seat.
Instructions with illustrations to rebuild the retractor when the seat belt retractor hangs, making it a PITA to get the seat belt out.

Seat Belt Button Replacement. [Query] The little plastic button, mounted in the seat belt near the edge of the seat, has broken and my buckle now falls to the floor. How do I repair this? [Editor] While the button is not available separately from the belt, you can fabricate a substitute using a "bachelor's button" from a fabric store. This is a button mounted to a thumb-tack-like post and can be inserted into the existing hole without damaging the belt.

Seat Belt Replacement. [Query:] I bought a 960 wagon as an accident victim. Replaced a windshield and fender and all is well except the passenger side seat belt is drawn tight and won't release. I opened the cover and see a cigar shaped item with a warning label. Can someone tell me my next move to solve our problem? [Response: Bob] Did your air bag deploy? If so, both front seatbelts MUST be replaced. The force of the pyrotechnic seatbelt pretensioners damages the inertia reel components, and the belts are streched. It is racomended all occupied belts be replaced after an accident, and the front belts always deploy with the air bag. If there was no bag deployment, there is a problem with the inertia reel and I recomend REPLACE that belt.

Air Bag Anti-Theft Devices. Has any clever Volvo owner out there come up with an airbag anti-theft device? At approximately $2,000 for each system, these have now surpassed radios as the number one stolen item on the car. I could imagine that someone could use anti-theft bolts to secure the bag asssemblies, or even cover the bolt/screw heads with epoxy to deter someone from a quick removal. Any ideas?
[Response: Tom Irwin] (un)Fortunately, I live in the car theft capital of the world [LA] and there are several solutions... The Robo Cap. This is an easy to use "half-cap" type device that slips over the underside half of your steering wheel. The Steel cap is covered with a good quality Nylon Material that has a sleeve sewn on it. From this sleeve you withdraw about a 14"l x .5"d

Chrome steel rod. Insert the rod down through the face of the cap and under your dash. It will snap into place and lock automatically. A simple twist of a high security key will release it and it stows in reverse order.   Using it myself adds about 20 seconds to my day.   Freon WILL NOT touch it. You can't get at the locking area. Hacksaw to steering wheel? Nope! Half the wheels circumference is covered. You need only protect ONE of your airbags. Since they deploy in pairs, a single (unprotected passenger side)airbag is virtually worthless on the black market. Oh, and it locks the steering too. Cost? About $50 US. [Response 2: Steve Ringlee] Try placing some hot melt glue in the recesses of the torx screw heads holding the airbags in position. This makes removing the bags impossible unless you use a pick to remove the glue, a deliberately tedious task designed to deter the thief .

Basic Information:

Electrical Diagnostic Supplies. [Editor] To assist in diagnosing and repairing electrical problems, consider acquiring:

- *Volvo OEM Wiring Diagram Manual*. This will be the best investment in manuals you ever made.
- *Silicone Dielectric Grease.* This protects all connectors (save low voltage circuits such as the oxygen sensor) from corrosion. Available at auto supply stores.
- *Electronic De-Oxidizer Spray*. This removes oxidation from connectors.
- *Conductive Grease*. OxGard (one brand for protecting aluminum home wiring) also protects chassis grounds. Not for use on electrical connectors.
- *Multimeter*. Numerous multimeters are available; look for a digital unit.
- *Continuity Tester*. This is a simple buzzer or lamp that shows continuity in a circuit. Available from auto, home electrical, or electronics supply stores
- *Wire Crimper.* Sears Craftsman or Radio Shack both have good hand crimpers. Harbor Freight has a surprisingly good ratcheting crimper that modulates the pressure on the crimp.

Wiring Diagrams Website. [Editor] See http://www.autoelectric.ru/auto/volvo/740/1989/740-89.htm for some scanned OEM wiring diagrams of selected 740, 940 and 960 cars. These are limited; you should purchase, as one of your first manuals, an OEM wiring diagram book from Volvo.

Electrical Diagnosis Tips. For a superb introduction to basic automobile electrical diagnosis using a digital multimeter and accessories, see Fluke Corporation's website reference at http://www.fluke.com/application_notes/automotive/beatbook.asp?AGID=1&SID=103

Wiring Fault Diagnostic Tips. [Tips from Import Car Magazine]
DIAGNOSTIC THOUGHTS
Wiring failures occur as open, shorted or short-to-ground (grounded) circuits. An open circuit, obviously, is a broken or disconnected wire. Shorted circuits occur when the insulation between two wires fails. Grounded circuits occur when a bare wire is allowed to touch the vehicle's powertrain, sheet metal or frame. As for narrowing diagnostic probabilities, let's remember that:

1. Before wasting hours of expensive diagnostic time, test all fuse circuits with a DVOM or approved test light. Remember that fuses can fail without showing signs of an obvious burn-through. Since a loose or corroded fuse connector may also cause many intermittent circuit failures, thoroughly inspect and clean the fuse circuits before proceeding with your diagnosis.

2. Most wiring failures occur at either end of the wire as a bad connection. Although splice failures inside the wiring harness are rare, some nameplates are notorious for splice failures. Technical service bulletins (TSBs) and Internet sources offer valuable insight to typical nameplate problems.

3. Corroded harness connections cause most intermittent circuit failures. Simply unplugging the connector and applying an electrically compatible corrosion inhibitor will repair most connector failures.

4. When diagnosing intermittent failures, remember that suspect turn signal flashers, fuses, bulbs and relays can be replaced more cheaply than they can be diagnosed. When diagnosing an intermittent lighting failure, for example, I always begin by cleaning the bulb sockets and installing new bulbs. How much diagnostic time are you willing to spend testing a $0.98 light bulb that's nearing the end of its practical service life?

5. Engine, computer and body ground connections should be checked first, especially if the vehicle has recently visited the collision repair shop.

6. Keep in mind that most electrical systems, when left untouched, perform very reliably. When they do fail, the failure will be predictable, such as a bad current or ground connection, blown fuse and the like. Most predictable failures can be solved within a two-hour time block.

7. On the other hand, the DIY mechanic "short-testing" a cooling fan switch or fuel pump relay can create a multiple failure with unpredictable consequences like burning a wire within a wiring harness. Obvious tampering should always create a red flag... Electrical "red flags" may include newly installed sound systems, electrical accessories, trailer brakes, auxiliary lighting and the like...

8. Many circuits serve more than one accessory or function. Years ago, for example, I found that a burned brake light fuse was caused by a loose courtesy light in the ashtray. Without a good magnetic short detector, the problem would have been difficult to solve since a relationship between a brake light and ashtray light isn't immediately logical or clear, to say the least. In other unlikely cases, I've found an instrument cluster fuse that also supplies field current to the alternator. The moral is, never rule out the effect of one circuit upon another...

10. In fact, avoid using test lights altogether. When testing fuses, for example, I use an LED-type test light (available from a major tool manufacturer) that indicates open or grounded fuse circuits and voltage availability. This eliminates guesswork and protects ground-sensitive electronic circuits like air bag sensors.

11. Use a professional DVOM with a min/max voltage feature and alarm to test intermittent failures. The min/max feature will record the highest voltage reached in the circuit and sound an alarm each time a higher voltage is reached. For the technician working alone, this feature is a real time saver, especially when performing a "wiggle" test on an intermittent wiring problem. In the same sense, lab scopes are particularly useful to find loose ground connections. During a wiggle or vibration test, loose ground connections will show up as a voltage spike in an otherwise zero-volt lab scope waveform.

12. Remember how hard it is to find the trim screw driven through a wiring harness hidden underneath a headliner? A good short detector will help you quickly locate concealed short-to-ground circuits. For about 30 bucks, it's a great time saver for you and your customer alike.

13. Tips on Finding Open Circuits. An open circuit is the opposite from one that is "shorted", because it is similar to a cut wire that is not connected to anything. This can be tricky to find since in an "open" circuit, there is no electricity flowing to help you locate the spot with a meter or short finder. This diagnostic trick uses the car's radio and any device with a large LCD display like a calculator to find an open circuit, but only if the car's antenna mast is metal. Let's say the brake lights are inoperative due to an open positive feed from the brake light switch. You have already found the wire to be open somewhere by an ohm meter test, but you don't know where and would like to shorten the search. Before you go ripping the carpet and interior trim out of the vehicle looking for the broken wire, grab your calculator. Start by disconnecting both ends of the line (unplug the lights end and the brake light switch then consult a wiring diagram to make sure any other devices attached to that circuit are disconnected). Connect an insulated jumper wire between the antenna mast and one end of the offending wire. Tune the car radio to a quiet (unused) AM channel. Turn on the device you are using with the LCD display (like your calculator) and pass it down the offending wire. You will hear the "Radio Frequency" noise generated by the LCD display in the car's radio speakers as you pass the good sections of wire and will fade out as you pass the break. You can demonstrate this test by tuning any radio to a quiet AM station and passing an LCD display device over the antenna.

14. Tips on Finding Short Circuits. See the Special Tools section of the FAQ for suggestions on tools capable of rapidly locating shorts in wiring harnesses.

Fuse Locations. See the following diagrams for fuse locations in 740/940 and some 760/all 960 cars:

740-940 Fuse Panel Location

960 Fuse Panel Location

740/940 Fuse Locations 960 Fuse Locations

Relay Basics. For a good site explaining the basics of relays, see Basic Car Audio Electronics.

Relay Locations. See the illustrations below left and middle to identify relays in *740/940 cars*. Caution: relay locations vary by model, year, and market: to determine differences, use an OEM wiring diagram book. To access relays, remove the ashtray (push the spring clip at the top) and fuse panel cover (push the plastic snap at the bottom). Then remove the snap-on cover over the cigarette lighter with your fingernail or a small screwdriver. Remove the two philips screws securing the storage box: one of these is angled in. Remove the storage box by gently tugging on the left side, pulling it and the cigar lighter wire out from the console. Beneath it you will see the relay tray behind the fuses. For *760/960 cars*, starting in the 1988 model year the relays are mounted under the left hand console panel, just the the left of the front passenger's left knee. Pull gently on the panel and it will unsnap. See the right illustration. Beginning in 1995, 960 cars have relays in the engine compartment and in the fuse panel shown above. *1994/1995 940 B230FD* non-turbo cars using either Bosch or Regina have rather square, squat, blue-colored fuel injection relays in the front row, second from right.

740-940 Relay Panel to 1993

740-940 Relays to 1993

760-960 Relays

Relay Removal. [SGFM] Relays in most cars pull straight up from the relay base. However, in some 760 models (with relays located behind the lower dash panel below the stereo, facing the passenger side) the relays have retention devices. Two sides of each relay are held by plastic clips that must be pried OUTWARD at the same time to allow removal of the relays. Unless you accomplish this maneuver, you'll either break the relay or the retention device when forcing the relay out. I found that toothpicks wedged into each side retention device allowed the relay to be removed with the least amount of pain. In the 760/960 diagram shown above, A, B, F, J, L, and M are permanently attached to the board.

Air Conditioning Relay. [Inquiry] The 700/900 FAQ shows the relay cluster, but there is no AC or ACC relay shown on this panel. Where is it? [Response] Check your wiring diagram. If an air conditioning relay is fitted, it generally will be located behind the glovebox.

Relays and Fuses:

Fuel Injection Relay Applications. FI relays can differ by model. According to the Pocket Date Book from Volvo, all F/T engines (both Bosch and Regina systems) through 1993 use the -608 white relay regardless of turbo/non-turbo. For 1994 and after, B2XXF NA-engines use the -270 relay and T turbos use the -608 relay. All E engines use the -639 relay. However, some 760 Turbos use the green 1362914 relay. Per John Marshall in New Zealand, some of the later 9 series (1994 onwards) have a different layout of relays and use a blue Hella fuel pump relay, mounted second from the right in the front row. The one to the right of it is the same Hella relay, used for high beam lighting. The Hella relays on have 5 pins in the base and are marked as follows: Hella 12V/ 4RD/ 003-520-52. Even a diligent search of Volvo Technical publications (e.g., the wiring diagram, that for other electrical equipment, etc.) will not show this change in the color, size, and location of this relay (versus the white, rectangular, second-row position, for earlier 940s).

Relays and Fuses Overheating. *Relays.* The fuel injection relay should not get hot even if the pump is drawing too much current...until the excess current starts to kill the contacts. Either way, a hot relay is a bad relay. There are three possible reasons for a hot relay:

cold solder jointcracked

bad crimp jointin the base
bad relay contacts

Resoldering Internal Relay Solder Joints. All mean that a point in the relay has resistance and when current flows through that point there will be a voltage drop which means work is being done and that work manifests itself as heat (P = E * I). Over time the bad joint gets worse due to the heat and maybe heat/cool cycles, the resistance goes up, the joint gets hotter, the voltage at the pump goes down so it needs more current to do the same work so the joint gets hotter, it gets worse, well you get the picture. At its worst this kind of scenario can destroy a motor because the low voltage condition causes a high current draw which over heats the motor. The relay may or may not be fixable. I usually try to fix them and am often successful. Note that Volvo released an improved relay, which has silver base terminals, to solve this problem. If the car's existing relay has copper-colored terminals, replace it with the newer relay. [Another:] Your description of the innards of the fuel pump relay sounds right.... the wires from the solenoid coils to the PCB are small and fragile -- but I've never experienced them breaking (at least, breaking from vibration). Because they're fragile, fingers off! Soldering the PCB is done on the other side from the components. You'll notice the component leads (including the fine wires) stick through and are soldered to so-called "traces". These traces are copper, but are usually completely covered by solder so have a silvery color. You'll also see where larger tangs stick through and are soldered -- these are the heavy-current leads from the relay contacts as well as the relay connectors. I usually solder the heavy connections using a soldering gun (but carefully, because these deliver a lot of heat quickly, and can damage a PCB). The smaller solder connections are best done with a small 25-Watt iron. Of course, you must use electronic solder, not plumbing solder (which contains an acid-based flux).

Soldering the Relay Base Crimped Connections. I've seen several instances on 740s of excessive contact resistance at the fuel pump relay base connector. This causes overheating and melting of the spade connectors and plastic socket. It probably wouldn't hurt to examine the male spade connectors and socket for signs of high resistance and overheating (discoloration of metal, melted or burned plastic). [UK Club] The problem seems to be poor connectivity at the terminal end of the wire. Over time, the factory crimped wire and relay base connector increased in resistance and overheats. I eliminated the problem by soldering the wire and connector to correct or reduce resistance heat. Unplug the relay. Pull up the base and cut back the wire insulator just slightly. Prepare the surface areas and solder a bridge between your wires and connectors. You do not have to put on new crimped connectors. Re-insulate the exposed areas with a liquid insulator. Install the relay. *Crimp Integrity.* [Rick Taylor] After my wipers and heater stopped working, I took the fuse panel cover out and discovered that for the relevent fuse, Volvo uses one hot wire for three fuse positions. This single hot wire fed the blower, wipers and the SRS system fuses! It was loose under the panel and I re-crimped the contact to make it fit tighter. This seems to have solved the problem.

Drilling Holes in Relay Covers to Cool Them. Problems with the 740 fuel pump and headlight relays are well documented. Volvo has a tech. bulletin that recommends replacement of the relays and the sockets, which have both been done to my car before I purchased it. Driving today, I put my finger on the fuel pump relay and it was darn warm. I could just hold my finger on it - any hotter and I wouldn't be able to. Is this normal/acceptable? If no, what's the fix (another relay??). [Response:] Relays on Volvos run hot. That's why I drill holes in the covers. You must first remove the circuit board to drill the cover. On overdrive relays, I have never had to replace a relay with holes in it, it seems to help a lot. I have also run cooling to the relay/fuse board from the crotch cooler port, so when the A/C is on, it blows cool air on the board via hose. It may help and can't hurt.

Socket Integrity . [Bob Kraushaar] If a relay/fuse is not firmly set in its socket, a poor contact can result, which results in overheating and melting plastic. If the plastic holding the wire connectors melts/softens enough, the connector can be pushed out of the retainer and make contact with nearby wires or metal parts. This, in fact, happened to my headlight relay with resulting smoke and intermittent light failures.

Relay and Fuse Panel Removal and Replacement .

Preventive Maintenance. [Jim McDonald] Relay and fuse connectors carry a great deal of current. Removing and reseating the fuses and relays every couple of years will ensure that the connections are seated and will also diagnose loose connections prior to failure. Look for evidence of burned fuse or relay holders when you do this.

Removing the Fuse Panel. It is possible to pull the whole relay panel out the front of its opening. Use a good light so you can see well. First remove the plastic storage box (which also contains the accessory socket) above it to facilitate this. The trim around cigarette lighter will pry off to reveal two screws, one going straight in and the other going in at a 45 degree angle. Put your hand below the screws as you remove them as there is a great likelihood that the panel nuts into which the screws are secured will fall out when the screw is pulled out.
To remove the relay tray beneath, look for the white catch on the left towards back of relay panel (back meaning towards back of car). Push this to the left and then lift the relay board up at least 1/2 inch before the tray is pulled rearward and out. If the tray does not side out toward you, the plastic tab might be catching on a side lip of the fuse tray or the spliced and bundled electrical wires running to the back underside of the tray might be catching. Pull gently to allow the wire bundles to unflex as they are removed. The opening in the console is just the right size--the tray does not need to be turned or twisted.The wire umbilical attached to it is long enough to allow the panel to be pulled out quite far. This is also how you can hook up accessories to the fuse and relay connections under the panel.

Replacing the Fuse Panel. [John Sargent] If the airconditioning and heater fan are used much, all 1984-87 760s, and all 740s and 940s (not the 940SE) will eventually wear out the fuse holder for these functions. It is fuse 14 on the early 700 series, and fuse 16 on the later 740s and 940s. The heater fan and AC quit working at all on my daughter's 1987 744T, and the fuse block looked like this. Fuse holder 16 is melted.

Burned Fuse Position 16

I was originally going to bypass fuse 16 with an external fuse holder, but this fuse block was so bad I decided to replace it. Replacing takes a little more time but it isn't hard to do. Get a good fuse block. Disconnect the battery ground before you start. Remove the ash tray, fuse cover, cubby hole, and radio. Then you can lift up on the Central Electric Unit, pull it towards you, and turn it over. Yes, the wires are long enough. They were made to do this.

Once the CEU is out and turned over, this is what you will see.

Fuse Panel Color-Coded Wires and Connectors

Everything is color coded to its location. The supply wire for each fuse is in the plastic socket,and is marked with a wrap of black tape. Remember this. Some supply wires feed more than one fuse, as the fuse supply sides are connected inside the fuse block. The supply wire for fuse 16 also supplies fuses 14 and 15 on this car. If you are uncertain, take a picture with a digital camera before you start removing wires.

Once the wires are removed, use a small screwdriver to raise the black plastic over the three lips on the front of the fuseholder. When re-installing the wires, be sure to push them all of the way onto the spade fittings. I use needle nose pliers for removing and re-installing the wires.

Relay Tray Removal and Replacement. My headlight relay got into a bad habit of getting real hot. I had the same problem and after replacing the relay, I replaced the plastic base. It's quite easy, get yourself a Volvo part1307160 (CAD$2.89) and pull your relay/fuse tray out of there. After removing the relay, flip the tray and remove each wire (tape the lug & mark the position). You can usually coerce any crimp-on connectors out by bending the little tab internal to each connector (with a small screwdriver).Once the relay base is clear of wires, unclip and push it out. Install your new base and re-install each wire in the proper position. With crimp-on connectors, you can use a knife to "restore" the little tab on each crimp connector so that it "clicks-in" when you re-install the connector in the base. I find that, It is vital to have firm connectors or else they slide out when you push-in your relay! One additional note... The base melts because there is resistance & arcing between the crimp-on connector and the relay lug. There is quite a bit of current going through there and you want to make sure that you have tight connections. You can do that by "squeezing the gulls" of each crimp-on connector. Contacts #30, 87 & 87b are the culprits (not sure if they are all used though). My relay panel is all plastic. Double-check the part number of the relay base by removing a relay and reading the part number in the center of a "good" relay base.

Crimp Failure. Note that cases of relay or fuse panel socket connector failure have been traced to the crimp on the wire. To solve this, solder the connector to the wire and re-insulate with liquid electrical tape.

Melted Heater Blower Fuse. [Inquiry] My 1984 740 Turbo has a melted fuse that protects the heater blower/ac circuit. The fuse did not blow, but instead heated up enough to melt the fuse and the surrounding fuse box. Suspecting a short to ground fault within the circuit, I have examined the wiring and do not visually see any bare wire. I have replaced the blower motor, relay, and the fan motor switch without solving the problem. [Response: John Sargent] This can be fuse number 14 (early 740s) or 16. The fuse and fuse holder are simply overloaded in the basic design. There is too much current draw on the fuse holder. It was fine when new, but too many heating cycles weaken the grip of the fuse holder on the fuse after 15 years. This is a very common problem on 700 series Volvos. Unless your car has over 200,000 miles on it, the only part of the central electrical unit that will be bad is the fuse holder for fuse 16. Nothing lasts forever, but fuse 16 is the weak point. The wiring to the CEU should be fine, although high mileage cars can have troubles at other relay sockets. You have two choices:

1. Replace the entire fuse block panel with a new, or good used unit.
2. Buy a new fuse holder and power the AC and heater with it.

If you choose option 2, you must pull the central electrical unit out and turn it over. Splice a fuse holder into the lead supplying power to fuse 16. Splice the load side of the new fuse into the black lead supplying power to the heater and AC unit. You must continue to supply power to fuse 16, as fuses 14 and 15 are fed from the supply side of fuse 16. It is possible to intercept those black wires elsewhere, but it is easiest for me at the CEU. If you can get enough slack in the black wire which supplies fuse 16, a red wire nut works great for spicing the new fuse holder in and keeping fuse 16 supplied with power. The fix will be less than $5 US.

Fuse 5 (Clock, Etc.) Failure Diagnostics. [Tip from R. Duke] I had the classic symtoms of a blown fuse #5 due to a short - lost power to clock, etc. The "ding ding" indicator signal was also constantly sounding. It looks like one of the most common causes is the courtesy/dome light. The circuit board in it can develop a short. The circuit board contains the timing circuit for leaving the light on after you enter the car until you have time to put the key in. Apparently this part has gone through several updates. The internal parts are quite different on the updated one. The new one cost about $78, but it does come with the lenses and bulbs. It actually works better too (better switches). Volvo has a parts bulletin about the change. The new one has a different connector and you are supposed to crimp new pins on each of the 4 wires (Volvo can supply those too). Those pins are hard to crimp unless you have the correct crimp tool, so I just soldered 4 jumper wires on to the circuit board and used insulated spade connectors on the jumper wires to attach to the 4 supply wires. If you ever get this problem. Pull the fuse and take a reading to see which side of the fuse holder has 12 volts on it. Then take an ohm reading from the other pin to ground while you look for the short. That is easier than blowing a bunch of fuses. There are a lot of devices on that fuse.

Repairing and Resoldering Relays. Here's a generic statement about your relay -- this statement displays my bias about the poor quality of Bosch wave soldering. If you can pop the cover off the relay using a small screwdriver to pry the cover at the edge, try resoldering all the connections on the circuit board before you replace it. (After all, you have nothing to lose but a few minutes.) The heavy connections that go to large components like the actual relay may need a large soldering iron or gun, whereas the connections at smaller components, such as transistors, should be reflowed using a smaller iron, like a 25-Watt iron. Use rosin-core electronics solder. If you're not comfortable soldering, find a friend who is.

Cracks in Relay Solder Connections

[Don Foster:] Over time (like 10 years), the solder used in production manufacturing tends to become crystallized and cracks. The type of solder used in high-volume production is different than that used in an electronics repair shop. The problem with the relays is tiny, almost invisible microscopic cracks in the solder. These cracks usually encircle one (or several) heavy connections, such as from the relay or a main lug connector. Under a bright light, and using a magnifying glass, inspect the soldered connections. Don't forget to look for broken conductive traces as well. Simply resoldering these circuit board very often restores them to perfect performance, and it's a whole lot better (and cheaper) than a $50-$100 replacement part. I have recovered literally dozens of Bosch relays (OD, fuel pump, wipers) to perfect performance this way at $0. In fact, I resoldered ALL the relays in my family's 6 Volvos before a failure stranded us. The illustration shows an overdrive relay with solder cracks. Not shown is a broken trace (discovered with a magnifying glass) at the top of the board, repaired with a soldered jumper wire [courtesy Don Foster] [Murph] It's very helpful when resoldering a relay to treat the pins with some Caig "ProGold" or "Gold Guard Pen". It can go a long way in preventing oxidation. Easy to apply & no waste, but expensive. Any good electronics parts shop will have it

Soldering Tips and Techniques. [Don Foster] See the excellent Heathkit discussion of how to correctly solder circuit boards and contacts as well as Jay Simkin's tips below.

Overdrive Relays. See the photos to the left. *Other Relays*. [Ed Lipe] Relays fail the same way in any early model vehicle: solder joint cracks on the boards. Keep this in mind when you have intermittent problems with any of the relays in your car.

Lamp Failure: Bulb Out Relay.

General. The bulb-out relay senses differential current flows to paired lamps to detect a bulb failure. If it senses a bulb failure, it illuminates the instrument panel warning lamp. However, if the relay itself fails, then the brake lighting circuit (among others) will fail completely and the cruise control will also cease operating.

Brake Light Failure:
[Inquiry] The brake lights on this car don't work. The fuse is okay, there is power at the brake pedal switch and the switch works. I get no continuity, power at the white junction block leading to the rear harness. Could it be the bulb failure relay itself or is there a little rats nest in there somewhere. [Response: John Sargent] The brake light

failure in our 87 745T was caused by the bulb failure relay. You may be able to re-solder, or you can replace it. The bulb failure relay is in the front left corner of the relay plate, and is red and round. [Self-Diagnosis from Guy Jett] It was the bulb out relay. The counterperson at the local Volvo dealer said "Oh yeah, they go out all the time." Note on diagnostics. It was helpful to disconnect other bulbs and see that the bulb out relay still was not working. I think I will keep a bad bulb or two in the future for such testing. [Jason Kneier] I opened the bulb failure relay up and traced the path the brake light circuits took. I saw two suspect solder joints, both of them 'bridging pins' that connected between the three boards, and so I resoldered them and put the relay back in - Success!

Headlamp Failure:
[Inquiry] Driving headlights only work when high beams are selected. Please help. [Response: John Sargent] Are your low beam fuses okay? If they are (and they probably are) you either have a bad high/low switch (unlikely), or a bad Lamp Failure Relay. The Lamp Failure Relay supervises the Low Beams, the Tail Lights, and the Brake Lights, but not the High Beams. Lamp Failure Relays do go bad. Remove the Lamp Failure Relay from it's socket, and test for voltage at the pin connection for terminal 56b, which is one pin clockwise from the pin socket labeled S in the relay base of the Central Electrical Unit. Terminal 56b is the output for low beams from the high/low switch. If you have voltage there, the high/low switch is good on low beams. Re-install the Lamp Failure Relay and test for voltage at the input side the the low beam fuses. If you don't have voltage there, the Lamp Failure Relay is bad. You can pry the cover off and attempt to re-solder it, or get a used one. The headlight relay is energized by the light switch and supplies current to the high/low switch. If it was bad you would only have high beams when pulling the high/low switch towards yourself. In this momentary position, the current for the headlights comes from fuse 2.

Engine Wiring:

Removing Engine Wiring Connectors and Ties . [Inquiry] What's the trick for removing the Bosch connectors with the wire spring retainers? I know I'm missing something simple here... [Response: R Haire] Depress the spring toward the connector to release the locking action, then pull. It can be frustrating with oily fingers groping under the manifold for the right pinch.

Releasable Wiring Ties. [Carter] The releaseable ties that attach to little posts along the firewall and elsewhere in the engine compartment are Volvo part number 969019/ product number 489492-001 costing about $7.50 for 10.

Baked Engine Relay Connectors. [Tip from Dick Riess] Son's car decided to have some relay problems. Wasn't the relay, but the plug in ends had turned to mush. After chasing my green manuals, I found the answer. These are in stock at Volvo. They are terminals, the insulated kind that insert in various grey connectors, including relays, wiring harness hookups and fuel pumps. These are complete with a pigtale so they can be soldered or crimped together. Volvo number is 3523813-8. Suggested retail is 5.29, got mine for 2.95, so they are reasonable.

Wiring Harness Connector

Wiring Harness Connector

Baked Engine Wiring: 700/200 Cars. [Early-80s to 1987 240 and 7xx cars:] Harness failure often causes multiple symptoms such as rough idling, stalling, hesitation, overall erratic performance and random misfiring. The symptoms may mimic ignition or fuel injection trouble you've encountered on other cars. I cannot address 240 vehicles newer than 87, the friends I help do not own anything newer. In all the 240's I've seen there are several wires that are "flaky": oil pressure; alternator wires and alternator dash signal; knock sensor; water temp gauge; starter from ignition; starter to coil; primary ignition wiring near the ignition coil; and on 7xx cars, harness connectors in the right rear corner of the engine compartment below the ignition coil. ALL the wires from the ECU do not show any signs of deterioration in any of the harnesses we have opened up. Since the flaky set are wrapped into the main harness to replace them means replace everything. At big $$$ for Volvo & the service center. After getting nailed for the 85's harness, I took preventive measures on my 83 and others until we find a long down time to correct the problem. We replaced the alternator and the oil pressure sending wires rerouting them around the right side of the engine bay. We believe that if the alternator wire shorts to some other wire that is where the big problems could occur. The alternator wire has the potential to supply a constant 12+ volts to any of the others (which are to ground) and act as a heater wire inside the harness, getting hot enough to melt all the others. In my 85 it was from the starter wire to the alternator wire up by the dash connector and was caught before much damage was done. Had it replaced by the dealer thinking insurance only to find that insurance refuses to cover this problems in Volvo's. Cutting open that harness revealed NO damage or deterioration to any other wires in the harness except the above wires. Our solution: We reroute with new wires to all of the above sensors. Best done with some other time consuming task. To make it really easy we release the intake manifold. Takes two of us about 3 hours to reroute all wires and replace the manifold. Tried it first without releasing the manifold and it took 8 hours. I believe Volvo could have created a replacement harness consisting of just these wires but did not do so because of $$. Another is that if you catch the problem soon enough no other wires will fry because of a short between two of the bad wires. Wait too long and other wires will be damaged from the heat of the short. Since this is probably about the time Volvo found out about the problem, it looked to them like all the wires in the harness are bad. See Dave Barton's extensive discussion of wiring harness woes.

[Quick preventative:] Watch the wires coming from the connector directly under the windshield below the driver and the oil pressure and alternator wires on the right front of the motor. These are the first ones to go. If it starts reroute the alternator wire first as this can cause the most damage if left in the harness. Then replace the starter, then the coil wire as these have the next greatest potential for damage. If you can, get the wires replaced before they cause other damage, do so as the cost will come out of your pocket.

[1983-1987 7xx cars:] If you are referring to the problem of wiring harness rot that affects the 83-87 models, it usually affects the harness on the engine. On the LH cars, this usually includes a fuel injection harness and a separate ignition system harness. However, I have seen some deterioration of other underhood harnesses including the wiring that goes to various lights (turn signals, corner markers, headlights, etc.

[Advice on replacement:] The engine wiring harness went bad on my 1983 240 Turbo (170,000). I noticed it first when my starter would try to engage occasionally when I hit a bump or turned a hard right. The wires up by the firewall on the left side of the car were bare at the connector. I tried to separate and tape them, but that did not work. I found out why when I replaced the harness. The harness runs along the left side of the block, and EACH of the wires was completely bare the majority of the length of the block!! As you know, depending on which ones touched which, anything could happen. REPLACE the whole harness!!!!!! Trying to patch it will only lead you into hours and hours of nightmares both as you attempt to cob it together, and as soon as moisture gets in your cheesy butt connectors and your gauges, idle, starter, etc go wacky!!!
Remember: My Volvo is Turbo. Although a similar process, I can not speak directly on the naturally aspirated version. The job took me (a former diesel mechanic but working with limited tools on this job) 5 hours. I unbolted the intake and pulled it away from the head. Of course to do this you will need an intake gasket. I recommend you do this also, as to work around and under the intake would be treacherous. With the intake pulled away, you can see straight down in there. You may want to replace your flame trap when you are in there as you have a straight shot at it. Any troublesome vacuum lines could easily be swapped out also.
The new Volvo harness is color coded exactly as the original. (big advantage). It is also exactly correct in length. (huge advantage). Just remove the old one, being careful at each connection - temp sensors, alt, oil press, etc. are all very dry. You may have to cut the old harness out in pieces as it is not pliable at all. Install the new one by starting at firewall and working your way along the block and around to the oil press and alternator. It is pretty self explanatory really. Leave about 5 hours to do it. This sounds like a lot, but multiply it times the hourly rate of

your local shop, or the cost of burning up a starter (and a tow) like I did, and you will have a little more incentive to clear up some time on Saturday morning. No special tools. (May want torque wrench for intake if you are REALLY particular). I shopped all over and I purchased it from NILS SEFELDT Volvo in Houston Texas (281) 721-1600 (800) 468-0041 for $230.22 and the gasket for $11.70. [Additional tips from Dick:] My suggestion: do not remove the intake manifold on the 700 series. Remove AMM and hose to intake, idle speed motor and hoses, also flame trap and oil trap. Label stuff carefully. Begin your rewire from under the car, ie the oil pressure sender light, removing the old stuff as you go. Your new harness has yellow bands indicating where the clamps should be. Remove the harness from the AMM and replace with new. You will have to remove the knock sensor wiring and mark it . I think you get the picture. With the oil trap removed, you can clean it and put a new O ring on it (leak source) and new flame trap. Other suggestion is to remove the 3 plug ins on the passenger side and pull then through and under the manifold along with the injector harness stuff.
Believe marking and labeling is extremely important. I blew the brains out of a 240 by mixing up two similar 3-prong connectors. Label the old harness too because you can always compare wire colors in the connectors that are alike.

[More from a VCOA Wiring Clinic, courtesy of the BrickBoard:]

Scope: The problem afflicts 200 and 700 series Volvos manufactured during the period 1983-1987 [Note: several commentators would also include the 1981 & '82 models of 240 series.]. The problem has also appeared in other vehicles manufactured during the same period with Bosch electrical systems. Owners of all vehicles manufactured with Bosch electrical systems during the period should inspect the engine wiring harness. Anyone considering purchase of such a vehicle should inspect the engine wiring harness if the harness is the original.

Presentation of problem: Disintegrating insulation on wires exposed to high temperatures for long periods (10 years or more).

Symptoms: All vehicles within scope are vulnerable to the problem. Close inspection of the engine wiring harness will reveal the problem before it causes short circuits. If a vehicle within scope exhibits drivability problems that are intermittent and cannot be otherwise diagnosed, short circuits in wiring harness caused by deteriorating insulation may be the cause.

Inspection: Use a strong light source and check wiring, paying particular attention to wiring passing close to high heat sources. High heat sources include intake manifold, exhaust manifold, turbocharger, block, firewall.

Common locations presenting problem: B23: firewall near main connector, alternator, intake manifold. B230: ground wires on intake manifold, oil pressure sender, water temperature sensor on block. B28/280: no engines were available for inspection.

Solutions:
Temporary solutions: liquid electrical tape, applied in several coats over several hours, good between -20 and 255 degrees F; shrink-fit insulation, applied with heat gun or torch, good past 400 degrees F, but hard to fit correctly over end connectors; spliced wiring, recommended by some Swedishbricks and SAAB list members as the most nearly permanent fix that does not require a new harness. Standard electrical tape is at best a one-month reprieve. Any solution short of splicing lasts no more than a few months. [Editor] Normal PVC-insulated wire, used as a replacement, will not last long in high underhood temperatures. [Tip from Jim Bowers] DO NOT use teflon insulated wire around your car. While it has the best high temperature rating it is notorious for "cold flow". Where it is bent around a corner the insulation will eventually "flow" out of the place where the pressure is and it will short. Kapton is a another high performance insulator that is so good in tests, that it passes the tests with very thin dimensons, saves space and weight. However, over time vibration can wear through the stuff. It has superior mechanical, temperature and radiation properties. "Flex" circuits are often made using it as an insulator. Its "natural" look is orange and semi-transparent. Its so $$$ that it isn't used often. After considering everything, irradiated polyolefin is a good choice. [Tom Irwin] It may be best to get a good one from a wrecker and graft new sections onto the rot. 1" strip and a union twist in the wire. Silver Solder and a 1,200 degree iron. FLOW it in there. Use a 3M product "self-sealing silicone wrap" used for field repairs on high power lines. Stretch

it til it just about tears and wrap your wires tightly. As it heats and ages it melts together and forms a tough, conformal coating. Stuff it in a split loom and tie wrap it up.

Permanent solution: new wiring harness, cost ranges between $250 and $350 (US). VCOA has been successful in persuading Volvo to lower the price of its wiring harnesses for vehicles within scope, and current price range quoted above reflects those reductions. Prices have been cut from 33%-50% from previous levels (Example: old price of engine harness for B230FT engine was approximately $500, now reduced to $270). Dealers who offer club discounts will add their standard discount to the current prices. It is absolutely critical that you order the correct harness. Very difficult to do when there are 3-4 variants out there, yet little way to tell the harnesses/ engine applications apart.

Labor Requirements: Owners who prefer to have a mechanic install the new wiring harness can expect to pay 4-6 hours of shop time for the job. Owners who prefer to do the job themselves should set aside one or two days. For the B230 engine, it is recommended that the owner have all vacuum hoses replaced at the same time, as well as fuel injector seals. In addition, performing the job on the B230 engine involves removal of the intake manifold and air intake valve, and so requires replacement of the intake manifold gasket and the air intake valve gasket. Owners who have replaced wiring harnesses of B23 and B280 engines may wish to offer advice on other maintenance that should be performed at the same time, as well as other parts (besides the wiring harness) that may be required. Dielectric grease for multi-pin connectors, as well as an oxidation inhibitor for single connection points to aluminum ground, are recommended. Do not interchange the two, as dielectric grease is an insulator, while oxidation inhibitor is a conductor.

Picture References. Check out http://www.homestead.com/volvo2/harness.html
for visual images and instructions for wiring harness replacement and other maintenance items. See Dave Barton's excellent site for details on the harness problems.

Replacement Procedure:
[Dick Riess] For those feeling threatened by this job, it can be done relatively easily, in my case under 4 hours of puttering slowly. Also, a good source is Dave Barton and his super choice used harnesses.

- Unhook the ground battery cable.
- Remove the intake hose from the AMM to the throttle body.
- Remove the idle speed motor, sliding it out of its holder. Hoses too. Remove top portion of flame trap and hoses.
- Jack up passenger side of car and remove splash pan. Remove oil pressure wire--a push together clip. Remove the two 10 mm nuts and clips holding the wire under the engine. Take clips off wire. Label all wires you remove---DO IT!!! You can screw up.
- Remove the two wires from the alternator. Detatch the blue ground as it will be easier to work in the area.
- Unhook the inline connector to the AC compressor--easier to work in area. Remove clamp holding wires to the manifold-engine brace--10 mm.
- Remove the top 10 mm bolt holding the power steering reservoir and loosen the bottorm one. Now lay it toward the firewall. Trace the wires from the engine and you will find another clamp on the fender well that needs to be removed, 8 or 9 mm I think. Unplug the large gray connector and the AMM connector.
- Lay out your new harness and get acquainted with it and lable connections. Now start to remove the old harness toward the engine and start to plug in new stuff. This is a real mess of wires and connectors, but your labels help.
- Remove knock sensor plug and temp sensor (gray). Knock sensor wire is not replaced, just easier to work with it out of the way.
- Remove the two wires on the starter, remembering (write it down and label) what goes where. You will need to clip a number of black nylon cable zips along the way. Unplug the coolant sensor by the heater hose inlet on the block. Clip more zips. Go along the fire wall and try to unhoop the black zips---they will probably break. Now you can remove the harness from the engine area and install the new. Look carefully at the routing of the harness around the flame trap and dip stick.
- Remove the two large phillips screws holding the coil in place, lay it toward the center of the engine bay.

Clip the zip holding the two large gray plugs and remove the one wire from the coil. After removing more zips you can remove the old harness and replace the new. Install new zips where old ones were. Recheck and reinstall things as they were.

This is a good time to service oil and flame trap area if needed. The main thing is to make drawings, write things down and lable harness ends, both old and new.

Baked Engine Wiring: 960/90 Cars. See the notes in the 960 section regarding deteriorating wiring harness connectors near the coil packs in 960 six-cylinder engines.

Running Wires From Engine Compartment to the Cabin. [Inquiry] I need to run wires through the firewall into the back of the instrument panel. I notice that where the main wiring harness goes through the firewall, it's encased by a large rubber plug. Along the edges of this large rubber plug, there are two or three smaller rubber teats that stick out, with caps on them that look like they can be cut off. Can these be used for running extra wiring through the firewall? [Response] Those extra "teats" are for wire passage through the firewall. Cut the top off in the engine compartment, fish the wires through, and seal the gap with a little silicone caulk. To reach the instrument panel easily, use the rubber caps right behind the strut tower: this opens near the hood release on the other side, and wires can be easily strung to the panel.

Grounds and Circuit Repair:

Maintaining Engine and Chassis Grounds.
Maintaining 700/900 Chassis Grounds:
[Inquiry:] What do I have to do to keep the grounds in my chassis circuits in good condition? [Response 1: Steve Ringlee] This is tough to do without the pictures in the Volvo OEM wiring diagram book (the best $25 I've ever spent, by the way) but here are the grounds for my 1990 745:

- Battery chassis near the battery: frequently corroded
- Engine main ground under the p/s pump (typically OK because of oil coating)
- Engine ground straps from the distributor and intake manifold to the firewall: crimps can loosen or corrode
- Right auxiliary chassis ground (behind right headlamp): frequently corroded
- Left auxiliary chassis ground (behind left headlamp): frequently corroded
- Inside left A-pillar: underneath the trim panel by the bottom front left door hinge; damp carpets can corrode this
- Inside right A-pillar: just beneath the engine computer by the right front door pillar; this is important since so many functions ground here and humidity/salt can affect it from the carpets.
- Left and right taillight grounds; often corroded and a cause of malfunctioning rear bulbs
- On the right console between the seats: usually not a corrosion area but the strap to the transmission can corrode
- Courtesy lamp ground above the left B-pillar; usually not a problem
- Fuel pump and sensor ground next to sending unit on fuel tank: frequently corroded
- SRS ground beneath the driver's seat next to the crash sensor. It goes without saying that if you are going to touch this, you need to **disconnect the battery negative and wait some time** for any charge to dissipate from the crash sensor.
- [Don Willson] Injector ground wires on the intake manifold: frequently corroded. Just cleaning them and tightening the bolt is not enough. The wire must be soldered to the crimp lug. The

internal resistance of this crimp increases until injectors start to missfire, the O2 sensor sees too much oxygen and feeds the engine much too much fuel. Mileage drops to 10 mpg with smoke and no power. Check the main engine grounds at the firewall as well.

These grounds, if corroded, can play havoc with your car's electrical system, including causing the loss of engine computers and ignition amplifiers. A lot of the problems brought up in both Brickboard and Swedishbricks forums relate to faulty ground connections. It pays, especially for those in wet or salty climates, to clean and de-oxidize the ground connections (DeOxIt from Caig Tools is great, at electronic stores) then coat them with OxGard conductive paste (get it at Home Depot) which is designed to protect electrical connections where conductivity is important and shorts across circuit connectors are not a problem.

Overall Discussions of Ground Fault Problems:
For a good overall discussion of Volvo electrical system grounds, see the article “Volvo Electrical System Service: In Search of Good Grounds”, Bob Kraft, ImportCar magazine, December 1997 at http://www.underhoodservice.com/ (see their searchable archive for ImportCar Magazine.)

Ground Diagnosis. [Tips from Mike Dale, Motor Magazine, Jan 01] Many devices achieve their electrical connection to ground by way of a bolt or screw attached directly to the frame, body or drivetrain. As in the ring terminal example, the integrity of these grounds is dependent on the quality of the mechanical connection. There are several basic problems inherent in achieving reliable grounding. First, there's the issue of the mechanical connection itself. As an example, take the typical tin-plated brass ring terminal. This is crimped on one end of a wire to be grounded and fastened to the body by a self-tapping sheet-metal screw. Think of all the things that could go wrong with such a connection: The crimp to the wire could come loose, corrode or become mechanically damaged in a collision. The sheet-metal screw could back out as the body flexes during use and thermal cycling. The terminal and the place on the body to which it attaches could corrode due to salt, water or other corrosive fluids such as battery acids.

While identifying ground-related problems is not necessarily easy, there are some scenarios that should automatically raise a red flag. Multiple, seemingly unrelated failures are often ground-related issues. Mysteries such as the dome light flashing in unison with the turn signals are often fuse- or ground connection-related. Sensor outputs that are either out of range high or a constant value can be an indication of a ground problem. Poor performance of power loads such as the starting system, solenoids and fan motors may be the result of a poor ground connection, as well.
Analog sensors are much more susceptible to ground offsets and electrical noise in the system. The output of these sensors is often low (oxygen sensors, for example) and any loss due to poor connections can result in misinformation being sent to the computer.

Finding bad grounds is not always easy. Often, those sheet-metal screws I mentioned earlier can be buried in places that have never seen the light of day. Connections that look terrible may actually be okay, and vice versa. Just finding the location of a ground sometimes can be an all-day affair. Fortunately, much of the newer service literature does include ground location information. Once you've found the connection point, there are a couple of things you can do to check ground integrity. One is to attach one lead of a DVOM to battery negative and the other lead to the ground lug, ring terminal or metal body of a grounded assembly. When you operate the device, there should be less than a 1-volt drop across the connection; 100 millivolts is better, especially if it's in a low-voltage computer circuit. You can do much the same with an ohmmeter if the circuit is not powered up. What you're looking for is pretty close to a zero resistance connection.
Straightening out a bad ground often can be accomplished by simply loosening a screw or a mounting bolt, then retightening it.

In those cases where the integrity of a ground remains in doubt, there is something else you can do as either a diagnostic technique or as a permanent solution-hook up a redundant ground. To do this, attach one end of a wire to a known-good grounding point, such as the vehicle body or the negative side of the battery. Then bring the opposite end to the body of the grounded part or to the ground terminal in the connector to that part. Assuming that the wire doesn't get tangled in some moving part, the very worst that can happen is that nothing will happen. If the problem really is a ground issue, the wire may confirm the diagnosis or, when properly secured, be a permanent solution.

The key to identifying and fixing ground problems is to remember what the ground system does. It provides the return path for power and information distribution and forms the reference that voltages are measured in relation to. When your diagnosis says that neither of those two things is happening, it's time to go hunting for that bad ground connection!

Note: for intermittent driveability problems, see the section on de-oxidizing engine wiring connectors in the Performance section of the FAQ as well as brief notes on engine ground straps.

Dielectric vs. Conductive Grease to Protect Connectors and Grounds. [Inquiry:] You have repeatedly recommended the application of dielectric grease to underhood wire connections. Isn't the insulating property of such grease counter to the goal of IMPROVING the integrity of electrical connections? I would think that a conductive paste (such as Eastwood's Kopr-Shield) would be better. The only potential downside I can think of is that sloppy application could cause short circuits, but care and common sense should preclude this. [Response:] This is a good question and one that I have received several times. Yes, it is true that the dielectric grease is non-conductive. However, in the context of connections that carry voltages larger than 1 volt, the grease will not result in a bad connection. The male and female connectors will wipe enough of the grease off at the mating surface so that the electricity will flow just fine. The important part is that there is no chance of the grease creating a conductive path between adjacent terminals in a multi-terminal connector. The main purpose of the grease is to seal the terminals against oxidation which creates a high resistance barrier and moisture and dirt which can result in shorts and ground paths. CAUTION: DO NOT do this to any SRS/Airbag/Seatbelt connectors: these are all gold-plated and do not oxidize. If they get dirty from spilled drinks, etc., just clean them with a no-residue cleaner.

It is important to note that on all Volvos, the Oxygen sensor signal lead carries a very low voltage (0.2v - 0.8v) and the dielectric grease must NOT be used on this lead as it will interfere with the signal voltage.

For the GROUND connections - especially those in the engine compartment where the ground leads are fastened to aluminum surfaces like the intake manifold, I recommend using one of the conductive greases like OxGuard. These are found at electrical supply houses and are typically used by electricians to treat the end of aluminum electrical cables to prevent the very high resistance aluminum oxide from forming at connections - this was a common cause of house fires. The same high resistance oxide plays havoc with engine management system signal voltages. You can eliminate the problem by cleaning the aluminum surfaces and treating with the conductive grease. Also note that many of the spade type crimp on terminals that are available are made of aluminum. It is very difficult to find copper ones. [Note: see also the note on greasing connectors under Engine Tune, Performance.] DON'T use OxGuard on engine or chassis electrical connectors or sensors.

Oxidized Electrical Connectors and Malfunctioning Wiring: Diagnosis and Repair. [Editor] For information about how to remove oxidation or corrosion from engine and chassis electrical connectors due to age, humidity, or corrosive environment, see the FAQ section in Engine: Performance. For more information about diagnosing malfunctioning circuit wiring or corroded battery or starter cables using voltage drop methods, see the FAQ section in Electrical: Starting.

Circuit Board and Contact Repair. [Tips from Joe Ward] My rear taillight has been blowing the bulb rather frequently. Upon a closer inspection I noticed it had worn the copper trace where the lamp holder contacts the copper trace. I removed lamp holder, lightly sanded copper trace areas with some 600 grit, cleaned with alcohol, applied a thin film of conductive epoxy on all three copper traces and let dry overnight. Next morning it was hard as rock and conductive! This product was found at a local electronics supplier (it was near the check-out counter and it occurred to me this would be a good product to try before replacing). Product is used for field repairs for circuit boards that have cracked or broken traces and soldering not available. Cost ~8.00 for tube but it didn't take much. [Tip from JohnB] I had a similar problem with the plastic/copper circuit board below the steering wheel on my Saab. So I sanded the copper circuit and placed about 5-6 strands of copper from some 12-gauge multi-strand twisted together and flattened onto the copper on the plastic and using a 350w Weller soldering gun and electronic rosin core solder, just flashed the copper/wires together

Soldering Tutorial. See the excellent Heathkit discussion of soldering techniques for more information about how to solder electronic boards. [Tips from Jay Simkin] To reflow the solder around the pins on a circuit board:

1. Use an electric soldering iron, with not more than 25 watts capacity (this limits risk of burn-out).
2. On the underside of the board, where the tips of mounting pins stick through the surface, touch the tip of the soldering iron to each pin for 1-2 seconds. NOTE: The break causing the problem likely is too small to be seen with the unaided eye (even with a magnifying glass). Thus, treat all of the solder joints on the relay and the main connector, as if any one could be the cause of the problem.
3. If any pin seems "dry", i.e., if it has no or very little solder on it, add a small amount of ROSIN core solder. Note that ROSIN core solder is NOT plumber's solder, which is acid core. Rosin Core solder is the only solder to be used on electrical/electronic work. Acid core solder should NEVER be used on electrical/ electronic items: it will cause serious corrosion and ruin the device.
4. If the solder does not take - adhere - to the pin, clean the pin with some fine steel wool. Be sure to remove any steel wool fibers (blow them away) before applying solder.
5. Be careful not "to drag" solder between pins. That will connect pins, causing power to flow in undesirable ways, and possibly produce serious damage. If you put too much solder on a pin, clean the tip of the soldering iron with a damp cloth, and use the tip to attract and hold the excess solder.

Power Window and Door Switches:

Power Window Switches.

Switches Don't Operate the Windows. Take apart the individual window switches and clean them out. The switch pivot has a bit of oil or grease on it and some of it gets on the ball bearing contacts, causing dirt to get stuck and faulty contact points. The same may be true with your child safety locks for the rear windows. It worked for mine, but I think I need to clean the switch once more as it only operates correctly 80-90% of the time going down, and all the time going up. I was even thinking of replacing the switch itself if that didn't work. No experience on the power relays, though. [More] These are fun to fix. Pop the switch out (see below: I usually wind up doing them all as long as I'm there) and pry the side off the little nipples so the cover comes off each switch. Be careful since there is a spring in the rocker, you don't want to lose it. Take out the little metal "lever" and use some very fine sandpaper to neaten up the contacts on the lever and the contact points inside the switch. [Tip from John Yuristy] . I wouldn`t use sandpaper or steel wool on contacts, some are just plated and you will remove the good stuff.

[Response:Steve Ringlee] For a detailed analysis of the window switches, take a look at Michael Ponte's analysis at http://www.mikeponte.com/volvo/pwin.htm. Another solution is disassembling the switches (be careful in removing them from the black plastic holders), de-oxidizing and cleaning them using an electronic de-oxidizer such as DeOxIt from Caig Labs, then using a fine Scotchguard nylon scrubber to burnish the contacts, and finally reassembling them using Caig ProGold protective coating (very small quantities precisely applied) on the contacts to prevent further dirt and oxidization from ruining the contacts. Caveat: I have tried the "rebuild" approach on these switches and found that it did not last that long; I ended up buying a new driver's door switch from RPR for around $30 just to save more work. [Jeff Pierce] I had the same problem with the front switches on my Mercedes (the switch design is very similar). I cleaned them several times, and each time the fix would last for a shorter duration. About a year ago, after cleaning the contacts, I tinned them with solder (I figured I had nothing to lose -- if it didn't work, I would just replace the switches.) It's a year later, and I haven't had the problem since.

Removing the Switches. Behind the switch cluster in the recessed area where the inner door lever lives there is as plastic screw. Turn it and pop it out. Now gently pull up that whole plastic trim piece in which the cluster rests. The switch block will come up and out of its mount point by gently prying up on the edge of the plate that the switches are mounted to. You may need to push at the carpeted trim that is behind the cluster to remove the plate. The switches snap into this plate from the underside. Gently push them out from the top or pull them out from the bottom. Disconnect wires and attatch to the new switch.

Power Windows Operate in OFF. 1986 740: I just noticed that my power windows work without the key in the ignition. [Response:] a stuck relay would do that. Either that or there's a hot short at the relay socket or in the wiring between the relay and the ignition switch. Should be leftmost relay in the front row. It also powers the electric radiator fan, so given a hot engine on a hot day it too could run when the key is out. A hot short between the relay and the fan thermostat would also enable the power windows. Try tapping on the relay to see if that doesn't at least make a temporary difference. If that helps then you may be able to salvage the relay by opening it and using contact cleaner. If not, then pull the relay anyway and inspect socket for evidence of shorting. After that it's either try a new relay or start tracing with a multimeter.

Power Door Lock Failure. [Inquiry:] There has been a failure of the door locks on my 740 wagon. The tailgate unlocks with the drivers door but no other function works. Do I need a new lock actuator or is there something else to check? [Response:] There is a switch in the driver's door that sends a signal to a relay mounted on the central relay panel. The relay then sends power to all the lock motors (all doors except driver's door). If some of the locks are operating and others are not, then you have either a wiring problem or a ground connection problem. Either way, the place to start is to remove the door panels on those doors that are not working. Unplug the lock motors and check to make sure they operate freely. If so, proceed to check the wiring with a multimeter - look for bad ground connections, no power on lock/unlock leads when door switch operated, etc. I expect that the three passenger doors are on one harness and that the tailgate has a separate harness lead that comes from the relay. So look for those points which are common to the three passenger doors.

Troubleshooting:

Slow Battery Discharge. See the "Starting" section for more information. See "Special Tools" for information about tools to help diagnose short circuits.

Multiple Electrical Failure: Ignition Switch Bad. [Inquiry:] After stopping our '90 745T the ABS light came on, the blinkers did not work, along with the power windows. Wife managed to get home and call me at work. My first reaction was, of course, a fuse. But when I got home and started up the car, everything was fine, along with the fuses. Any ideas on a solution to my quandary? [Response: Abe Crombie] The electrical switch behind ignition lock is almost certainly the culprit. You can test for this by starting car and then turn key a few degrees either way and see if you can't duplicate what your wife observed. The switch has the spring in it that returns the key to run position after you go to the starter position and it can weaken or wear. The switch is easy to change and is readily available through a good parts supplier.

Volvo Maintenance FAQ for 7xx/9xx/90 Cars

Version 7.5

Rear Brake Lights	**Lamp Reference Diagram:** Lamp Diagram and Part Number Charts

For information regarding instrument panel and interior lamps, see the Electrical: Instruments file.

Circuit Maintenance:

Caution When Working on Car. When working on the car, there is a temptation to lean on the headlamp or foglamp capsules. Don't do this, lest you break off the fragile adjustment screws and have to special order the replacements from Volvo.

Lighting Circuit Preventive Maintenance. Outside of routine maintenance, there's one thing that needs to be done periodically: remove the headlight grounding spades (behind the headlamps on the inside fender) from the grounding strips and clean the contact points. These crud up (oxidize) and create some weird and funky problems with the headlights. Protect them with a conducting grease such as OxGard.

Silicone Dielectric Grease Application. Regular application of silicone grease (NOT conducting grease) whenever you replace a bulb will keep the sockets and bulb bases from corroding and oxidizing.

Bulb Failure Warning Sensor. [Editor's Note:] See http://www.mikeponte.com/volvo/bulbsen.htm for Michael Ponte's discussion of how the bulb failure warning sensor operates. This sensor is located in the relay panel shown at Relay Locations.
For information on brake light failures and this relay, see Lights Don't Work: Bulb Out Relay

Sensor Illuminates Even When All Lamps Are Operating Correctly. [Inquiry] My bulb out indicator light is on when I apply the brakes, but all of the bulbs are functioning. I replaced all of the bulbs (including 3rd brake light) with new ones, but it still happens. [Response] Clean and deoxidize the contacts in the bulb holders using electrical contact cleaner such as CRC or (better) DeOxIt. If you see brown/black deposits, use a toothpick or unlighted match as a base for some very fine sandpaper to gently remove deposits. After you clean out the sockets, apply silicone dielectric grease to the bulb contacts before reinserting them to protect them from further oxidation.

Headlamps:

How to Replace Headlamp Bulbs . [Kane] Carefully disconnect the headlamp wiring connector by slightly bending the locking tab up. Around the bulb is a black plastic collar ring. Twist that until it's loose (you'll feel it), and the bulb and ring may be eased out. Often, you will need just a little extra effort, as there's a rubber o-ring on the base of the bulb that helps hold it in place too. Do not touch the glass portion of the bulb when handling/reinstalling: the oils from your skin will kill it in a short time. When reinstalling, it helps to use silicone dielectric grease on the electrical connectors to prevent corrosion.

Headlamps Burn Out Frequently. [Inquiry:] The halogen headlamps burn out on my ' 93 Volvo every 3 or 4 months. Does anyone else have this problem? The dealer assured me that there is not a short in my car. As a matter of fact, the dealership went as far as to blame it on moisture. [Response 1:] When you install the light bulb if it is touched at all by your hands or anything oily or if it is scratched it has a very high potential of burning out or even exploding. Also, water vapor inside the headlamp due to a hole or badly sealed headlight will cause bulb failure. You might want to check all seals in the headlight area. The bulbs will go out rather fast once the seal has been breached or there is a crack in the glass. [Response 2:] I have had the same problems with two Volvos we bought and found that the voltage regulator had an intermittent fault. One day I noticed that suddenly the lights were very bright for a few seconds and then back to normal, bulbs don't like that. I replaced the voltage regulator on the alternator. This solved the problem. These screw-on voltage regulators are not expensive (US$25) and are available from your Bosch agent.

Headlamps Flicker and Die. [Inquiry] My head lights decided to flicker, then die. All the other lights in the car work, and my brights work as well. The brights only work if you hold the lever in position though. Just the tail lights and the head lights are all out. [Response: John Sargent] Relay K is energized by the headlight switch, and supplies electricity to the dimmer switch and fuses 21 and 22. Fuses 21 and 22 supply all lights except the headlights. The high beams work because the momentary position of the high beams is supplied with electricity by fuse 2. For a better description of the loads for fuses 21 and 22, see the listing on the back of the fuse cover which is behind the ash tray. Relay K is the second relay from the left in the row of relays nearest the Central Electrical Unit. The CEU is in front of the ash tray. Since all the lights work except the headlights, either the dimmer switch is bad, or one pole of relay K.

To determine if it is relay K, remove it and install a jumper from socket 1 to socket 5 of the relay base. The sockets in the relay base are numbered, but if you can't see the numbers, socket 1 mates with terminal 30 of the relay, and socket 5 mates with terminal 87b of the relay. If you have lights with the jumper in place, the headlight relay is bad. If the headlights still don't work, the dimmer switch is bad.

Headlight Circuits/Relay Won't Function. [Symptom 1:]My lights are out. The car is a 760 turbo '86.The parking lights work fine but not the beams, although I can flash the hi-beams. I've checked the fuses already as well as the wires. [Diagnosis:] Funky headlight behavior is a KNOWN bug in 700 series cars. First thing to try is removing and cleaning the headlight connections at the headlights and, more importantly, removing the wires (spade lugs) at the grounding strips located on the interior fender well behind each bank of headlights and giving them a good cleaning (sanding is suggested). If that doesn't clear it up, it's likely you have a bad headlight relay which is typically located on the relay panel behind the lighter/ashtray assembly. Consult a manual or the chart on the back of the ashtray for the proper relay. I'll lay odds that the ground points are the problem. [Symptom 2:] My 85 740 has a problem with the headlights blinking. I've traced this down to the relay, which is getting so hot that the plastic insert in the fuse panel is melted. One of its terminals must have been heating up substantially, to the point of major discoloration of the relay terminal, and rusty-looking gook in the socket, only for the one terminal blade. [Fix:] Replace relay at relay panel. However, I found a Volvo TSB on headlight and fuel pump relays that described this problem, and indicated that the fix was replacement of the relay, its' socket, AND the wire terminals which connect to the socket.

Headlights Cause Engine to Stop: Poor Grounds. [Inquiry:] My 740 is doing something odd. I turned on my high beams tonight, and immediately the engine stopped producing power - and once it reached lower RPMs it stopped running. After turning the car off and starting it again, it did not show any problems until the high beams were switched on again. When the high beams are put on, the drivers side turn signal indicator light goes on (dimly) and the whole drivers side headlight cluster shuts off (including the parking light) while the other side remains functional. The volt meter stays put - at 12 volts of charge - even while the gremlin has taken over. Visual inspection revealed nothing - but there are a lot of wires and harnesses, and I could use a hint as to where to check for a short. [Response: Abe Crombie] Raise the hood and look behind each headlamp on side inner fender panel and you will see a multi-spade ground strip bolted to inner fender. Tighten up the bolts on both of these and your problems will cease. If the bolt or inner fender is corroded you will have to remove the strip and clean the area.

Headlight, Driving Light, and Foglight Aiming. The following notes apply to North American market cars. Euro and Japan employ different reflector and aiming methods.

1. Headlamp Aiming:

Adjustment Mechanism:
[Tip from John] Look for plastic + bits that operate plastic shafts that go down/over to bevel gears that rotate horizontal screws that move the upper and lower corners of the headlight assemblies. Of course, these screws are invariably corroded and difficult to turn, therefore the plastic bevel gears strip when you try to turn the + bits. I've found it helps to spray the screws

with WD-40 and then drip/spray some synthetic oil on them.   Don't strip the bevel gears or you'll end up buying big bux parts or haunting a junkyard for parts. If the shafts/screws won't turn easily, about all I can suggest is removing the entire headlight assembly and freeing it up by hand at the screw. It might entail disassembly and chasing/lubrication of the adjustment screw.

Aiming:
[Procedure and illustration courtesy of IPD and Daniel Stern] Check and adjust the aim of your headlights at least once a year to ensure maximum performance and to make sure that they are not blinding other drivers. If you don't have easy access to a shop with the proper equipment, you can adjust the headlights yourself, following the steps below. You'll need an assistant, 25 foot tape measure, masking tape and a large black felt tip marker and a flat blade screwdriver if your Volvo does not have adjusting knobs.

Most Volvos 1960 to 1985 have adjusting screws which are accessed by removing the headlight trim. Most 1986 and newer models have adjustment knobs that are accessed from the back side of the headlight in the engine compartment. Before you begin, make sure that your car has dose to a full tank of gas, that the tires are properly inflated and that there is nothing heavy in the trunk or cargo area that Is not normally carried in the car. This will provide the best accuracy under normal conditions.

1. Find a nice flat parking area with a smooth fight colored wall, preferably a place where you won't be disturbed or have to move your car during the procedure. Some ambient lighting helps; just make sure that you can dearly see your low beams shining on the wall (often your driveway and garage door will work well). Park your car perpendicular to the

wall, making sure your headlights are 20 feet from the wall. Use a tape measure to get it close. Mark the position of the car's wheels in case you have to move or need to readjust. Rock the car a little bit to settle the suspension.

Headlamp Aiming, Courtesy IPD

2. To determine the position of your cars vertical centerline on the wall, put a small piece of masking tape in the very center of the windshield and the back window (use the tape measure for accuracy). Now stand behind the car and use the masking tape marks to "sight" a spot on the wall where the exact vertical centerline of the car is aimed. Have your assistant place masking tape on the wall at this point and then mark it with an "X" using the black marker.
3. Now back at the car, measure the height from the pavement to the center or axis of your low beam headlights. The "axis" is often marked with a dot, cross, bulb type designation or name brand, but if not, it is directly in front of the bulb. Also measure the distance between the two light axes. Transfer these measurements to the wall using the vertical centerline you previously marked on the wall. You now should have marks A and B on the wall that closely correspond to the center axis positions of your headlights.
4. Make a mark on the wall about 3.5 inches to the right and 1.5 inches below the point where your headlight marks are. This will give you the proper aiming points. See the diagram for an example of what you should have on the wall. (As viewed from the front of the car.)

- LOW BEAM AIMING Turn your lights on low beam.. Now, have your helpful assistant stand in front of the passenger side lamp while you aim the other driver side lamp so that the point where the horizontal cutoff begins to sweep upward hits point C on the wall. Now do the same for the passenger side using point D. Slight leftward aim (-1") increases seeing distance down the road, but excessive leftward aim increases glare to oncoming traffic. It is not necessary to aim the high beams on cars with only 2 headlamps as the high beam is correct once the low beam is aimed properly.

- HIGH BEAM AIMING This only applies to cars that have 4 head light systems as once the low beam is set, the high beam should be good on cars that have only 2 headlamps. On 4 headlamp cars, aim the center of the separate driver side high beam hot spot at position A on the wall. For the passenger side aim for position B. Cover or disable the hi-low lamp to prevent it from interfering with the separate high-beam adjustment. This sets the high beam a bit higher than your low beam setting for maximum distance. You may want to experiment with setting the high beam hot spot 3 to 4 inches out board of the above settings to light up the sides of the road a bit more.

5. Take the car for a test drive. If they aren't quite right, return to the aiming point and park in the exact spot where you marked where your wheels were located during the aiming process and adjust as necessary.

2. Driving Lamps, High-Beam-Only Lamps in 4-Lamp Systems, and Euro-Code High-Beam Lamps.. These instructions apply to ECE high beam headlamps, US DOT high beam headlamps marked "VO", and all driving lamps. These must be adjusted so that the bright, center "hot spot" of the beam is straight ahead of the lamp in both the vertical and horizontal planes. Use the intersection of the horizontal and vertical lines at points A and B for each headlamp as "cross-hair sights" to center the high beam hot spot. Make sure to work on one lamp at a time. It is best to disconnect the power to the headlamp you are not working on, so light from the other lamp's beam pattern doesn't mislead your eyes. Also be sure to disconnect or cover the adjacent high/low beam lamp when you are aiming its high-beam-only neighbor.

3. Fog Lamps. Fog lamps are aimed using a procedure very similar to that used for low beam headlamps, but the vertical drop is different. Follow the vehicle-preparation and wall-marking instructions given above for low beam headlamps, substituting "foglamp" for "headlamp", but with the following changes: If the fog lamps are mounted below the bumper, your C-D line should be 2" below the fog lamp axis height. If the fog lamps are mounted above the bumper, your C-D line should be 4" below the fog lamp axis height. Fog lamps produce a wide, bar-shaped beam of light. Horizontal aim is much less critical than it is with headlamps. The fog lamps should be pointed straight ahead, not leftward or rightward.

Glass Headlamp Protection. [Tip:] Use clear plastic laminating sheet, available from office supply stores, to protect your glass headlamps and lenses from sand and stone chips. [Editor's Note:] I have tried these and they are not too effective against larger stones, and the adhesive tends to craze over time. Unless you are on a tight budget, try Stongard instead: they are custom fit to the lens and use a thick 3M clear urethane that is amazingly tough. They cost around US$ 60 for a kit with covers for the headlights and corner markers. Another alternative is to buy 3M Scotch Brand 300LSE Hi Strength Adhesive and cut to fit. [Tip] For less expensive vinyl protectors, try http://home.earthlink.net/~vicrocha/

Plastic Headlamp Clarity. [Problem:] Is there any way to deal with the loss of clarity/yellowing in those plastic lights in the late model 240s/7xx/9xx? I was able to re-seal the leaks, but all that water in there for such a long time seems to have made the lenses somewhat opaque.

[Fix 1:] I use two products called Meguiar's Plastic Cleaner and Polish, available from auto stores. It cleans and polishes plastic. Use it with a random orbital buffer and clean terry buffing cloths. This product is not very aggressive in terms of grit. Another choice is Meguiar's Plastx Plastic Cleaner and Polish.

Fix 2:] [Kevin] I use Mother's aluminum paste cleaner. After polishing the lens with this compound, wash with a liquid dish soap and water and let air dry. Then, if you wish, use a high quality clear spray paint to protect the lenses and keep them clear for years. This technique is faster than Fix 1 above.

[Fix 3:] Next time you replace them, use a sheet of iHg from 3M. It's a 1/8" thick, flexible, ultra-clear, UV-stabilized polyurethane sheet with 3M ultraclear adhesive on the back. You clean the lens with rubbing alcohol and press the stuff in place, and it disappears. Its flexible surface shrugs-off the rocks and stuff, and if it ever gets damaged, you can peel it off and replace it. It's available for many makes and models of cars (and even has the three little cutouts for the three little pips on the lens if you buy the precut kind) or in bulk sheets. Anyone running a post-85 US spec Volvo should consider covering up those headlight assemblies. Very spendy, and you don't want them absorbing the road-grit/rock impact. There is a company in Bellevue WA that specializes in clear protective automotive films (Stongard, 800-350-4897 www.stongard.com) They sell a 3M film that's supposed to be fairly easy to apply. Their stuff is very popular with the local Porsche Club(since the way the front end of a 911 is shaped, it collects a *lot* of rock hits, and those round H1/H4 headlights are an amazingly spendy integrated unit), and the 9004 headlight is a pretty common shape, so they've probably got pre-cut sheets for them already. 1990 740: Headlamp kit 76-04-70 $59.95.

Headlamp Unit Cleaning. [Inquiry:] How do I clean the insides of one-piece plastic headlamps? [Response:] Note that gassed headlamps can be cleaned. This is when the lenses have not yet deteriorated, but there is an accumulation of dirt or film on the insides of the units. The degassing procedure is rather simple: Remove the headlamp from the vehicle, taking careful note of the locations (number of turns in or out from "seated") of any aiming screws you must remove. Write this info down.
Remove the bulb and have the lamp on a towel on the counter near the sink, lens down. Pour each lamp 1/4 full of 50/50 mix distilled water and rubbing alcohol. Add ONE small drop of liquid dish detergent (Joy, Dawn, etc.). Put the palm of one hand over the bulb hole, grasp the lens firmly with the other hand, and shake/slosh the lamp vigorously, being careful not to drop it. Pour the liquid down the drain and repeat. Then do it twice more, the same as above, but WITHOUT any soap. If you heat the water first, the lamps will dry much faster. Dry them in the open air, bulb hole facing down but not blocked. If you're in a hurry or there are crevices that won't dry, place the lamps in a CLEAN oven, hole down, and close the door. Set the oven on bake-300 for 60 seconds, then switch off. Leave the oven door closed. The lamps will be dry in about 30-45 minutes.

Headlamp Capsule Loose. [Inquiry] I leaned on my headlamp and broke an adjuster screw; now it is loose.

Single Unit (No Fogs) [Response] These screw adjusters come in an assembly. The up-down axis is adjusted by Volvo p/n 3534201-3; the side axes by p/n 3534202-1. They cost about $20 each. Carefully prise off the headlamp capsule from the broken adjuster screw and replace from the front. It helps to lubricate the plastic screws with spray lube before you adjust the headlamp directions.

Headlamp with Fogs. [Response] The lamp capsule frame is held by small ball cage nuts (Volvo p/n 1392718) in fittings on the back of the capsule frame. The adjusters screws are similar to those above: side axis for both headlight and fog is adjusted by Volvo p/n 1392717-3 (left) or 1392731-4 (right); up-down by Volvo p/n 1392716-5 (left) or 1392730-6 (right);. To remove the adjuster units, first remove the W-shaped plastic springs holding the vertical torque rods in place by pushing on one side with a screwdriver: the springs are located right under the thumbwheels. Then withdraw the vertical rods. To remove the ball cages, push each of the sides inwards while pulling the capsule out, which will disengage the ball. Use spray lube to help things along.

Headlamp Replacement.

Headlight Assembly Replacement. [Inquiry] How do I remove the headlamp and its mounting frame? [Response] 1. Pop hood 2. Remove grille by taking off tabs located at top left and top right. 3. Remove 2 Torx screws holding plastic radiator air director. 4 Remove 2 bolts located on the inboard side of the headlight frame 5. Pop out turn signals by pushing on plastic locking tab (located behind and probably buried under wires) 5. remove outboard side bolts 6. Remove bulbs and pull that baby out.

Capsule Replacement. [Inquiry] Just got a new headlight insert to replace the cracked one on the right side. I cannot figure out how to get the old one off. I am hesitant to start prying on the plastic parts since everytime I do that on a Volvo something breaks. I was told the little plastic nipply things often break. [Response: Joe] Get from the dealer 5 or 6 bucket clasps per light, they will also give you a copy of the headlight assembly parts diagram if you ask. When you get the dealer parts ask the parts guy/girl about this process; that's how I learned how to do this. The clasps snap into the headlight assembly to hold the new headlight in place.

1. Remove the grill by removing the u-type clips on top of the grille. Use a pair of pliers and squeeze and pull. Be careful of grill brackets on each side and the bottom tabs: these can break. Remove the torx screws holding the side rubber/plastic air dam; remove the dam.
2. Remove the corner light. Remove the bulb by turning 3/4 of a turn, pull out bulb. Squeeze the bracket on the side of the light and it pulls out. Remove bulbs from headlight and foglight.
3. You will now have access to the bolts on both sides of the headlight assembly. There are

two bolts on each side.

4. The headlight assembly will come out of the car, it consists of the fog light and headlight and the bracket that supports them.
5. Unscrew the adjustment screws all the way out of the headlamp, these are two large adjustment screw on top. This will give you access to the ball cage bucket clasps. Cut the basket clasp with a knife. Don't cut the nipple part that snaps into the basket just the thin basket clasp. (look at the new ones)
6. Insert the new clasp and snap the new headlight into the assembly. Replace the adjustment screws. There will be a line of dirt on the scrw threads; screw it in to that line so you will keep the same adjustment or mark them before removing.
7. Put everything back the way you took it out. Screw in the screws for the headlight assembly, replace the air dam, grill and corner light and bulbs. Make sure the corner light snaps in or that will fall out while driving. This is a good time to change your bulbs at the foglite and headlight (don't touch bulbs). It's easier to put the bulbs in first and then connect the terminal. I also covered each headlamp with headlamp tape to protect the new bulbs.

Lens Replacement. To remove the old glass or plastic front lens, try a heat gun. It softens the caulk and allows you to scrap and dig at it with a knife. Open the seam as much as possible this way and then use the heat to soften the adhesion all the way around the lens. Then take a putty knife and insert in the groove and turn it to apply pressure to move the lens from the body of the assembly. Another approach might be to try the "caulk remover" paste tubes sold at home improvement stores to remove silicone caulk from bathtubs. If you remove the lens, avoid the temptation to "clean" the silvered reflector surface with anything other than low-pressure compressed air. It is sprayed on, is VERY fragile, and will be destroyed if you rub it with anything, even a sponge and water.

960/90 Headlamp and Wiper Assembly Removal. [Tip from Warren Bain] After removing the bolts holding the capsule in place as above, you can then remove the lamp and wiper assembly. The headlight wiper and washer motor shaft goes through the plastic bumper cover. To save time, I cut the top piece above the shaft. No one can see the cut. The old one comes out with some twisting and turning. The wiper motor is attached to the bottom of the headlight housing. I swapped the metal clips and the wiper motor from the old headlamp assembly to the replacement unit. Make sure the electrical pins on the new headlight are the same as the old ones. If not, swap the harness inside the housing. Use slip joint pliers to free the headlight electrical connector on the back of the housing. It takes some work to get the old connector out but it can be done. On mine, the new pins were shoved back inside the connector and the lights would not work. I had to swap the internal harness. Replace the housing and the electrical connectors including the wiper motor, and put the turn signal back in. See also the FAQ section on 960 Wipers.

Parking and Other Lamps:

Parking Lamp Capsule Removal.
740/940:
[Inquiry] How do I replace the front parking light lens on my 94 940? [Response: Dan Ray] Behind the parking light assembly you will find a tab of white colored plastic, gently push it towards the fender while pushing it forward. This tab snaps in to secure it. Once pulled away you turn the socket to have access to the bulb.
960:
[Response: Tom Irwin]   The corner lamp assemblies have a little plastic lock tab at the rear. When they are installed in the fender, that plastic lock tab engages a metal tab inside that fender and it click-locks in place. Using a strong flashlight, look from inside the engine bay, behind the corner lamp and find that plastic tab. Using a screwdriver, push down on it slightly and you can withdraw the entire lamp housing from the car. From there, getting to the bulbs is cake.   By the way, if you have odd flashing patterns, pull every turn/hazard bulb on the failed side and inspect the contacts of both the bulbs and sockets for overheat. If those contacts melt together it can cause bulbs to flash together incorrectly or not at all. Turn the bulbs over and check the contacts visually. They should be hemispherical, not flat and pushed together. They are made of a lead alloy and melt at a low temp

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Rear Brake Lights.

Bulbs. Has anyone else out there tried the Wagner #3275 Krypton brake light bulb for their Center High Mount Brake Lamps or lower brake lights? I had the CHMBL light go out on my 90 740T and put in the #3275 because it's supposed to have a higher lumen output (it does and it is hotter) and last longer. It's lasted for over a year and hasn't melted the plastic (at least any worse than it already was distorted) and looks kind of like a fog light in the rear window!

Sockets. [Carl Millard] It appears as though the brake light sockets are specific to each side and that the white socket fits on the right. If reversed, current will flow to the parking lamp and not the brake.

Center Stop Lamp.

Sedan/Saloon. [Inquiry] The high-level brake light (the one that sits in the rear window) is dead in my car. I can't seem to figure out how to access the bulbs. The manual has an unhelpful picture of a screwdriver underneath the cover with the description: depress the catch with a screwdriver. I can't seem to find this catch. [Response: Bob] For 740/760 sedan cars, there should be a hole in the bottom side of the cover. The catch is tricky to find. Keep probing and push up with a screwdriver while wiggling the cover. For 940/960 sedan cars, try to spread the stop lamp cover outward to release the hooked catches on the sides that hold it to the lens assembly, which in turn is secured to the chassis mount screwed to the package shelf. Once the cover is off, reach up beneath the lens assembly and locate the hooked tab on the chassis mount below the center bottom of the lens assembly: depress this tab and pull off the lens. Be careful: the plastic can embrittle from UV exposure.

Wagon/Estate. [Response: Jay Simkin] *To remove the brake light housing cover:*

1. put the tips of your index fingers at the "sharp" corners of the housing, which are closest the the window
2. put the tips of your thumbs at the rounded corners of the housing, closest to the sharp corners.
3. using the tips of your index fingers, pull each side of the housing outwards about 1/16" (i.e., towards the gas struts that hold up the hatch)
4. pull the housing downwards (i.e., straight towards the ground). You should feel it release. It will come free. Set it aside.

To remove the brake light bulb holder:

1. You will see two black plastic tabs sticking downwards (towards the ground) from the brake light assembly
2. Using a thumb and index finger grip each tab and press inwards about 1/16" (i.e., towards each other) while pulling downwards gently
3. You will see and feel the bulb housing release from the mounting.

To remove the brake light bulb:

1. Grip the bulb gently and press downwards gently (as if you were trying to press the bulb into its fitting). You should feel some "springiness".
2. Turn the bulb. If it does not move, turn it in the other direction. It should release and "pop" free.
3. Replace the bulb, with an exact replacement.

Backup Lights Not Working: Neutral Safety Switch. If your backup lights stop working, your transmission neutral safety switch has most likely failed. See the FAQ file for repair information.

Brighter Brake and Tail Lights. [tip from Ceferino Lamb] Just in time for the Christmas drunk driver tailgating you season, here's a handy tip. The tail and brake lights on our classy older cars are not quite as big or bright as those of newer cars are. Some of us believe that brighter lights are a bit safer. Here's how to remedy things.

1. CLEANING FRENZY. Clean the reflectors and lenses with a can of compressed gas such as that for cleaning computer keyboards or circuits. That should get rid of accumulated dust. In cases of heavy dust/dirt, you can clean manually with alcohol and soft rags or big Q-tips, but be very careful not to scratch the reflectors or remove the reflective coating. If that coating is poor, buy new light clusters or disassemble completely and repaint the reflectors with silver paint. If

there is heavy dirt in there, find out why and fix it. The gaskets sealing the exterior may be "perished" (as the Brits would say). You can replace crumbling gaskets with silicone seal - apply a thin bead to the seating groove, then lightly oil the lens side and mate them while the silicone is still soft but has skinned over slightly. If you can't get the taillight clusters apart to clean them, one trick is to put raw rice and soapy water in there, shake it around, drain, rinse repeatedly with distilled water, then air dry for 24 hrs.

2. CHECK CONNECTIONS. Check the condition of the various electrical connections to the bulbs back there. Often there is room for improvement, especially in Volvos. Benz connections are usually OK in my experience. In some cases, a better connection at the bulb base is as easy as bending the spring connections deeper toward the bulb, so that it exerts more pre-load against the bulb when it's installed. Many Volvos have fragile connections molded into the reflector assembly and there is no practical way to repair them. Benz connections are often ferrous, so accumulated moisture in the trunk causes rusting which in turn causes resistance in various places. Renew or clean thoroughly.

3. WIRE UP UNUSED BULB SOCKETS. Many of our cars have unused rear fog lamp sockets in the tail light cluster. One trick to get brighter brake lights is to use those reflectors as additional brake lights. You may have to install a socket first, because there usually is none. This is especially easy in Volvos due to the twist-in bulb sockets - find one at a junkyard. Then connect the new socket in parallel with the existing brake lights. Make sure that your brake light fuse and wiring is sufficient to handle the extra load. I've been doing this for years and never had a wiring problem or blown fuse.

4. IF YOU HAVE ONLY DUAL-FILAMENT BULBS, STOP HERE. I'm not aware of any way to replace dual-filament tail/brake bulbs (1034 or 1157) with brighter ones. If you have any tips, please let me know.

5. BRIGHTER TAIL LIGHT BULBS. Replace the stock single-filament tail light bulbs with #105 bulbs. 105 is the number that Sylvania/Osram uses, and I suspect that it's a standard in the US. Don't worry that it says they are for trunk/courtesy/map lights - they don't run too hot such that they would damage your reflectors or lenses. I've been doing this for years. This takes you from 4-6 watts up to 10 watts of light, making them noticeably brighter. There are also 20-watt bulbs available in about the same size that will fit, but I don't recommend that because of heat and the fact that your taillights will be about 50% as bright as your brake lights. However they might be useful for your front market lights if you want a pseudo-DRS look (why anybody would want DRS is a mystery to me).

6. BRIGHTER BRAKE LIGHT BULBS. Replace the stock single-filament brake light bulbs with #3497 bulbs. These are relatively new from Sylvania/Osram, and their high price makes me suspect that they are halogen. They're about 30% smaller than the stock bulb, but rated at 28 watts instead of 21 watts. The smaller size should keep any additional heat away from the plastic lenses. Just the same, I would monitor the lenses closely for a few months, because this is a new setup for me and I'm generally cautious when trying out hotter bulbs.

Replacement Lenses. [Question: Who sells used/new Volvo lenses (I need the front passenger wraparound turn light - white?] [Answer:] Check out Matt's Lenses:

> http://www.internetcarparts.com/ MailTo: volvo@internetcarparts.comvolvo@internetcarparts.com

[Another source:] I have had good luck (and good prices) from Hirsch Industries. They are out of Arizona. Check out their website for more info - http://www.hirschindustries.com/ . I got a replacement for $6-7 plus $4-5 shipping.. It was brand new and came with instructions. They also have the whole taillight assembly (if you had lost any other cover, you would have had to get the whole new thing back there) for under $45 or so..

[Note:] Don't buy USED 700 series corner markers....the faulty part of these units is the adhesive (holding the lens to the housing) and if it's been around, it WILL fall off. If you do get a used unit with the lens intact, epoxy it for a safety measure. So far it's worked for me on the one *new* unit I have on my car. [Problem 2: any solution to the falling out backup light problem; i.e., a source for the white plastic lens?] [Fix:] Just go down to your local Volvo dealer and buy a new clear backup light lens for about $4 to $6 and glue it in with silicone sealant. Volvo knows they had a product problem with these lenses and came up with a fix much cheaper than replacing the entire tail light assembly. [Brad Grimes] The Volvo part numbers for these are: left lens: 271447; right: 271448. . See also *Re-Glueing the Lens Components*

Rebuild and Repair of Parking/Tail Light Lens

Re-building the Lens from Components. [Tip from Robert Adriaansen] Volvo taillights are extremely expensive (something like $180 for the 740 wagon) and are glued together so that they cannot be disassembled. I decided that it would be an interesting project to try to put together good parts from two different sets of lenses. In my specific case matters were complicated by the fact that both the donor and the recipient taillights had broken lower red lenses, though thankfully they were broken in different places. [Tip from Rob Bareiss] The clear reverse lens is the only one available separately for about $7. The others can't be removed but the clear lens does come out (falls out, usually) and can be replaced individually.

Here is how I went about it:

1. Using a soldering iron with a flat (ie cutting) tip, I cut out the part that I needed from the donor lens making sure to cut it about 1/8" oversize. I couldn't find a way to unglue the lens from the black plastic back of the lens, so I cut that also using the same method.

2. Using the soldering iron, a utility knife and a Dremel tool, I removed the black plastic back and the glue so as to remain with only (part of) the lens itself.

3. Using the same method, I removed the glue and broken pieces from the recipient taillight.

4. With files and the Dremel tool, I adjusted the donor and recipient parts until they fitted together perfectly. Obviously there is no need to do this if you have a whole good lens.

5. Once everything fitted, I glued together the 2 parts of the lens with plastic glue (more flexible than epoxy) and glued the transplanted lens to the black plastic back using silicon sealer. I used black but would recommend transparent since you do see some of it through the lens.

6. I used a permanent red market to cover up anything that didn't look quite right and with a fine brush filled the seams with... my wife's transparent nail polish.

That's all there is to it. Unless you're specifically looking for where the two pieces of lens are glued together, it now looks just like any other taillight in good condition. The whole matter took me about 2 hours, half of it figuring out how to go about it. It shouldn't take much more than half an hour if you transplant a complete good lens.

Loosening Old Adhesive. [Tip from Dave Jenkins] Try 3M Release Agent, an aerosol spray used to release adhesives on weatherstrips.

Re-Glueing the Lens Components. [Inquiry] You know those clear back-up lenses (cemented onto the the rear lights housing) on 900 and 800 models that tend to pop off at the car wash? What is the best cement for sticking them back on? [Response: Tom Irwin] Remove all the old adhesive, clean the surfaces with denatured alcohol, PRIME both surfaces with a cyanoacrylate primer such as loctite #770. Then a thin viscosity cyanoacrylate (super glue) adhesive on ONE surface. Press into place for 30 secs. [Response: Jim Bowers] I used clear RTV adhesive sealant to put the one back on my old 745. It held for more than 5 years. [Response: Dave Stevens] The Volvo replacement lens comes with a small tube of clear RTV silicone sealant and it seems to hold well. Best to choose an exterior/marine grade sealant with UV inhibitors. Clean the mating surfaces with something like isopropyl (rubbing) alcohol or 3M Adhesive Remover for good adhesion. [Tip from Terry] To re-attach the front cornering lamp lens on my 87 745t (luckily, it came off in my hand while washing) I removed the assembly, used a product called "GOOP" (the one specified for marine applications as it had UV tolerance) and and a lot of rubber bands to allow a 24 hr cure time. It has held for 5 years and is still tight and the car is never garaged.

Repairing Cracks and Holes in Lens. IPD is now selling the Plastifix Lens Repair system, consisting of three colored epoxies which effectively repair holes and cracks in amber, red, and clear lens. Each costs $20.

Water in Taillamp Lenses. [Symptom:] My tail lights (85 740T) are half-full of rainwater from el nino. After much frustration from changing gaskets repeatedly with no results and making repeated trips to the dealer to buy the replacement bulbs, I am contemplating drilling small drain holes in their bottoms. Is this advisable? [Fix:] I had this problem more than a year and half ago. I drilled such holes, and never had a problem since. I live in England where the weather is wet more often than dry, all year round. [Scott Jackson] I've had this problem as well. It's actually due to a leaky trunk seal. Mine was cracked at the part near the rear window. If water gets into the hollow part of the seal through those cracks it will drain into the trunk, usually near the tail lights. The water is coming in from the trunk and that's why replacing the lens won't fix the problem. Check the wells on the side of the trunk for signs of water and you've found the culprit. It's an expensive seal to replace, but I put a few layers of black electrical tape over the cracks in mine and haven't had the problem since.

Door Contact Switches. [Editor] The door contact switches on the door hinge frames, operating the overhead lights and key warning indicator, can corrode and stop operating. They can be rebuilt. Disconnect the battery negative. Remove the switch by unscrewing the grounding/earthing screw on the bottom of the switch. Carefully pull it out and remove the rubber boot and the connectors. At your bench, pry up on the plastic lock on the back, remove the spring and the plunger along with the side and center contacts. The ground or earth contact point (the middle blade on the center connector) is usually pitted: sand this down with very fine sandpaper. Coat the middle connector blades with a light coat of Oxgard conductive grease (electrical department of DIY home store). Reassemble. The side contacts go in the slots on each side with the button pointed inwards. The center plunger has a pin: engage this in the slot. The center contact has three blades: the middle one contacts the ground. Insert the spring and then the back cover. Reinstall the rubber boot. Now is a good time to replace the screw with a stainless steel screw to prevent corrosion, since that is your ground path. Coat the screw, the metal ground contact, and the chassis hole with OxGard conductive grease, then insert the connectors and screw it in.

Horns:

Horn Failures.

Location. Horns are mounted on the left side of the car, just behind the front bumper.

Horn Wiring. If the horns fail, note that fused +12V is supplied to the yellow wire connector on the windshield wiper wash switch, then directly to the horns. These in turn are then grounded through a blue-black wire back through the steering column to the collector ring, thence to the horn button, thence to ground at each button.

Horn Buttons. [Inquiry] How do i pull off the horn buttons on the wheel to clean and check power to the horn switches? [Response: Dick Riess] Disconnect the battery before attacking. Use a small flat blade screwdriver and push under the the button betweeen the steering wheel and the 'button'. Pull up at the same time to release the unit. Take your time and be gentle.

Horn Failure Mode. [Randy Starkie] I find bad horn buttons many times on the 700 series cars. I think the circuit carries too much amperage for the contact size in the horn button. The heat causes the raised plastic nipple inside to go flat (a sure sign that this is probably the case is if you find the horn button to be loose and easily moved around). You can test the horns while they are in place with some 12v leads (+ and -). If you can get the horn to sound with those I will wager a cold Guinness that you have bad horn buttons. If your car is like the 700 series horn buttons they can carefully be pried out without removing the airbag. But make SURE you disconnect the battery negative ground first.

Horn Corrosion. [Inquiry] The horns on my wife's 945 are rusted out to the point where one of them is completely gone and the other is hanging on for dear life. What is a good replacement for these? I think anything from the local auto store will rust out in one New England winter under there. The Volvo parts cost about $60 each. [Editor] IPD has dual replacement FIAMM horns for $29. [John Horner] Local pick-n-pulls here in Northern California have plenty of Volvos and charge $6.99 each for good used horns with 30 days guarantee to work. Rust is only minimal surface rust.[Gene Stevens] If you buy aftermarket horns, you need to find isolated coil type - two terminals. The more common one-wire horn will not work unless you add a horn relay. [Editor] The Bosch replacement horns are: low frequency (335 kHz) 0.320.043.147 and high (420 KHz) 0.320.043.148. They go for around $60 each online. Volvo OEM horns are less expensive at FCPGroton or Borton Volvo ($55 each); both (6846320 and 6846321) are drop-in replacements.

Horn Replacement. [Editor] To replace the horns, remove the 13mm fixing bolts. Rotate the electrical connectors to free them up, then try to pull them off after squeezing the lock tangs. If they won't budge, pry them up with a narrow screwdriver in the slot on the plastic barrel. Spray the connectors with DeOxIt or contact cleaner to remove corrosion and then fill them with silicone dielectric grease. Install the new horns, reinstall the connectors, and you are all set.

Lighting and Horn Upgrade:

Euro Side Marker Lamps.

Installation. See the separate file describing these side marker lamps and their installation.

Removal. Just use your fingers to push the light forward (towards the front bumper) it will then come free on the back side and then it's loose.

Daytime Running Lamps. DRLs have been standard in some markets for years, but in the US only arrived in the 1993 model year.

Installing DRLs in an Earlier Volvo. [Editor] You can install a DRL module to an earlier Volvo by purchasing a module from DesignTechInternational or IPD. Easy installation.

Removing DRL Function.

1. Later 960 Cars. [Sam] The daylight running lights on later cars can be disabled (or enabled) by turning that small screwdriver slotted switch at the 5 0'clock position. It has two positions. ---daylight on-daylight off.

2. Other Cars. [Dave Stevens] If DRL bothers you, replace the headlight switch with one from an earlier model 740 or 940 that doesn't have permanent DRL mode. The switches are a direct fit and there will be no need to change vehicle wiring. My favourite is the '89 (or thereabouts) 740 switch with 4-lugs on the back side (standard for the Canadian market in those years). It gives you DRL when the switch is left in the ON position, but you can manually still select PARK or OFF as desired. There was also a 5-lug switch with a visible set screw in the switch body that allows you to select permanent or switched DRL mode. If you search the archives here I think there's even instructions on which way to turn that screw. This switch was commonly used in the U.S. during the late 80's and early 90's. Note that the stock switch varied by year and market and maybe model, so be sure to look at the switch for the features I mentioned. You should be able to pick up a used one for about U$10. Tips: You will need to pull the switch knob off the shaft and they are often stuck on pretty good, so pry evenly with something suitably padded so as not to mark the dash panel or knob (which you may want to re-use). Slip an appropriately sized socket (forget the ratchet or nut driver handle if you don't have deep sockets) over the knob to remove the nut (pliers tend to slip and knick the dash). Unless you enjoy working upside down with the brake pedal in your ear and all the blood rushing to your head, you will probably want to remove the knee bolster panel for access behind the dash. Although you don't need to pull the light switch panel to change the switch, it makes it far easier to remove and replace the connector on the back of the switch if you do. It also makes it easier to find and replace any burnt out dash bulbs at the same time. Before beginning removal, note that the light switch panel is pushed out at the left which is retained by a side mounted spring clip -the right side is held by tabs which only disengage once you've swung the panel out a bit. To avoid almost inevitable damage to the dash opening if you try to pry it out from the front, reach up behind the dash and press the aforementioned retaining clip firmly inward (to the right) as you start to push the panel out.

Euro-Code Headlamps. [Inquiry:] What is involved in installing Euro-Spec headlamps in my car? [Response 1: Jason Kneier] You can get Euro units (all glass), but you'll have to get the turn signal assemblies, too (they're incompatible w/US ones) [Response 2: Mike Sestina] There is no rewiring involved if you open up a 9004 bulb for use as a plug and wire to its connectors. It will just plug into the North American wiring harness so you can unplug to restore NA style when you sell the car. See detailed headlight technical article in Oct 99 ROLLING by Duncan LeBay on installing E-code (Euro) lights in a 240. I have installed E-code lights on our 945. One must replace the corner lamps. Corner lamps are Clear/Yellow. The upper Clear lens is for the Daytime Running Lamp and the Yellow is for the turn signal. I had to swap out the standard OEM 945 grill, because my car came without foglights. The E-code main lights come as one integral assembly combining the 3 beams into lo/hi/fog lights. See the photo. The 960 grill is made for these European lights because the North American 960 normally came with fog/headlamps. OEM parts came from Verrigni at a price close to $400 each side though. These lamps were the best upgrade to the car, second only to the IPD bars [Response 3: Stoney] All Volvo ECode headlamps and turnsignals are available from Verrigni Marine at 800-888-6586. See also http://www.eurosporttuning.com for a $495 package of everything needed.

Lighting Upgrade Information. Check out Daniel Stern's website for good information on headlamp upgrades.

Basic Upgrade Information. [Inquiry:] What kinds of after market fog/driving lamps are you guys using? I need suggestions on a good pair for my1990 740. I'm not too afraid of drilling and all that other stuff, so what would be the place to mount them? [Response: Daniel Stern] This question has no real "correct" answer, but it has a whole bunch of INcorrect ones, so let's get those out of the way first.

Don't waste your money on the trendy little "eyeball" or "flat oval" shaped junk from e.g. Blazer, Tenzo, Catz, or any of many copycat companies. They're toys, meant primarily for kids who want to think their car looks "kewl". (Nobody has ever given me a definition for "kewl"...I'm still waiting...)

Now, to answer your question with a question: What is your goal? You're dealing with *ROTTEN* original-equipment headlamps, so neither your low beams nor your high beams are much of any good. My first and loudest suggestion would be for you NOT to buy any auxiliary lamps at all--from me OR anyone else--and instead to save your money up for a European-code ("E-code") headlamp changeover. This will not be inexpensive, but will make tremendous improvements *EVERY* time you drive your car at night.   Adding auxiliary headlamps to rotten main headlamps is a band-aid; replacing the lousy main headlamps with real working ones puts auxiliary lamps back in the category they belong in: Additional supplements to handle special situations, not necessary stopgaps. The E-code headlamp changeover can be had at favorable prices from Verrigni.

Suppose, though, that you are fully aware of your current headlamps' low performance, but you also have determined that you will not spend the money--now OR later--for the E-code headlamp changeover. In that case, your task becomes one of making the best of a bad situation and choosing your auxiliary lamps wisely. You need to be discriminating not only on the basis of lamp performance, but also on build quality (skip the low-end "consumer grade" plastic stuff...find units made out of glass and metal) and on long-term serviceability (find lamps that have replaceable lens-reflector units so you're not stuck shelling out the cash for a complete new lamp assembly when a rock takes out a lens or when 10 years' hard use deteriorates the reflectors.) There is, as I say, no need to uglify your car with the odd-shaped black plastic stuff on the market; there's also no call to plaster great big chrome lamps on the front of your car (unless that's the look you're after). Sufficient stylistic variation exists in the realm of *good* lamps that you can find something that will integrate well with the front end of your car AND work well.

I imagine you'd want rectangular lamps on that car (though I may be wrong; maybe you prefer rounds). If in fact rectangulars are what you have in mind, I recommend two pairs of Cibie 35s. One pair of yellow fogs, to be mounted below the bumper as far apart from each other as practicable. One pair of clear drive beams, to be mounted above the bumper just inboard of each headlamp. The fogs would fill-in the black hole" left on the road foreground by the low beam headlamps and add width to the coverage. The driving beams would add punch to the high beams.

Other alternatives exist...Marchal 950s, Cibie 95s or 175s, Hella 220s...make sure you know what you're getting, though, because some of the widest-available manufacturers (I'm thinking of Hella here) make a random mix of junk and good stuff.

New High Performance Headlamp Bulbs. There is test of PIAA, Philips, Osram bulbs. It is first issue in October Autobild "Heft 39" under "Produkttest und Gluhlampen" title.

Brief translation of article from Marc:

Tag line: In headlights there are a variety of lights, yellow, blue, etc, that promise more light, but not all deliver light brightly....

For the last 27 years, approximately, driver's haven't had to think about what kind of bulbs to use. If you were using H4 lamps, you just stuck in another H4; the only real choice was which manufacturer's bulb you used (Osram or Phillips). But for the last two years there is motion in the bulb market, in the form of Xenon lights, with their blue cast. Purists will roll their eyes and claim that they're not blue, but rather produce true daylight spectrums. This is true, but compared to other lamps, it seems blue. It's also the target lighting type that various individuals and firms want to make happen with regular [H4?] type bulbs, by using different methods. Shortly after the decision to go with real Xenon lights in the BMW 7 series in 1991, the were aftermarket laquers that could be painted onto regular headlights to supposedly provide "trouble-free Xenon effect". There are supposedly actually people out there who seemed to believe these claims... Then comes the next chapter of the story: after the painting on of the laquer, when the headlights first were turned on, the heat from the bulb was to vaporize the laquer and the resulting mist coated the reflector and the glass of the housing; as a result, the light was truly blue, but also much too dark. The problem cured itself inevitably, as when the car had to go through TUV, the inspectors would madate a complete headlight assembly swap to get rid of the problem (TUV = German vehicle inspection -- comment by Marc: the toughest inspection I've ever seen/been through). We have to add here that in writing this article, that we received a pair of blue Xenon-Caps; these blue plastic caps fit over the headlight to supposedly give the Xenon-look, but the plastic got smokey/opaque/warped/melted the first time we turned on the lights, and the off-gases ruined the reflector and glass. Even so, we had our reason to be happy: had this happened in the testing device at Phillips, the cost to fix their tester would have increased the damages by some 20,000 DM (about $14,000), and they had been nice enough, as the leading provider of automotive bulbs, to provide us free access to their quality-assurance group & the test equipment. The test equipment (called a light-globe/marble/ball) did it's job, which is to measure the actual light emitted by a headlight lamp in Lumens, as well as where that light ends up (vs. the raw amount of light emitted). The should-be-produced light amount from a manufactured H4-lamp should be 1000 lumens (+/- 150 lumens). Therefore we took the lamp in a normal headlight assembly and pointed with the light-globe at a measuring wall. This allows us to see the beam pattern and to measure the actual output at any point directly. On this surface, on the left above the center, is where on-coming traffic would be exposed to light; this portion of the light pattern can not be very strong, otherwise the blinding of on-coming traffic is too strong. By contrast, the right side can never be bright enough; the light thrown to the right side, about 50 meters out from the car is important for the driver's identification of road hazards and foot traffic. In order to have good light there, the geometry of the bulb must be correct, sending the light to the right spot. We also check for this in our comparisons/testing. But before testing, each of the twelve candidate bulbs have to burn in for an hour. For this purpose, Phillips has cabinets full of the right connectors; the doors covered with a fine mesh steel grill, to protect you in case one of the bulbs should happen to shatter. It never came to that, but one of the four PIAA Super White and Blue Laser Light bulbs didn't survive the burn-in period.

Generally, the the test bulbs fell into five catagories:
(1) standard bulbs, including GE and Osram - reasonable quality at low costs;
(2) 100-watt-bulbs, including the Jahn brand. In open headlight assemblies (Marc's comment - headlight assemblies where the bulb can be changed independently of the reflector casing), this are not permitted under German law, but every car parts store seems to carry them;
(3) Premium bulbs - to this end, Philips has the majority of the market, with the Osram Super being the competitor -- these lights supposedly produce 30% more light;
(4) Super-All Weather - yellow bulbs, which inherently produce less light make up for it by concentrating on a wavelength that is more visable. The Osram Allseason Super should at least take care of bad lighting conditions;
(5) Xenon-imitations, divided into two catagories: those not permitted under TUV rules and those that are certified for use. The first type can't be used in regular street traffic and is therefore hereby listed as "not worthy of recommendation". The other type provides a bluer light than a regular bulb and can be considered as an alternative to a regular bulb. The price differences are very wide. The best price/performance ratio is the Jahn Superblue, although it failed the test for where the focus was directed. Point to be made: in none of the listed bulbs was the focus geometery correct/perfect.

Brief translation of the summary from Ross Gunn:

In summary: "If you want really good light, use Osram Super or Philips Premium. If you would like to lend a legal xenon Touch to your auto, try True Blue or Blue Vision. If you only would like to replace a defective lamp, buy a name brand original equipment quality lamp. The remainder is simply junk and not worth the cost of the packing it is in."

Auxiliary Lighting and Wiring Information. [Tip from Mic:] Check out the following link for information on installing and wiring replacement headlights and auxiliary lights: http://catalog.com/susq/other/useful.htm

Fitting Higher Wattage Bulbs in Existing Frames/Reflectors. While you can easily install higher wattage bulbs in your existing lamp reflectors, most users have reported that the reflectors melt after a short time due to thermal overload. The earlier four-lamp sealed beam frames do not melt. However, in both cases you will have to upgrade wiring and relays.

Driving Lamp Mount on Front Bumper. [Inquiry:] Has anyone mounted driving lamps on top of front bumper on a 90 744T? The mounts I have (CIBIE 175) have short (1.5" or so) bolts (non hex head for clearance, probably can't change to longer bolts without a hassle) and I don't want to go punching holes in the bumper cover without knowing what's under there. I've looked under the bumper through the spoiler access holes (two plastic covers left and right) but the solution doesn't jump out at me. Or is this just a case of fabricating a bracket and mounting it to the bumper mounting studs? Is there a factory bracket for Volvos for mounting auxiliary driving lights above the bumper? [Response: Mats Walroth] Here in Sweden Volvo has a mounting bracket for driving lights on top of the bumper. I have it on my 90 940. You don't have to drill a single hole to put it on, it is clamped. It also comes with wire harness relay switch and stabilizer bars. The Volvo part number is 3529 080 Price in Sweden is 645 krs which is about $80. For lamp aiming instructions, see Headlamp Aiming.

Mounting Foglights to 90+ 740. [Inquiry:] How do I mount foglights to a 740/940? [Response: Steve Seekins] The 740 through 89 had the foglight that mounted on a plastic bracket that bolted to the bumper and the light came through a cutout on the airdam. In 1990, the bumper, airdam, grill, hood, fenders, and headlights were all changed. The headlights were single plastic lens units and the air dam was a smoother unit with a grill in the center portion. For aiming instructions, see Headlamp Aiming.

1990+ OEM Foglights:

The OEM accessory foglight kit for these cars uses a molded plastic piece that fits the contour of the airdam and has a custom shaped reflector and lens that is faired with the mount and it all fits snugly against the bottom of the bumper - much nicer looking than the earlier version and also a bit less prone to damage as it does not extend down so far. In mounting the foglights for the 90- 700 series on the spoiler, you will need to cut the spoiler according to the patterns included in the instruction booklet. You will also need torx driver as the mounting screws are torx head. Wiring will pass through the firewall using an existing harness grommet which has spare ports. Some stiff wire and wire pulling lubricant will be very helpful. You will need to pull out the relay tray in the center console to install the new relay and hook up the wiring to the fuse connections. There are about 4 different wiring options and a couple of different relay options depending on what jurisdiction you are in. I used the European option which allows the fog lights to be ON with parking, low, or high beam. I often use the fog lights during the daytime with the parking lights (in metro DC area you need all the visibility you can get!). The local rule here is that you can have no more than 4 lights lit on the front of the car, so since the headlights are single beam, you can run the fogs with either low or high. With a quad light setup, you must wire fogs to come on only with the low beams. These lights make for a very nice installation on the 90- 700s, and they seem to be very good quality lights. However, being low and under the bumper, they are prone to sand and gravel damage. Get some of the heavy adhesive clear vinyl protection sheets (available from IPD and others) and apply it to the lenses. This will stop all but the biggest stones. Then, you will have to be careful about high curbs and parking lot stops.

1990+ Aftermarket Foglights:

[Editor:] You can mount Hella or Bosch fog or driving lamps in the small cutout on either side of the lower airdam. Fabricate a rectangular bracket from stiff steel plate or 3/8 inch ABS (to minimize vibration) that is approximately 2 inches by 6 inches. Drill two holes for bolts in the bottom front of the bumper shock frame mounting tube (the part of the frame to which the bumper shocks are mounted.) Rustproof the holes, then mount the bracket to this tube (tight fit for the bolts and nuts!) and then drill the mounting hole for the foglight in the center of the bracket. Hang the foglight from the bracket and wire it up. The location in not ideal: it is low down, limiting the effectiveness of the lamps and subjecting them to stone and curb damage, but cosmetically it is superior.

Fog Lamp Upgrade Information. [More good tips from Daniel Stern:] For lamp aiming instructions, see Headlamp Aiming.

A fog lamp, in general, is a lamp which produces a beam with a horizontal cutoff at the top of the beam, above which minimal light is thrown.

A *GOOD* fog lamp produces a very even, very wide beam with minimal "hot spot" effects, with a sharp upper cutoff and with a bulb shield or other method used to eliminate or reduce upward stray light.

The function of a fog lamp is to illuminate evenly the foreground area of the driver's field of view, without creating backdazzle in the rain, fog or snow. In other words, the idea is to throw a wide, even beam of light UNDER the rain, fog or snow. Fog lamps are most effective when vertical separation is maximized between the lamps and the driver's eye height. This means it is best to mount fog lamps low to the ground. The benefit of correct (low) fog lamp placement is double, because a low-mounted fog lamp can be aimed with the cutoff at the same height as the lamp unit. This gives maximal illumination range. A fog lamp mounted where driving lamps should be, at headlamp level or above, must be aimed with the cutoff at a declination of at least 3 inches in 25 feet (1 percent) to avoid creating glare to oncoming traffic and backdazzle to the driver. This declination limits the illumination range of the fog lamps, however, since the cutoff hits the road at a defined point which can be determined using simple right-triangle geometry. The factory fogs on my 164 are in the wrong place, inboard of theheadlamps. They're soon to be replaced with driving beams, and good round fogs placed under the bumper.

Selective-yellow fog lamps are widely held to perform better in adverse weather conditions. There is controversy on this point in the lighting and regulatory communities, as little proper research has been done to confirm or refute the poor-weather benefits of selective-yellow light. There are physical reasons why selective-yellow light should not be any better in conditions found on the road, but there are physiological reasons why the eye should be less affected by glare and backdazzle with the selective yellow light color. So the controversy continues! Bulbs in funny colors with bogus performance claims (PIAA "SuperWhite" and similar) can be dismissed right out of paw.

The central issue, however, is beam pattern. Many of the "fog lamps" found on vehicles in North America are cheaply made and rather worthless, with low-output bulbs and unsophisticated optics. Those plastic jobs on some 700 and 900 series cars DEFINITELY qualify--and they're in the wrong place, too. These lamps do little to improve foreground illumination, do even less to help in bad weather, and often create dazzling glare for oncoming traffic.

How can a low-performance lamp do that? It's because most fog lamps are rather small, but contain halogen bulbs which create enough light to be painful to look at, even if not enough to do much for road illumination. The small reflector and bright-enough-to-glare bulb create *high unit luminance*. That's the technical way of saying that the reflector reflects a lot of light per unit area, and so creates a very bright *signal image* (what we see when we look at the operating lamp*. This is true even for correctly-aimed fog lamps, and it's why the fog lamps of an approaching vehicle often appear much brighter than the low beam headlamps, even though the fog lamps always use bulbs that produce about the same amount of light as the low beam headlamp bulbs.

The reason why fog lamps are wired to switch off when the high beam headlamps are activated is because high beam headlamps create a *lot* of upward light (which is not considered "stray" in a high beam or driving beam when you need to see for a long distance down the road), and are therefore worthless in bad weather. Therefore, if you're using high beam headlamps, you've no need of fog lamps because your vision is not impaired by poor weather. At least, that's the supposition in the minds of the same folks who insist that we in North America use headlamps with minimal (some would say "insufficient") foreground illumination on low and, often, high beam.

There is recent research indicating that in poor weather conditions, a lighting combination of front, rear and side position marking lamps (parking lamps, sidemarkers and taillamps) plus fog lamps WITHOUT
headlamps can be advantageous due to reduced backdazzle for the driver. Many of us who modify our vehicles' stock lighting systems already know that! However, before such a change becomes advisable, we'd want to see an increase in the minimum performance requirements for fog lamps in North America.

Louder Horns. If you want a set of loud electric horns, cheap, pull a pair from a late model Audi 100/200/5000 series vehicle. These horns sound similar to the brand name aftermarket ones I bought a while back...I *think* they were Fiamm.

Lamp Reference Diagram:

Lamp Diagram and Part Number Charts.

Bulb Diagrams:

Bulb Descriptions and Ratings: [refer to figure above]

Lamp Part Number Table:

Bulb Diagram	Part Numbers		Descriptive Notes
Number	Volvo	Osram	
1	966326		VDO panel: bulb soldered into base
1		2721	Yazaki panel: bulb with separate base
2	1363149-4		Panel switch lamps
Similar to 2 with two metal prongs	9130288		Blue 1.2 Watt lamp with holder: ashtray
3		2721	Yazaki panel: bulb without base
3	1323462-0		Blue 1.2 Watt lamp without holder: dash
3			Blue 1.2 Watt lamp with holder: ashtray
4		2821	Instrument panel illumination 3 Watt
4			4 Watt
4	949671		5 Watt
7		6418	5 Watt
7		6411	10 Watt roof/engine/trunk lamp
14		H3	55 Watt Fog lamp

960/90 Interior Trim and Panel Lamps. See the FAQ section describing these bulbs.

Wipers:

Wiper Arms.

Loose Wiper Blade Falls Off. [Don Foster] If you lose a wiper blade, IMMEDIATELY lift the arm so it simply waves in the air. Get it off the glass to prevent gouging.

How to Remove. [Tip from Sheldon Fast] There is a plastic black cover over the end of the shaft. Take this off and you will see a nut on the end of the shaft. Remove the nut and pull the wiper up off the splined shaft. Same for front and rear wiper arms.

How to Tighten. [Tip from Don Foster] If your wiper arm is loose, remove it (the nut is under the cap), clean off the metal chips from both the arm and the splined shaft, reinstall, and add Loctite to the joint. Then sock down the nut tight. Volvo recommends new nuts, but Loctite allows you to reuse the old ones.

How To Reposition Arm on Windshield. [Editor] If your wiper parks in the wrong spot, remove the shaft nut and arm. Clean off the shaft with a wire brush to expose the tines. Place the wiper in the correct park position, press down real hard on the arm over the shaft and remount it on the shaft. Fasten the nut with Loctite and torque it down firmly but not overmuch.

Replacing Wiper Control Stalk. See the section in Electrical-Instruments for more information.

Wiper Motor Problems. [Symptom:] Whenever I use either my intermittent or low they work for maybe five minutes and start to slow down until they stop. The weird thing is that my high wiper setting seems to work fine. [Fix:] I had a problem like that and found that the motor brushes were marginal. I guess the low speed stress them more and tend to over heat and bind in the holder... at higher speeds the momentum is a help and also lower current flow and less heat generated... in a nutshell replacing the brushes cured my problem..

[Related Comment:]Not sure about the 740, but the 240 equiv. failure mode is usually due to the permanent magnets inside the motor shell separating from the case due to rust infiltration on the glue. They shift and drag on the rotor, as well as mis-align the field. Can be repaired quite easily, if that's what it is. You can replace the brushes same time, if needed, and if you can find some, but I found my 1984 original brushes were fine. (Stretch the springs a bit if the brushes have shortened). I found my high speed was slower than normal, and low was very slow. And then it stopped.

[Another Comment:] Assuming 740 is not too different than the 240, fix involves pulling the motor out, (you have to disconnect the linkage clip under the dash), and open the shell. Careful to not drop the magnets, they are ceramic. They have a tendency to follow anything ferrous, I smashed one once when it followed a screwdriver I had picked up and it accelerated right off the bench. Clean up the rust, and epoxy the magnet(s) back in. Note position and orientation when you remove the magnet. Buff up the brush contact segments on the armature if necessary, lube bearing and reassemble. Brushes are a bit tricky to compress while inserting the armature, a loop of thread and masking tape works great.

{Another Comment:] Also: first you may want to check the ground connection; my 745 had a bad ground to the wiper motor, which consisted of a jumper across the rubber-mount at the driver's side. I wired in a new ground and voila.

Wipers Are Slowing Down. [Inquiry:] I noticed my wipers to be sweeping slower than usual lately, and a whirring sound to be coming from the wiper motor. There was even an instant that the wipers would not sweep, before it suddenly came to life and began to sweep slowly. Fuse was OK. Windshield was very wet with rain. Wiper rubber strips are 3 months old. Is my wiper motor about to die? Or should I squirt some WD-40 somewhere to "loosen" up the motor? [Response: Richard Klasic] It's hard to describe but the wipers are mounted on the shaft going through a bushing. After years of usage. this bushing becomes dry and corroded making the wipers move more slowly until they freeze completely. You need to take out the shafts and polish them gently with sandpaper and then lube the shaft with a grease that doesn't go away with water. You can always unhook the motor from the ball joint to the wipers and see if it runs fine. I bet it does. This was the case on my wipers on the old 760 I had. It really squeeked when running. And after 15 minutes hammering at the tap with a plastic hammer and lot of WD-40 it finally came loose. After my operation WOW the wipers were dead silent and swept like lightning over the windshield.

Wiper Linkage Becoming Loose and Wobbly. [Walt Lear] The wipers in my 85 740 started to wobble over the years. I figured age, linkage getting sloppy, elongated holes, etc. Decided to get some junk parts and fix the linkage. The Haynes manual showed a picture of a "cable adjusting nut" with no explanation. Removed the entire assembly and found the nut under the left side shaft. If I grabbed the frame the cable rides on, it would twist/move. Cable end has a flathead slot, so I held the nut and tightened the cable a couple of turns until the frame would not move/ twist. Replaced and it works like new.

Front Wiper Failure to Park. The wiper motor gets power from two sources. One is from the switch on the stalk. The other is from the battery via the ignition switch, but in series with this path is a switch internal to the wiper mechanism which opens up once per cycle. If the second circuit is functioning, when you release the stalk switch, the second circuit still carries current to the wiper motor until it reaches the wiper position where the internal switch opens. At this point, if the stalk switch is disengaged, the wipers park. If the second circuit isn't working, either because of a faulty wiper park switch (inside the wiper mechanism) or because the external wiring isn't delivering current to this switch, then the wipers park immediately when you shut off the stalk switch, as you describe. First thing I'd check is the wiring.

Removing Cowl Screen for Windshield Wiper Motor Access. [Tip from Richard Klasic]
1. Remove the wiper arms
2. Remove the rubber trim around the wiper axle. This trim is held on to the wiper arm shaft by a locking tab on the front: use a narrow screwdriver to carefully prise this away from the shaft, then pull upwards. You may pull off the thin plastic shield beneath and crack it; get another at the dealer.
3. Open the hood
4. Locate three screws (you'll need a 10mm socket and a short extension) one near the fenders and one in the middle

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|here               here               here|
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|                                          |
|           Engine Compartment             |
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5. Gently move the cowl panel (the the painted chassis part where the air inlet is located) back

and lift it up, pulling the rear up toward the windscreen. It has two hooks at the rear corners and clips under the windscreen so you have to wiggle it some: lift the ends where the 2 endbolts were to clear the rubber stop. Once clear, pull towards the front. The molding comes off with the cowl (but under the molding area are windshield clips that remain.) It can be helpful to do this with the hood in two positions. To get the tab over the firewall, close the hood just a bit so that you can lift the cowl enough for the tab to clear. Then reopen the hood so as to allow the cowl to be drawn forward. Lifting the hood to "full open" (by adjusting the stops on the hinges) makes the final removal easier.

6. Under this cowl panel, the wiper assembly is found. It can removed by unhooking the electrical socket and unscrew maybe 2 screws. See the section in Heating for more information on the air intake screen replacement and the water shield. Now is a perfect time to clean the side drains of leaves and dirt and inspect the water shield over the air intake.

Wiper Transmission and Linkage Replacement. [Neil Noonan] To remove and replace the wiper transmission, open the hood to its fullest extent.

- Mark the wiper arms with a piece of tape and label “Right” and “Left” . They are different and it will save you time trying to figure out which one is which.
- Remove the wiper arms and the big rubber escutcheons from the wiper shaft.
- Remove the cowl
- Disconnect the ground wire on the bracket that holds the wiring connector. My bracket bent a little during this part but was easily straightened out.The connector for the wiper motor can be released from its holder by sliding it one way or the other. There are two posts on the bottom that slide and lock into the holder.
- Disconnect the wiring harness for the wiper motor by squeezing the connector and rocking it apart.
- The wiper transmission is attached at 4 points. There are two bolts that are up near the windshield and two nuts that hold the lower part of the transmission. These are very easy to see.
- Once these are removed lift the transmission from the bottom (where the 2 nuts were) and lift it out, over the studs, with a slight rolling motion. It should come out rather easily.
- Remove the nut on the wiper motor and work the transmission arm off the motor. Make a note of the way the arm is aligned on the motor; it must look the same when you’re done.
- Remove the three bolts holing the wiper motor.
- Install the motor on the transmission.
- Don’t attach the transmission arm to the motor yet.
- When reinstalling the transmission fit the top part in first and lower the bottom part over the studs.
- Screw the nuts on the studs, but don’t fully tighten yet. Put the 2 bolts in the top part. When I did mine, I tightened the two top bolts first and the tightened the two nuts.
- Plug the wiring harness back together and attach the ground wire. The connector can then be slid back into the bracket.
- Turn the wipers on and after a few seconds turn them off so the motor parks in the correct

position.

- Now you can attach the transmission arm to the motor. Remember how it was originally attached? The arm should be in a straight line to the motor or as close to a straight line as possible. The shaft has grooves on it and so does the inside of the arm. It has to fit into these grooves. Once it’s on tighten the nut. You may want to use a bit of Lok-Tite here although I didn’t.
- Put the wiper arms on and test the movement of the arms, adjust if necessary.
- Take the wiper arms off and reinstall the cowl. Make certain the edge next to the windshield fits into the groove in the windshield molding.
- Install the rubber escutcheons.
- Install the arms and make any final adjustments.

Rear Wiper Motor. [Various diagnostic tips on rear wiper motor failures]
Diagnostic Tips:

- *Motor Won't Rotate.* I pulled the entire wiper motor out, took it apart, and (believe it or not) everything worked great after I put it back in. Problem was tarnished electrical contacts on the brushes and commutator of the electric motor. I polished them up with a piece of emory cloth, and it's working great now. [Editor's tip: prevent this by operating the motor every few weeks.]
- *Shaft Seizure.* The reason for the constant failure of these motors is because the linkage going out through the rear window needs greasing every year. This takes a salt pounding all winter and seizes up, over-stressing the motor and burning it out. Remove the rear wiper arm, pull the rubber protective cap, remove the tiny C-clip and push the linkage into the car. Clean the hole, sand the shaft, grease with a synthetic grease (still viscous in the cold weather) and reassemble.
- *Linkage Bearings.* My rear wiper motor (1985 740 wagon) kept going slower and slower and I ignored it (bad move). It was the pivot bearing (white metal?) that had just corroded to the point where it was freezing up and eventually burned out the motor. Strangely enough, my independent dealer cleaned up the "bearing" and reinstalled it (and a rebuilt motor, too). My first instinct would've been to replace the bearing with as new one but, so far, so good. So, if you're fiddling in those parts, check it out.

Rear Wiper Motor Park Position Reset. There is only one way to get the arm to rest in the correct position. First, note which side the wiper arm is supposed to park. Remove the wiper arm from the shaft, this is the last part to go back on. Now turn the key to the "on" position and start and stop the motor so you are certain it is in its rest position. Remove the inner panel. On the motor is a 10mm nut holding the short linkage piece of the wiper arm. Remove it and pop off this short piece. Turn the short piece until it is parallel to the long linkage arm to which it is attached: not outward but inward, so the total length of the linkage is not longer than the long piece. They're now overlapped. Now pop the short linkage onto the motor and replace the nut. This requires deft hands as the nut is exactly between the two pieces of linkage, but don't worry, there's room. Before you tighten the nut, ensure the two linkage pieces (the short and long) remain perfectly parallel. Tighten. Reinstall the wiper arm, making sure you place it on the correct parking side. Mine is a 745, so the arm rests to the driver's side.

Motor Removal. [Al] To remove the rear wiper motor, first remove the tailgate panel. Then pop the cap on the wiper arm and remove the small nut releasing the wiper arm. Sometimes you need to rock the arm to get it off the spindle. There is a large silver flat nut beneath. Unscrew that and the assembly is freed from the glass section. Don't forget to loosen and remove the nut on the motor to release the arm assembly from the motor first. That just makes it easier to drop the assembly out when you remove the nut.

Motor Gear Repair. [Tom Kaylor] My rear wiper motor stripped the driven (big) gear. I removed it from the vehicle and noticed there are no screws holding the case cover on; while they look like rivets they are actually protrusions of the die cast housing and will break off flush. I reinstalled the cover and drilled and tapped the housing for 8-32 screws. Be sure to use the cover for a template so everything lines up. The shaft has serrations that deform the plastic gear ID to hold it in place. When it fails it enlarges the bore of the gear. This was my first experience using JB Weld so I had my doubts. Anyway I used a small 3 corner file to create several "keyways" or notches in the plastic gear to give the JB Weld something to flow into. Be sure to prep the shaft and gear with a non-petroleum based solvent, something that won't attack the plastic; brake cleaner worked for me. Clean the housing, check and clean the electrical contacts. The old grease was dried out so I used Lubriplate 105 white grease but not to excess. Reinstalled and ran the motor until it reached "park", then re-attached all the linkage. You could or maybe should give it about 24 hrs to set up since the JB cures slowly before reattaching the linkage. At this point it has performed flawlessly for 2 weeks and saved me about $140.

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960 Headlamp Wipers.

960/90 Headlamp and Wiper Assembly Removal. [Tip from Warren Bain] After removing the bolts holding the capsule in place as above, you can then remove the lamp and wiper assembly. The headlight wiper and washer motor shaft goes through the plastic bumper cover. To save time, I cut the top piece above the shaft. No one can see the cut. The old one comes out with some twisting and turning. The wiper motor is attached to the bottom of the headlight housing. I swapped the metal clips and the wiper motor from the old headlamp assembly to the replacement unit. Make sure the electrical pins on the new headlight are the same as the old ones. If not, swap the harness inside the housing. Use slip joint pliers to free the headlight electrical connector on the back of the housing. It takes some work to get the old connector out but it can be done. On mine, the new pins were shoved back inside the connector and the lights would not work. I had to swap the internal harness. Replace the housing and the electrical connectors including the wiper motor, and put the turn signal back in.

960 Euro Spec Wiper Removal. [Adam Stevens] After finding that my headlamp wiper parks in the middle, I decided to replace the wiper motor assembly. It is in fact a very easy job! Braydon Motors sent me a second-hand unit for £26 (new about £95!). Disconnect the fog lamps, take off the grille, remove the headlamp wipers and undo 6x16mm nuts holding the bumper, air-dam, fog lamps etc to the chassis and slide the whole assembly forward as one unit - simple! Take out headlamp, swap motors, reverse process for re-assembly. [Cautionary Tip from Ryan] I learn't the hard way never to tuck the blades under the 2 plastic arms before going into an automatic carwash. With the best will in the world its all too easy to forget them and a couple of miles down the road use the wash/wipe. Mostly the relays will prevent damage to the locked arms but not always, as I know to my cost!

Washers:

Windshield Washer Jets and Check Valve.

Aiming the Nozzles. [Tip from Peter Rhyins] The nozzles are all adjustable. You need a pretty stiff piece of wire or a stout needle that fits into the jet to get them to move. I used a strand from a stainless steel wire brush I have. A very tiny needle will work but these are brittle and can break off too. You can drip a small amount of 3-in-1 oil onto the base to get the round mount to rotate.

Removing and Replacing the Nozzles. [Tip from Nathan] You need to partially remove the sound insulation on the inside of the hood. Then you'll be able to see a couple tabs on each jet. You'll need 1 or two small flat head screw drivers to pry in the tabs.

Nozzle Repair. [Response 1: Dennis Hamblet] The best tool for cleaning washer nozzles can be bought at a welding supply house and is called a tip cleaner. It consists of a graduated series of very small round files that can be fitted into the jet and remove the deposit which is generally mineral deposits. Jets may be adjusted by inserting a pin (or a tip cleaner) into the jet and rotating it into proper position. [Response 2: Michael Brown] Do you have access to compressed air? I took off the hose at the plastic connector under the hood and put a compressed air nozzle in the end of the hose. It blew out the blockage and all is well. [Response: Stephen Ringlee] Use a sliver of thin steel wire to clean out tip deposits and buy an in-line filter from IPD or Volvo to keep debris from clogging the lines. A needle can be used to adjust the aim. [Response: Jack Reed] Clean them with the finest wire that will fit in the hole without binding. Prevent the problem in the future by buying a lawn mower sized gas filter. Fits perfectly into the main feed line from the pump before the T. Just cut the line in the best spot for the filter and remove a filter sized section. Change it every few years and you should be fine. Considerably cheaper (~$1.50) by the way, than the $5 IPD wants for the same thing. [Response: GN] I took out the nozzles and put it in an ultrasonic-cleaner with the regular vinegar (it has only 5 %) and some drops dishwasher liquid. Approximately 10 minutes each side then rinse it and spray with teflon oil and put it back in the hood.

Windshield Washer Check Valve:

Valve Function. [From GN] The T-valve with red cap under the middle of the windscreen is a backflow-suppression valve. It will keep some water in the lines to be ready. Otherwise it will take 1-2 seconds to deliver water to the nozzles.

Washer T-Valve

Check Valve R&R. [Tip from John Kupiec] These valves commonly leak from the small hole in the red cap, a sure sign the internal diaphragm has failed.   To test the check valve: Disconnect the tube that feeds from the washer to the check valve. Try the washers. If you get a stream of washer fluid, you know the pump is okay. Next, reconnect the feeder tube to the check valve, and disconnect one or both of the tubes leading to the jets. Try the washer. If you fail to get a good steam of fluid from either of the two tubes leading to the jets, the check valve is bad. Replacement check valve run less than $10. [Steven Sherman] You can rebuild them for pennies and actually make them better: take a nitrile surgical or mechanics glove (or plain old latex, which will wear faster) cut out a square inch, and then pry open the valve carefully using a knife blade. Don't lose the spring that will pop out. Take out the busted membrane. Take a needle and clean the narrow groove between the black diaphragm and the red cap to remove accumulated crud. Then lay in the piece of polymer that you made. Snap the top back on, and you are in business. If you are a neat-freak, trim the excess material.

Washer Filter. [Tip: Stefan Schader] I found that the windshield washer fluid bottles contain sometimes small plastic shavings which clog up those nozzles and the fluid tank filter does not stop them. To prevent this, I put a small in-line fuel line filter in the washer fluid line a few years ago. Voila! no more problems since then. (Editor's note: this style of filter is also sold by Volvo, IPD and NAPA. [From GN:] NAPA 3011 BP - $ 2.70 has the right connector size to fit in the hoses .

Tailgate Washer

Check Valve Failure. [Inquiry] My rear washer does not work; the nozzle is fine. What is the problem? [Response: Dave Stevens] When mine quit, I figured maybe the hose was pinched shut somewhere. Starting ripping off trim panels along the passenger side. Eventually I found the hose going over the wheel well and followed it back to discover (surprise) the small right-angled check valve in the hose in the hole near the tail light assembly. I knew the problem right off as I've often encountered check valves with disintegrated diaphragms. I decided to try a DIY fix of the check valve. I pried it open with a knife edge and carefully picked out all the white gum. I then cut a new diaphragm and it now works again without leaking and without any chance of back siphoning.

Nozzle Replacement. [Inquiry:] I bought a new tailgate washer nozzle for my 745 and now realize that I have no idea how to get the old one off or the new one on. I tried pulling out the old one but either you have to pull really hard or I am about to break something and really screw things up. [Response: Nathaniel] This is a delicate operation but very simple. The nozzle that is in your tailgate is held in place by expandable clips that squeeze in when you push the nozzle into the tailgate and expand once firmly seated. If you take a look at your new nozzle you'll see what I mean. In fact, study this nozzle and you'll begin to get an idea of what you have to do in order to get the old one out. Seems simple but these things are real buggers to get out without scratching your car. What I do is simple grab the old nozzle with a pipe wrench (provides good leverage and grabbing strength) and wiggle it back and forth to weaken its seat in the tailgate. Sounds crude but, at this point, if you try to slide a screwdriver between the nozzle and your tailgate you are certain to scratch the paint. Once you have the nozzle loosened up and you've got a gap between the tailgate and the nozzle, carefully take a screwdriver and push against one of the detents on the side of the spigot that connects to the washer hose. You may have to really work at this so be patient. While you are pushing against the detent continue to pull out on the nozzle. With any luck, and a little pratice, the nozzle will eventually come out of there. If you've done it right, your old nozzle should be all beat to hell from all the pulling and prying. NOTE!!! Be careful not to let the hose fall back into the hole after you disconnect the nozzle. Pull the hose out as far as you can before disconnecting and clamp it down so it won't fall back in while you've got your back turned. When your ready, simply push the male end of the nozzle into the female end of the hose until fully attached and do a quick check to see if the connection is working properly (good time to go get your dirtiest kid). Do this check BEFORE putting the nozzle back in or you'll be buying a new one to replace the old new one because you failed to make sure the connection was secure. Ask me how I know.

Aiming:
[Tip: Steve] Use a pin in the nozzle outlet to re-aim the nozzle down so the fluid stream hits the window glass. The nozzle moves easily with little pressure.

Washer Pump Repair.

Motor Commutator Repair. [Tip] On both my 93' 940T and 89' 740T cars the windshield washer motor had locked up, probably from infrequent use. I jumped power directly from the battery and could feel the motor want to turn over but wouldn't, even tried tapping the motor with a hammer - still nothing. Then I tried reversing the polarity to run the motor backwards and it spun immediately. Then I changed the polarity back to the right direction and the motors work perfectly now.

Removing Deposits. [Inquiry:] I have an 87 745 and its rear washer pump is dead. I never added anything but standard washer fluid. Is this pump a known failure item in high mileage bricks of this vintage? It worked fine until I added the orange colored fluid booster additive sold by IPD and other sources curious about replacement cost and difficulty... [Response: Robert Haire] Before trashing them, take the pump out and unscrew the tiny screws in the bottom. You will often find the crude from old washer fluid has precipitated and clogged the gears. If you clean them out, they might start running fine again. I have salvaged several of mine this way and have never had to buy one.

Removing Deposits from Pumps With Glued Casings. [Matt Webb] Some Bosch motors have a cap (to which the connector is mounted) glued to the body of the motor. To access the pump innards, bend or break the plastic tab of the casing that interlocks with the cap. Lightly grip the connector with channel locks or pliers and twist to break the glue joint. If stubborn, a little cement solvent or some heat should help. Carefully remove the cap from the body; there's a washer that goes between the armature and the cap's bushing... don't lose it. Now you should be able to twist the armature by hand to break up the crud that's clogging the pump... remove armature from pump body, set it back in place in the lid-- the brushes can easily be spread apart by hand w/out any drama. Carefully re-insert the armature/brush assembly into the body of the pump... do not let the magnet in the body pull the armature away from the brushes. Once down, a little twisting of the lid will rotate the armature shaft into position and it will easily push down in... line the lid back up with tab and dab a little epoxy between the lid and the body; ziptie or rubberband it together to clamp it. A little bench testing before glueing it back together doesn't hurt; I like to flush the pumps with a bath of rubbing alcohol while I'm at it -- this helps prevent loosened grit from entering your cars lines and clogging the jets.

Heater, Vents, Vacuum Controls, and Blower Motor:

Heater Vacuum Controls, Source, Leaks.

Leaking Sound from Heater Controls. [John Sargent] One of my 740s made a hissing sound from under the dash in the area of the heater temperature control lever. The manual heater control assembly supplies vacuum to the under hood heater valve to shut off coolant flow to the heater core in the cold position of the control lever. The vacuum connection had come off the heater valve, and the free flow of air caused the hissing sound at the heater control. Connecting the vacuum hose to the heater valve cured the hissing sound, and shut off the flow of coolant through the heater core. See also the notes below under "Vacuum Check Valves". See instructions for help on removing the vacuum hoses at the back. This rear connection has been known to leak.

Leaking Sound from Under Dash. That vacuum leak is almost certainly your floor/defrost diaphragm. It is on the left side of case just above the accelerator pedal. This diaphragm unit is double acting, i.e. it has vacuum to pull it both ways, blue hose for defrost and yellow for floor. There is a boot that seals the side that yellow hose applies vacuum to and when this boot goes bad it leaks when you use a/c or floor settings. It is a HARD job to replace this diaphragm unit. It requires removing a lot of under dash parts and ducts and then standing on your head to reach two extremely hard to get at nuts. I would try blocking the yellow hose with an old style fuse (the glass w/ metal end cap kind) and see if you notice any real compromise in operation, you won't ever get the full flow to floor and you'll always have some air out of defrost any time that you aren't on a/c.

Vacuum Check Valve Failures. [Inquiry] I have a 1990 760T and the H/AC is losing vacuum during low vacuum and during boost from the turbo. There is a tee above the intake that has two black & white fitting that connect to two smaller hoses that go to the fire wall. I suspect these supply vaccum to the H/AC but does anyone know if these are actual check valves to prevent loose of vacuum or boost from entering the system? [Response: RL] There are numerous sources of potential vacuum leak (including some of the vacuum motors (bellows) on the actual heat AC system) but those two valves are a common problem. They are check valves to prevent lose of vacuum and if you bench-test them individually, you may find that they perform well under a fair amount of vacuum but that as soon as you try minimal vacuum, the valves will give up. You may try cleaning them out in WD40 or some rubber-softening substance but failing that, your best bet is probably an OEM replacement. [Tip: Chris de Courcy-Bower] If the air conditioning misbehaves and hisses when accelerating, check the two "one-way" valves that connect the climate control system vacuum pipes to the inlet manifold. If they let ANY air through in the "from manifold" direction when you gently blow into them then replace them. (The good news is they are cheap.) [John Sargent] The two black and white check valves are shown in the picture to the right. The car is a 1988 760T but most are similar. One hose is for the ACC, and the other is for the temperature sniffer in the dome light (if so equipped). I found that the hoses leaked at the check valves and using the small worm drive hose clamps took care of the leaks. Prior to that the panel vents would snap shut as soon as you depressed the gas pedal

Climate Control Check Valves

Application of Vacuum to Water Control Valve. [Inquiry] My heater won't shut off. When is the hot water control valve in the engine compartment shut off? [Response] Vacuum to close the water valve is only applied in max AC mode or when the MCC temperature selector is fully "cold". This varies according to the type of control system in the car (MCC, ACC, ECC) and the Volvo OEM service manual should be consulted for details of vacuum signals.

Heater Problems.

Heater Does Not Heat:

[Inquiry:] The heater in my 745TD still thinks it's summer... The engine itself heats up in a normal period of time, coolant temperature is at a normal level. The coolant system builds up pressure in the expansion tank. This morning I put a piece of cardboard in front of the radiator. I still got cold feet, so the thermostat is OK, right? The hoses that go towards the heating element are fairly warm. The air from the top dash vents is not very warm and even on position 4 the flow is rather weak. The middle vents are warmer and the flowrate is good. The flowrate below is nearly neglible and the temperature is just above 0 C.

[Response: Dennis Hamblet] Several suggestions:

- Your thermostat needs replacement and your dash gauge is not reading correctly. Cheap and easy to put in a new thermostat to confirm.
- Your heater core has a deposit of sediment or minerals restricting the flow of warm coolant in which case the system may benefit from a backflush.
- The heater water valve has a blockage restricting flow and may be in need of replacement;
- You have a vacuum leak which causes the heat vent control to work improperly;
- Your firewall-side heater water valve was installed backwards; The arrow on the valve points to towards the firewall inlet, not back towards the engine.
- Control cables from the heater control unit to air mixing doors are maladjusted or broken. In heater-only cars (no AC unit), the water valve (which is inside the cabin, above the left footwell) is controlled by a cable from the air mixing door.
- [Pete Fluitman] Check the heater hoses, I have seen several 700's where they are swapped over and it results in ZERO heat. See the section on Water Valve Replacement for correct installation instructions.

Heater Won't Completely Shut Off Hot Air.
[Tip from John Sargent] 700 series, with manual temperature selection, have a reputation for not being able to completely shut off all of the warm air when the manual temperature selector is fully off. The problem is the flapper door in the heater is not fully closed. There is an adjustment for this in the cable, just behind the heater control. If you remove the glove compartment, you can see the heater controls. The cable on the bottom controls the flapper valve for heat. The adjustable part of the cable is at the heater control. If you see a larger part of the cable, about 3/8 inch and about 2 inches long, that is it. Turn that larger part of the cable until you can feel the temperature control knob moving off of its left hand stop. You are done!

Heater Core Leaking? [Inquiry:] I guess that the heater core in my 86 740 Turbo wagon is leaking cause I have antifreeze on the front floor. Is this as nasty a job as it looks? [Response:] The heater core is a pain in the @#%&* to replace. Try to find out where the coolant is coming from. Usually if the core goes bad you get a coolant mist on the windshield with the defrosters on , and you can get some drainage from the A/C condensate line or onto the carpets. As a temporary fix, you can add a stop leak additive to the cooling system. But plan on a new core soon. [Tips from Bob] I have done 2 heater cores on 700 series cars. It is rather labor intensive. You have to take apart the lower half of the dash and partially disassemble the heater case. The heater core is on the left lower side of the case. You need to remove radio, fusebox, left side center console panel, bracket that holds fusebox,bottom left side air distributon box. When you can finally see the heater core, it looks like a hand grenade went off in your car. If you have done a lot of 700 dash/interior work and are VERY familiar with it, the job takes about 5 hours. If you are not familiar, plan on a weekend. You MUST have a good shop manual. I strongly recommend getting the Volvo OEM climate unit manual (see Volvo Technical Literature.) [Editor] Note that air conditioned cars do not have hoses or a water valve inside the passenger compartment. Cars with heater only have a water valve on the left side of the

Heater Core for air conditioned cars

console against the firewall inside the passenger compartment and this can leak.

Heater Core Replacement:

See the separate FAQ file which explains the replacement procedure for the Manual Climate Control-equipped car. ACC and ECC are similar.

Repeated Heater Core Failures:
If your car suffers from heater core failures, consider coolant breakdown due to combustion gases from headgasket leaks as one possible source.

Leaking Hose Connection Masking as Core Leak. [Jim Parker] When I replaced the heater hoses, I gouged the surface of the brass core nipples with a razor knife or screw driver when cutting and prying off old hoses. The new hose was pushed up tight against the fire wall that has a opening around the nipple filled with a porous ubber sponge , where it leaked. I pressure tested my core before pulling it and it held pressure! So I sanded/cleaned the nipples and reinstalled hoses, which sealed the second time and my leak/problem was cured.

Water Valve Replacement. The heater water valve controls the flow of coolant to the heater core. If this plastic-bodied unit cracks, you will instantly lose a majority of your coolant. The engine-side valves installed in air conditioned cars are exposed to much more heat and have a shorter lifespan than the passenger-side valves in heater-only cars. The engine-side units last about eight years and should then be discarded. When you replace this, consider new heater hoses as well.

Heater Water Valve for AC-Equipped Cars

For Air Conditioned Cars: The heater water valve is installed in the engine compartment, right near the top of the transmission fill tube and under the intake manifold near the firewall. It's hard to see it and the area is crowded: best to feel down the bottom heater hose until you find it. To replace:

1. Disconnect battery ground. Pinch off both heater hoses in the engine compartment
2. Remove the vacuum line attached to the valve
3. Remove the valve. Clamp screws are 7 mm and you will need an extension and universal joint to access them.
4. Install the new valve and tighten the clamps. [RMagoo] The valve goes between the heater hose connected to the short pipe coming out the cylinder head and the heater hose entering the bottom tube of the firewall connector . The arrow on the valve points toward the firewall. The top heater hose goes to the red pipe behind the head leading to the water pump.
5. Install the vacuum line

For Heater-Only Cars: The heater water valve is installed in the left side footwell, up near the left edge of the center console behind the kickpanel. It is mounted to a plate on the firewall. It is round with a hose entering it from the heater core.

To remove:

1. Disconnect battery ground and remove left side dash under panel and air hose
2. Remove the accelerator pedal and the the ignition control box and, if you have it, the cruise control connector, all for better access.
3. Clamp off lower hose from valve to heater core
4. Clamp off lower hose in engine compartment then disconnect
5. Place cloth on carpet to soak up spilled coolant
6. Remove lower hose inside car connected to valve
7. Remove control housing from water valve
8. Remove plastic valve by rotating clockwise. Unhook cable

To Install:

1. Reconnect cable to water valve
2. Install valve by placing it on the mount and turning counterclockwise
3. Mount and adjust the control housing
4. Reconnect hoses under dash and in engine compartment
5. Remove hose clamps

Make sure that the heater hoses are held by the plastic clips that keep them away from the block, the EGR system, and other areas they can wear and leak.

Vents Blowing Black Foam Specks. [Inquiry] I have black foam blowing out my vents. What do I need to do to fix this? [Response: David] This comes from deteriorating foam sheets on air doors within the system. I popped all the air direction vents out with a small flat tip screwdriver. There are only two small nipples (one on each side) holding the vents in place. A little leverage and they come out easily. (BE CAREFUL!!! THE SMALL CURVED WASHERS THAT PROVIDE THE TENSION TO HOLD THE VENTS IN POSITION AREN'T ATTACHED TO ANYTHING!!!). I figured I could snake a small piece of garden hose taped to my shop vac and suck the stuff out. I cranked the A/C on high recirc and all the stuff just blew out. Didn't even get a chance to test the garden hose vac! Left the vents out for a couple of more weeks just to make sure there were no late arrivals. Armor All'd the vents and put them back in. No problem since. [Response: Wong] I closed all the vents except one. Put the blower motor on the highest setting. Maybe if you turn the heat on it would help even more. Then stick a vacuum cleaner up to the vent and suck that crap out. Should take a few seconds. Use a little pick to help get some of the foam thru the vent slots. Move around and do the other vents one at a time.

Heater Blower Motor Replacement.

Repair or Replace? If your motor is squeeking, you might be able to oil the bearings but most 740/940 motors have sealed and inaccessible bearings. Plan on a replacement motor. [Tip from John McIntosh] It is quite easy to dismantle the motor by bending the tabs holding it together. Mine had been squealing and making sundry horrible noises. The rotor was encrusted with iron filings and the bearings were dry. I lubed the bearings with 3 in 1 soaking the felts, blew off the iron filings. Mounted the rotor in my drill chuck and filed the armature with a smooth flat file, finally polishing with glass paper (not emery which I am told is conductive). The hardest part of re-assembly is ensuring the brushes are held back whilst the armature is put in place. This was done using pieces of wire. Dont forget the cooling pipe when re-installing. My fan motor now runs silently and well.

740/940 Procedure. [Response: Kevin Lawler] If you have done several 240's you should be able to do a 740 blower motor with your eyes closed! Remove the under dash hush panel on the passenger side. Next remove the right side kick panel over the fuel ecu, then remove the 2 screws holding the ecu and remove the ecu. next remove the 3 screws holding the ECU bracket, and remove the bracket. Now remove the 3 or 5 screws holding the blower motor in place and remove the blower motor. Remove the ground wire from the old motor if so equipped and unplug the power wire or the connector. Install new motor in reverse order. Some cutting and modification may be required depending on the style of the motor. I had to rewire the connector with a soldering iron, but that was no big deal. I have done several of these, always in less than 1 Hr. [Response: Ney] The only important tip is to remember to disconnect the battery, because the ECU may need to be removed in order to gain access to the blower. Also remember the small black wire with self-tapping screw is ground on the single-connector motors. Newer motors are dual-prong. [Karl Siegler] Make sure any dirt and dust caked on the fan is removed as even a little build up will cause the fan to be out of balance and thus reduce the life of the blower motor. Some soaking in hot soapy water and an old tooth brush completed the job; be careful not to disturb the balance clips.

740 Modified Motor Mount. [Response: Gary Defrancesco] In the last 6 months, I have replaced the blower motors in both of my late '80s vintage 745Ts. The replacement kits came from IPD and include the adaptor ring required to mount the new blower to the heater/AC box. Apparently Volvo made a design change in the motors and the replacement ones require a slight mod to the box. In fact the IPD kit contained the part from Volvo for the mod. TheVolvo shop manual also describes the mod, so I am convinced it is a Volvo design change and not an aftermarket attempt to make a "universal" motor fit a Volvo. My '87 745T apparently had already eaten a motor and the mod had already been made. So replacing this motor was a piece of cake. My '88 745T had not had its motor replaced, so I had to do the mod. Follow the above procedure and read the directions for the modified mounting plate that came with the motor. You may need to cut off a short plastic drain pipe using a hack saw blade, apply some sealant to the adaptor ring, screw it in place, and drill a vent hole. No big deal. Then mount the new motor, solder the wires, and close everything up.

Resister Check. [Tip from Jarrod Stenberg] If your blower motor dies, it can take the resistor pack with it by causing overcurrent through the resistors. Make sure your heater control runs the motor correctly at all the settings from "off" to "high": if it doesn't, replace the resistor assembly. This is located right next to the motor on the air plenum.

760 with ECC; 960; S/V90 Blower Motor Replacement. Remove the battery ground lead, the passenger kick panel, the glove box, the kick panel in front of the door, the a/c ductwork, the bracing/crashbar (left bolts remove easiest from radio compartment)and the right crashbar mount. Remove the terminal strip and bracket holding the back of the motor, then the electrical connector and the motor itself. When reinstalling, don't forget the rubber gasket around the housing. The vent system in the 960 can suck paper and debris very easily when in recirculation mode. It usually ends up inside the blower motor assembly, located underneath or behind the glove box. Get used to removing the blower motor to retrieve the debris from the inside of the squirrel cage. You'll probably be surprised at what else you find in there.

Blower Motor Only Runs "High".
General: Resistor Pack Failure
[Inquiry] Several days ago my blower/fan motor stopped working. It works on the highest setting which is number 5 but does not work on the lower settings. Local dealership diagnosed a failed resistor that they determined was faulty in the motor.
[Response: Warren Bain] Probably a failed resistor pack. Remove the lower panel under the glove box, remove the glove box. There are two small covers on either side of the box with screws under them. The resistor pack is attached to the plenum with several wires close to the fan motor. Replace it. My car is 14 years old and has the original resistors. Make sure the blower motor works OK.

Heater Blower Motor Resistor Control

Specific to 1992+ 740:
[Inquiry] Fan switch only works on 5, no 1,2,3,4,? Is it the switch or is there a resistor pack or can it be the motor?
[Response: Abe Crombie] There are two things that come to mind dependent on how a 92 is wired. There may be a blower relay on the case behind glove box. It passes all the current from resistor to blower but on high the relay is energized and its contact switches over and feeds direct 12 v to blower saving the switch from having to carry the high amperage. If the contacts on the lower speed side are burnt this failure would occur. The other is the resistor itself. I believe a 92 has this feature but it might not have occured until 93, anyway, the resistor may have a temp fuse integrated into it that will go open if the blower resistor has debris around it or if the blower motor drags. Either of these two will make the resistor get hot enough to trip the temp fuse. If the resistor has the temp fuse it will be a green ceramic covered resistor and the temp fuse will be adjacent to ceramic core. It is a silver 3/16" cylinder with tapered ends , one of which is white. In either case i can tell you w/o too much doubt that you will have to go behind glove box as the relay is there and the resistor is stuck into the blower case in that area also.

Replacement Blower Motors.
Pre-90 740 Cars: Earlier blower motors used generic units from GM. GM mid-80's blower motors for AC-equipped Chevy Citations are exact replacements. Another exact replacement is a Siemens-made replacement blower for a 1984 Chev Citation with the single power connection for use with air conditioning (Siemens part number is PM-105). Also: look for an '81 Olds Delta

88 w/ air conditioning blower motor. *Pre-90 760 Cars:* The replacement for the 760 series fan motor is a standard GM fan motor; at NAPA the part number is 455-1076. I was shopping for a fan motor for a '87 760. The clerk responded, $57.94 and we'll have to order it. Then, I said ok, Try a '83 Chevy Impala with AC. In-stock and $17.99 with lifetime warranty. In all cases, you will have to reuse the blower cage. *Post 1990 740/940 Cars:* A Factory Air #35339 that lists for $49.88 on the PartsAmerica website will fit with a different wiring pigtail made using an adaptor pigtail from a bit of heavy automotive wire and some female and male crimp on spade connectors. This will allow you to connect the original harness plug to the motor without hacking anything. Make sure the polarity is correct on installation so it does not run backwards. This is the same blower as used in any '91-'96 rear wheel drive full size General Motors car. Note that post-1990 cars use a different plastic mounting plate.

The reason the original fan failed became quite apparent in today's rain. Water showed up around the new fan. Apparently the 740 has a tendency to leak on the passenger's side with the water ending up in the plastic basin that the fan sets in. [Note: See Volvo TSB for a fix for this problem.] [Second Comment:] After posting an e-mail question regarding heater blower motors on the Swedishbricks mailing list, I received a response from Bill Cheb that he rebuilds heater blower motors and adds ball bearings which should add an extra several hundred thousand miles to their endurance. Bill was easily accessible via e-mail at bill.cheb@ualberta.ca. He promptly responded with information on how to order. His delivery was prompt and included detailed instructions on how to install the new motor. The total cost including delivery was $125.00.

960/90 Series Cars: I found what was supposed to be a replacement at Advance Auto Parts for $29. It was an exact fit mechanically but had the wrong electrical connector. I returned the motor and ordered one from FCPGroton for $60, which was the same motor with an additional electrical adapter to fit correctly.

Blower Motor Fails: Melted Heater Blower Fuse. See the FAQ section Melted Heater Blower Fuse

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Interior Water Leaks: Loose Water Shields/Clogged Ventilation/AC Drains. [Tips by Steve Seekins, courtesy of Guri Roesijadi] [Inquiry:] Water is leaking into my front footwells and soaking the carpets. How do I diagnose this?

Clogged Evaporator Drain:

[Responses: Dave Stevens/Norm]   The single most likely culprit for the wet carpets is a plugged evaporator drain - look on the firewall, passenger side - you should see the drain outlet there - may be flush with the firewall, or there may be a tube attached that runs down toward the frame rail. The plastic casting for the lower air-box half actually includes the drain spigot. It is likely clogged with leaf debris or other stuff. Suction it out by poking and then vacuuming. [Response] I found the drip tube grommet at firewall had deteriorated and cracked at bottom (probably due to heat/age).Lathered with silicone caulk inside and out. I suggest placing a small downspout tube to extend drip pipe as the drain only extends about 1/2" thru firewall and water was dripping out and running back inside firewall.

Location of Evaporator Drain

Clogged Cowl Drains, Leaf Screen Loose

Check the air intake behind the hood - there should be a screen under the slots and bonded to the bottom of the slots. If it has come loose, it lets stuff into the air box. To repair, you need to remove the cowl piece -three bolts along front edge under rear edge of hood (no need to remove hood) and remove the wiper blades and rubber pieces. Middle bolt is usually hidden behind the rubber weather strip. Cowl moves forward and then pulls back off toward the windshield. There are pins on each side that fit into slots on the cowl. It also fits into clips along bottom edge of windshield. See the section in Electrical-Wipers. Getting the cowl back in is a bit more difficult than getting it out. First, often the small plastic pins at the ends break - they are sort of a blind plastic rivet affair - good to have one or two new ones on hand. Second, getting the cowl properly lodged under the clips at the lower edge of W/S can be tricky and if you don't, the cowl will not lay down against the lower edge of w/s properly. Push down on the cowl while a helper pushes back against the firewall edge.

Leaf Screen and Drains:

The leaf screen is fastened to underside of cowl with sticky black adhesive caulk. The black glue can be replaced with Butyl Tape (3M WindowWeld Ribbon Tape in 1/4 inch diameter from an auto parts store) which is the stuff used to glue in an older windshield: this lasts forever. Duct mastic from a heating contractor might also work. Warming it up with a hair dryer will make it nice and sticky, then mash the screen into it. Place some pieces on to the screen and squeeze these into the screen so it will not fall down in hot weather. Wear gloves or use paint thinner to remove from your skin. Consider fastening the vent screen with 8 small zip-ties, since the mastic adhesive tends to soften and fail in summer heat. The cowl drains to each side, where leaves can accumulate and block water flow. Clean this out.

Loose Cowl Air Intake Water Shield:

[Response: CW] If your water leak is on the right side then the shield over the air intake for the heater fan on the passenger's side could be loose. The shield is plastic and is underneath the cowl in front of the windshield. If the shield becomes detached from the window edge, the water runs right off the windshield and into the intake, down onto the blower motor and then on the floor. I had this problem on both my 745s. If this is your problem use the 3M WindowWeld tape noted above on the window edge of the shield to keep the water from getting in. Before you install this, clean off both surfaces with lacquer thinner.

Debris in Interior Air Plenum:
PITA to try to dissassemble the air box, but you might try removing the blower motor (which may be trashed if the lower bearing has been running in water!). Blower is held in with 4 or 5 screws, one electrical connector, ground lead, and there is a motor cooling air tube. Motor housing is usually sealed with RTV to prevent any air leaks. To get it out, remove panel above passenger feet, remove the right side hard panel, unplug and remove computer and the computer bracket. You should now have enough space to get it out - 8mm nut driver on flex extension is helpful. Remove the tube from the motor housing and inspect the lower bearing - any signs of water or rust in there likely means lower bearing is trashed and motor will soon fail. Then use air nozzle to blow in to the drain and force any debris/leaves out through the blower motor hole, or try clearing with piece of coat hanger. Just be careful not to damage the A/C unit inside. Of course, the air method may only move the debris away from the drain temporarily. [Editor's Note:] Check that the blower motor mount in the air plenum is not cracked.

Front Footwell Vent Seals. See the FAQ section describing leaks at the seals behind the front footwell vent panel covers. These can leak and soak the carpets.

Other Leak Sources: See the Body: Glass section for other sources of leaks.

Air Conditioning:

Air Conditioning System Maintenance. [Procedure from Rafael Riverol]

Recharge After Leaks. See the FAQ Section below for the correct procedure.

Basic A/C Operation Information and Safety Caveats. [Chris Herbst] A/C does differ between RWD models, so it is important to relay the CORRECT information about which side of a particular system the components are on. Don't up getting something backwards, or reading high pressure on the low pressure side and overcharging (and exploding) a system. And possibly getting hurt in the process. For these reasons, it is HIGHLY recommended that anyone who is unsure of what kind of system they are working on, stops and either figures out what it is, or abandons the job until they can figure it out. Also it would probably be good for people who are confused about these differences, to STOP giving advice before someone destroys their A/C or gets injured. This is a review of systems on the 740/ 940. The 940 information applies to certain models as noted in the section labeled "940". Models are listed by vehicle model because most of the confusion I have seen is primarily caused by people applying 240 TVX A/C information to 940 CCOT A/C systems. Included at the end of the review is a breakdown by model. Information on model years is stipulated when known to be true; otherwise model information is suggested as being "possibly earlier" or "possibly all models" because of the inability to verify this information at the time of writing. Model years are included where known. The purpose of this review is not to include every screw, pipe, and switch in the A/C system, but is merely to educate about the fundamentals of two different kinds of A/C system found in RWD Volvo models from the mid-1980s to 1998.

940 Models This system also applies to 700 series cars and 960 models. It also applies to *ALL* 240 models from 1991-1993. The mechanics of the system are the same between climate controlled and non-climate controlled systems; electronics vary and are beyond the information covered in this review. The 900 system is a clutch cycling orifice tube system, abbreviated CCOT. The CCOT system cycles refrigerant through the following components:

1. Compressor begins high pressure cycle at compressor outlet.
2. Condenser
3. Fixed orifice tube (locations vary slightly, ALL are high side fixtures) *** Transition from high pressure to low pressure side via Fixed Orifice Tube ***
4. Evaporator (downstream of F.O.T.)
5. Accumulator-dryer. NOTICE this is on the LOW SIDE
6. Refrigerant returns to compressor via suction side.

The CCOT system has the accumulator-dryer (large silver can at the firewall) on the LOW PRESSURE SIDE. It is suitable to charge into the accumulator, as is plainly evidenced by the presence of a charge valve attached to the same low side pipe adjacent to the accumulator. Again, it is STRONGLY recommended that anyone who is unsure about the components of an A/C system, avoid work until a time at which they have become sure about it. Damage to the system, and injury can result. Verify all information before attempting any air conditioning repair or maintenance. As a review, here is a breakdown by model: CCOT systems (GM-type) 240 1991-1993 ONLY; 740 1988- (unable to verify, should be all 740 models); 760 1988- (unable to verify, should be all 760 models); 940 all; 960 all; S90/V90 all.

Recommended System Maintenance When the System is Open. As soon as you have warm weather, evacuate your A/C, raise the front of the car, remove the air guide (not engine pan) and front grille. Disconnect and mark or identify the three connectors at the bottom of the condenser on the passenger side. Unbolt the lines in and out of the condenser. Cap or cover with tape those lines to keep air and humidity from entering the system. Undo the clamps that hold the radiator in place, push the condenser up from its moorings and pull it out from under the car. Undo the screws that hold those plates at the bottom of the condenser and put plastic or rubber plates between the steel plates and the condenser to keep metal to metal contact between steel and aluminum. Perhaps the plastic-like shims that come with Volvo rear brake pads will do the trick. This is a good time to flush that condenser before you put it back in the car. While you are under the car, you may want to remove the engine pan and take out the A/C compressor to flush it and refill it with fresh oil. Sanden specifies Sanden SP-20 oil (8.45 ounces), but I think this is PAG 100 oil, perhaps with additives. Eight ounces of PAG 100 should do in a pinch to refill the compressor. Taking the compressor out is not bad if done from under the car. If possible, put in an Airsept screen in the suction line at the compressor. Airsept has illustrated instructions at its website. Check and replace the orifice valve in the high pressure line connection on the passenger side, not at the evaporator connection. Perhaps a variable orifice valve is called for, but I get 32-34 degrees Farenheit air at the vents with the factory orifice valve. Change the accumulator if it has been there for several years or many miles or lines were left open more than ten minutes so air got in. Otherwise, Volvo says it can be changed every second or third time you open the A/C lines. Put in at every connection you open brand new R134 O rings (yellow, not black) lubricated with either mineral oil or an application-specific, silicone-based lubricant instead of PAG or POE oils. (PAG or POE oils should not be used due to their hygroscopic nature that can promote moisture attraction, possibly causing o-ring deterioration or thread fitting seizure.) Draw a vacuum of 29.7+ inches of mercury for at least an hour. Check that the system maintains that vacuum after you turn off the vacuum pump. If you use Johnsen's R134 refrigerant in liquid form (you turn the can upside down rather than hold it upright like with Dupont Sava R134) preferably with UV dye, the vacuum in the system sucks in a can or two right away. As soon as you start the engine, suction from the compressor will suck a third can. That is 36 ounces rather than the 32 ounces called for the A/C on the 960. That works for me, but I remember Tom Irwin recommends a small food scale to put in exactly 32 ounces of R134. If you have to change the condenser, I found the direct fit aftermarket one from FCPGroton has the advantage over the condenser that was in the car (Volvo?) of no steel plates against the aluminum. Otherwise, that aftermarket condenser is a bit shorter top to bottom than the one that was in the car, with round rather than flat tubing. I cannot compare capacity (BTU) between the two condensers, but so far that aftermarket unit gives me 32-34 degrees Farenheit air at the vents in the tropics!

Useful Air Conditioning Parts, Products and Tools. AScanTech (Avantia) direct fit aftermarket condenser is $175 from fcpgroton and a Volvo one is $439 from Swedish Engineering. A new (not remanufactured) Sanden SD7H15 compressor is $320 from FCPGroton. Locally, I was quoted $995 (yes, $995) sight unseen so I do not know whether it was new or remanufactured. An accumulator will cost you $50 from FCPGroton and maybe a couple of dollars more from Swedish Engineering. A Mastercool flush gun is $43 and flushing solvent is $20 a bottle from www.ackits.com You will need shop air to use those. The Airsept kit with screens to keep debris in the system from getting into your new compressor costs $67 from www.jcsonlinetoolshed.com. For leak detection, get an Airmax LED penlight for UV leak detection from http://www.keep-it-kool.com(costs about $40) and a set of UV-enhancing glasses from JC Whitney for about $5. You can purchase air conditioning dye injectors from NAPA. The glasses are necessary to see the dye. To seal pipe joints with o-rings, get some Nylog, which is compatible with the o-ring material and prevents corrosion.

Poor A/C Performance: Diagnosis. [Inquiry:] I have a 1993 945 turbo. The air conditioner (134a) works ok on the highway. when it is less than 90 degrees outside, but only makes the car bearable in city driving. I checked the charge level and it appears to be fine. Does anyone have any ideas? [Response: Abe Crombie] I had a car like yours and the a/c was fine in the southeast US summer. The problem could be any one of several possibilities like heater valve not being closed at full cold position of the temperature control, partially blocked condenser, cooling fans not working correctly, etc. The only way to know you have the right charge level is to recover and then refill a/c system. The hot water valve should be getting vacuum via a vacuum switch on the heater control when the temperature knob is turned that last little bump to the left. Bugs and stuff will block the condenser over time and this will make performance suffer even more on R134a systems. The electric fans must work properly for the same reasons.

Fan Operation and System Charge. [Inquiry] Need help with my '91 740 Turbo Wagon A/C system. It works great when I'm on the highway (ie. speed greater than 40 mph) but when I slow down or stop I lose cooling. I believe that I am not getting good condensing action even though there is a belt driven fan on the engine. I suspect that the small electric fan in front of the radiator needs to come on with the A/C. [Response: Rob Bareiss/Norm Cook] If you have one electric fan and no booster as in the 940 cars, then it is supposed to be on AT ALL TIMES when the AC is running. If you have two fans (a belt-driven main fan with an electric a/c booster fan in front), you will find that the booster fan is thermostatically controlled. My guess is if you pull your grille out, and reach in there to test the booster fan, you'll find it does not turn freely. So the motor probably burned out when it seized up. Just had three of them do that, all on 740's like yours. A good used one can likely be found at a junkyard- new one is $211 from Volvo (!!!!). It's probably worthwhile to have your AC system leak checked now as well- if it's leaking at all, consider a conversion kit to R134 refrigerant. It's at the point now that it's almost cheaper to convert it than to recharge with R12. A kit costs $61 from Volvo, and R134 ought to be less than $50. If your system was fully discharged, a full charge of R12 would be over $110. A partial charge would be cheaper, and since yours works mostly, it's probably got close to a full charge in it. Keep in mind also that you'll be getting a new expansion valve and receiver/dryer with the Volvo kit, so it ought to be pretty efficient for years.

Simple Leak Detection. Mix dishwashing detergent and water in a spray bottle and spray every connection. If your system has pressure, then soap bubbles will show the leaks. Look for an oil stain on the tubing or the connectors, since a leak will allow compressor oil to escape the system. More accurate leak detection may be made by injecting fluorescent dye into the system (no more than 1/4 ounce at a time and no more than twice) and using a UV lamp to look for leaks, by drawing a vacuum on the entire system and looking for loss of vacuum, or by using an a/c "sniffer" designed to detect the presence of refrigerants. If you inject a dye into an R134a system, make sure it meets the SAE J2297 standard for refrigerant and oil compatibility. One dose of dye is enough. Adding extra shots of dye not only won't help, but because dye changes the viscosity of the oil, excessive use can adversely affect compressor life.

Control Unit PCB Solder Cracks. See the FAQ section describing common electrical failures in the heating/air conditioning system control units. These can be intermittent: sometimes teh a/c works fine, other times not.

A/C Compressor Cycling or Not Engaging. [Inquiry:] Is it normal for the compressor to cycle on and off like this? The one on my wife's old Mitsubishi cycles on and off but it runs for a longer period of time than this one. [Response: Chris Herbst] The clutch cycling orifice tube ("CCOT") A/C systems such as the one in your Volvo are designed to cycle the compressor on and off to maintain a workable system pressure. While the thermal expansion valve systems in other cars

vary other factors, the FOT (fixed orifice tube) needs to have the flow maintained at a steady pressure. That's why the pressostat is on the low side of your system. It senses when pressures are too low, and therefore too cold. It stops that to prevent icing. The reason for the frequent cycling of the compressor clutch is not dependent on only one factor. The clutch on the compressor will cycle when the refrigerant pressure drops to 25.
The pressostat causes the clutch to cycle. If the pressure is lower than about 20 on the low side (I prefer that to 25psi for better cooling with R134) then the evaporator will ice, as will the accumulator and its associated tubes. Then you've got no cooling at all, and the compressor will shut off.   The compressor will cycle for the following reasons:

1. Ambient temperature low, refrigerant pressure low as a result of low ambient temp.
2. Ambient temp high, cabin temp low, evaporator exchanges little cooling because cabin is already cool.
3. Ambient temp warm to high, fan set on low, same reason as #2.
4. Ambient temperature high, cabin temperature high, system charge low.
5. Faulty pressostat switch

To put it all together, the system is cycled to maintain the most useful pressure for commonly encountered temperatures. With a FULL charge, the system will cycle very frequently in cooler temperatures, and sometimes will not have the pressure to EVER come on. That is how the CCOT systems work, and why they cycle the clutch a lot. The thermal expansion valve systems cycle the clutch less. If the charge is proper, in high temperatures, you might never see a time when the compressor clutch cycles off, until the cabin is cool, or the temperature drops outside. If the charge is too low, it'll cycle frequently to keep ice away.

If the charge is too high, you will blow the system up. That's why you need to know how much refrigerant is in the system. In very high ambient temperatures, it's occasionally advantageous to have a slightly low charge, only because the pressures of the system are maintained at a more optimum level despite the huge outside temperature differential. But that same system will be largely ineffective if the temperature is lower.

The whole picture is, you should make sure you have the proper charge as often as possible, especially if the system has a leak. That way, you'll be assured proper cooling, good compressor life, system integrity, and for you, sanity. Fortunately, A/C work is NOT very hard if you take the time to read about it a little bit and learn about what causes it to function as it does.

Why Keep the Correct Charge in the System? [Motor Magazine, Apr 03] A "just-low" R134 refrigerant charge (typically a 10% to 20% undercharge) significantly reduces oil flow, according to Four Seasons' Jim Johnson. He gave this example for 88 F ambient: The a/c duct temperature rose just 3 degrees (from 46 to 49F), hardly enough for a customer complaint. Yet so much oil was trapped in the evaporator under low-refrigerant conditions that oil circulation dropped from about 10% to 25% by weight to just 2% to 4%. That's a prescription for increased compressor wear and therefore short compressor life. Other causes of similarly low oil flow, he said, are internal restrictions (typically from contamination, which increases rapidly with low refrigerant), poor airflow through the condenser and high coolant temperatures.

Compressor Cycling in Post-92 Models. 93 and later models that have R134A refrigerant as factory fill have a compressor high temp shutdown switch at compressor clutch circuit on comp. This can make compressor go off for 5-10 minutes if one of two things is happening:
1. refrigerant level is getting low. The un-boiled refrigerant on a full system that returns to compressor will cool it. If it's low this doesn't occur and off it goes.
2. If it's over 100 F outside the a/c shutdown will occur due to compressor getting too hot. You can prevent this manually selecting recirc when it's this hot as the re-circulated air entering evaporator will allow the return refrigerant back to compressor to cool it down enough to prevent this. Don't let it stay on recirc forever as this will lead to a much increased likelihood of a/c odors. Turn it off recirc at night or when the temp gets back to normal (if it ever does in TX)

Compressor Cycling in 960 Models. [Inquiry] My 960's a/c compressor cuts off during city driving when accelerating. When coasting or on the highway just maintaining speed, the a/c works great. The Volvo manual says it is a fuel economy issue whereby the a/c compressor cuts off during acceleration, but this should occur only at wide-open throttle. [Responses] Problems are likely to be found in the vacuum system that controls the opening and closing of the flaps in the AC vent ducts; namely, the vacuum control check valves, diaphragms and/or defrost/floor vacuum motor, located just above the accelerator pedal, or in the integral vacuum reservoir built in to the evaporator case.

Faulty Control Unit. See the FAQ section below about solder failures in the control unit that can prevent the compressor from engaging.

Faulty Low-Pressure Switch. [Inquiry] When the A/C button is ON, my compressor is not engaging nor the cooling fan is coming ON. Supplied 12V to the contacts at the low pressure switch, (compressor did engage), charged the A/C to 30 PSI on the low side, installed the switch back, but again same thing as above. [Response: Chris Hollis] I had the same problem with my '94 945T. You might check continuity of your low pressure switch: I had a bad low pressure switch. I bought TWO bad switches from Volvo, before I bought a third aftermarket switch from a place called The Volvo Site, part number 1343216. I forget the exact pressure ratings, but they switch off (open) around 20psi and back on (close) around 40 psi. The bad ones I got would switch open at around 20 psi then almost immediately close again. This caused the compressor to cycle faster that you could count. Trying to figure it out drove me nuts. [Editor] The location of switches on the receiver-dryer makes them subject to damage when replacing distributor caps, etc. Unexplained compressor cycling when you know the system is charged should lead you to suspect a faulty low pressure switch.

Air Conditioning Leaks. [Tips from Chris Herbst/Paul Willems] The common freon leak spots are the condenser, any O-ring, suction line, and the high pressure pipe along the right side frame rail. The last one is the most common, because the rubber from the straps that hold it down deteriorates from engine heat, leaving a lovely condition for bimetallic corrosion. Some cars suffer from low pressure aluminum pipe leaks in the pipe beginning at the accumulator that dips down running along the passengers side before turning 90* and crossing above the splash pan (where it becomes a rubber hose) below the front of the engine again becoming an aluminum pipe where it connects to the compressor. The intake pre-heat shield or air intake tube rubs against the aluminum low pressure hose causing it to break through.

960 Condenser Leaks. [Tip from Rafael Riverol] Markku from Finland reported epidemic corrosion of the A/C evaporator on '93-'95 cars due to lower corner attachments with steel bolts in direct contact with aluminum. As he reports it, iron in contact with aluminum in the presence of water and road salt corrodes the evaporators in four to six years. If your 960 is like mine, then the A/C condenser is held by bolted through steel plates touching the aluminum of the condenser which will corrode and leak refrigerant and PAG oil. This can ruin your compressor too and send debris through components and lines that will prove difficult or impossible to flush successfully before putting in a new compressor and condenser. BTW, To save all the trouble and expense of an A/C overhaul after your condenser corrodes and leaks, see if it is held by bolted through steel plates at the bottom both right and left sides. On the condenser in the 960,it is easy to take out the steel bolts and plates to replace them with aluminum, plastic or stainless steel bolts and nuts with plastic or aluminum shims between the steel plates and aluminum of the condenser body. That can be done by taking the condenser out of the car from below, or taking the radiator out of the car and working on the untouched condenser in place.

Should I Use a Sealer? In a word, no. There are two types of sealers: stop-leak for perforation leaks and seal sweller for leaking O-rings and O-ring type gaskets. They're often combined in a single product. While the first will seal pinhole corrosion leaks, it won't seal anything else and because it works by reacting with moisture, it can clog up your system. The second can distort o-rings.

Should I Use Teflon Tape on Connections? Don't use Teflon tape. Refrigerant causes Teflon to soften and fray and little pieces will break off to clog the expansion device. The teflon tape will also buffer threaded connections to cause bridging [a gap]on a o-ring fastener and other types of compression seals. All sealing is accomplished by the o-rings, not the threaded connections which are only used to compress the o-rings.

Should I Use a Tracing UV Dye? Yes. If your system has a leak, using a UV dye will allow your tech to trace it that much more easily, especially the leaks that are intermittent or hidden. See Tools above for a source of UV lamps and detectors. If you do use a dye, add no more than 1/4 ounce at a time and only twice. More than that may dilute your compressor oil. If you inject a dye into an R134a system, make sure it meets the SAE J2297 standard for refrigerant and oil compatibility. One dose of dye is enough. Adding extra shots of dye not only won't help, but because dye changes the viscosity of the oil, excessive use can adversely affect compressor life.

A/C Recharge Tips.

Recharge Connection. [Inquiry] Can anyone tell me how to distinguish between the high and low side connection in order to recharge the air conditioning on my Volvo (1990 760, 4 cycl. turbo)?   [Replies: Bob and JohnB] The flow in the system goes from the compressor under high pressure to the condensor. Then via the receiver/dryer to the evaporator inside the cabin. From there it flows at a low pressure (the suction side) back to the compressor. Locate , it'll be the low side. High side port is on the compressor, low side port near the hose from the firewall to the compressor on the big silver round cylindrical container (receiver/dryer). There should be a cap covering the low-pressure schrader valve. Don't do this unless you have a set of manifold gages so you can ascertain high and low side pressures. You should also have a digital thermometer to tell the cabin vent temp. Figure around 30-40 psi on low side and 150 or so on high side at 2000 rpm, 85F, system stabilized for 5-10 minutes, and inside cabin vent should run about 40-45F at recirc.

Recharge After R134 Conversion. [Inquiry] Can't I just use the $15 recharge kit from Walmart with the hoses and R134? [Tips from Chris Herbst/George Downs] The "complete recharge system" is the way to go if you want to destroy your A/C system. Topping off a system that has a leak is totally unscientific and will yield less-than-optimal performance.

- DON'T try to recharge an empty system without first evacuating completely using a vacuum pump at a minimum vacuum of 29.7 inches of mercury for 45-60 minutes.
- DON'T try to charge without keeping track of the high side pressure.
- A cycling compressor clutch is not the definitive factor in determining proper charge.
- Don't overcharge your A/C, especially an R134a system. You must keep track of the weight of the recharge using a scale.
- If you don't know how to recharge a system, get someone else who knows how to either do it for you or show you how to do it right.

System Pressures. For a chart to compare system pressures at ambient conditions using various refrigerants, see AirCondition.Com.

Refrigerant Capacities (per Volvo T/P 8701201)

Model	**Years**	**Engine Type**	**Factory Fill Refrigerant**	**Factory Fill, grams**	**R134 Conversion or R134a Refill, grams**
760	82-87	B28/B280	R12	1200	1100
760	88-90	All	R12	1100	900
780	87	All	R12	1200	1100
780	88-91	All	R12	1100	1100
740	84-90	All	R12	1200	1100
740/940	91	All	R12	1100	950
960	91	B6304F	R12	1250	900
740/940	91-92	B230F	R12	1100	950
700/900	91	B204	R12	1000	900

700/900	92	B204/234/ Diesel	R12	1050	950
700/900	92	Other	R12	950	900
900	93-	4-cyl	R134a	950	950
900	93-	6-cyl	R134a	950	950

Belt Squeeling After Recharge. [Symptom] After recharging my a/c system with R134, my compressor belt squeels and the clutch will only operate when I apply direct battery power to it. [Duane Hoberg] You've overcharged your system. The high system pressures caused the compressor to lock up which caused the squeeling since the metal-to-metal clutch was slipping. Place a gauge on the low pressure test port and if above 40psi on the low side (R134), bleed some off and get the low side pressure to about 28psi.

Air Conditioning: R134 change from R12 in Volvo cars.

Basics on Air Conditioning R134 Retrofit.
[Tip from Larry Carley, Underhood Service, April 1999] In most instances and in most vehicles, a "basic" R134 retrofit procedure is all that's required to retrofit an air conditioning system. By basic, we mean recovering any residual R-12 that may still be in the system, draining out the old mineral oil, replacing the accumulator or receiver/dryer, and then evacuating the system to purge air and moisture, adding the specified amount of POE oil for the compressor and recharging the system to 85 to 90 percent of its original capacity with R-134a. It's important to remember that R-134a or any other alternative refrigerant cannot be mixed with R-12 or used to top off an R-12 system. If an A/C system still contains any R-12 at all, it must be removed using approved recovery equipment (venting is not allowed) before a new refrigerant is added to the system. This is an absolute must to prevent cross-contamination of refrigerants and cooling performance problems. R-134a and mineral oil won't mix. So if somebody recharges an R-12 system with R-134a and doesn't add a compatible lubricant, the compressor will soon fail.

Volvo was the first auto maker to approve POE oil (P/N 1161442-7) for R-134a retrofits. Volvo retrofit kits include a new receiver/dryer and O-rings (color coded yellow) for the expansion valve, and a new expansion valve or orifice tube. Volvo says the system should be evacuated for at least 50 minutes following recovery of the R-12 and component replacement to pull out as much residual R-12 as possible. Volvo also says the shaft seals on Sanden 508 and 510 compressors must be replaced when converting to R-134a. The new seal is P/N 9134344-2. If the compressor is being replaced, it should be filled with POE oil through the fill plug only, never through the inlet or outlet ports. Also, if the compressor is being replaced, Volvo says not to add oil to the receiver/dryer.

[Editor] At conversion, consider adding both a variable orifice tube and an in-line filter in the compressor suction line (both described below) to your system to improve low-end cooling and protect the compressor against any system debris.

Procedures: How to retrofit R134 into R12 systems.
Dave Urban developed a series of HTML pages showing the instructions and illustrations for the Volvo retrofit kit for 7xx cars, adding Dave's annotated comments from his own changeover. These files are duplicated, with thanks to Dave, here:

[Illustrated R134 Retrofit Procedures for Volvo Cars by Dave Urban]

[Chris Herbst] There is only one way in my mind: using the Volvo kit. It is expensive compared with Wal-Mart's kit, but it is clearly one of the best kits I've seen for doing the job. All you have to get on top of the Volvo kit is the two compressor O-rings. There is no other way, there is no "acceptable alternative", and there is no insta-conversion kit that allows you to bypass ANY ONE OF THE STEPS OUTLINED IN DAVE URBAN'S DESCRIPTION ABOVE. Skipping all or some of the above steps will result in a less-than-optimal conversion that may cause poor performance, system damage, or lack of proper function.

More How-to Tips.
About a month ago, I retrofitted my wife's 88 765T to R134a, using the Volvo retrofit kit, which contains a new receiver-dryer, orifice tube, o-rings, and ester oil. I did it right. First, I had the system evacuated. Then, using compressed air, I blew out all the lines. Then I installed the new receiver-dryer and orifice tube, and then I pulled off the compressor (that was a job!) so I could empty the old oil out and add the new oil. Volvo gives you the oil for this, but doesn't tell you how you're supposed to change the oil without removing the compressor -- and apparently they don't expect you to, since they don't include o-rings for the hoses. What, do some Volvo compressors have a drain plug on the bottom? Mine has a fill plug on top, but no drain hole on the bottom. Anyway, I took it back to the shop, had them draw down a vacuum on the system, then recharge it with R134a (it takes LESS R134a, BTW). The result? 41 degrees F at the vent -- which is Volvo spec for the '88 765T. This was with the car sitting at the A/C shop, just idling, too.
[Tips Ex Post Facto.] My turn to share some info since I have just finished my part of the 134A conversion (vacuum/charge to be done at the shop next Tuesday. Here are my comments and advice:

- You get a lot of hardware in the conversion kit for the money
- Make sure you ask for the instructions a few times when ordering. (Rusty at RPR was able to fax me 27 pages before I finished). Basically the same instructions that you can get off the www but a bit more clear and detailed. I have them stored in a file (RightFax) and can email to anyone who wants them.
- The R134 conversion is not that hard. I'm not sure how to get to the measured torques using open ended wrenches; I went by feel.
- The toughest part of the job was replacing the compressor. Mine was a back breaking job since it was so low: below alt and P/S pump. The lines running to the

compressor were tough to get off and on (seemed to be too much bending involved. Perhaps mine were not original Volvo.

- Be very careful threading lines into the soft Aluminum threads on the compressor. Go by hand as much as possible before using the wrenches.
- The electrical connector for the new Seltec compressor was not the right size for the old line.
- I had to file the hole in the compressor wire holder that bolts into one the the compressor mounts so it would fit.
- The Seltec compressor did not have a drain so I was advised by Rusty (RPR) to turn upside down and rotate to get fluid out of the inlet/outlet. Ester oil was added to the receiver/dryer only per advise.
- I'd consider ordering all new hoses if I did it again (hopefully I'll get by)
- I do not know why the kit did not come with new seals for the whole system: hopefully not needed?

[Tips from Lee Fox] RE: 740 AC conversion and variable orifice tube. I just got done converting my wife's 1990 740GL from R-12 to R-134a and thought I would report on the process. Many thanks to David Urban's most helpful web page describing the entire procedure. He gave me the encouragement to try it myself and he saved me at least $100. I purchased the conversion kit from Brentwood Volvo for about $50, but could not get one of the connections on the old accumulator off, so had to buy the supplemental kit for pre-1988 models for an additional $28. My system had leaked out all of the old R-12 from the original factory fill valve. The folks at the dealer said that this was common and now install the supplemental kit whenever they do the conversion. Following David's instructions, the changeover was easy, taking less than one hour. I rented an AC vacuum pump and gauges for about $25 and bought three cans of R134a plus some leak detector (I wanted to make sure I didn't have a leak elsewhere) and a charge hose for about $30 from Auto Zone. You have to evacuate the system for about an hour and it took about another hour to get it charged up. I had to jumper the low pressure switch to get the compressor going to suck in the first can. When I returned the vacuum pump I had to wipe to condensation from my glasses walking into the store - it was that cold inside the car! [Chris Herbst] Consider adjusting the R12-calibrated pressure switch on the receiver-dryer to cycle off around 20lbs. R12 is set higher.

Flushing Debris Out of System.
[Larry Carley, Underhood Servide, April 1999, ed.] When a compressor fails, it can throw metallic debris into the system. Most of the junk ends up in the bottom of the condenser, but some of it can also be blown back into the suction hose. Flushing the condenser, hoses and evaporator with refrigerant or an approved solvent may remove most of the debris. One aftermarket supplier's A/C flush solvent, "Dura 141," has seen successful acceptance by the repair industry. It has a boiling point below 90 degrees Fahrenheit, so leaving residual solvent doesn't appear to be a problem. However, modern parallel flow flat tube condensers cannot be

flushed effectively because debris jams in the narrow tubes. Replacement is often recommended if debris is found in the system. Most experts also recommend installing an in-line filter (high side and/or low side) to protect the replacement compressor and orifice tube or expansion valve. [Editor:] Highly recommended: filter screens that can be installed in the suction line to prevent any debris from reentering the compressor (see AirSept, Inc. for such a product). Some Volvos may need to have this screen installed at the receiver-dryer because it will not fit at the compressor. Many compressor suppliers now require this to maintain warranties and avoid unwarranted comebacks.

If You Replace Any Hoses. Make sure you replace with R134-compatible barrier-type hoses.

Lack of Adequate Cooling After Retrofit: Diagnosis.
I would have to say that the person responsible for updating this particular 7xx system missed something. I have performed probably 25 of these conversions on 200 and 7/900 vehicles using the OEM kits provided by Volvo and all of them have worked as well or better than the R12. The secret is to use the proper amount of 134, if you overcharge or undercharge, the cooling output is diminished. In our shop we use the Snap-On charge station that charges the system by dialing in the amount digitally and forces it in by the kg or ounce. The only way to get the proper charge is to weigh the refrigerant before installation; no way you can guess and be accurate. The lack of cooling at idle could be from over/undercharged. Partially blocked condenser/ radiator (bugs, dirt). Inoperative clutch fan or auxiliary fan. Too much oil in the system, wrong orifice tube (should be changed to a tan one), weak ac compressor, blocked accumulator or ac cycle switch set too high. The 200's are a different story but I have never had a complaint for insufficient cooling here in Georgia, even from a 245 owner. The new evaporator that comes in the Volvo kit is about 30% larger in surface area and the cooling capacity seems to be better than R12. Just for comparison purposes: Our shop gets $187.00 to convert an operating 12 system to 134 on a 7/900.(parts and labor) $375.00 for a 200. (parts and labor).
I recently did the same conversion on my 1989 745GL. I'm not terribly happy with the performance at idle either. After some experimenting I've decided there are a few things that can be done to improve things, none of which I have implemented yet...First thing is to make sure the fan clutch is in good working order. Second problem is if your mechanic put in TOO MUCH 134a! Problem is that the Volvo conversion kit only includes a low-side 134 filler port. There's no way to measure the high side using the new SAE 134 fittings. Because of this there's no way for the mechanic to know what's enough refrigerant in the system other than looking at the dials at fill time. The third thing that needs attention is the all too rudimentary aux cooling fan setup. In stock, on 7xx cars (excl 760 1988-), the cooling fan in front of the condenser is triggered by a temp sensor in the radiator. That's all well and good, but doesn't do squat about the condenser cooling. What's needed is the aux fan being ON whenever the compressor is on. A simple relay that lets either the engine coolant temp OR the compressor turn on the aux fan would be a good first line of defense. This would probably be sufficient for most apps in most parts of the world. BUT, this will also mean that the aux fan comes on when the system is put into DEFROST mode, as the A/C is always on then to dry the air.
If you're like me, you don't want that to happen when it's really cold outside. So that would require the addition of a temp cut-out switch to the above mentioned two-input relay. In addition, having the aux fan on at highway speed actually will DECREASE cooling performance because the fan is "basically in the way". So add a speed sensor cut out to the above circuitry. Now you've basically got most of what the more modern 9x0 (1993-) cars have as standard. As a first

test for you, skip all of this and try wiring things up so that the aux cooling fan comes on whenever the compressor comes on. You can fake this by connecting the two wires at the temp sensor up at the top right corner of the radiator (effectively bypassing the temp switch itself.) Use a paper clip or something, wrap it with tape, close the hood and drive around and see if this makes any difference. If this doesn't help I'm out of ideas.

If it does help somewhat (you'll obviously need some temp gauges to measure all this), there's always the option of grafting the 780 aux cooling fan onto your 740. Volvo has a kit for this, which I imagine is pretty pricey since it includes a brand new fan etc., but they needed it for markets such as Arizona, even BEFORE going to 134a! As far as I remember the kit doesn't include any of the logic suggested above, so I'm not sure it'll do anything unless some sort of A/C triggering is added as well. [Editor] See Recharge Tips above.

Variable Orifice Valve Addition.
[Lee Fox] I wish I had heard about the variable orifice valve tubes before I converted. It sounds like a good idea. You can find out about them at http://www.aircondition.com/vov/ This is also a great site to learn all about automotive air conditioning. You can even take the test online to become EPA certified to buy R12. In summary, I would recommend the conversion to anyone who needs to fix an ailing AC. We be chillin'. [Chris Herbst] I've used several VOVs, and they are worth the money, the time, and opening the system to put them in.   The VOV does not make a great difference on the highway, but in the city, under high transfer load, it does fantastic work. Sometimes it can lower vent temps five degrees plus. R134 is not the best refrigerant; the VOV makes the best use out of it. Also I believe that pressure-wise, it's better for the compressor since there is better oil transfer and the compressor system doesn't get backed up (too much heat to effectively transfer out between entering the condenser and exiting the condenser). Opening the A/C system is not a problem. In fact, it won't hurt to purge the system, add a little oil, recharge (and replace any or ALL available O-rings while you're at it) and enjoy better cooling especially in the worst conditions.   If you are in a very hot climate (like Arizona or other areas where temps are routinely near 100 or more) get the VOV for high temperature environments. It has a slightly different operating range for best results in those conditions.

[Tips from A/C UPDATE: Retrofit Vs. Recharge, Retrofitting Techniques, Improving Cooling Performance & Alternative Refrigerants, Larry Carley, ImportCar, May 2000 (Excerpts)]:

> One way to improve cooling performance when retrofitting an older R-12 system to R-134a is to install a "variable valve" orifice tube in place of the standard fixed orifice tube. These aftermarket variable orifice tubes allow the flow rate through the valve to change for better cooling at idle and low speeds. Such a valve can lower the A/C outlet air temperature by as much as 5 to 8 degrees, which can make quite a difference if the vehicle is crawling along in stop-and-go city traffic. Installing a larger or more efficient condenser can also help compensate for losses in cooling efficiency with R-134a. If the original condenser or evaporator is being replaced because of a leak, damage or defect, make sure the replacement unit has the same or better BTU rating. Some aftermarket

replacement condensers and evaporators may not deliver the same cooling performance, and create a problem your customer didn't have before.

Location of Orifice Tube. [Chris Herbst] Later cars have the orifice tube installed in the expansion pipe. The joint at which to access the expansion valve is located along the right side frame rail in the engine compartment. It is where the high side pipe gets a little bit bigger in diameter. You'll find the OT in that joint. The earlier cars (with very small diameter pipes at the firewall) had it in the evaporator. The expansion tube location started in 1991, I believe, but that is not a guaranteed model year for the change. As a 1993 model, your car is sure to have the OT in the expansion tube.

R134 versus Refrigerant Alternatives. [Editor] The R134 conversion debate seems to be over and it is widely accepted as an alternative to R12. Numerous other refrigerants are also approved by the EPA as having met safety and environmental criteria. Unfortunately, the EPA does not test these alternative refrigerants for compatibility with refrigerant oils, elastomers, and other components in your car's cooling system. Santech Industries, a major producer of air conditioning components, has done some tests and found R134 the only acceptable substitution product for most applications. See the link for more information in the "testing and reference" section: http://www.santech.com/

Volvo uses HNBR in its black and yellow o-rings (some earlier seals were blue neoprene). They also recommend the use of ester oil as the replacement lubricant in R12 to R134 conversions. After testing HNBR and ester oil, Santech rated the following fluids for compatibility with HNBR seals:

"Poor" compatibility: Freeze 12 (80% R134a and 20% R142b)

"Marginal" compatibility: FR-12 (Frig c: 59% R134a, 39% R124, 2% butane), RB-276 (Freezone:79% R134, 19% R142, 2% mineral oil)

Similar results came from the use of mineral oil instead of ester oil. "Poor" means seal swelling in excess of 40%; "marginal" between 16 and 40%. They note: "HNBR and Nitrile are used predominately in air conditioning systems worldwide and were not generally compatible with the alternate refrigerants." Some of the problems reported from material incompatibility include:

- Seals swelling where they would no longer fit into the glands
- Seals splitting open
- Seals extruding between metal gland surfaces
- Seals turning into a gum type material
-

- Hoses leaking throughout the length of the hose
- Hoses collapsing on the suction side due to softening
- Refrigerant later fractionating and leaving behind debris, poor performance,and damaged systems

Conclusion: when you convert your Volvo from R12, *use R134 and an ester oil.* To improve performance, consider a variable orifice valve.

Condenser Replacement. [Inquiry] How do I replace the condenser after I have experienced a large system leak? [Response: Editor] To replace the condenser in a 90+:

- Remove grill, top grill cover panel, and upper radiator support member
- Remove the front air baffle, air filter intake and sensor connectors to condenser
- Remove bottom air baffle between spoiler and radiator bottom
- Disconnect condenser. (Note: this may be a challenge due to rust and corrosion: use PBlaster) Plug pipes to prevent dirt and moisture from entering system
- Remove by lifting straight up (careful of chrome!) and once removed, measure the oil that drains out the old one if any
- Remove pressostat sensors
- Install foam rubber seals on new condenser (remove from old) and rubber bushings on bottom and/or top
- Clean oxidation from condenser connectors and ensure you will have a good seal.
- Add compressor oil in the correct quantity.
- Reinstall using all-new o-rings coated with mineral oil or an a/c-specific, silicone-based lubricant such as Nylog made especially for o-rings, and antiseize on the outer threads (don't get this near the o-rings). The lubes noted are not hygroscopic as is the ester or PAG used in the compressor, and therefore will not corrode the fittings.
- Torques: to condenser: 25 Nm (18.4 ft-lb) from condenser: 20 Nm (14.8 ft-lb) Apply rustproofing liberally to the fittings to prevent corrosion
- Reinstall other parts and connectors and recharge system.

If you had a leak leading to discharge in an R12 system, then convert to R134. Install the correct amount of oil per system specifications. In 1993+ cars, a new type of condenser and compressor pipe termination was used requiring different pipes that terminate in non-screwed ends. Make sure you buy replacement condensers that drop into your car without the need for new pipes.

Should I Flush or Install a Filter? [Tip from Underhood Service magazine, Apr 2003] Condensers are trash collectors. Any debris that comes out of the compressor goes straight into the condenser. It’s a low spot in the system so debris and oil naturally collect in the condenser. But the debris doesn’t stay put. Refrigerant flowing through the condenser can pick up debris and carry it to the orifice tube, expansion valve or back to the compressor. Debris can plug up the orifice tube or expansion valve, causing a blockage and loss of cooling. Such blockages also can prevent the circulation of oil in the system, starving the compressor for lubrication. If the condenser is dirty, why not just replace it? That's what many experts recommend. But condensers are expensive to replace. The alternative is to clean the condenser with an approved flushing chemical that hopefully will remove most or all of the contaminants. Flushing can save a customer a lot of money, but it also increases the risk of a repeat compressor failure or an orifice tube or expansion valve blockage if the flush fails to remove all of the gunk from the condenser. To reduce the risk of residual debris from a flushed condenser passing into the system and causing problems, an in-line filter should be installed in the liquid line after the condenser to trap any debris before it can cause trouble. A filter screen also should be installed in the suction hose at the compressor inlet to trap any junk before it can enter the compressor. Debris can be blown backward into the suction hose and evaporator by a compressor failure, too, so don't overlook this part of the system if you're flushing to get rid of contaminants.

960 Condenser Leaks. See the discussion on steel bolt-on-aluminum tube leaks.

Evaporator Replacement.

MCC 740/940 Lower Plenum Cover Beneath Evaporator

740/940 Procedure*.* The most difficult thing about this job is finding all the screws that need to be removed. Plan for a full day. Patience is vital, because if parts of the evaporator housing are damaged, you will have a very difficult time remounting the blower and obtaining a satisfactory seal. I paid $175 from fcpgroton for a new evaporator. The dealer will charge you about $1000-1200 to replace the evap and recharge the system.

1. Take appropriate safety precautions. Consider disconnecting battery for extra safety.
2. Properly drain refrigerant
3. Disconnect evaporator to drier/receiver connections in engine compartment. Be careful to use 2 wrenches to apply the proper amount of counter-torque to prevent damage. Be sure to have new o-rings on hand. Tightly plug the drier open connections immediately

because moisture may damage the drier. Since I was replacing the compressor too, my parts supplier suggested a new drier. Might be something to consider with a new evap anyway.

4. Remove right side sill trim, side panel, panel under glove box and the glove box. Removing the dash is not really necessary. Doing this job is much easier if you remove the front passenger seat, then lay some padding down on the floor.
5. Disconnect control module cable (clip), remove control module (2 screws), and its mounting bracket (3 screws)
6. Disconnect electrical connections to blower and resistor (3 plugs). Remove 3 screws to remove the blower.
7. Remove approximately 9 screws around front, side and back of the evaporator housing. Note that 740's/760's/940's/960's may have different evaporator housings so the number of screws and procedure may vary. What you are trying to remove is the lower half of the duct which extends from the cylindrical portion containing the blower going to the left to a point where you may see a label for the evaporator. Coming down vertically from this point, underneath, you will see 4 circular grommet-looking things. That is the other end of the lower housing you will need to remove.[Tip from Gary Hammett] My 91 940 turbo had more than 9 screws on the cover. All were evident with the exception of one on the upper right side of the drain tube section next to the firewall and buried in the foam padding. Most of the screws faced downward, but this one faces outward toward the passenger door. Because I did not see it, I broke the plastic when pulling the cover down, which could have been avoided by first removing the glovebox to see the screw. Being extremely patient and flexible is a vital skill. Make sure you find all the screws because they are hard to find, particularly near the firewall. I used a combination of sockets (7mm), ratchets, flexible socket driver, and bought a cheap box wrench and bent it into shape to be able to get all the screws out. When you have all the screws out, gently pry the lower half off. This may require a little bit of force, because there is very sticky mastic sealing the lower half to the upper. It may be a little difficult to tell the difference between mastic and a screw, but if you leave a screw in and break the duct, you’ll have to install some more screws to get a good seal when reinstalling the housing. I found that I had to install some new screws anyway, because various parts of the housing broke anyway, and plastic doesn’t seem to care for having screws removed and reinserted. I had to oversize some of the screws to get a good bite. [**See *Tips* below.**]
8. Pull out the old evaporator and install the new one. Add compressor oil to the new unit in the correct quantity. Transfer the filter and rubber seal from the old evaporator to the new. This will require cleaning the old filter and gluing on the seal. I used duct tape to keep the nuts from sliding down the pipes while installing the evaporator. Also, this will take some trial and error to get the evaporator up into the housing high enough to get the threaded connections at their proper location in the engine compartment.
9. Remove all of the old mastic with a flat-blade screwdriver and replace with new. It's sold as windshield sealant, and it comes in 20' rolls at AutoZone. I bought 3/8" diameter sealant and stretched it until the diameter was appropriate for the A/C cover. I also put a bead of silicone around the drip tube foam where it contacts the firewall. Replace the lower duct housing, blower, electrical connections and trim (**See *Tips* below**).
10. [Notes from Adam/Randy:] It is hard to get the lower housing back in place [**see *Tips* below**]. The problem is that the back of that lower cover (nearest the firewall) needs to slip over the evap, which has a pipe loop hanging at the lowest point. That pipe loop

hangs right where the firewall takes a bend towards the cabin, and the proximity of that pipe and the incline of the firewall makes it nearly impossible to sneak the cover between there without breaking the plastic. One thing that helps is to reach back with one hand and press the evaporator away from the firewall a bit, since the housing catches on the tube on the bottom of the evaporator. I also cut the drain foam plug in two on the bottom and resealed it with RTV, which gives you a little more room. **See the *Tips* below**.

11. Reinstall evaporator cover screws. The screws are easy to strip from too much torque. It's best to watch the box while you're turning the screw. Stop turning when the cover contacts the box (as opposed to turning until the screw "feels" tight.)
12. Reconnect evaporator-drier/receiver connections in engine compartment. Again, be careful to use 2 wrenches to apply the proper amount of counter-torque to prevent damage. I recommend using new o-rings.
13. Evacuate and refill with refrigerant.
14. Reconnect the battery.
15. Enjoy cool air.

Evaportor Lower Housing

Tips For Removing and Installing the Evaporator and Plenum Cover. [Jan Kinner] Taking an evaporator out of a Volvo 940 is not an easy job!! There is ZERO clearance to get to some of the screws that need to be removed (see illustration of MCC plenum unit in right side footwell). And even when all the bolts were taken off I still broke the evaporator drain spout pulling the thing out of the car. [**Editor's Note: Broken drain spouts are quite common, so be VERY careful.**] The mating surfaces are filled with sticky mastic which must be pried apart. The evaporator, once disconnected from the a/c tubes on the engine side of the firewall, came out easily enough, but the new one was as stubborn as a mule. Note that the evaporator has two tubes that extend through seals in the firewall. We finally got it through the firewall and hooked back up, but that was the easy part. The tough part was putting the evaporator cover back on -- this took almost 6 hours to do. Tip: take out all the insulating material around the drain spout that goes through the fire wall. That will at least give you enough clearance to put the cover over the evaporator. Another suggestion... everytime you get a screw back in take a break. You are laying upside down in the car working over your head in the dark...very frustrating!!!

Tips for Removal of Lower Cover. [Adam Burke] It does not appear possible to remove that lower cover without breaking it unless you first remove the bolts that hold the HVAC box in place. The evap drain extension is in the way. When you have removed the screws and you are trying to figure out "what else is holding the cover", it's wedged between that extension and the protruding evap drain. To get around this, remove two bolts at the fresh air intake and one on the firewall behind the receiver/drier. Instead of removing the exterior cowling and rain guard to get at the fresh air intake bolts, reach up through the fan shroud from below with a 10mm open/ box-end combo wrench. Looking through the hole where the fan motor goes, the bolts are on the top of the metal bar, facing upwards. It's easy enough to do with the right tools and saves a LOT of time. The bottom evaporator cover comes out much easier front-end (firewall end) first. It's counter-intuitive, but there is more room to pull the drip tube clear of the firewall drain hole this way. The wrong way: If you pull the back of the box down first, the front part pivots against the bottom of the evaporator and pushes the drip tube forward against the firewall -- not what you want. Worse, this puts a load on the drip-tube area of the box, and it's likely to break at this point. (You can't see what's going on while the lid is in place, so you can't actually see the cover wedging against the evaporator.)

Tips for Installation of Lower Cover. But - if you've loosened the bolts and air intake mount that anchor the HVAC box, it probably will have dropped some. If it has dropped even 1/4", the lower cover won't fit at all: It will run into the firewall before the screw holes line up. If I had to do this again, I would first see if it would help to have an assistant push up on the evaporator while I remove (and later replace) the lower cover, although this will be difficult because you both need to be in the same place at the same time. . If that wouldn't work, then I would remove the HVAC box mounts and pull the whole thing away from the firewall as much as it could go before I would work on the lower cover. A wedge - such as a rag stuffed behind the box - might help hold it out temporarily but frankly it didn't work for me. When reinstalling if you don't have a helper, use a ratcheting strap (those flat, nylon straps with ratcheting tighteners you can get almost anywhere) wrapped around the HVAC box just to the left of the evap and anchored around the pillar between the front and rear doors. It doesn't take a lot of force, but it helps to have something holding the box away from the firewall. You also need to have the box pushed up while being held out, so place a small hydraulic bottle jack and a large, flat piece of wood under the box (about in the same location as the strap). Again, it's not force that is needed; just something that will sit there and patiently hold the box for you. To re-install the evaporator cover, put the rear in place first, then swing the front of the cover upwards. You'll still have to wrestle with the whole thing to get the drip tube back up into the firewall, but it won't be nearly as difficult as trying to put the cover on front-end first. [Gary Hammett] When reinstalling the cover, make sure you align the passenger side flange at the firewall (inside), or you never get the cover pushed back. There is a flange or rib on that side. Rotate the cover into that flange first and then worry about the driver's side. The small bulge in the cover for the evaporator pipe at the rear of the cover is just large enough for you to use the sole of your shoe to help push it into place. After I did that with a bit of working the cover back and forth at the front, it popped into place. Don't use a rubber mallet to fit the cover or you'll crack it and have to repair it.

Cracks in the Lower Cover. [Adam Burke] I don't know of any way to repair this kind of plastic. It doesn't respond to the plastic primers and glues that I normally use. If you sand it, JB Weld epoxy will adhere, but JB Weld won't give you the strength the plastic had before it cracked. I also tried to patch it from both sides with fiberglass, but the fiberglass wouldn't stick - even to the sanded surface.

960 Procedure*.* [Editor] Your evaporator is far easier to remove than that in a 740 or 940. Remove the battery negative and evacuate the air conditioning system. Remove the firewall connections, including the metal plate and washer, for the pipes leading to the evaporator. Remove the glove box and passenger kickpanel, then the plastic evaporator cover. Pull the evaporator out. You may have to remove the air bag bolster (the large metal bar near the glove box) if it is in the way of the evaporator.

Hose Replacement. [Tip from Rafael Riverol] When I retrofitted my 760T A/C from R12 to R134, I put in all new Volvo parts from Swedish Engineering including new hoses. Soon, I found the entire hose from the compressor to condenser glowing green with UV dye because R134 was leaking right through the body of the hose. Later, I found out that Volvo has information out recommending use of barrier type hoses when retrofitting A/C to R134. It turns out, original hoses will hold R134 only when saturated with mineral oil used with R12. New hoses or flushed out old hoses (cleaned of mineral oil) will not hold R134 because its molecules are smaller than those of R12. I had received and put in the car an original Volvo hose good only for R12. Be sure to put in new barrier type hoses designed to hold R134 when retrofiting from R12.
Rebuilding Hoses. I've found that flexible ac lines typically start leaking at around 100k miles and can be expensive to replace. I've located a repair service in Tucson that can fix your existing line for around $50: mail them the old hose and they rebuild it . They seem to do good work. Century Auto Air.

A/C Compressor Failure.

General Notes. [by Larry Carley, Import Car Magazine] The most common symptom of a compressor failure (besides no cooling) is a seized compressor. It won’t turn when the magnetic clutch engages, and you may hear squeals of protest from the drive belt. Or, the belt may have already broken or been thrown off its pulleys. Loss of lubrication is unquestionably the most common cause of compressor failure. This can happen when there’s a refrigerant leak somewhere in the system that allows refrigerant and oil to escape. Typical leak points are hoses, hose and pipe connections (O-rings and flange gaskets), the evaporator, condenser or the compressor shaft seal. An electronic leak detector or dye should be used to find the leak so it can be repaired. A restriction inside the A/C system can also starve the compressor for oil. Oil circulates with the refrigerant, so if the orifice tube or expansion valve is blocked it may cause the compressor to run dry and seize. Even if a compressor is still turning, it may have to be replaced if it’s leaking, making excessive noise or not working correctly. Some compressors are naturally noisier than others, but loud knocking noises can sometimes be caused by air in the system (the cure here is to vacuum purge the system to remove the unwanted air, then to recharge the system with refrigerant). Metallic noises and bearing noise are usually signals that the compressor is about to fail. A new compressor may be needed if the unit is leaking internally or not producing enough pressure due to bad reed valves, worn piston rings, or worn or scored cylinders, etc.). A worn compressor or one with internal problems will not be able to develop normal operating pressures with a full charge of refrigerant. This kind of problem can be diagnosed with an A/C gauge set. Poor cooling can also be caused by a lot of things other than a bad compressor, so don’t replace the compressor until you’ve ruled out other possibilities such as a low refrigerant charge, too much oil in the system, air contamination, a clogged condenser, plugged orifice tube, inoperative electric cooling fan, etc.

Compressor Clutch Failure.

General Notes. [by Larry Carley, Import Car Magazine, May 03] If the compressor isn’t turning, make sure the magnetic clutch engages when energized. Underlying problems here may include a bad relay, fuse, wiring problem or a defective clutch. If the clutch fails to cycle on and off when the A/C is turned on, jumping the clutch lead with a jumper wire from the battery will show if the problem is in the clutch or elsewhere. If the clutch engages, the problem is the clutch power supply (relay, fuse, wiring, switch or control module). Refer to a wiring diagram and work backward toward the battery to find out why the voltage isn’t getting through. Many A/C systems have a low-pressure cutout switch that prevents the compressor clutch from engaging if system pressure (the refrigerant charge) is too low. This is designed to protect the compressor from damage in the event of a leak. So if the clutch isn’t engaging, check the refrigerant charge and the cutout switch.

Diagnostic Notes. [Diagnostics] Where can I hook up a jumper wire to see if the AC compressor clutch is still good? [Herb Goltz] In 740 cars, remove the connector at the low pressure switch on the accumulator/dryer (the aluminum cylinder at the firewall). Jumper across the two terminals inside the connector (a paperclip works fine). With the AC set to on and the engine running, the compressor should engage IF the terminal inside the connector is receiving +12V power via the 10-second delay relay behind the glove box. In 940 cars, remove the same low-pressure switch connector at the receiver-dryer and jumper it: current comes directly from terminal 10 of the MCC control unit with no relay.[Larry Spooner] If there is a circuit problem after the above test and you want to test the compressor directly, unplug the connector in the black wire going into the clutch assy. If you have an ohm meter there should be a low resistance 3-5 ohms measured at the compressor side of the connector to the compressor body or engine block. You should be able to jumper this directly to the pos battery terminal or the B+ terminal on the back of the alternator and see the clutch activate. The engine does not have to be running. Because of the low resistance of the clutch coil there's going to be a little bit of a spark. [Symptom:] My '86 760T is losing its compressor clutch. What does it take to change this clutch? [Diagnosis:] First is it really the clutch?1) If the compressor is starting to seize internally that will cause the clutch to slip and burn but the fix is a new compressor. 2) Is it the pulley bearing making noise? That requires a special tool to hold the front plate while you unscrew the big nut on the input shaft. The clutch and pulley then press off. You need to remove the freon since you're working at the front seal. 3) If the clutch is really worn out get the special tool and press it off. However compressor rebuilts are not that expensive and once you're at a u-pull-it yard the cost of a clutch vs a compressor is about the same. So I'd say replace compressor, either used or rebuilt.

Apparent Clutch Failure Caused by HVAC Control Unit. [Jim Holst] My '93 945 AC compressor would not come on but I measured nearly 12 v from compressor lead to ground. I was puzzled that the compressor was not engaging. Eventually I pulled the control unit out of the dash and inspected the printed circuit. As noted below, the solder connections at the small,black relay box were cracked. I resoldered the relay connections and the AC now works fine. What was happening was this: the cracked solder joint made a high resistance connection. This allowed enough current to flow to let the voltmeter read nearly full battery voltage. When the compressor tried to run, the high resistance, cracked, solder joint would not let enough current through to energize the compressor clutch. If you know Ohm's Law, think of a series circuit with the 3.4 ohm clutch in series with something like a resistance at the crack of 100Kohm. A 10 megohm input meter would read nearly the full supply voltage but not nearly enough current would flow to operate the clutch. There is a way to test this without pulling the control unit. If you connect your voltmeter to the compressor connection from the rear of the connector without disconnecting the compressor, you can measure the voltage when the compressor tries to engage. If the solder connection is cracked, the voltage will drop to nearly zero. With the connector open, the voltage will be nearly 12v.

960 Sanden Clutch Failure. [Tip from Ross Gunn] My '95 960 clutch disintegrated due to heat damage to the bearings. The compressor is a Sanden SD7H15. I suspect the order of events was: 2 out of 3 clutch springs broke, clutch started to slip causing great amounts of heat, bearing lubricant dried/burned, plastic bearing cage melted, bearings became unevenly distributed around the race, clutch contacted windings of coil. I searched far and wide for a new clutch. The only source I could find was Volvo (over $350 Canadian - $225US). I ended up having the compressor replaced at a non-Volvo A/C shop. They used a different model Sanden compressor, but the system seems fine now.. 3 1/4-20 (IIRC) screws to pull the pulley, I don't know what the spec is.

Clutch Bearing Replacement. [Robert Reagan] If you have noise coming from the A/C compressor bearing you can replace the clutch and/or bearing without removing the compressor. I was hoping to avoid having to open the system to remove the compressor and then having to replace the receiver dryer and recharge the R134a. The tricky parts of the job were maneuvering the circlip tool around the shaft of the compressor using a mirror to see to remove the circlip holding the pulley on, plus pulling the clutch off the shaft without a proper pulling tool. But it can be done. A local bearing supply house was able to match the bearing with a duplicate - it even had the same number stamped on it. I pressed the bearing into the clutch with the help of a little oil on the outer bearing surface. Put the clutch back on the compressor, installed the circlips and nut, and was off to the races. Engine is much quieter now that there is no bearing noise, and I don't have to worry about a seized bearing interrupting any trips. The entire repair cost $20.

Clutch Removal [Tips from Loren Rux/Ross Gunn] Remove the radiator for better access. There are three threaded holes for 5mm bolts in the clutch plate, and I just assumed they were for removing the clutch plate by evenly screwing in three bolts, forcing the plate off the shaft. Whether or not that is the purpose of the threaded holes, it worked. After the plate was about ½ inch out, it came easily. Then remove circlips/snap rings to get the bearing and coil off. There are also some shims that adjust the clutch gap; it is important to get these right on reassembly. [Tip from David Steffy] If you don't want to open the A/C system, you can replace just the clutch & bearing ass'y. (It's possible to get just the bearing, but not to replace it in the clutch.) Got mine at the local import auto parts store for ~$125. You'll need a puller tool to get the clutch off. The K-D one for GMs works, and can be borrowed or rented at some auto parts stores. Note, this is not an ordinary 3-arm type puller. Otherwise the swap is straightforward and leaves you with a new clutch plate as well. [Another Response:] There is a special tool (naturally) but it just pushes it off by attaching to the threaded fitting in the hub of the face of the clutch. Once that is off, there is a snap ring at the front which holds the pulley and bearing on. Tapping on the pulley will slowly move the assembly off the front of the compressor. Then there are 3 Phillips head screws which hold the coil on to the front of the compressor. These round off easily so try tapping on them with a 3/8" #2 phillips bit before trying to turn them.

Clutch Sources. [Tip from Rafael Riverol] Clutches alone may be had from www.hancockindustries.com. Most suppliers sell only the complete compressor with a clutch.

Rebuild or Replace A/C Compressor?

Diesel Kiki Models. [Inquiry] My '87 700 has a Diesel Kiki a/c compressor that has seized. Is it rebuildable (by me?) or smarter to just remove & replace? Are rebuilts available? Are they good as new? [Response: Tom Irwin] In the years I worked in aftermarket I probably bought between 50,000 and 100,000 Diesel Kiki's, as rebuildable cores. What can I tell you... Well, in general they are CHEAPLY built and not very reliable compared to Nippon-Denso, Panasonic, etc. "Is it rebuildable (by me?)" No. "Are rebuilts available?" TONS! EVERYWHERE! "Are they good as new?" Sometimes they are better...the aftermarket KNOWS which components fail and endeavor to improve the unit. Look for who manufactured it... Murray/Moog, Four Seasons, AC Plus, are all EXCELLENT rebuilds. ASK the parts guy who makes their private label stuff "Can the clutch be replaced without discharging the system?" Yes. One last note... Diesel Kiki's, that were converted to 134a are shit. Since you are going whole hog... get a 134a pump...new receiver/drier... do it right. 12 is just too much hassle. [Response: Lamar] You can get a new one for just over $200 at Autozone or Advance. They come ready to use either R-12 or R-134a. I just replaced one on an 88 740.

Sanden Models.   See the Sanden Corporation website, under "Support", for a full service manual and parts information for their compressors.

Lubrication Capacities: Use the correct compressor oil!

Volvo 7XX/9XX Air Conditioning Compressor Lube Capacity Chart

Note: OEM lube oils for R134 OEM systems come in two viscosities: one for Sanden SD-7H15, and one for Seiko-Seiki SS-121DS5. They may not be intermixed. Volvo p/n for the first is 1161425-2; for the second is 1161426-0		**Lubricating Oil**	
Note: R134 retrofit oils are always ester; Volvo p/n 1161442-7		R12: Mineral Oil R134 Retrofit: Ester Oil R134 OEM Install: PAG Oil	
Compressor:	**Model:**	Metric (L)	English (Qts)
Delco	R4	0.30	0.32
Diesel Kiki	DKS-15BH	0.20	0.21
Sankyo Sanden	SD-510	0.24	0.25
	SD-709	0.24	0.25
	SD-7H15	0.24	0.25
York	210	0.30	0.32
Zexel	DKS-15BH	0.20	0.21
	DKS-15CH	0.20	0.21
Seiko Seiki	SS121 DS5	0.22	0.23

If you remove any components of the air conditioning system, you need to add back the amount of oil usually found in that component using one of the oils shown above. Here is a guide:

- Compressor (same as amount removed from old compressor OR 75cc/2.4 oz. minimum)
- Condensor 22cc/0.7 oz.
- Evaporator 53cc/1.7 oz.
- Accumulator/Dryer 95cc/3.0 oz.
- Lines 22cc/ 0.7 oz

Mold Odor from A/C System. [Tip from Editor] I have had a similar problem on both my 1990 745 and 1995 944: mildew-like odors from the air conditioning system, especially when starting the car again after it has been sitting for some time in the heat and humidity. To prevent it, limit your use of the recirculation function and turn the a/c selector to "vent" about three blocks before you reach each destination, allowing the evaporator to dry out before shutdown. Before you proceed, try cleaning out the evaporator drain so that debris does not cause the problem to recur.

You have two effective means of fixing the odor problem once it starts:

a. *Mild case of mildew; evaporator and plenum don't have accumulated leaves, etc.* Buy a spray can of BG Frigi-Fresh. This is an evaporator disinfectant made just for a/c systems by BG, the same people who make BG44K. Contact BG for a local distributor (http://www.bgprod.com/). InterDynamics makes a similar product, found in auto parts stores. A small can, sufficient for many treatments, costs approximately $8. Remove the passenger kickpanel under the glovebox and the right side kickpanel covering the computer module. You will now be able to see the air plenum and the blower motor. Near the blower motor is the blower resistor with wires going into it. Using a 1/4 inch drill, carefully drill a hole in the side of the plastic plenum about one inch to the bottom-left of the resistor and slightly above the bottom, sufficient to allow you to maneuver the spray tube of the can so as to spray toward the driver-side of the plenum. Approximately two inches to the left of the hole is the evaporator core, which is around 8 inches wide and 8 inches tall, oriented on the long axis of the car. (If you want to inspect the system, remove the glove box and blower resistor.) Turn on the engine, engage the a/c system with the blower on "3". Spray a generous dose of FF through the drilled hole all over the evaporator core. Turn off the engine and let the treatment dry. Cover the hole with duct tape and re-assemble the kickwell. You will have a disinfectant odor for about a week, and the treatment should last a good part of the season. The hole will make it easy to reapply the FF next time. The whole job should take about an hour.

b. *Worse case of mildew, along with accumulated crud in the system.* Same disassembly procedure as above, only remove the blower motor in addition to the resistor. This requires removing the glove box and engine computer to secure good access, then the blower motor and resistor. Using a shop vac and a small tool kit (such as the "computer vac" kits), remove accumulated crud (leaves, dust, etc.) by inserting the wand through the resistor hole and vacuum the face of the evaporator with a small brush attachment to remove mold, dust etc. from the aluminum heat exchanger. Swab out the plenum with disinfectant through the blower motor hold. Either use a treatment of Frigi-fresh on the evaporator as above, or go the whole nine yards with some "Airsept", a cooling coil coating treatment applied by spray (such as a garden sprayer.) This costs around $60 and can be bought from Volvo dealers as part number 1161570 or from GM dealers ("GM Cooling Coil Treatment"). I haven't used it, but it results in an acrylic coating on the evaporator coils that inhibits mold growth. GM claims good results. This procedure is described in great detail in the Volvo shop manual for heating/air/conditioning systems. While you are at it, make sure as well that the cowl leaf screen is in place to limit ingress of crud which will be caught in the plenum and result in mold growth. A new company makes a foam cleaner called DWD2 that cleans the front of the evaporator, although so far it is sold only to trained installers. You may also want to consider a product from ATP (1-847-967-6790) called Clean 'N Coat. This uses the same two-part chemical formulation as AirSept's coil coating, except it comes in a convenient aerosol can, obviating the need for a fancy blowgun and wand driven by shop air. The product comes individually (Part No. AT-211) For further information on various cleaners and coatings see the article at IMCool.com: http://www.imcool.com/articles/aircondition/evap_stinks.htm

c. *Real crud in the system; clogged evaporator; downstream dirt.* Bad news: you will have to remove the plenum lower cover. Do all of the above, then around ten screws holding the lower plenum on. These screws are in all kinds of weird places, requiring extraordinary personal dexterity and a few socket extensions, bendable extensions and magnetic tips. The plenum cover is held on with thick mastic and is a bear to remove without damage. Once you pull it off, clean everything out, insert the drain tube, replace the mastic and put it back in place. Don't do this unless all else fails.

Removing Panel Vents. [Inquiry] How do you remove the vents from the dash? [Response: JohnB] A straight screwdriver used as a small pry bar works, since the vents are just popped into holes in the sides. But be careful: there may be a cupped thin metal friction washer used to hold the vent in a set position. To avoid losing this down the duct, close the vent before removing it. [Noel DeSouza] On my 85 740, you press-in and then pull-out from the side to retract the hinge-stub. [Editor] Insert a small flat screwdriver between the surrounding plastic trim and the side of the moving vent opposite the air flow selector wheel. Carefully lever the vent out.

Climate Control Units:

Access to Climate Control Unit.

Removing the CCU Unit. [Jay Simkin] To remove the CCU control unit: (a) Remove storage tray/lighter unit (removal bezel around lighter [lifts off with fingers, grip on the edge at the "passenger side" of the bezel and pull gently], two Philips head screws, and three electrical connectors to the lighter). Using a blunt-edge putty knife, press the edges of the console outwards, so that one side of the storage tray can be pulled out. Then, the other side will come free easily. This is easier than trying to pull the storage tray straight out. (b) Remove the black plastic faceplate around the climate control unit. It is fragile, so be GENTLE. Start at the section around the climate control unit. Using your fingernails, gently lift, to disengage the thin plastic rim from the lugs that secure it. It will come free with little effort. To free the center part of the faceplate, from the clip that secure it, use a 1" wide flexible putty knife - with the edges blunted (use sandpaper to do this). You need to lift the center section of the faceplate, that is between the climate control unit and the switches (which are to the right of the ignition). There is a metal clip behind this center section. Insert the putty knife edge at the bottom of the center section. With the putty knife at 45-degree angle to the face of the console, insert the edge of the blade into the opening at the bottom edge of the faceplate's center section. Push the knife handle downwards, gently, levering outward on the plastic faceplate. When the clip "pops" free, move towards the driver's door (US/Canada models) the end of the faceplate, that goes around the climate control unit. This disengages the end of the faceplate around the ignition switch, from the two lugs, which secure it. (c) Remove the radio (d) Remove the radio housing (two T-20 screws in the roof) (e) Remove the steel radio housing support bracket (4 hex head machine screws, 10mm, two on either side, of the bracket) (f) Remove the four philips-head screws in the front of the climate control unit and gently pull the unit forward, until you can access the back of the unit. (g) The CCU should also have two electrical connectors (one for the fan selector switch, and the other for the control functions). Remove both. (h) Remove the climate control vacuum lines block. This is a single piece of flexible plastic, to which all vacuum hoses are molded. The hoses likely will be of different colors. To remove this connector from the back of the CCU, simply pull it gently. (i) Remove the climate control unit from the car

Light Bulb Replacement. See the Electrical: Instruments sections describing bulb replacement.

MCC Climate Control A/C Malfunctioning.

Relay. [Inquiry] The 700/900 FAQ shows the relay cluster, but there is no AC or ACC relay shown on this panel. Where is it? [Response] Check your wiring diagram. If a relay is fitted, it generally will be located behind the glovebox.

Removing Vacuum Lines. [Tip from Bob] The individual vacuum hoses at the back of the climate control unit are fused to the "plug" on the back of the vacuum valve. The plug is held on by two spring washers pushed over 2 plastic pins. You need to carefully wiggle off the 2 spring washers, then the vacuum plug assembly should slip off. *Vacuum Leak Notes:* [Tip from Peter] If the terminal plug on the vacuum lines leaks air, try coating the base of the plastic vacuum pipes with silicone sealant. You have to coat around the base of each pipe. Be careful not to put any near the top, so that it doesn't plug up the openings in the pipes.

Climate Control Unit PCB: Note Area of Potential Cracks

Diagnosis Notes.
[Response: Patrick Paul] If you have power to the pressure switch then all components before that are OK as far as turning the power supply off and on. You can go to the electrical connector on the compressor and check if you have power there. If yes, then your problem is the control unit. Any loose solder on the control board lets just enough current flow for you to get a voltage reading. But the amps are not enough to turn the compressor on. The repair is very easy once you find that spot in your control unit circuit board (see red circle in photo to the left). [Response: Abe Crombie] The control panel with the knobs is the control unit. The electronics are part of the control. The a/c compressor relay on the 91-95 740/940 with the manual a/c

system is integral with the control assembly. The relay usually isn't the problem, it is the solder joints from the connector to PC board or PC board to relay pins. The relay is soldered to the circuit board. When you remove the control panel you will see the metal enclosure for PC board. [Response: James Abercrombie] The time delay for compressor start is integral in the electronics of this board so there can be a failure of the circuit that stops the a/c compressor that is not related to the solder connections, but this is very rare.

Applications: Solder board cracks can occur in the MCC, ACC and ECC heating/ventilation control units and account for many of the system failures in these cars. If the heater works and the a/c does not, take a look at the board.

Broken Relay Solder Joint in Climate Control Unit

Gaining Access to the CCU PC Board. [Jay Simkin] To access the printed circuit board: (a) Gently straighten the four twisted metal tabs, which secure the shiny metal inspection plate. (b) Once the tabs are straight, lift the plate gently, using a small, flat-blade screwdriver. (c) Remove the four small screws that secure the circuit board (d) Do not touch the ribbon connector: the board can stay attached to the rest of the CCU, while you repair the printed circuit board. You will work on the underside of the board, where the mounting pins for the devices at the top of the board, stick through the bottom surface of the board. (e) Find the relay, a square, box-like device towards the edge of the circuit board (f) find the main electrical connector - opposite where the ribbon connector is attached - which electrical connector has 12 or 14 pins.

Re-Soldering the Control Unit PC Board.

Soldering Techniques. See the discussion and FAQ section under Circuits and Relays for correct soldering techniques on boards.
[Responses: Philip/James Abercrombie] We had intermittant AC problems on our 94 940 turbo that were cured by resoldering bad solder joints on the control board (behind the switches). As usual you need a magnifying glass to see the bad solder. Ours looked OK, but had a dark circle around the outside and black marks on the PC board from overheating. Re-soldered it and saved $400 for a new one (there are no service parts for this unit.) Two key areas should be examined closely: the connector joints and the relay (black box in center), especially the compressor connections. The solder cracks at the points where the high current load is passed through the PC board connections. [Tips: Patric Paul] The faulty solder spot is in the lower half, a little to the left. Take your time and you will get it done. Don't overheat the circuit board while

soldering.
[Response: Brian Oliver] The A/C failure was caused by the solder joint between the AC relay and the CCU controller's circuit board, as suggested. All this stuff is integral with the CCU control panel in the dash. Once you have the panel on your bench (or kitchen table in my case), remove the black plastic cover to expose the circuit board mounting screws, take out the circuit board. In the middle of the circuit board there is a black plastic box, probably the largest component there.This is the main relay which switches the compressor clutch current. On the solder trace side of the board, you may find barely visible cracks in the solder holding this part's pins to the copper traces.   Mine was easy to see, but I do know that they are not always so: it was an open circuit at one of the larger legs of the box on the board. I enlarged the solder pad by scraping off some solder mask to allow greater wetting area, which I think will help prevent future failures. Once you find suspicious solder, you need to "reflow" the metal with a soldering iron until it is smoothe and shiny, possibly adding a but more solder while you are at it. The small electronics soldering iron may not be powerful enough, but be careful you don't over-do it if you use the big gun-shaped tool. Reassemble, install in car, and enjoy. These HVAC control panels can be fixed as long as you don't need parts. They are at least as repairable as Bosch relays. They are sturdily built, too, except for this one badly designed trace on the circuit board. I am a physicist by training, but years of working in failure analysis in the telecommunications industry tells me that the solder joint in question is under-engineered.

Temperature Control Selector Not Operating . [Tip from Allan Hewick] Problem: temperature selector knob inoperative. Knob controls the distribution shutter servo motor behind the glove box. I looked all around the board with a magnifying glass and then found the very small section of burnt out / broken wire, circled in red in the image to the right. Burnt / broken section of circuit board in red box goes from MCC pin #1 solder connection to another solder connection for a resistor (or something) and then into the maze of connection within the circuit board. In the green wiring book, pin #1 appears to have no direct connection to the servo motor control the shutter for air temp, but it ultimately connects to ground. Solution: I took a single copper filament from a wire and soldered it at each end where the burnt wire was connected, marked bypass. Multimeter now showed good continuity between the 2 solder points. Imagine my surprise when I put it all back together: the MCC works perfectly!

MCC

ACC Heater Control Not Working. [Inquiry:] Re 1987 765T; while at the dealer getting a new transmission put in, I also had them install a new heater control valve. The automatic climate control system will not put out any heat, at any setting...even with defroster on. The dealer believes the problem is a vacuum connection in dash. The heater control valve is not getting vacuum. Previously I pulled the glove box out and checked the vacuum hose and shutter doors there...they seem fine. The A/C works fine. Dealer says it is about an hour’s labor to look in the center dash to find the vacuum problem. Can I do this myself? [Response:] Several things could have happened, most likely because the dealer who put in the new trans broke a vacuum line or crimped one somewhere...if you had heat before the trans was put in!   I think there's a vacuum reservoir underneath the car, passenger side, up front...it's a plastic reservoir, should have a line leading to engine and one leading to passenger compartment. Check for vacuum at the engine line and at the line leading to the passenger compartment. Fix as necessary. You might try putting straight engine vacuum or vacuum pump to line going to passenger compartment (there are check valves somewhere too, it IS a turbo engine!) and see if that actuates the heater valve/flappers.   The actual vacuum switch is pretty reliable, but I've had to replace the climate controller/computer on my 87 764T. If the vacuum terminal plugs leak, see this tip.

Air Conditioning Failure. Note that the ACC system may also suffer from the same PCB solder joint failures as the MCC unit above.

ACC Climate Control Instability. [Inquiry] Recently I have noticed that my climate control has a new personality; in fact, several of them. Our early Spring days in Charlotte sometimes require heat, and sometimes a/c. My trouble is that the hvac system delivers heat, then coolness, then nothing, then more unpredictability. This happens when set to a temp or total heat or total cool. What's more, the system's ability to select the right venting for defrost, heat, a/c, etc. has also gone mad. Anyone had this problem, or recognize the symptoms? [Response: Abe Crombie] The manual on this version ECC contains no troubleshooting charts. It only has the list of fault codes. The fault code list contains no fault tracing either. Any fault codes that would impact temp regulation would make the A/C button flash on start up and this was not mentioned.
Does it not provide heat if you go to absolute last stop HOT and cold air if you go to the absolute last stop COLD? These end points override the temp sensors. The temp knob being set to either full end point should make system default to the respective mode. If this isn't happening then the servo that moves temp door needs inspection. If the temp goes to the proper mode at end points but not in any other temp setting (normal operation as opposed to end point defaults) then the ambient sensor next to blower in blower case would bear inspection.

ACC Temperature Sensor Not Operating.
Blower Motor Ambient Temperature Sensor:
[Inquiry:] When its cold out, usually around 50 degrees, the air conditioning works OK. When its warm out, it doesn't work at all. No fan, No a.c. I assume its one of the sensors, probably the one on the dash. Its a 3 wire affair with a small lens in front. The other one is in the ceiling light, but I don't think that's the one giving me a problem. Any suggestions? [Response: Abe Crombie] The solar sensor is not going to cause anything to fail to function on that system. It only makes the system go slightly colder when it's sunny. It sends no signal anytime it's dark outside. The sensor next to blower motor may be at fault. Turn the air distribution knob to face vent, the temp to full cold, fan in AUT, a/c switch off, and recirc on. Now punch the a/c switch on and then off and count the flash code, punch a/c switch again and repeat reading two more times. This will give any fault codes that are present in system. The sensor can be bad and give no code as the system doesn't know it is defective as long as it gives a reading that is within -50F to 180F. If it says it is 60 deg out when it is 96 the control unit doesn't know it is a bad

reading.
Location of Ambient Temperature Sensor: [Steve Oakes] Remove your glovebox and lower plastic shroud under the glove compartment. The sensor is mounted on the air plenum: it has wires running to it and removes by twisting 90 degrees.
Interior Cabin Sensor:
[Tip from Mike Sullivan] Just a heads up for those of you with ACC systems. My '93 960 had been holding cabin temperatures lower than the level set on the dial (at least for heat, where 72 was more like 66-68 over the last year or so). For a while I thought this was going to be a problem with the dash computer or some other complex piece of the automatic system. Some had suggested that it was likely to be the sun sensor located on the top right of dash at the speaker. On studying the system more, I settled on the most likely problem as being the temp sensor located in the overhead dome light fitting, where there is a little hole and air is sucked in past an electric sensor. Note that there were no fault codes showing. Just before I ordered a new sensor, I found the answer - dirt collected in that tube in the dome light leading to the sensor. The fix turned out to be a couple of squirts of an electrical contact cleaner into the small hole where air is drawn into the temp sensor in the dome light. The excess runs out, and in my case, brought out a bunch of black dirt/ dust that was insulating the sensor.

ECC Climate Unit Not Operating. The ECC climate control unit in 960/90 cars can suffer from the same solder board cracks as the MCC unit above. Symptoms included irregular compressor operation. In addition, the solenoid valve controller, mounted under the dash in the passenger footwell just after the evaporator, can also have these cracks. Symptoms include both irregular compressor operation and vent doors closing at random, not correlated with acceleration. The solution is to remove the units and resolder the boards. The former is in the upper dash above the radio and the latter is identified by seven or eight vacuum lines and an electrical connector.

ECC Climate Unit Diagnostic Codes. The ECC climate unit in air conditioning-equipped cars can detect certain system faults and display the appropriate diagnostic trouble code by flashing the lamp in the A/C button. If the control module detects one or more faults, the driver is warned by the flashing A/C button. If a fault is major, the lamp will flash continuously while the engine is running; if minor, the lamp will flash for 20 seconds after the engine is started. To read the diagnostic trouble codes, the engine must be running; the blower selector in AUTO setting; the function selector in VENT setting; the temperature switch set to maximum cooling; the recirculation switch pressed in; and the A/C switch released (out). Shine a strong light on the solar sensor in the dash speaker; otherwise, the DTC for the sensor will be displayed even if fault-free. Retrieve the DTCs by pressing the A/C button in and releasing it within 5 seconds. If several DTCs are stored, they will be displayed sequentially. All will be erased when the ignition is turned off. If no faults are set, then "1-1-1" will be displayed. Note that faults may be in the component or in its wiring.

To diagnose cars with ECC but without air conditioning, no trouble light will illlumine; the system will fail. Remove the ECC module from the dash panel, take off the cover plate and press the diagnostic test button twice within 5 seconds. Read the DTCs from the nearby LED lamp, pressing the button after each DTC to read any more codes.

Table of ECC Diagnostic Trouble Codes.

[Fault Classes: A: Serious; M: Minor; I: No warning to driver]

DTC	Fault Component & Description	Fault Class
1-1-1	**Fault-free**	
	Ambient temperature sensor (on blower housing):	
1-2-1	Short-circuit to ground	A
1-2-2	Open circuit or short-circuit to 12V	A
	Interior temperature sensor (in roof light):	
1-3-1	Short-circuit to ground	A
1-3-2	Open circuit or short-circuit to 12V	A
	Coolant temperature sensor (in heater):	
1-4-1	Short-circuit to ground	M
1-4-2	Open circuit or short-circuit to 12V	M
	Generator:	
1-5-1	D+ signal level in generator	A
	Solar sensor (in speaker grill)	
1-6-1	(Note: illuminate this with a lamp to clear code)	I
	Servomotor/potentiometer:	
2-1-1	Open circuit or short-circuit to ground	A
2-1-2	Short-circuit to 12V	A
	Servomotor Drive:	
2-1-3	Pin 17 or 18 connected incorrectly to 12V	A
	Servomotor:	
2-1-4	Motor activated for too long > 10 seconds	A
	(blocked motor or failure of motor supply)	
	ECC Control Panel:	
2-3-1	Faulty temperature control	A

	Blower Motor:	
2-3-3	Starting current too high, motor seizes or	A
	turns sluggishly	
	Power terminal incorrectly connected to	
	12 V for the solenoids as follows:	
2-4-1	Water valve	A
2-4-2	Bi-level	A
2-4-3	Vent	A
2-4-4	Recirculation	A
2-4-5	Defroster	A
2-4-6	Floor	A
2-4-7	Maximum blower relay	A
2-4-8	Compressor	A
2-4-9	Blower relay (cars with air conditioning)	A
2-4-9	Engine cooling fan relay (cars without a/c)	A

Vacuum Servos:

Panel Vent Stops Working Upon Acceleration.

General Notes. [Inquiry:] My friend has a '94 960 and the air stops blowing from the vents while the car is accelerating (the a/c fan is still spinning but no air is coming out) when ever the car reaches a steady speed it starts blowing again. The same thing happened to me in an '90 760t and it turned out to be a hole in the vacuum line that goes to the vacuum reservoir. However I can't locate the reservoir in this car. Does anyone have any ideas?

General Diagnostics. This is usually a result of a vacuum leak, whether it be an interior hose or servo motor, in the engine compartment, or at the vacuum reservoir. Find the vacuum line that goes to the vent diaphragm (vacuum bellows) under the dash behind the steering wheel. Uplug it and stick a vacuum gauge into the line using a "T". The vacuum should read engine vacuum at idle. Then accelerate the engine: if vacuum drops, your vacuum check valve may be bad. The vacuum gauge should keep a high vacuum reading when you accelerate. If the check valve and tubing under the hood are fine and the vacuum reading still drops, you have a leak under the dash, most likely one of the 4 bellows. The electronic solenoids and the vacuum reservoir appear to be more robust and don't give out that often. The rubber caps on the reservoir (in older cars located behind the front bumper) and rubber tubes under the hood have been known to fail

Look For Vacuum Failures Under the Hood First. [Response] First check the black/white vacuum check valve near the firewall under the hood. This part is very cheap. In order to check the valve, just remove it and blow into both sides gently. If air goes through only one way then you are fine and this isn't the problem. If air goes through in both directions then you have a bad check valve. If it sticks or malfunctions, it causes the a/c vent to stop acting on acceleration. It can mimic the failed servo problem noted below. [Tip from Bob] Next check the vacuum supply hose under the hood. The vacuum hose for the A/C-heater can be found under the intake near the trans dipstick tube. Look for a small (1/8" diameter) flexible plastic hose. It goes from the firewall near the heater hoses and winds its way to a tee with a vacuum check valve connected to a larger hose, ending at the intake. It is common for the hose to rub through from chafing on other hoses or wiring harnesses. When you find the leak, cut the hose and splice with a small piece of rubber vacuum hose. Then check the passenger cabin side of the same hose, which can be crushed where it exits the firewall or behind the control head where there is a "y" fitting in the source vacuum hose. Repair it with a piece of the rigid little spray tube that comes on aerosol cans like WD-40.

Bad Underdash Check Valves. The small vacuum check valves can fail. One valve feeds the ECC system and the other feeds the inside temperature sensor in the dome lamp assembly. Part number 9134341-8, each costing about $11.

Try Cleaning the Air Intake. [Tip from Larry Jacobson] Before doing any cutting and sawing, your arm up into the air intake that goes up in back of the glove box. You may be able to feel bits of plastic or paper or other light foreign matter that has been sucked into the system and is causing the flappers to not close. The vacuum motors huff and puff and hiss trying to slam the doors on the accumulated crud. I've had to do this twice and both times found all sorts of stuff up in there. My wife has a habit of clipping coupons in the car. Bits of paper fall to the footwell and some get sucked into the AC system. Makes a racket like baseball cards in the spokes of the old Schwinn bike.

Diagnosing the Vacuum Motors. [Inquiry:] My heat/ac won't come out my vents, it will come out the defrost and the floor vents, but not my regular vents. [Response: Dick Riess] The vacuum motors are located on the drivers side. You need to take down the portion under the dash and kick panel against the radio area. These are not easily replaced (if that is what is wrong), but through a shortcut suggested by Tom Irwin and receiving some of my mods, I have done one on my 91 940SE. It is kind of the Don Foster approach, in his case replacing the heater motor on 240s. There are 3 motors and fortunately the most accessible is generally the culprit and has two hose connections. First try a Mighty Vac and hook up a tube to each of the connections and see if they hold a vac. If one doesn't, you have a bad vacuum motor. Have to disconnect the hoses on the motor first, of course. Do your diagnostics first.
[Response: Abe Crombie] To expand on what Dick posted: The likely culprit, assuming the vacuum supply is coming in correctly from the engine compartment, is the floor/defrost servo. It is a double acting (no vac centered= floor/defrost split, vac on blue hose = defrost, vac on yellow

hose = floor) and has a boot on the floor side that retains vac on that side of diaphragm. The boot fails and you lose vac. Blocking yellow hose fixes it simply with compromised floor air volume (floor would be floor/defrost). All of this aforementioned stuff is usually the case if symptom is loss on acceleration.

740 or 760 Tips. The 760 has an electric vacuum valve set to left behind glove box and a cold soldered joint on it at one of the end pins will cause no response in any position which defaults to floor/defrost. The 740 has a rotary vacuum switch linked to slide lever for vent selection and the hoses behind panel (white is source) can be crushed or the feed hose (white) above accelerator pedal at firewall can be crushed. The 760T with ECC has a floor/defrost servo sprung to return to center when no vac is applied. This will direct air reaching this part of the air distribution housing to the defrost and to the floor outlets. The yellow hose applies vacuum to the side of diaphragm that will extend the servo rod to push the door up blocking most of the defrost vent air and directing 90% +/- to floor. The seal that rides the servo rod can dislodge or just split and you have the result you observed: air stops coming out of any vents during turbo boost (manifold pressure instead of vacuum), indicating a leaky push-pull vacuum servo. Disconnecting the yellow hose will not allow you to get full floor air. When the floor air position is selected (by you or by the ECC logic) the air will be split between floor and defrost. This is likely not a problem unless you have really poor leg circulation that gives you a severe tendency to cold feet long after the rest of your body is warm. The logic in the ECC always has the floor position selected on this servo when it is directing air to the dash face vents so if it leaks you lose the vac for entire system and all the doors go their respective sprung positions.

960/90 With ECC Tips. [Tip from Steve Long for 960 ECC] If you have done the tests above and you are still having a problem while in recirculation mode, try to pinpoint the cause to a specific vacuum motor. With the recirculation on and the controls set to max fan speed and dash vents, accelerate until the air no longer flows from the vents and then put your hand down under the dash to see if air is flowing from the floor vent. If this is the case, then the recirculation vacuum motor is likely leaking. [Tip] In a 960, you can pop off the panels on either side and put a clamp on the recirculating bellows (orange hose)and drive the car and see if the problem is gone or put a clamp on the floor side of the bellows (Yellow hose IIRC), or both (as in our case), and see if it goes away. If it does, the respective solenoid is at fault. The vacuum reservoir located behind the glovebox may also have a leak (common problem on this model). Unfortunately, in their infinite wisdom, Volvo opted to make the canister part of the evaporator case (VERY expensive). I replaced mine with a separate and independent canister. Any good A/C shop can do this. You can also just permanently cap off the offending vacuum line (probably orange or yellow), although you will lose some functionality. Remove the glovebox to locate the vacuum junction box with the lines installed.

Replacing the Vacuum Motors. Tom Irwin and Dick Riess developed a shortcut method requiring cutting the driver's side inner kick panel. Another technique is listed from Beka at Brickboard. Both are in the FAQ reference document.

Punting on the Fix. [Tip from GregV] After reading the FAQ's I was tempted to go under the dash and tear everything apart. However, I talked to the guy at the volvo dealership and he recommended a "less then perfect" solution. The servo valve that is going bad is used to control the recirculating air function of the Volvo. If you simply plug that one vaccum line, the recirculating function will not work, but the rest of the system will work fine. He asked me how many times a year I actually use the recirculate button, and if it was worth 4-6 hours to tear up my dash. He made a good point, so consider this as another option to actually "fixing" the problem.

Replacing Vacuum Servos in ACC-Equipped 700/900 Cars See the file link for more information.

Homemade Cabin Air Filter. [Tip from Rafael Riverol] My '95 960 has sucked enough tree leaves, pine needles, etc. through fan blower air intake and into evaporator chamber to turn into dirt, grow mold, blow out air vents and block drainage for evaporator condensation. To stop this, I bought a Shop-Vac 3 inch Reusable Dry Filters and Mounting Ring" (Shop-Vac P/N 901-07) at Pep Boys for about $5. I suppose it can be found through www.shopvac.com too. The bag contains three large sheets of filter paper, one sturdy plastic ring and one large rubber band. I took one sheet of paper and cut from the edge one round piece with a radius about two inches larger than the plastic ring (or four inch larger diameter). Put this round piece of paper over the air intake and pushed the plastic ring down over it (narrow end down). Perfect fit! Of course, one has to remove windshield wipers and that plastic drainage channel to get to the air intake. I will cut the rest of the sheet of paper to fit over air intake inside the car (below the glove compartment and behind plastic trim) to hold it in place with the large rubber band. Two more sheets of filter paper are left over for future changes. I tried the A/C with the blower set at maximum speed and the paper filter looks like it will remain in place and not blow into the squirrel cage. For a 740/760/940, I think one could use the filter paper with the rubber band that comes in the bag. In my 760 I have put a flat (grease) filter with a plastic grid backing from a stove hood, wedged between that brace tube and the rubber lip for the air intake and held with a couple of zip ties. With the plastic grid facing down, the filtering element is kept from being sucked into the squirrel cage. [Dick Riess] This idea works for 960 cars; it would also work on the 940 SE as it is basically a 960 body. The air intake is similar.

Steering:

Fluid and Maintenance:

Power Steering Fluid Cleanliness. I keep inside the power steering fluid reservoir a small but VERY STRONG magnet. I lowered it down inside on a wire and because it is strong it attaches to the metal bracket holding the reservoir. After first two weeks I was cleaning it every second or third day and you would be surprised how many metallic particles it was able to take out. For the first week the magnet was all covered and black every time. Now my power steering fluid is so clean, that I can see the bottom of the container with a flash light. Of course I changed the fluid after I take most metallic particles out. Besides there was a bulletin issued by Volvo stating that inside PS container there should be a magnet.

Power Steering Fluid Change. *Fluid Specification.* [Editor] Your manual calls for "ATF" which means Dexron. Many people have had outstanding results with synthetic ATF such as Mobil 1 or Castrol.

Draining. [Tip] If you want to drain the system, loosen the fittings at the steering rack, from the pump & reservoir, let all the fluid drain out, then refill system with Dexron ATF. Fill the reservoir, then start the engine. When the pump empties the reservoir, then refill it. Then bleed the system.

Flushing by Removing the Return Hose. [Inquiry] My power steering fluid looks pretty bad. What's the best way to replace it - without disassembling the entire system? [Response: Steve Ringlee/Jerry Andersch] While you can try to remove the top (return) hose and flush all the fluid out that way through a hose into a bucket, the return line is VERY TOUGH to remove because of an aggressive barb at the end of the outlet pipe. Be careful not to be overly aggressive in removing the return line to the plastic P/S reservoir. Lines that have never been removed can be tough to free up. Resorting to yanking, twisting, and swearing can result in a unexpected trip to the wrecking yard to find a replacement reservoir. Easy does it and save yourself some grief. Be prepared to cut about one inch of hose, enough to peel it off the reservoir, so make sure you have a little extra hose you can pull up from the pump. To make life easier next time, file off the sharp edge of the barb to make the hose removable. [Response: Gary DeFrancesco] In my car, the oil was never changed by the PO, and it was black. Be prepared to dump in more than a quart of new ATF while flushing. The flow rate through the pump surprised me, even at idle. I went through 2 quarts of oil as fast as I could dump it in. And I mean DUMP. Have a friend or spouse start the engine and turn the wheel lock to lock. I found it best to do this with the front wheels off the ground. Have your partner start turning the wheel as soon as the engine starts since it will not take too long to go through the ATF. [Tip: Maldin] Because of the high flow rate at idle, merely disconnect the coil wire at the coil and run the starter to move the fluid. Then bleed the system.

Flushing Using a Turkey Baster. Better to use a turkey baster and just replace the fluid several times in the reservoir as it cycles through. Get a quart of new fluid (I use Mobil 1 synthetic ATF.) Start the car and have a friend cycle the steering wheel back and forth. Shut down, suck out the fluid in the reservoir, and do it again. When you've used up the quart, you will have completely flushed out the old fluid. Bring the reservoir up to level and you are back in business. If you suspect metal contamination in the old fluid, place a strong magnet on a thin wire into the reservoir and leave it there for a week, removing it to check it and clean it off. Then bleed.

Flushing by Removing the Return Hose at the Rack. If the car is on jacks, you can remove the return hose at the rack, place a bucket beneath, and pour new fluid into the reservoir as the pump pushes the old fluid into the bucket. Have a friend turn the steering wheel. Don't lose the small copper washers that seal the hose to the rack. Then bleed.

Power Steering Fluid Rack Bleeding Procedure.

ZF Rack Bleeding Procedure. [Editor] To bleed the rack of all air after changing the power steering fluid, turn the engine on and then rotate the steering wheel full left and full right several times until air bubbles no longer appear in the reservoir. Make sure the reservoir is properly filled and that you do not run out of fluid while doing this.

Cam Gear Rack Fluid Bleeding Procedure. [TSB courtesy of Alldata] Volvo: Bleeding Cam Gear

- Power Steering Racks The Cam gear power steering (p/s) rack has shown an increased sensitivity to the bleeding method used to remove air from the system. Described below is a bleeding procedure that introduces fluid at a sufficiently low rate so that fluid foaming is minimized.   Failure to follow this method can result in air retention in the fluid which could result in steering wheel pulsation under certain driving conditions until the air is purged from the system.

Bleeding Procedure:

After installing the steering rack in the vehicle, continue with the following additional steps:

1. Connect all fluid and mounting hardware, but do not attach tie rod ends. Top up fluid level in p/s reservoir and maintain throughout the bleeding procedure. Do not start engine at this point.
2. With engine off, purge system of air by turning steering wheel full left to full right at relatively low speed until air bubbles do notappear in the reservoir.
3. Turn wheel to full lock, for instance full right, and hold in this position until air bubbles stop appearing in the reservoir. Be patient. This can take up to five minutes. Turn wheel to full opposite lock, full left in this case, and let air bubble out as above.
4. Remove fuel pump fuse to prevent the engine from starting. Crank engine and turn steering wheel simultaneously full left to full right slowly until bubbles stop appearing in reservoir. Note: Do not crank engine for more than 30 seconds at a time.
5. Install fuel pump fuse, start engine and let idle. Turn steering full left to right slowly until air bubbles stop appearing in the reservoir. If the steering continues to pulse or vibrate, continue bleeding by rotating the steering wheel full left to right until vibrations diminish.
6. Reconnect tie rod ends and adjust toe-in to specifications. Check for leaks and proper fluid level.

Note: If the system is filled too quickly, the fluid can be prone to retaining air. Once this occurs, it can take one to two days of normal driving before the air is released from the system.

Pump Bracket 1346267

Power Steering Belt Wear/Noise: Pulley Misaligned. [Editor] If your power steering pump pulley is canted in toward the engine and not aligned with the crank pulley, then the pump bracket (Volvo p/n 1346267-6) is worn and in need of replacement. One usually discovers this when the belt makes noise. This bracket has holes that wear and enlarge over time, allowing the pump to shift position. Buy a new one from the dealer and replace the old one, which will restore correct alignment.

Power Steering Failing? [Inquiry:] Problem: power steering pump seems to be failing, 1988 740GLE, 190k miles. Symptoms: Squeeling power steering pump during harder corners at low RPM's (under 1200 RPM) and at start-up for about a minute. Power steering assistance sometimes intermittent during slow cornering when the wheel is more than 30 degrees off-center. Power steering fluid blackened, as if contaminated with heavily used engine oil or carbon soot, but levels have not dropped at all over the past month. Help Needed: Other possible causes, recommended solutions, sources/pricing for the power steering pump (any aftermarket pumps out there? should I go new/rebuilt?), and any special notes on the actual removal/install process. Also considering draining and replacing the fluid to see the effect on the system -- any feedback on this?

[Response: Ross Gunn] This may be stating the obvious, but is the belt in good shape (not glazed) and tight? Look at the fluid: black would usually be from seals in the rack (sorry if I spoiled your day). I don't believe there are any o-ring type seals in the pump moving parts. Try stirring a small powerful magnet through the reservoir to see if there are steel particles in the fluid. If none, then the discolouration is probably seal material. If there are steel particles, this is an indication of pump breakdown. Definitely change the fluid before investing time and money on a new pump - empty the reservoir and refill with clean fluid, turn wheels lock to lock with the pump running, shut off engine, repeat about 5 times. This may seem a bit mickey mouse, but is a lot easier than disconnecting the fluid lines at the rack to drain the system. [Rob Bareiss] There isn't any "power steering mechanism" other than the rack and the pump. No other parts. If the rack starts to get stiff when it's cold or is leaking a lot, then you need to replace the rack. The power steering pump can go bad, though its not common. Should be really easy to find a good used one. Make certain fluid is full up to the HOT line and turn the wheel through 10 full lock-to-lock turns to work any air bubbles out. If it still groans, I'd replace the pump whenever it gets too annoying. No rush, I doubt it will fail completely and leave you without power steering. [Lazar Weiss] I had similar symptoms: it felt as though the power steering wasn't working well, I felt 'bumps' galore when trying to turn at slow speeds and steering wasn't smooth at all. I was afraid it may be the pump or rack. The best course of action seemed to be to do a thorough power steering bleed/flush and install an in-line filter on the return line from the rack to the reservoir. I purchased a Magnefine very cheap on eBay, installed it, and lo and behold within DAYS my steering was as smooth as I can ever remember. I don't know if your problem is related, but I would certainly first try the inexpensive way and do a good PS oil flush and install the filter. It will get rid of a lot of the gook that collects in the rack over the years, and leave you with clean fluid and a much cleaner rack. If this doesn't solve the problem, I'd give a closer look at your pump and rack.

Failing Harmonic Balancer on Crankshaft. [Tip from Neal Lemerise] My power steering became rather stiff. Checked fluid and it was full. I thought the pump was beginning to fail and we were experiencing a cold snap (subzero).Then a few weeks ago my son couldn't start the car. Check alternator output and it was erratic...sometimes charging well and sonetimes not. Replaced the brushes which were worn and it continued to charge erratically. Then one day I had the hood up and noticed that the harmonic balancer seem to be slipping a bit. Long story short - replaced the harmonic balancer and that solved both the power steering problem and the alternator problem. Had I not noticed that slippage I probably would have dumped a bunch of money in parts that were not needed and I would still have the problems.

Stiff Steering.

Pump and Rack Issues. As some may remember, I have had a problem with the power steering

on my '90 745 GLE (steering heavy, particularly in colder weather). It was of only a little comfort to know that I was not alone. There has been some discussion about what to do with this, (change fluid, add anti-leak additive, etc.) but no clear fix was mentioned other than replacing the rack. In my continuing effort to exhaust all possibilities, before taking a step as drastic as replacing the rack, I disassembled the pump control valve to see if there were any obvious faults. There were none, so I decided to make a little seat of the pants improvement. In order to increase the pressure output of the pump, I stretched the spring of the control valve. Originally 5cm long, it is now 5.5 cm long. The result is more power assist making the steering act more like I believe it should have all along. It will be interesting to see what happens when the weather gets colder.
The service manual gives a procedure for checking the pump pressure, but since I did not have the fittings and gauge, I took this trial and error approach:
Technical details: my pump is the Saginaw TC type as used on 760/740 diesels 1987-, 4 cyl E and carb 1985-mid 87, 4 cyl F, FT & ET 1985-, 16 valve B204/234 1988- and 780 diesel 1985-. The control valve on this pump is reasonably easy to get at without removing the pump from the car. It is under the pump outlet fitting. If anyone is tempted to try this fix, be careful stretching the spring, because if you over stretch it, you can't compress it back again. Use a graduated procedure whereby you try stretching it a little and check the length, then if not long enough, stretch it a little harder and so on until you get the desired length. It is interesting to note that "later versions (don't know what years specifically) of this pump have a higher pressure than earlier and other current variants and produce a greater steering force during parking, etc." (Quoted from Volvo service manual.) The Saginaw TC pump has the remote plastic reservoir mounted on the left inner fender. There are also ZF pumps (carb and E engines without turbo 87-), and Saginaw P pumps with a round (6 cyl B28/280 1982-mid '84 or oval (6 cyl mid '84-, 760/740 diesel '82-86, 4 cyl F, FT, ET, E and carb '82-'84) reservoir. These are the type pumps that are housed inside the reservoir. All have a Control valve, but the reservoir of the P pumps must be removed to gain access to it. The ZF pump control valve may be accessible without removing the pump from the car, but I cannot be sure.
If you are having similar problems and feel adventurous, undertake this modification procedure at your own risk. All I can say is that so far the system is working well. Note that I also have a minor balance problem with steering being a little heavier to the right than the left. This is not severe enough to be a problem when driving and as far as I can see, there is no balance adjustment possible on this rack. The service manual simply says to replace or recondition the rack if balance exceeds limits. Without the test gauge, I cannot determine whether mine is within limits or not. I guess the next step should be a wheel alignment to be sure misalignment is not a factor.

Steering Shaft U-Joints. [Fitz. Fitzgerald] The universal joints in the steering column in my 780 were binding, and only when turning to the right (which caused my right turns to be significantly harder to make). I soaked the joints in Mobil 1 spray lubricant every day for about 2 weeks and the problem went away. You can buy new universal steering joints for about $65 each through various sources, or raid a parts car in the salvage yard for about $5 each. [Chris Moooney] To help diagnose it, follow the steering shaft from the firewall down to the rack, there'll be 2 u-joints in it, try blasting them one at a time, lower one first, with a decent penetrating lube & see if the binding diminishes. If it does, replace the offending part promptly. Oiling it up isn't an acceptable fix, it'll get just as bad (if not worse). See the FAQ information.

Strut Mounting Bearings. [Tip: Dave Hearne] I noticed my steering was getting gradually heavier over the past few months so, while I had the car on axle stands I decided to remove the struts to investigate the problem further. Turned out the top bearings were so stiff that I could barely turn them by hand without considerable effort. I removed the top mountings (after comressing the springs) & gained access to the bearings. They came apart very easily, I cleaned them up with some petrol & found the balls & tracks were un-damaged so, after greasing them up, I reassembled everything. I cannot overstress how different the steering feels now! It's like a new car! It leaves me thinking just how hard the rack/power steering pump must have been working before?

Steering Pull. See the FAQ notes under Front Suspension for more details about this.

Components:

Rebuilding Power Steering Pump.

Removing Pump Pulley. [Tip from Bill D.] Use a power steering pulley removal tool. Pounding or trying to use a gear puller will only bend the pulley. I got the $9.99 one from Harbour Freight. Lisle makes one for around $50.00 as well.

Rebuilding Power Steering Pump. [Tips from Herb Goltz: these relate to Saginaw P with integral teardrop reservoir; Saginaw TC not dissimilar] I want to share some information about rebuilding Saginaw power steering pumps. My '89 760GLE was leaking fluid all over my driveway at an increasing rate, and would lose significant quantities of fluid on longer trips. This last weekend I finally worked up the courage to tackle it. I called around for replacement parts, and was quoted a staggering $285 + tax (CDN) for a rebuilt pump/reservoir combo-- that didn't include the $75 core charge! Another shop offered just the rebuilt pump for $119. I called Canadian Tire and asked about a pump rebuild kit, and they had one for $16.32! The kit was fairly complete-- 7 o-rings and a new oil seal for the shaft, with reasonably comprehensible instructions. The pump didn't have a bearing, rather just a bushing, which appeared to be in pretty decent shape-- very little axial play of the shaft when reassembled. There is an o-ring that goes on the high pressure fitting that screws into the back of the reservoir, and the high pressure hose connector (a banjo fitting on my 89 760GLE) has two copper crush washers. The rebuild kit I bought came with the o-ring, but not the copper washers. I re-used mine, but no leaks so far, touch wood...
After 150K mi, most of the seals were well worn and very brittle. It took me all of an afternoon to dismantle, clean and reassemble the pump. Putting the reservoir back over the pump without displacing o-rings was a bit fiddly, but not too bad. At several points it was very helpful to have a second set of hands. Total cost, including replacing the fluid, the return hose, some hardware bits and all clamps was under $25. It seems to work great so far, and no more spots on the driveway!

Rack Failure. *Diagnosis of Power Steering Failure.* [Courtesy Import Car Magazine, Dec 2006, by Gary Goms] Any power steering gear can develop a “lack of assist” complaint. Generally speaking, a worn power steering pump is usually indicated if steering assist deteriorates as the steering oil begins to warm up and lose viscosity. In contrast, some rack and pinion steering gears may develop an intermittent condition called “morning sickness.” This particular lack of steering assist is caused by the metering valve oil seals wearing grooves into the soft aluminum steering gear housing. As the steering gear oil warms up, the valve assembly reseals itself to the housing and restores steering assist.

Causes of Rack Failure. [Tips from Phil Fournier, Motor Service Magazine, Aug 2001] Ray Fitgerald, technical specialist with Cardone Industries (rack rebuilder), noted the following problems found when racks come back under warranty. Ray cites the following common mistakes that cause premature failure:
The system wasn't flushed. Crud left over a previous rack failure will do a number on a replacement rack in short order. Flushing any R&P every two years as a maintenance item is not a bad idea, either. Old, rotting hoses weren't replaced. Hoses may look okay on the outside, but debris coming off the inside will circulate in the system even after a flush is done, particularly when hoses are flexed during rack installation. Hoses installed on the wrong rack ports. For reasons unknown, some manufacturers put identically-sized ports on the rack for pressure and return hoses. If the hoses are installed backwards, the rack will slam to one side when the engine is started, often causing immediate rack failure. Twisting the boots when doing a front end alignment and failing to straighten them. This will cause the boot to crack or rip, which will result in rack damage from road slop. Cardone, along with other remanufacturers, recommends the installation of an inline filter whenever a rack is replaced, as long as it has a bypass valve to prevent pump damage should the filter plug up. In my opinion, getting all the crud out and replacing the hoses as needed is a better solution.

Repair Options [Erik Esplund]. If your rack is leaking or otherwise failing, you have four options:

- Continue driving until it fails, which will require a fair amount of oil and also risks your power steering pump if the oil disappears
- Rebuild rack yourself: not advised; see comments below
- Install used rack from wreckers, with the attendant work and lack of guaranteed results
- Install a rebuilt rack. These usually come with a lifetime guarantee.

Should I Rebuild My Own Rack? [Responses] The cost of the parts kit and special tooling required to reface bores, extract bushings and other parts, makes it prohibitive for you to consider rebuilding. Buy a rebuilt unit for $300-350 with a guarantee.

Rack Identification. See the diagrams below to identify your power steering rack as either a CAM or Z-F. Illustrations copyright RPR, used by permission. More photos exist at VLV World.

Later 900 cars can come with CAM, TRW, ZF, or Koyo racks. On the Product Service Plate (see photo below), the last digit in the lower right (shown as yellow highlight) will be 1 (Koyo), 2 (CAM Gear), 3 (ZF), or 4 (TRW). [Steve Sherbundy] 940 cars with VIN ending in chassis numbers 173671 and below have a CAM type rack unit, or Volvo part number 5003682. Those with VIN ending in 173672 and above have a TRW unit, or Volvo part number 5003908.

Product Plate above right front headlight

For rebuilt racks, see also Source of Rebuilt Power Steering Racks.

Rack Replacement. [Tips from Jerry Andersch]

To replace your power steering rack:

On a level surface ... jack up the front end and support both sides with jack stands ... set the parking brake ... put the tranny in park (auto) or in gear manual ... block the back wheels to assure it wouldn't come off the stands. Turn the steering wheel until the front wheels are pointed straight ahead and keep it there.

- Remove the front wheels.
- Remove the belly pan (black plastic tray under the engine)
- Remove the cover from the middle of the cross member revealing the bottom of the rack.
- Pull the spring clips from the upper and lower bolts on the steering column U joint and loosen both upper and lower bolts (getting access to these bolts is tough). Remove the lower bolt. Slide the U-joint up off the steering rack pinion. [Alternative Method: James Sousa] I did not remove the splined end of the U-joint, I removed the upper end which is a slip fit onto a round shaft with flat sides. I took the bolt out all the way, and used an offset screwdriver to spread the slotted universal portion a bit, it came right off. I did the splined end on the bench. I cleaned and sanded the upper end a bit so that it went on pretty

easy.
- Disconnect the tie rod ends from the steering arms.
- Clean all the gunk off the connections for the two hydraulic lines and remove them. You will have P/S fluid leak so have something to catch it. I'd cover the end of the P/S lines with baggies and secure them with twist ties to keep dirt out while replacing the rack. Save the copper washers.
- Now there are two large mounting bolts holding the rack into the cross member. Remove them and the rack will drop down and out.
- Set your replacement rack next to the old rack and make sure the tie rods extending from the rack are the same lengths. This will allow the new rack to be set with the wheels pointing straight ahead.
- When you install it make sure your steering wheel remains centered as you reconnect the u-joint from the column.
- Don't over torque the fluid line connections ... the threads in the rack can easily strip out. Just get the connections tight enough not to leak ... new crush washers help.
- Consider installing new tie rod ends, ball joints and radius rod bushings if they need renewal or are getting close to it.
- Refill the system using Dexron III or (preferably) Mobil 1 ATF. Flush the old, contaminated fluid by disconnecting the return line at the rack, placing a pan beneath, and cranking the engine with the coil wire disconnected while you pour new fluid into the reservoir. This purges the pump and rack of old fluid
- Get front end alignment when you are done.

If you’re replacing a rack on an air bag-equipped vehicle, don’t rotate the steering wheel while the rack is disconnected. Center the wheel before you disconnect the old rack. The clockspring forms the electrical connection between the air bag module in the steering wheel and the rest of the air bag system. If the steering is not centered when the rack is installed, it’s possible to overextend and break the clockspring when the steering is turned all the way to one side or the other. A broken clockspring would prevent the air bag from deploying in an accident, and would also cause the SRS warning light to come on.

Reconditioning Copper Washers. [Genaro Lopez] When replacing my rack, I had to use the original washers since the new ones had a sloppy fit. Here is the trick:

1. Lay a sheet of 320 grit sandpaper flat on your workbench.
2. Rub the washers on it till both sides are nice and shiny.
3. Lay the washers on the flat portion of a bench vice (to use as a heat sink).
4. With a propane torch, heat the washers till they turn rainbow colors. This anneals the copper so it will crush down upon torque and form a good seal. You only need to do the heating on one side of the washer.
5. After letting the washers cool,finish the job.

Steering Column U-Joint Noise. [Symptom:] I have a 89 740t with an annoying steering wheel problem. When I turn the steering wheel more than 1/4 of a turn a single loud click is heard (and

felt only very slightly) and then repeated again at random points while completing the turn and then returning it back to center. Lock to lock you can hear it click six to seven times in all. It seems to get louder when the cars not at rest. The rest of the steering feels tight. The sounds are emitting from right behind the steering wheel where the turn signals levers are located. [Another Related Inquiry:] My steering is very stiff at centre and anywhere 90 degrees from centre. If I am at a point at 90 degrees from centre, or at centre, it will loosen up a allow a little play. This makes cornering very jagged. The same thing happened last year, not as bad, but went away as suddenly as it came. It's a soft stiffness, like a tight bearing feel, not a definite notch. I would like to fix this soon before I break something from forcing it.
[Diagnosis:] You may have a U-joint in the steering column that is seizing due to drying of the lubricant and corrosion. Does the noise occur every 180 degrees when you turn from lock to lock? That is a pretty good indication of a u-joint problem. Try spraying some penetrating oil on the U-joints every day for a week. To isolate which joint is the problem, you could start out by spraying one joint each day for a week and if nothing happens do the other joint the next week. If the situation improves, then apply a heavier lubricant, but something thin enough to soak into the bearing of the u-joint. If it does turn out to be a faulty joint, you could always replace it, but that would cost money and/or time. After two weeks, if nothing improves, follow up the Volvo technical service bulletin lead.
[Response 2: Brian Oliver] Sounds like one of the U-joints in the steering intermediate (just above the steering rack) shaft is seizing. Give them a good spray of molyslip grease or something (not WD-40!) to see if this frees it up. Then you will know if this was the problem by whether you solved it or not. Unfortunately you will likely have to replace the damaged parts sooner or later, probably more sooner than later, if you are left with a lot of play in the steering. You don't want this worn to the point of breaking.

Steering Wheel Delamination. [Editor] If the plastic cover of your steering wheel delaminates from the metal support beneath or develops bubbles, you can re-adhere it using moisture-cure polyurethane liquid adhesive such as Gorilla Glue or similar brands. Buy a veterinary syringe (one used for injecting drugs into farm animals) or get a large human syringe from your local drug lord. If it is a dry day, then first inject a few droplets of water where you plan to put the adhesive to accelerate curing. Put some adhesive into the syringe. Use gloves and a drop cloth since this is sticky and tenacious stuff. Inject this into the delamination, between the foam core and the metal. As it cures, the adhesive expands, so be prepared to wipe some off the wheel cover as it oozes out. Don't inject too much or you will expand the cover. Let this cure overnight and the cover will re-adhere to the metal support. Your syringe will not be reusable.

Loose Steering Wheel and Column. [Inquiry:] The steering column seems to be very slightly loose on occasions when cranking the wheel. If I shake the wheel vigorously to the left and right, it appears the whole assembly, including the ignition switch, moves independent of the dash board. I expected to find two bolts clamping the column up against the dash structure, but couldn't see anything. [Response: John Kaiser] Pull lower valance (under steering wheel). Check for loose bolts on support beam(black metal runs right to left. You may want someone to shake wheel while you take a good look. Not usually a 740 problem except on high mileage cars.

Steering Wheel Removal. [Inquiry] How can I remove a steering wheel equiped with an airbag? [Response: Greg/Bob] First remove the negative battery cable and wait several minutes. Now the airbag will be safe to work with. You will need a torx screwdriver, size T30, and a deep 17mm socket. Remove two Torx screws from the back of the steering wheel. If you turn the wheel 90 degrees you will be able to access them. Carefully center the wheel. Now the pad will come off. Carefully pull the pad off, and the disconnect the airbag wire from the pad. Now loosen (but don't remove) the center bolt. Align the front wheels to straight ahead. Now remove the center bolt. You then need to LOCK the airbag contact reel before removing the wheel. You will probably find a yellow warning label attached to the airbag wiring, with the other end attached to a screw on the wheel parked in a hole under and to the left of the bolt. This screw is provided to lock the contact reel.There is a hole in the steering wheel through which the airbag wire comes. Inside this hole is a small round hole in the plastic housing of the contact reel. Keep the wheel centered and insert the screw (still attached to the plastic strip) into this hole. Screw it into the contact reel. This screw prevents the airbag contact reel from unwinding when the wheel is removed. Now pull the steering wheel off **without turning it** and allow the wiring and plastic strip to pass through the hole in the steering wheel. Reinstall the wheel and torque the center nut to 33 Nm. When reinstalling the airbag, snug both screws and torque the RIGHT side first to 8 Nm (6 ft-lb)

Maintenance:

Wheel Alignment Adjustment.

Wheel Alignment Basics.

Camber Wear on Tire

- *Camber* is the angle of the wheel, measured in degrees, when viewed from the front of the vehicle. If the top of the wheel is leaning out from the center of the car, then the camber is positive; if it's leaning in, then the camber is negative. If the camber is out of adjustment, it will cause tire wear on one side of the tire's tread. If the camber is too far negative, for instance, then the tire will wear on the inside of the tread. If the camber is different from side to side it can cause a pulling problem. The vehicle may pull to the side with the more positive camber.
- *Caster.* When you turn the steering wheel, the front wheels respond by turning on a pivot attached to the suspension system. Caster is the angle of this steering pivot, measured in degrees, when viewed from the side of the vehicle. If the top of the pivot is leaning toward the rear of the car, then the caster is positive, if it is leaning toward the front, it is negative. If the caster is out of adjustment, it can cause problems in straight line tracking. If

the caster is different from side to side, the vehicle will pull to the side with the less positive caster. If the caster is equal but too negative, the steering will be light and the vehicle will wander and be difficult to keep in a straight line. If the caster is equal but too positive, the steering will be heavy and the steering wheel may kick when you hit a bump. Caster has little affect on tire wear.

- *Toe.* The toe measurement is the difference in the distance between the front of the tires and the back of the tires. It is measured in fractions of an inch in the US and is usually set close to zero which means that the wheels are parallel with each other. Toe-in means that the fronts of the tires are closer to each other than the rears. Toe-out is just the opposite. An incorrect toe-in will cause rapid tire wear to both tires equally. This type of tire wear is called a saw-tooth wear pattern as shown in this illustration. If the sharp edges of the tread sections are pointing to the center of the car, then there is too much toe-in. If they are pointed to the outside of the car then there is too much toe-out. Toe is always adjustable on the front wheels and on some cars, is also adjustable for the rear wheels.

Toe Wear Pattern

Alignment Tips:

Camber: [Tip from John O] Volvo's revised this procedure in their latest suspension manual (several years old now) and IF you're presently in a shop and on an alignment rack, it's easier than that. While on the alignment rack and doing the alignment, you remove the front upper strut nut (holding the upper strut plate to the body), then take a hammer and pound the stud out of that plate. Loosen the rear nut, then adjust the camber by rotating the the top of the strut plate about the rear bolt using a pry bar until the camber is right (you can get it perfect), then drill through the upper strut plate using the front body hole as your template and install a new bolt and nut. Reusing the pressed-in bolts may be difficult; I used standard hex-headed ones. I've done it many times and it's a piece of cake, but I wouldn't even consider messing with this unless you're actually the technician doing the alignment yourself. [Response: Phil Bradley] There is another way that may be easier for some people. Remove the strut and slot one of the two tower mounting holes. I usually slot the forward one; the strut can pivot on the fixed rear one. No need to change anything in the strut top this way. You are still limited in the amount of negative camber you can get -- not much with stock ride height (maybe half a degree each side). With lowering springs, the geometry changes so that you can get a bit more (maybe 1 degree each side).

Caster: [Editor] Caster is adjusted by replacing the control arm strut rod. The standard length (distance between the centerline of the rear bushing and the front of the rod) is 390.5mm; the shorter version which reduces caster angle by 0.8 degrees is 385.0 mm and the longer which increases caster angle by 0.8 degrees is 396.0 mm.

Toe is adjusted by rotating the inner tie rod within the outer tie rod end to pull or deflect the wheel in the desired direction.

Specifications. Wheel alignment angles for 740/760/780/940 cars are:

Angles	**15 inch wheel**	**16 inch wheel**
Caster	5° +/- 1°	4.5° +/- 1°
Camber	0.1° +/- 1°	0.1° +/- 1°
Toe-In Angle	Toe-in angle: 18' +/- 8'	Toe-in angle: 18' +/- 8'
Toe-In Distance*	2.2mm +/- 1.0	2.3mm +/- 1.0

* when measured from left to right from rim center to rim center, front and rear of wheel

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Wheel Alignment and Spring Sag. Anecdotal experience from Brickboard indicates that spring sag in Volvo 700/900 cars is endemic and occurs most often in the rear springs or on the driver's side of the car.

[Tip from "Servicing Coil Springs," Brake and Front End Magazine, Jan 2000) It's imperative that you make a ride-height check part of your pre-alignment inspection along with all the usual ball joint, tie rod, tire, and other examinations. Specs can be hard to find in repair manuals, and OEM methods of checking ride height are not always easy. While you will occasionally find a broken spring, or someone who wants an upgrade, the main reason that you'll be replacing springs is to restore lost ride height. Ride height is critical to proper alignment angles, both front and rear.

A vehicle that sags in the rear may also increase front caster angles. This is because the sagging rear effectively moves the top pivot point of the front suspension (upper ball joint location on a control arm-type suspension) rearward, which obviously tilts the steering axis rearward, increasing caster. Furthermore, uneven ride height across the vehicle (left to right) can cause a steering pull.

Don’t forget that a sagging rear spring can also cause a ride height change in the front of the car. Careful measurements are needed at all four corners because it is possible for just one spring to be weak. This can cause a ride height difference diagonally, where the left rear corner, for example, is low, the right front may actually be high. Volvo recommends that ride height be checked at each of the four jack point bars and that it not vary by more than 1/4 to 3/8 inch from one corner to the next.

[IPD] If your tires or wheels differ at each corner or tire pressure is not identical, eliminate their effects by measuring instead between the fender lip and the wheel center as noted in the photo at the right. Measure each wheel and then compare as noted above.

Ride Height Measurement, Courtesy of IPD

Wheel Balance. See the FAQ file for information about wheels, rims, tires, and balancing.

Bushing Inspection Notes.

Control Rod Cone Bushings. [Tips from Randy] There are some symptoms to make you want to check the cone bushings. Some of them are difficult to sense just as with worn shock absorbers- the real difference is only felt when they are replaced. Symptoms that you WILL notice (other than those already discussed): 1) A squeaking when the suspension is at long travel such as when going over a speed bump at slow speeds. 2)A clunking knock, with matching feedback through the steering wheel when turning at slow speeds with the steering at full lock, particularly when on a dirt or gravel surface. 3) Eventually when the suspension is in a long-travel situation, the squeak will turn into a clunk like hitting a solid chunk of wood with a mallet. When you hear the squeak it is time to check the cone bushings. The squeak is the rubber against the control arm. It happens because the rubber is worn, compressed, and worn. As soon as it begins to move (causing the squeak) its wear will rapidly increase causing poor handling, uneven breaking, accelerated tire wear, and can eventually lead to a very unsafe and even dangerous situation.

Need to Replace All Bushings? [Tips from John Kupiec:] I recently rebuilt the suspension of my 744T. Since the car was 13 model years and 167K miles old at the time of rebuild, I anticipated a complete bushing replacement, and planned accordingly by purchasing a complete bushing kit. To my surprise, the only bushings that required replacement were the control rod bushings. All other bushings tested out fine in the "pry bar test". 45 minutes of up close and personal inspection with two sets of trained eyeballs and a pry bar showed all bushings (even the rear link bushings) to be fine, with the exception of the strut rod bushings. What we did find was one strut rod with significant corrosion on the front end, significant enough to merit replacement of the entire strut rod.
Suggestions: 1. If you have the opportunity, put the car up on a lift and perform a bushing inspection before you buy replacements. If possible, do it with someone who is experienced with Volvos and 700 series in particular. 2. If you do not have the opportunity to follow suggestion 1, make sure you purchase your bushings from a retailer who will allow you to return the ones you do not need (Thank you, IPD!) Information I have obtained from other 700 series owners is that replacement of the strut rod bushings is almost a certainty. Replacement of other bushings depends on the age of the car, road conditions, driver's habits, etc.

Component Replacement:

Control (Radius) Rod Bushing Replacement. [Editor's Note on Symptoms Evidencing Need for Replacement: See Brakes Pull When Applied]

Detailed Procedure for Control Rod Bushing Replacement. [Editor's Note: This four-piece conical bushing set is the big wear item in your front end. Usually this is all that is required; the rear control rod round bushing does not wear as quickly.] [Tips from Rod Johnson] I noticed that my 740 had steering looseness and the condition of the strut rod bushings was bad. Both sides were badly split, and the right side was extremely sloppy in the lower control arm. I could move it about a half inch, just by pushing on the wheel.
So to the main crux of this post (how to replace the conical bushings)
I found a strut rod bushing kit on a well known internet auction site, and for $51 delivered, I was ready to install them. I've not done this before on a Volvo, but I do have many years of experience working on automobiles in general. It took me just over an hour to complete the job, after I had the car on the stands. You will need two long breaker bars (one about 18" minimum) and a 22mm and a 15 mm 1/2" drive socket. A ratchet will speed things up when you finally get the bolts loose. A pry bar and small hammer may also be useful.
Jack up the car and place it on jack stands or other suitable supports under the control arm (not the strut or radius rod). All work is done from under the car, and considerable force is needed to get the bolts to come loose, so if you consider yourself a bit on the 'weak' side, get a 24" breaker bar. You do not need to remove the wheels or any other parts. The rear

end of the strut rod is a round bushing with a bolt going through the frame mount and the bushing. The nut is probably coated with undercoating, so you will need to clean some of it off to get the 22mm socket over the nut, or just hammer the socket over the undercoating like I did.
The head of the bolt is a 15mm hex (and again heavily undercoated on my car), so you will need a second socket, or long box end wrench (don't even think of using an adjustable wrench on these-you will need a very good fitting socket. If you have a 6 point socket, find it and use it). Again, the undercoating is the biggest issue here.
Brace yourself against the frame of the car and break the nut loose, then use the ratchet to get it off the bolt, and make sure the bolt is loose in the bushing. If it is corroded, you will need to get it free before attempting the next step.
Now go to the front end of the strut rod, and look where it comes through the lower control arm. Under that gob of undercoating, is another 15mm hex bolt, which screws into the end of the strut rod, clamping the bushings into the strut rod.
Using the long breaker bar and the 15mm socket again, remove the bolt and outer bushing. Now remove the rear bolt completely from the frame mount. Pry the rear end of the strut rod down and out of the mounting bracket, and slide it to the rear and out of the control arm. Remove the remaining half of the front strut rod bushing. Don't forget to clean out ALL the residual old bushing material: you made need a chisel as the old rubber is often stuck to the control rod. Then be sure to clean the threads of all the nuts and bolts, just in case there are some deformed threads or rust. Use a wire brush. When reinstalling, use some 'Lock-tite' (or other brand) bolt retainer on this mounting hardware. On the replacement bushings, usually the part numbers go toward the large support washers.
Now replace the strut rod, with the new bushings, back into the lower control arm, and get the front bolt started. Then pry the rear bushing back up into the frame mount (you might need a small hammer or mallet here) and pry it forward to line up the bolt hole with the mounting bracket. Insert the mounting bolt, install the nut, and tighten both the front and rear bolts. [Tip from Hakan Carlsson] When the bushings are in place compress them slightly by screwing in the bolt without the washer. This will make it easer to actually fit the washer, since it otherwise will be a little hard to start the thread. Use some force to push the radial arm into place. It takes a little patience but it works. [Tip from JohnB] Here's a useful trick if you can't get that end bolt to start with the new bushings in there...take off the bolt that holds the sway bar link to the strut control arm (same thread...longer bolt!) and use that bolt to start/compress the new cone bushings. Then unscrew the long bolt and put the correct bolt in with loctite. [Tip from Paul] After replacing the strut rod bushings (also known as cone bushings because of their shape) it is better to lightly snug the fastening nuts while the front end is supported off the ground. Then lower the front end back to earth and tighten the nuts to the specified torque. The reason for doing this is so that the bushings can find their "sweet spot" or neutral setting in the position that they will spend 99% of their time in. If you torque them up with the front strut arms hanging down and then lower the car to the ground it is possible that there is tension in the bushings as the load of the car is put on them. This is probably something you would never feel driving the car, but it could contribute to decreased bushing life.

Do the other side the same way and take it for a test drive. I will be willing to bet the steering feels quite a bit more precise. You are done with your part, but now you need to contact your local friendly alignment shop to have the alignment set again, as it is probably in need of a bit of adjustment. You have just saved yourself about $100 in labor and parts costs.

[Tip from W Bain] Once the new ones are in, lower the car and tighten to specs. I've got the Volvo green manual for our cars and the torque specs are: Bushing, washer and bolt for control arm: 95 Nm - 70 Ft-Lbs Then rock the front end a few times, torque the rear nut and bolt to 85 Nm - 63 Ft-Lbs.

More Tips. [Inquiry on 89 745T:] What's the best procedure for replacement of the front suspension radius arm bushing with minimal disassembly? I simply removed the sway bar end link (replacing them anyway) and the bolt holding the control arm to the radius arm. So I was obviously able to get the front conical bushing out (man, was it trashed) and now I can't get enough play to clear the tube from the radius arm where it goes through the control arm. Do I remove the radius arm from its rearward mount (to the chassis)? [Response 1:] You have to remove the arm.
[Inquiry 2:] How about the chassis end? [Response 2:] The rear bolt has to come out. It is the only way to get the rear bushing off.
[Inquiry 3:] If I am replacing struts and balls joints, is it better to remove the CONTROL arm instead of the RADIUS arm? Is it more likely that the control arm's chassis side bushing is in need of replacing vs. the RADIUS arm's? [Response 3:] Control strut bushing (the conical $20 bushing, two each per side) is the one most likely to need replacing. BTW, IPD sells the whole front end bushing set for $130 or so...if you're replacing four conical bushings for $80 and your car has over 100k on it, you should just bite the bullet and buy the IPD bushing kit and do them all. However, it's not trivial to replace the other front end bushings (much like the rear) - you need a press.
[Tip from Warren Bain] If you round off the radius rod rear bolt, replace with a 9/16 3" bolt which will work for the rear radius rod attachment point. The combo was about $4.80 for the set, nut, bolt and two washers. SAE quality only, no lesser quality will work since they might break and cause loss of vehicle control.

Grease on Bushings? [Inquiry] Should I apply grease to the bushings? [Response: Don Foster] Do NOT put grease on rubber components. Oil-based grease will quickly damage rubber bushings. I'd only add that you can grease the outer metal sleeves where they slide into a bracket or mating fixture, such as with the large trailing arm bushings—grease the metal-to-metal interference fit. It might ease the installation. Also, you can grease a bolt that slides through a metal sleeve—it might make disassembly easier ten years from now when you redo the bushings. [Response: Jim Baron] The point underlying the first two responses: rubber bushings are not supposed to move or slip at all against metal surfaces: they are designed to absorb the various twisting and compressing forces imposed on them within the body of the rubber itself. If you grease the area where the rubber meets the metal, you create a sliding friction situation which will wear out the bushing very rapidly.

Weird Bolt Heads. [Inquiry] The head of the strut rod bolt towards the rear is a 6-point star -- an inverse Torx head (looks like a giant Torx bit)! A 13/16" 6-point socket fits the nut end, and a 14mm wrench fits this weird star head, but I decided to abandon the job for fear of stripping the thing. [Response: Jim McDonald] Go ahead: they will work.

960/90 Series Control Arm Bushings. Unlike 740/940 cars, in the 960/90 the rear bushing on the control arm is the one that frequently fails. If you don't have the tools to replace the rear bushing, you can inexpensively replace the whole arm. They're fairly easy to replace. Get the proper ball joint separator if you're planning on reusing the old ball joints. If you decide to get the whole arms I'd recomend against using Scan-Tech brand as I haven't heard many good things. Buy the Meyle arms instead of Scan-Tech.

Torque Values. All bolts to be tightened while the suspension is level on the ground, weight on wheels. Use Loctite Blue.

Front Suspension Parts:

- Radius rod rear bushing nut: 88 ft-lb +/- 22 ft-lb
- Radius rod front conical bushing bolt: 70 ft-lb
- Control arm inner arm-to-frame bushing: 63 ft-lb
- Ball joint-to-control arm nut: 44.4 ft-lb
- Ball joint to strut tube: 22 ft-lb then angle-tighten 90 degrees
- Tie rod end nut: 44 ft-lb
- Sway bar end link top nut: tighten so that the outer flats of the washers are 42mm apart.
- Sway bar end link bottom bolt (if so used): 63 ft-lb

Strut Components:

- Top strut large center shock nut: 52 ft-lb for 1985 + vehicles; 111 ft-lb for 1984- with the center nut cover
- Top strut small nuts (2): 36 ft-lb for 1985+ vehicles; 30 ft-lb for 1984-
- Large round gland nut: tighten to around 50 ft-lb by estimate; use liberal amounts of antiseize

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Polyurethane Bushings. [Inquiry] I bought a set of front control arm strut poly bushings for my 86 740 Turbo from FCP Groton. Trying to install them today and have a couple problems. The bushings are supplied with a steel tube that's about 60 mm long. The original bushings, when placed together, have a length just less than 50 mm. It would appear that the compressed length of the poly bushings will be about 10 mm too long. Also, when I put the new bushings in, with new steel sleeve, the bolt in the end of the lower arm is too short to engage the threads in the end of the arm. I think a longer bolt would work, but I'm still concerned that the length of the bushing from washer to washer will be too long, forcing the control arm (and the whole wheel/strut) forward, altering the wheel alignment. Has anyone tried this successfully?
[Response: Vince] You are correct on your observation of the control arm being pushed forward. I quite a while posted similiar to yours and got replies questioning my discovery. I got mine from IPD, they were blue urethane, and thicker than the originals. I put one side on, decided I didn't like way it altered my steering geometry, took them off, sold them to someone else. I don't know why they were designed so much thicker than stock, other than to induce a change in alignment. Since both sides move forward the same amount toe settings shouldn't change. What will change is caster, whether you want it or not, by adding positive degrees. I don't know if this is desireable. Those that have installed them say they notice a difference, which could be partly due to the geometry change as much as to the difference in the material of the bushings. I found this note on the GAPA and All OEM websites describing their urethane bushings: "This bushing is used on vehicles that have had had the control arm stays and related bushings replaced with service units designed to reduce brake vibrations. The length of these replacement control arm stays (#6819079) is 388.5mm...". If you look up the stock rubber bushings it has this note: "This bushing is used on vehicles with factory original control arm stays. Depending on model and wheel size, these control arm stays can be of the following lengths: 385mm, 390.5mm, or 396mm. Stays that are 388.5mm in length are replacements with a special inner bushing designed to reduce brake vibration. Cars with 388.5mm stays should use outer bushing #6819057 instead. It seems to me that the urethane bushings are meant to used with shorter stays(or torque/radius rods) because of their additional thickness and were never meant to be used with the 390.5mm ones that came on our cars. I believe the urethane bushings carried by GAPA are the reds. The IPD blues are even thicker.

Installation. [John Sargent] Some installers have found it difficult to install the PU bushings using the stock control rod bolt. It is not necessary to install a longer bolt. Use a longer hardware store bolt for installation only. The longer bolts are needed just to get the assembly of the new cone bushings started. Then re-use the existing bolt, which is a special grade necessary to keep your suspension intact. [Raidman] Or just buy a one centimeter longer bolt in 8.8 grade.

Strut Replacement.

Need for Strut Replacement. See the brief discussion of shock absorber wear in Rear Suspension. [Comments from Ken Dibnah] I spent part of a day replacing the front struts on my 940 SE with a pair of Boge Pro Gas that I bought from IPD. When last visited, I had replaced my Nivomats (I have IRS) and lo and behold, I found that not only had I realized my hope of a more controlled/compliant ride, but the rear end stayed where it was supposed to, following the front end obediently instead of hanging wwwaaaaayyyyyy out on wet, powered corners (myself being somewhat confused in my expectations as I returned to the world of rear drive from my 2 year sojourn amongst those who are pulled through life, I thought those swings were part of the charm of the car).

Results were disappointing at first - didn't see too much improvement on the test drive, and the car sat an inch or so higher in the front , I think. Seemed smoother, but not remarkably so. Difference really showed up on the drive home. Had to do some serious braking, (to avoid an SUV!) and the control was remarkable. Usually, wet, heavy braking had the ABS hammering away, and not anymore! Wheels stick to the ground and don't hop about like they used to, cornering is much flatter, and rough roads (like the camel track known as the Stanley Park Causeway) are actually bearable again - the glove box stays closed and you can hear the radio!

So get out and change those shocks. The 'bounce check' just does not reveal flaws. If your car is high mileage your shocks are worn out, even if it 'bounces' as it is supposed to. My old struts, you could just push 'em in and pull 'em out, no damping. The shafts were polished like glass with no machine marks visible. They aren't visible and they are expensive, but shocks have made the most remarkable difference in the car's handling. Change those shocks! (I don't sell 'em, by the way)

Tips, Tools, and Procedural Notes. [Courtesy of Jim Burton, via Joel Reiter's Volvo homepage.]

I just replaced all the struts/shocks on our 87 and 88 740's. I used KYB because I got a great deal on them, but I'm not sure I would buy them again. The job is not bad, just long.

Tools:

- You will need a spring compressor, a good set of 1/2 inch drive metric sockets, a 3 pound sledge hammer, Loctite Blue, a large pipewrench, and the remainder of a good tool chest. Also helpful are an impact wrench (for removing the top strut nut), a garage jack for raising the front frame cross-member, and a quality jackstand. There are some odd sizes of nuts and bolts underneath: 18mm, 24mmm, etc, and some of them require deepwall sockets. Finally, you will need to make a strut holder to keep the strut from falling. Buy an 18 inch long piece of 3/16 threaded rod. Bend one end into a 4-inch deep hook with a 3-1/2 inch diameter. Bend the other end down into a short hook at 90 degrees, one inch long. The whole tool is nine inches long. Use the large hook around the strut; affix the short hook into the sway bar end or a body cavity to hold the strut. (UK, OZ, Canada, Euros, etc.: one inch=2.54 centimeters. Sorry: we're strange.)

Tips:
Here are the areas you should watch for (not in any special order).

- Use Loctite Blue or an equivalent thread locking compound on all suspension bolts. Consider replacing some of the critical nuts and bolts if you have high mileage.
- If you have close to 100K, consider replacing all your ball joints while you have the front-end apart.
- Have two strut tower bearings handy in case you need them. You can always return them to Volvo if you don't use them. The yellow side goes "up". If you don't change them, at least lubricate them with chassis or bearing grease. [Editor:] If you lose a few balls, buy an all-new set (about 45 loose ball bearings); the closest English size is 3/16 inch.
- **Mark** the strut top bolts and plate so you don't mess up the alignment. Outline the circular cutout with a felt-tip marker, and mark a cross where the two front and back bolts emerge so you can replace them with no alteration. Note that the strut plate is directional and has a front side.
- Look at the top mounting plate rubber bushings and the rubber spring isolator and make sure the rubber is not cracked or brittle.
- Unbolt the brake line bracket on the inner fender so the lines have more flexibility. There is no need to disconnect a brake line. Pop off the wire holder on the backing plate for the ABS sensor for the same reason.
- Support the bottom of the strut with a garage jack so that the brake line is not under tension. Use a strong bent wire or rod holder to keep the strut from falling when it comes out of the car: one side should be in the shape of a "u" and the other a hook to fit into the sway bar end hole. A coat hanger is NOT robust enough: try some wire rod from a hardware store and bend it to fit.
- You will need a hook spanner or pipewrench and PBlaster to get the tops off the strut tubes.

- If you have 70K or more on the car (7x0 series only), you will need to [replace the bushings on the rod]() that fastens into the lower a-arm. I believe this is called the "radius rod" but I could be mistaken. These are about $60 per set. At least have them on hand. You can return them if they are not needed.
- When removing the strut and spring assembly, the upper strut bearing can come apart, spreading ball bearings all over your driveway. Sweep the area first so you can find them.
- If your car has over 100k miles, consider renewing the sway bar end link bushings (four on each side) and the sway bar mounting bushings (one on each side).
- If your new struts come with straps, cut the strap as soon as you get ready to install. It's only there to make the shock fit in the box; the shaft won't come out very fast, and you can push it back without too much strain, though you won't need to.
- [John Sargent] Center the cartridge in the socket at the bottom of the strut before tightening the gland nut at the top. Some cartridges have a significantly smaller OD than the ID of the strut. If they are aren't centered, they will eventually work to the center and there will be slack and a clunk.
- If you decide to change the ball joints, buy new bolts and nuts that fix the ball joints on the lower rear shocks. The old ones are typically pretty rusted and beat up. Use anti-seize on the sleeve part of the bolts and Loctite on the thread.
- Torque all your suspension bolts/nuts to factory spec as you reassemble. The suspension bushings should be torqued after the car is on the ground.
- Take your time and don't let yourself get frustrated. Allow all day and celebrate if it takes you less time. A couple rusted bolts or a missing tool or two can easily turn a reasonable job into long job.
- Use jackstands and tire blocks (stop rolling) to protect yourself.

There may be a loose washer/spacer in the bottom of the strut tube. Make sure this goes back in exactly the same way it was before. If it flips to the other side, you will not be able to make enough turns on the top nut that holds the strut insert in the tube. This one took me forever to figure out what was wrong.

When disassembling the outer tie rod ball joint, take off the nut, apply some PBlaster, and let it sit for 15 minutes or so. Then whack it with the 3 pound sledge hammer. A few whacks should loosen it. If you can't get it that way, you must drive a balljoint separator between the a-arm and the ball joint. This usually destroys the boot on the ball joint, so have spares ($26 each) available. Use anti-seize on the new ball joints. After you complete the job, get it professionally aligned. Take some of that money you saved and do something fun the next weekend. After all, you just spent all day Saturday working on the car when you told your wife it would only be 4 hours tops.

Detailed Instructions:

Inside the engine compartment, you'll notice that the top of the strut assembly has 2 bolts which secure the strut/spring assembly to the chassis. These 2 bolts are all you need removed to allow the assembly to pull out from the top and then swing outwards with its base still secured. Make sure you mark the location of the bolts with an "x" and outline the circular cutout on the strut mount plate so you do not lose your alignment settings. Use a permanent marker.[Photos by John Sargent]

- BEFORE you remove these 2 bolts you'll need the following tools:
  - a spring compressor which you should be able to borrow at an automotive parts store, and if that's not available to you, to rent from almost any rental shop. Or buy one from JCWhitney ($20 +s/h)
  - an air impact wrench to loosen the large nut at the top of the strut or the piston rod. This nut is not impossible to remove with conventional wrenches if you have a box-end that'll reach deep enough to allow you to hold the top of the rod from turning. The impact wrench will handle the job without having to prevent the shaft (or rod) from turning. An alternative if you don't have an air tools, is to stop by a tire shop or any place that has air wrenches and get them to simply loosen that centre nut for you. Then you can take the car back home and, at the proper step, remove the nut with a wrench. You can do the same for the re-install and have them torque it down for you.
  - You will also need a small floor jack, a good set of metric sockets and wrenches especially 1/2 inch; a large pair of water pump pliers or a pipe wrench; and a good chisel and hammer for undoing the special nut that holds the shock insert in the tube. I was fortunate to have a set of dropped box wrenches for the large top nut and a high quality crescent wrench.
- Unscrew this large nut on the top several turns before you do anything as it will make it much easier to undo it after it is out and the coil compressors are in place.
- Jack up the car, support it at the front jack points, and remove the front wheel. Jack it up high enough to allow the wheel assembly to swing down and to be able to place a garage jack underneath the ball joint stud.
- Remove the bolts from the bracket that secure the brake hoses to the wheel well. Mine used a twelve point, size 40 and yours may too. Remove the ABS sensor wire clip at the fender and free the sensor wire.
- Disconnect the tie-rod end. Apply a little PB Blaster to the bolt where it comes through the hole. Let it soak for twenty minutes then, whack the side hard several times and it should drop out. I actually put the nut back on and tapped it several times and it fell out right out probably from the light coat of anti-seize compound I used when I put the tie rod ends in.
- Disconnect the stabilizer bar (this is to allow the wheel assembly to drop sufficiently. Now is a good time to think about new bushings for the link.

- Secure a strut holder or a piece of haywire or its equivalent to the middle of the strut assembly and to the car chassis inside the wheel well so that when you remove the 2 nuts from the engine compartment, the assembly is not allowed to swing out more than about a foot. Any more of a swing-out than that will result in damage to the brake lines. Place the garage jack under the ball joint stud and support it so it does not drop precipitously.
- Remove the 2 nuts inside the engine compartment.
- Swing the assembly down and out. You will have to manhandle the top downwards by pulling at the spring and pushing on the wheel hub enough to get it to clear the fender. The photo shows how the assembly drops down and out from the wheel well.
- Compress the spring using the spring compressors to about 12 inches.
- Once the spring is compressed sufficiently to remove the pressure against the top plate, remove the large centre nut. Use an adjustable wrench on the flat sides of the strut rod and a box end wrench on the nut. You can now pull out the spring. [Additional tip from Simon:] After the spring compression, make a record of the sequence of strut support, bearing and cover (and mark the "top" of the bearing so as not to reinsert it upside down), rubber mold, washer, etc. and which way they are positioned. It is easy to disassemble, but assembling must be in the right sequence and position. You can figure it out if you forget the sequence, but why waste the time.

Strut Assembly Pulled Down with Compressor Attached

- With the spring out of the way, all that's left to do is to remove the large flat nut that holds the cartridge in place. A "C" spanner is perfect, although a large pipe wrench will do in a pinch or you can simply tap it unscrewed with a chisel. The photo shows two ChannelLock pliers being used to remove the nut. In difficult, corroded cases use heat and a large pipe wrench. Be carefull on the reinstall that you do not make contact with the piston rod. Treat it as if it were made of glass.
- Pull out the insert, put the new one in. Use antiseize on the gland nut for future removal! Simple as that. [John Sargent] Center the cartridge in the socket at the bottom of the strut before tightening the gland nut at the top. Some cartridges have a significantly smaller OD than the ID of the strut. If they are aren't centered, they will eventtually work to the center and there will be slack and a clunk.
- [Additional tip from Simon:] Consider lubricating the strut bearing using chassis or bearing grease. The strut bearing has loose ball bearings held with a cup/plate. The bearing assembly can be opened easily. If you do, don't lose the bearings: there are perhaps forty-five loose ball bearings inside, all in a metric equivalent of 3/16 inch, and they will fly all over. If you lose a few and have to replace them with loose bearings, buy a new set (don't mix old and new). Replace the assembly with the yellow side up.

Spring Removed, Gland Nut Being Unscrewed

- Renew the rustproofing where you scratched it. Spray 3M tar sealant works fine.
- Reverse the process for reinstall. Make sure the spring top rubber seat is on the spring correctly and the top assembly is not out of alignment. Use the garage jack applied to the ball joint stud to lift the strut top tube through the hole in the mounting plate. When you do this, have a helper spot the shaft so that you don't misalign it and tear the rubber bushing inside the plate.
- Tighten the large nut on top of the strut shaft after the strut is back in and the car's on the ground; you won't be able to tighten it before the strut is under load.
- Torques:
  - Top strut large center shock nut: 52 ft-lb for 1985 + vehicles; 111 ft-lb for 1984- with the center nut cover
  - Top strut small nuts (2): 36 ft-lb for 1985+ vehicles; 30 ft-lb for 1984-
  - Sway bar end link top bushings: tighten so that the outer flats of the washers are 42mm apart
  - Sway bar end link bottom bolt: 63 ft-lb
  - Tie rod end nut: 44 ft-lb
  - Wheel bolts: 63 ft-lb

One word of caution: treat the compressed spring with respect. If the spring compressor ever lets go, you have got a lot of energy to contend with.

Strut Tube Space/Washer Notes. [Inquiry] I'm coming around to doing front struts again, and want to make sure I get it right this time. I have an 89 744T that currently has Boge Gas Turbo's on the front. The strange thing is that the top cap on the strut cartidge tube has several threads showing. Is this cap supposted to screw all the way down? This got me wondering whether or not I had spacers at the bottom of the tube. I just replaced the lower ball joints, and could see the butt of the cartidge but no apparent spacer. Should the top of the cartidge be flush with the top of the tube, or at some depth? How big is this spacer, and did it come with the OEM strut, or is it a fix for aftermarket struts? Does anyone know which struts need this spacer? [Response: Abe Crombie] The strut top is normal to be as you describe it. The order should be special washer, bumpstop-boot washer, spring cap, bearing nut. Do a dry run w/o spring so you can see if the fit of the parts seems okay. The shaft of shock MUST HAVE THE SPECIAL WASHER THAT HAS THE CHAMFERED (bevelled) OPENING SO THAT IT FITS THE CORRESPONDING CHAMFERED EDGE OF SHOCK ROD 2 " DOWN FROM THREADS. If you miss this part the shock rod may show up through your hood one day. I would use the bump stop if at all possible. The spacer is really a shaped retainer washer that rests against a snap ring at bottom of strut tube. Some after market shocks may use an additional spacer or a substitute spacer. The gland nut needs to be tightened to something in the neighborhood of 50 ft-lbs(more than a little tight, not get-a-hernia tight) and a pipe wrench or large channel locks would work.   [Response: Patrick Collins] The top cap on the strut cartridge tube will have several threads showing when installed properly. I just finished replacing my factory original cartridges last night (the cartridges had "Volvo" stamped on them), and several threads were exposed before removal. As a matter of fact, I had to soak the exposed threads with penetrant to remove the rust and dirt before removal. The cartridge was almost flush to the top of the strut tube, but not perfectly flush. The main thing is to make sure the new cartridge does not have any play when inserted in the tube and the cap is run down. Also, be sure to re-grease the journal bearings. Mine were in desperate need of grease.

Seized Strut Nut. [Tip from P. Dwyer] Assuming you've tried PBlaster/similar product, pipe wrench, long lever, etc., might I pass along my perennial suggestion: heat it up, then (and here's the 'nutsy' part) TIGHTEN the nut, even just a few degrees: I hope you either hear a slight 'pop', or feel it, or both; then back the nut off. Not 100% sure-thing, but 99% ain't shabby. Also, there is a thing called a nut splitter, a tool that slips over the nut and is then tightened until a knife-like edge splits the nut. And finally, you can try a hacksaw or similar ploy. But whatever ya do, HAVE FUN, and wear safety goggles. [Tip from EPS] There is a way to remove these cartridges from the bottom of the strut housing, when the large nut at the top of the strut housing will not move. Remove hub/strut/coil spring assembly from vehicle. Place on workbench and safely remove coil spring and top bearing pieces. Remove strut cartridge from bottom of strut housing by first removing the lower ball joint from bottom of housing. Look into bottom and see circular snap-ring, lower support plate, and bottom of strut cartridge. Remove circular snap-ring carefully, and support plate will drop out with strut cartridge. Then the top nut on strut housing can be removed. I cut four slots downward with a hacksaw blade on the inner bore of nut at 0,90,180,270 degree positions. Be carefull that these slots are deep enough, but not deep enough into threads. Then hit the outside diameter of the nut at one of these slots, this will crush   the nut inward, and allow you to remove the rusted sob. Clean the inside threads on the strut housing well before installing new cartridge and new nut. [Art Benstein] Damage can be caused by lack of counterhold for the gland nuts. In every case but one car, I've done the strut replacement on the bench, electing to disconnect and later bleed the brakes. Then, I have the assembly on a plank and can use a big hammer on a spanner for the gland nut while keeping the assembly on the ground with one boot. When I did the one car by leaning the struts out leaving the brake lines connected, it was fiddly to keep the lines slack, but my impact technique on the gland nut was done with the strut resting on a wooden box. Reasonably I should have broken them loose while still attached to the A-arm, but my previous success doing it on the floor left me without a thought of it. Also, I later looked at the Volvo manual to see the ingenious S-hook used to support the strut in this on-the-car technique. Considering it later, I worry the damage would be to the rack at the pinion, or even the column u-joints or steering lock, if excessive force or impact is used to free the gland nuts in place. An alternative might be some large pipe wrench to counterhold against brute force.

Bench removal of gland nut using hook spanner

960/90 Strut Replacement: Which Struts to Buy? [Jim E] We have two '95 960's. Mine has the OEM Volvo front struts, while my wife's has the Monroe struts. The Monroe struts are slightly stiffer, but not harsh in comparison. Both pairs of struts are about 2 years old, but I'm thinking of switching to the Monroes for the sportier ride. [John Roberson] I replaced both front struts with Monroe-car rides a lot better than on the OEM parts. The Monroes provide somewhat stiffer control and flatter cornering.

Upper Strut Mount Bearings. While the upper strut mount does positively secure the strut regardless of the bearing condition, you can still experience a loose front end if the bearing is loose or unlubricated. The bearing is positioned with a moderate slip fit on the rubber under the mount. [Inquiry:] After replacing struts, ball joints and all bushings, the front end still feels loose. I've narrowed it down to the upper strut bearings. With a spring compressor, how big a job is this? [Response 1: Keith LaCrosse] Just replaced the struts and bearings in the my 960 this morning. With the proper spring compressor it is not really that hard. I used the Volvo manual for the step by step procedure and it was not bad. Sequence was to jack and support car, remove wheel, remove tierod end (use pickle fork), remove upper nut/bushing on swaybar, remove brake hose support bracket, once that was all done support the assembly with a jack and loosen the upper bearing plate nuts. Once those were removed let the jack down and the whole strut will lower from the housing. You will have to force the the strut assembly down to clear the fender well, once out it needs to have some suppport so it is not flopping around. You then put on the spring compressor and compress the spring. Once that is done you can remove the large (15/16) nut on the sturt and remove the upper bearing plate. Be careful on removal since the plastic bearing halves are only loosely assembled and you may end up with balls all over your garage. Once removed, give it a good soaking and cleanup to remove the grit and old grease, then repack it with a good grade of wheel bearing grease and snap the plastic cover back on. Assembly is, as they say, the reverse.

Upper Strut Mount and Bearing

Hints I learned: Loosen the large 15/16 nut before you have the strut assembly out, be careful not to loosen the nut to much or the spring will explode with some force (I only did that once a long time ago)
If you are going to remove the strut also I reach up between the coils of the spring and loosen the 55mm or so nut that holds the strut in the tube. [Editor] See the Strut section for more details and torque values. Note that strut mounts (not the bearings) are directional and have left/right orientations. [Editor] Anecdotal evidence seems to indicate that Scantech strut mounts are of awful quality: go OEM.

Tie Rod Replacement.

Diagnosis. [DougC] You can check the inner tie rod connection by raising the front of the car so one wheel is off the ground. Feel through the steering rack boots, but be careful: if they are really old, you might accidentally punch a hole in them. Feel at the exact spot where the ball and socket joint is. Have someone wiggle the wheel holding their hands at 9 and 3 o'clock. Feel for slop. There should be none. Study the tierod picture below beforehand so you understand the geometry.

Tools. [Question:]Are there any tricks to changing this? I suppose it's a good idea to change the tie rod ends with this job. [Answer:] It will take a few hours (if you're doing this first time), and you will need the following tools:

> A socket set; 2x 22mm open end spanners; locking pliers; a large breaker bar for extra leverage with stuck bolts;
>
> Car jack; Bottle jack (makes it easier - see text); good penetrating oil such as PBlaster; and a wire brush; Hammer.

I suggest you change both tie rod ends - First, if one is shot the other one is probably on it's way, and second - they're cheap. Change as well if the rubber boots are torn. You'll probably pay more for the tracking than you will for both ends.

Tie Rods:

The complete tie rod is made of two pieces. There is the "inner tie rod" which consists of the rod itself and the ball and socket joint where it connects to the steering shaft under the rubber boot. The rod part has threads at one end where it screws to the tie rod end. At the inner end it has the ball and socket joint that allows it to move up and down with the wheel movement, etc. The end of this ball and socket joint screws onto the steering shaft that is part of the rack and pinion system. The "outer tie rod" or "tie rod end" that connects at the wheel is the second part of the complete tie rod assembly.

The procedure is rather simple. You can remove either outer or inner tie rods or both. The rod end connects to the strut with a conical 'rod' locked with a nut, and the inner tie rod screws into the end and also has a locking nut.

Nut Removal. First, jack up the side you're working on and remove the road wheel. Using the 22mm (I think) spanner, release the locking nut on the tie rod (the one that locks the inner tie rod to the tie rod end). This may be quite difficult, but since the end is still bolted to the strut, it will not turn so this is easier. Sometimes the tie rod turns with the nut, in which case:

- Use plenty of PBlaster penetrant
- Use the wire brush to clean the threads (probably a good idea anyway)
- Make sure you are turning in the correct direction (examine the threads)
- Use heat if necessary: place the inner rod in a vise or secure it from turning. Wrap the stud end of the tie rod end with a wet cloth to keep the grease and the boot intact and then using an oxy torch quickly get the threaded end to a dull red. Apply a pipe wrench and turn it out as quick as you can. Allow the rod end to cool slowly.
- Count the exposed threads so you can reassemble with approximately the correct wheel alignment
- Use the locking pliers to hold the tie rod, and release the nut

Inner Tie Rod. To remove the inner tie rod, you disconnect it from the tie rod end by loosening the locknut on the threaded portion of the inner tie rod and unscrewing it from the outer tie rod end. Count the exposed threads before you start so you can get it reasonably aligned when you reassemble. You don't have to remove the tie rod end at the wheel where it connects to the steering arm, but you will if you're replacing the tie rod ends also. Once this is disconnected, you can pull the boot off if you haven't already cut it off. Then you disconnect the inner tie rod from the steering shaft. There might be an obvious lock washer affair which is great, or there might be a peen that holds the inner tie rod from working its way off the shaft which would cause a loss of steering on that side of the car. The peen dents into a recession in the shaft that you won't see really well until the inner tie rod is off. If yours is the peened style like mine is, you'll have to decide how to get the peen out so you can remove the inner tie rod. I carefully filed mine off because I didn't want to beat on the steering system too much. The Volvo manual shows a guy removing it with a small chisel. If you file it, go very carefully. Otherwise you'll file down into the shoulders of the recession in the shaft and the new peen on the new tie rod won't have as secure of a lock. Hopefully, you've got the easier style with the lock washer and bent tab. When reinstalling the inner tie rods to the rack ends, sometimes they do not screw on all the way, stopping about two full rotations shy of where it should be. Apply moderate pressure with a wrench: the last couple of threads are sometimes locking threads that provide an extra lock to add to the peen. And use Loctite Blue to keep this secure. Before reinstalling the bellows, clean it out and apply a palm-sized dollop of CV grease on the tie rod ball joint and inside the bellows. Don't use non-rubber-compatible chassis grease.

Bellows. Replace a torn bellows by unscrewing the outer tie rod lock nut (below), then counting threads to the end of the outer tie rod (so you can replace it with alignment approximately correct). Unscrew the inner tie rod and the lock nut. Cut the bellows inner tie and remove the outer spring clip. Peel off the bellows. Clean dirt from the inner tie rod and apply fresh CV grease to the ball area. Fit and secure the new bellows, then refit the outer tie tod end. Align the front wheels.

Tie Rod Ends. Using a socket, release the nut that locks the ball joint to the strut. You can expect this nut to be quite stuck as well. If you let the steering rack move to full lock, you'll have something to push against. Remove this nut completely. The ball joint must now be removed from the strut. And, it will probably be stuck as well... So, just use the bottle jack to hold the strut - put it under the bits that the ball joint is in, as close as possible to the ball joint, and lift it a bit - just enough for the jack to take the weight. Then hit the stud on the ball joint - sooner or later, it will pop out. [Alternative removal tool from Doug Weiss: I fashioned a tool out of an after market exhaust system u-bolt type clamp. Open the u-bolt to fit the bolt holes in the lower ball joint (Strut removed). Bolt it on, using decent sized (thickness) washers, then slip a pry bar between the loop created and the control arm. No ball joint can resist the torque now at your disposal.] [Editor:] If the outer tie rod end is stuck on the tie rod and cannot be removed, change the inner tie tod. Remove the rack boot by cutting the plastic tie, unscrew the inner tie rod while holding the rack screw steady with a wrench (don't let it revolve). Replace the inner tie rod, the rack boot (use a heavy-duty cable tie) and then install the new outer tie rod end. Use antiseize on re-assembly.

Inner & Outer Tie Rods for ZF Rack

When you have the tie rod end ball joint free, remove it from the tie rod, and count the number of turns. Then, put on the new one, with the same number of turns. This will set the tracking close enough so you can drive the car to the garage for an accurate alignment.

Put the ball joint in the strut, and tighten the locking nut (44 ft-lb). [Editor: I use a tiny bit of grease on the ball joint shaft to ease disassembly next time.] The ball joint may turn in its hole, so use the locking pliers to apply a *bit* of pressure to it while you tighten. Once it 'catches' it's usually OK. Tighten the inner to outer tie rod locking nut - this time, use two spanners, one on the nut and one on the tie rod end. The easier method is only good for a ball joint you're about to throw away.

Refit road wheel, and repeat for other side - and that's it! You're done - but don't forget to have the tracking done.

Tie Rod Ends Rusted in Place: New Inner Tie Rod Needed

[Editor] If your tie rod ends are rusted in place and can't be removed, you will likely need a new inner tie rod (the shaft mounted on a ball joint inside the rack boot. Get one at an auto supply store, along with a heavy-duty cable tie for the rack boot. In my case, I jacked up the car, removed the tie rod end from the strut, crawled under the rack, cut the rack boot tie, pulled the rack boot back to expose the ball joint, and used an adjustable wrench to hold the rack at the gear while I applied adjustable pliers to unscrew the inner tie rod and ball joint. DON'T allow the rack gear to rotate or you will ruin the rack. This freed the whole tie rod assembly, which I pulled off. I cut the inner rod with a hacksaw to remove the boot. Then I screwed the new inner rod into place on the rack end, using medium threadlocker, and staked it with a punch where the old one was staked. Clean off the boot and add grease to the rack gear, the ball joint and the inside clamping surface of the rack boot. I reinstalled the rack boot with a heavy-duty cable tie and the existing outer spring clamp and then installed the tie rod end. Ready for an alignment. BTW, the local NAPA parts store had my inner tie rod in stock for my '90 745 with CamGear. Make sure you get the right one with the correct length of both shaft and inner threaded portion. See the Steering section for help identifying your rack.

Ball Joint Replacement.

Test. [Import Car Magazine, Apr 2003] To check the ball joints for wear, have the vehicle resting on wheels. Using a large pair of pliers, squeeze down on the joint. The maximum axial play permitted is 0.12 (3.0 mm) and the maximum radial play is 0.02 (0.5 mm). Check the rubber boots; if they are torn or damaged in any way, replace them.

[Editor] You will need a deep socket set, a large breaker bar for leverage, and a garage jack, in addition to the ball joint kit which should contain not only the ball joint but two replacement bolts, a control arm nut, and a cotter pin as well. Because of stuck bolts, a six-point socket is recommended. Do not reuse the old bolts: they are torque-to-yield and cannot be reinstalled.

Removal:
Jack up the car and place a jackstand under the front jacking point. Remove the road wheel. Examine the ball joint: it is bolted to the strut tube bottom and is pressed into the control arm, affixed with a nut and cotter pin on the bottom. Remove the control arm strut rod bolt to free the arm (you do not need to remove the control arm from the car, but now is a good time to examine conical bushing condition). Remove the cotter pin and then unscrew the control arm nut holding the ball joint shaft. Remove both bolts on the bottom of the ball joint: these will be tight and will probably require the large breaker bar to remove. After applying penetrant oil, use a mallet to hit the control arm and free it from the ball joint shaft. Or use a puller.
Installation:
Apply Loctite medium threadlocker to the new ball joint bolts and reinstall the ball joint to the bottom of the strut tube. Torque first to 22 ft-lb then an additional 90 degrees angle tighten. Reinstall the control arm strut rod (if removed) and the arm onto the end of the ball joint. Torque the strut rod bolt to 63 ft-lb and the ball joint nut to 44 ft-lb. Reinstall a new cotter pin. Fill the top of the ball joint bolt holes with rust preventative (tar) and apply this to the cotter pin as well. Reinstall road wheel. You may want to check the front wheel alignment after this procedure.

Ball Joint Kit

Troubleshooting and Upgrades:

Vibration in Front End. In the event of vibration in your front end which may be transmitted through the steering column, first suspect wheel imbalance or worn conical strut rod bushings. Worn struts, ball joints, tie rods, strut mounts or bearings, other front end bushings, or faulty tires can also contribute to this.

Clunk in Front End.

700/940 Series. The two "most common" areas of clunkiness, if you will, on the 700 series are: *Worn ball joint* - Being ungreasable, these can deteriorate and cause the strut assembly to have play at the base of the strut cartridge. Not necessarily detectable through the bounce test but under vehicle load (dynamic), it can show up (audible). Correction: replace ball joint(s).- *Worn/broken upper shock mounting* - the large rubber doughnut inside of the mount can be split and there'd be no visible signs of it's demise except when removed. However, the warning sign of this is not usually a clunking under straight line driving or under the bounce test. It shows up under low speed cornering as a mild "clunk" at or close to full steering lock. However, my experience was that as it got worse, it did start to emit audible warning under driving load. [Editor:] The *upper strut mount bearing*, located within this doughnut, can also fail and give clunky feelings, usually on steering hard to the stops. [John Sargent] Have the *strut cartridges* been replaced? If so, some strut cartridges have a significantly smaller OD than the ID of the strut. This type of strut cartridge must be centered in the socket at the bottom of the strut. If they are aren't centered, they will eventually work to the center and there will be slack and a clunk. [Editor] And check the *large gland nut* holding the shock insert into the strut tube: this can loosen and cause a "clunk" in the front end.

Note: the infamous "bounce test" is NOT an accurate way to pinpoint any front end/shock/strut problems. Remember, that as you are bouncing the front, you are really having to "defeat" the spring strength first (since they are what's holding up the vehicle under it's own weight) before any other problem areas will show up. This usually takes dynamic (moving) loads to recreate. Other sources to look at:

- The *bushings*, as you've mentioned. Usually, broken bushings can actually be seen as cracks at the visible edges. Not always detectable as such but worth a look.
- The *strut inserts* themselves. Once they've exhausted themselves (and perhaps have leaked their hydraulic "blood", there's not much else to do but clunk against the side walls of the pistons.
- *Sway bar bushings* - if they are worn at the center mounts, the bar can be hammering the frame.

[Diagnosis comments, again on "clunk" in front end:] If your problem is not the spacer in the bottom of the strut tube, then it is time to start inspecting all of the front suspension. Check the sway bar bushings - both the ones at the end link and the ones that fasten the sway bar to the front frame rails. Check the control arm rear bushings - sometimes their deterioration is not evident and takes a large pry bar to see the problem. Also, inspect ball joints (they are spring loaded for wear, so need large channel locks to squeeze to check play), outer tie rod ends and also the inner tie rod ends, though these will probably not clunk when pressing down on front end. Try reaching over tire and putting hand around front strut while someone bounces front end to see if you can 'feel' the clunk. Did you already try tightening the big nuts that hold the shocks in the strut tubes? And if they are tight against the top of the strut, it is likely that you need to disassemble and install the spacers. When they are tight, there should still be several threads showing. Also don't overlook the upper strut mounts/ bearings. If the rubber is cracked and pulling away from the metal bearing in the center, consider replacing. Suspension is likely the problem, but also check the wheel and bearing. These are usually low speed clunks, but are potentially more dangerous.

Sorry to point out the whole blamed front end, but as I said, it could be anything... you just need to study each of the components and figure out which you want to attack first. If you have original shocks or just about anything with over, say, 50k miles (Bilsteins maybe higher mileage), I'd suspect the shocks first.

960/90 Series. [Inquiry]My 1996 960 Wagon (68k miles) developed a knocking/clunking sound on both sides on rough roads over the winter. [Response: J. Bowers/WilHome] Sway bar end links are a common problem with this design. Because they are connected directly to the struts they have to turn as well as carry suspension loads, so they are designed like miniature tie rod ends. Any rust & wear and they will be noisy. Mine failed after New England salted road water got into one. The part is an "outer stabilizer link" P/N 272991 same part number for both sides. List price is around 64.00 each. It can be replaced in about 30 minutes.

Steering Pull to Left or Right. [Editor] Steering pull is almost always due to either poor wheel alignment or spring sag.

Front Wheel Bearings and Hubs

Later Two-Part Hubs . [Inquiry:] I would appreciate anyone's input as to experience with alternatives to Volvo's idea of spending 240.00 US in parts to replace a wheel bearing of the simple ball-bearing type. Aftermarket sources? Rebuilts? Bearing kits? [Response 1: John Kaiser] Your bearing or hub assembly is pretty expensive from the dealer. Unlike the earlier 740s these are not rebuildable. They do go bad once in a while. Check with a good import parts place because this hub you need is available through the aftermarket.

Earlier One-Piece Hubs. Take the bearing out and look on the side, you will see the bearing number. March off to the local parts shop, almost any will do and ask for a bearing of the same type number. You can start with the listing for Volvo and then make sure it matches the number you took off. There are not that many tapered bearing makers in the world and the local parts guys usually stock the individual bearings not the kits like Volvo. Done it many times on Volvos and MBs. Just reuse the other bits and pieces.

Reusable Parts? [Inquiry] Don't you have to replace the hub nut and grease cap with new parts when this is done? [Fitz Fitzgerald] The axle nut used on the later vehicles (with the sealed hubs) is supposed to be replaced each time it's removed. However, there's nothing special about the nut itself, other than the top is "pinch" narrowed. When the nut is installed, the top is forced to open up a bit, and provides a tight grip on the threaded shaft. Since the "pinched" section at the top is opened slightly in the act of installing the nut, Volvo advises replacing it whenever it is removed. (about $5 to $9 per axle nut) [Jay Simkin] Do not add lubricant to these later two-part hub bearings. Do not clean them with solvents - e.g. trichloretylene - which will damage the seals. Do not re-use either the axle nut or the axle nut cap. A torque wrench should be the only special tool that you need for installing the late model nuts. The early style require a bit more finesse and is similar to the 240 style and should require no special tools.

Replacing Bearings and Reinstalling the Two-Part Hubs. To reinstall the bearings and hubs and keep the inner race for the outer bearing from falling out, you can buy or borrow a race driver (a set of tapered aluminum pieces that fit the contour of the race, withe a hole in the back to index a round aluminum driver which is then driven home with a hammer until it is flush) or try a slightly easier approach. [Jay Simkin] Here's a way to make a removable plastic ring to keep pressure on the inner bearing race, as you move it along the stub axle. Take a plastic cable tie, 1/8" wide, and put it on the stub axle, 1/8" from the leading edge. Adjust the cable tie, so it is just short of snug, i.e., so it will slide along the stub axle, when pushed. As you lower the hub towards the stub axle, use your fingers to hold the inner bearing race in place (from inside, letting your fingers press on inner edges of the inner bearing race). When you have the opening in the hub, level with and centered on the stub axle,slowly pull out your fingers, and push the hub gently onto the very end of the stub axle. The cable tie will at once contact the outer edge of the bearing race, and keep it from sliding freely. Push the hub towards the strut housing. If the cable tie won't slide back towards the strut housing, move it 1/8" with your free hand. Step-by-step, work the hub onto the stub axle. Once the hub is fully on the axle, continuing pushing the hub towards the strut housing, until the cable tie stops further movement. Using a piece of wire, with the cut end blunted (with sandpaper), hook the cable tie and lift one section, so you can cut it, with a pointed-end wire-cutters. Be careful not to let the cutter contact the stub axle surface. Remove the cut cable tie, and press the hub into position. Once you have the hub seated on the stub axle, use a ruler to make sure it is properly positioned. Measure from the face of the outer-most bearing race, to the edge of the "inner ring", which forms the well, in which the axle nut resides. The distance should be 23 mm. If it is not this distance, re-do the installation. The 23 mm distance is mission-critical.

Wheel Hub Spindle Nut Adjustment. [Inquiry] What are the proper spindle nut tightening procedures for my 740 with two-piece hub? [Response: John Sargent] The adjustment procedures are the same for the one piece hub/rotor, and the separate hub/rotor. If I remember right, the bearings are the same, with only the seal and bearing retainer being different. Install the hub and torque the hub nut to 42 ft-lb (57Nm) while rotating the hub. Loosen the hub nut half a turn and tighten only using your fingers (nominal torque of 1.1 ft-lb or 1.5 Nm). Tighten the nut if required to install a new cotter pin in the nearest hole. Then install the dust cap. [Jay Simkin] For the later 1988+ series hubs, tighten the axle nut slowly, "so that axial play just disappears" (Volvo Manual). Then tighten the nut to 73.8 pound/feet (100 Nm). Then, angle tighten to 45 degrees, using a protractor. Install the new cap, and you're done.

Later Two-Part Hubs Coming Apart in Shipping or Handling. If you accidentally remove the retainer or they come loose in shipping, here is how to reassemble. Don't just press them back together. Instead, reach in from the side of the inner race that did not fall out and push the bearings towards the spindle nut (the same direction as they were pulled when the half of the race was removed). Holding the bearings in position, the outer half of the inner race slides back in easily. This positioning of the bearings allows them to expand back from their plastic seats and allows the outer half of the inner race to expand them slightly. This is essentially what happened during removal - pulling on the outer half of the inner race pulled the bearings to a position where they could expand and the half-race slipped past them. Assembly is reversed, but rather than the force on the bearings from the race holding them in position, you must substitute your fingers.

Front Crossmember Failures: Fatigue Cracks; Starter Cable Shorts.

Fatigue Failure in Front Crossmembers. [Technical Note from UK Volvo Club, 700 Section] I have also been advised that there have been more than a few cases of Volvo 700/900's generating hairline cracks in the front crossmember, right next to the part where the lower suspension arm bolts on. These often go undetected because of dirt and in any case the paint has to be cleaned off to spot them for sure. [Rowan Mideke] My 85 745 developed some front end problems including no control in reverse, leaving black marks on concrete just from tire scrub, hideous popping noises on the highway, and excessive outer edge tire wear. I noticed some small fractures at the inner control arm mounts. It didn't look too serious, but that metal is not as tough as I would have hoped. Six months later, it's scary to drive; the crossmember is nearly ripped in half. It so happens that 1983-1986 cars suffer from cross member fatigue cracking at both the control arm and frame mount bolt holes that can lead to complete failure of the cross member and front suspension collapse. The later, redesigned cross member is a direct bolt-in replacement. If you have an earlier vintage Volvo, inspect this component on a regular basis.

Battery Cable Failures. [UK Club] Also on 700's the same crossmember has the heavy battery-to-starter cable running over its nearside front edge. These were the subject of a recall some years ago as they chafed, leading to a big electrical short (and under-bonnet fires in some cases). Apparently, most cars were caught, but the odd unmodified one must still be about. The recall modification involved 'fitting a sheathed clip, which lifted the lead away from the cross-member. It's screwed to the nearside front cross-member inside the fixing point of the lower suspension arm.

Broken Spring Seat Tray. Volvo makes a spring seat repair kit. They come in pairs.You pull the strut assembly. Remove the spring with compressors. Remove the strut. Then, you measure and cut the old seat flange at a certain measured spot from the bottom or top with a air cutoff tool (or hacksaw). Then the new spring seat is spot welded in 2-3 places to the strut housing. The spring seat has a couple U grooves in it... There are fingers on the new seat that slide in these grooves to lock into place and determine the height.

Upper and Lower Chassis Braces. [Performance Tips from Joshua OstroffSteve Seekins] The other day I got around to installing the lower chassis brace onto my 1994 945 turbo. I got the parts from my local dealer; cost with VCOA discount <$35. Installation took less than 5 minutes. It was a breeze, as it only fits one way. If the threads on the mounting stud are dirty or obstructed, you may want to spray a little WD40 to clean them up before mounting the brace. A couple of people on the brickboard asked for my impressions back when this thread last surfaced. In my case, I had some months ago put on IPD antisway bars to replace the stock bars, and I also recently mounted winter tires, so I can't really toss the car around too much until Spring. But for now, it feels like the car has noticeably less play & lean than before. I had been told, and it stands to reason, that this mod is the most bang for the buck to improve the handling of the 700 and 900 series. The 700/900 lower chassis brace is a crosswise brace that mounts using existing threaded holes and a stud on the rear bushing mounts for the radius rods. It provides additional frame stiffness at the radius rod ends where there is stress when turning and braking. The effects are noticeable. Volvo part numbers are: Brace: 3526694 (List price $38.21); Bolt (3 required) 967731; Nut (1 required) 971098 or look for them with threads at 10mm x 1.5 pitch. Takes about two minutes to install.

Try http://www.ipdusa.com for high-quality strut tower braces and lower chassis braces for 700/900 cars.

Front Lower Chassis Brace

Do-It-Yourself Braces. [John Sargent] My son has built a couple of lower chassis for 700 series cars braces using flat steel. The diagonal braces are made from 1.50" X 3/16" (40" total) flat steel bar, and the connecting bar is made from 1.00 X 1/8" (24" total) flat steel bar. A bench vice was used for the bending, and my drill press for the holes. If you don't have a drill press, a hand drill is certainly adequate for drilling the holes. The holes were drilled to match the available holes in the chassis. The lower chassis brace along with the upper strut tower brace he also made really stiffened up the car, just like the same parts you can buy. Total time to make and install was less than two hours.

Upper Strut Tower Brace

The upper strut tower brace is also shown. The round stock is 1/2" cold rold steel. Cold rold is more expensive than hot rold, but it was selected for it's good finish. The end tabs are made from 1/8" x 1", and the diagonals are made from 1/8" X 1". More diagonals were added by the time the strut tower brace was completed.

Sway Bar Installation.

Justification for Sway Bars. [Inquiry:] Can anyone give me the "skinny" on sway bars. Do they make for a more comfortable ride? Are all sway bars pretty much alike? I hear a lot about IPD sways. Are there any disadvantages in using them? [Response: Warren Bain] It was the best thing I did for my 744Ti. It used to roll a lot in the turns and it had the thicker turbo bars. I bought the IPD bars and what a difference. To get the maximum benefit, upgrade the shocks, replace bushings, get better tires, better brake pads because you will find yourself driving faster in the turns. The bars will also put an increased strain on the bushings, steering rack and other parts. They are definitely worth it. [Response: George] The bars will stiffen the ride. It will make for a better handling car but not for a more comfortable one. Your decision.

Installation. [Inquiry:] The IPD bars are finally on order for my 91 940T. I am concerned about performing the installation myself (for safety reasons). I can perform basic repairs but have never been comfortable with suspension or brake work due to the criticality of these components from a safety stand point. Question...should I be concerned and how difficult is the installation? Can the car be supporting its' own weight or should it be on jack stands? {Response: Michael Jue] IPD bars are actually quite simple to install IF you have basic mechanical knowledge. If you don't wish to do this, no problem! A shop can do it quite handily and the positive change in handling is still worth it.
A few tips:

- Support the car with jackstands, wheels off.
- Take note of what you are disconnecting.
- When reassembling, the trick is to make sure that the end link bushings/bolts are "pre-loaded", that is, the lower control arm, which is now at full droop hanging freely, should be raised back up to "normal standing position (as it is with the car at rest, sitting on the ground.) You can accomplish this using your floor or bottle jack under the strut base (front) and lifting until the control arm is in "normal position" BUT, be careful NOT to lift the car off the support stand.
- Torque the end links just to the point where the end link bushings compress, bulging nearly to the edges of the bushing cups. No more, no less. You have now pre-loaded the sway bar. Once back on the ground, sitting on the tires, you may need to crawl back under to check the attachment once again.

- Rear bar cannot be more simple: just unbolt it.

Sway Bar End Links. [Editor] Note that the rubber bushings in your sway bar end links will crack and wear. It makes more sense to replace the entire link, due to likely corrosion, than just the bushings. Note that there are two styles when ordering: the photo from IPD illustrates the differences between the early 4-piece link for steel control arms and the later 8-piece link for aluminum control arms..

Photo courtesy of IPD

Rusted and Stuck Bolts: Removal Techniques. [Inquiry] I was initially unsuccesful in removing the nut from the rear lower shock bracket on my 1990, despite penetrating oil and the old wrench + hammer technique. I guess the other trick I hear about here is using heat. Does this mean using a propane torch (the kind for sweating copper pipe)? Or something more mild like an electric heat gun? I'm a little worried about open flame near the gas tank, brake lines etc. [Response: Phil Ellsworth] My solution is the electric impact wrench. When I did the ASB and shocks on my 244, the wrench removed all nuts easily. (Credit to Balu Vandor for the tip). The least expensive one I've found is a 250 ft-lb unit for $69.95 at Harbor Freight. [Editor:] Home Depot has a Dewalt 290K electric impact wrench, US-made, for $89. See also Mechanical Tips.

Maintenance Manuals:

Volvo Cars Technical Literature and Service Manuals. The VCNA website also has a direct link to the Technical Literature ordering site: http://www.volvotechinfo.com/

Volvo Cars On-Line Owner's Manuals. For downloadable copies of Volvo owner’s manuals, visit the following Volvo Car websites:
US: www.Volvocars.US

Other Sites: http://www.volvocars.com and select your country. Few have online owner's manuals.

Volvo TSB and Recall Information. [Tip] See the Alldata website for titles of recall notices and Technical Service Bulletins for various Volvo models. You can buy their CD-ROM listing of the text of each title at the same site.
http://www.alldata.com/

Commercial Manuals. [Editor] You have several choices in addition to the exceptionally good but very expensive Volvo OEM manuals:

1. Chiltons publish a series of manuals for Volvo cars; my favorite is the *1990-1993 Volvo Repair Manual* (Chiltons Number 8428; ISBN 0-8019-8428-9) which is focused on RWD cars. Buy it new from IPD for around $20.
2. Haynes UK publish a nice *Volvo 940 Service and Repair* manual (Haynes number 3249; ISBN 1-85960-249-5) which is better than Chiltons on illustrated procedures but has fewer reference statistics. Buy it from IPD or Haynes UK or on EBay at prices up to $30.
3. *Volvo Problem Solver*, available from IPD, is a comprehensive troubleshooting guide to Volvo RWD cars. It is becoming a little dated, with no information about Regina or Motronic systems or 960s, and is best for mid-1980s RWD cars. Still, it has great troubleshooting charts for all major systems on cars up to Bosch LH 2.4. Buy it for $70 from IPD.

4. *The Gothenburg Bible*, by Paul Grimshaw, focuses on basics and the "whys" of preventive maintenance and is updated over the Internet. Buy it from IPD or from Paul for around $30.
5. *Bentley Bible for 240 Owners*, (Robert Bentley) available from IPD for around $47, is exceptionally good but limited to 240s. As a result, it will not reference 700/900 except in congruent engine and transmission systems.
6. *Bosch Fuel Injection and Engine Management* by Charles Probst (Robert Bentley, ISBN 0-8376-0300-5), available from IPD for around $30, is a comprehensive theoretical and practical guide to the Bosch engine management systems on Volvo and other cars. It contains troubleshooting, diagnosis and test procedures, but no specific diagnostics for Volvos using the Bosch diagnostic system. Very good overview of all engine management systems from Bosch.

Bosch Manuals. Having first found it at the local University library, I have now purchased a copy of "Automotive Electric/Electronic Systems," by the Robert Bosch company. If you own a Bosch-controlled car, as many of us do, this book is outstanding. For example, it has one of the best descriptions of what the knock sensor does, and what kind of signals it puts out, and how the computer handles them, that I have ever seen. If you really want to understand your car, you will buy this book. Even Swedishbricks, with the combined knowledge of the gurus cannot approach the succinct explanations offered herein. Anyway, the book is available in the US from SAE - the Society of Automotive Engineers - for $39. It can be ordered from their website - http://www.sae.org [Editor] You can purchase chapters of this book for around $10 each on selected subsystems such as alternators, starters, etc., also from SAE.

On-Line Technical Information. [Tip: Ross Winberg] To subscribe to on-line technical data and technical service bulletins, try http://www.alldata.com/ The same database professional mechanics use may be available free of cost to you. Many libraries subscribe to the AllData database. Call your local librarian to find out. AllData is basically a database of all factory repair manuals for all automobiles. It has the complete procedure as well as relevant pictures. It does not have everything, however. Regardless, it is a wonderful resource

Volvoworld, a retailer in Quebec, has a nice on-line manual for selected subsystems thanks to founder Stephane Lapointe.

Oil Filters. [Editor] Use only Mann or Volvo OEM filters in your car. Do not use Fram, Wix, STP or any discount house generics: they lack either quality filtering media or a working anti-drainback valve. Buy Mann/OEM filters from:

- RPR (http://www.rprusa.com) for Mann filters.
- IPD (http://www.ipdusa.com) for Mann
- FCPGroton (http://www.fcpgroton.com)
- Internet dealer: Borton Volvo (http://www.borton.com) for OEM filters
- Discount filter sellers: "redline2k", whose email link is ebaystuff for discount Mann filters. Often found on EBay.

Bosch Parts Finder. BoschUSA has an online parts list for all vehicles using Bosch parts: the link is Bosch Parts Finder.

Parts Sources

1. *OEM Volvo Parts:*
    - Borton Volvo in Minneapolis: great service and great pricing: http://www.borton.

com

- Verrigni Auto and Marine. I just took a chance on a friends recommendation and ordered some stuff from Tony Verrigni. When it arrived it was all genuine Volvo and he absolutely Killed dealer prices.800-888-6586 or 561-338-0884 Fax: 561-338-0880 [Response: Mike Sestina] Tony has great prices plus Tony can get hard to find European only parts like the H4/H1 Swedish headlights for my 940.
- Toyota/Volvo of Keene, NH. George Vacarri has good discount prices, 1.800.445.6171 or email salesvolvokeene@top.monad.net But Tony Verrigni can often beat George's prices

2. *Volvo Aftermarket Specialists:*
   - IPD in Portland, OR: http://www.ipdusa.com. Great catalog, the only source for many perfomance parts, manuals, tools, and unique aftermarket items.
   - RPR in Berkeley: http://www.rprusa.com/... Another great place with great service.
   - Swedish Engineering: http://www.swedishengineering.com/
3. *Internet Parts Retailers:*
   - Imports Parts Specialists http://www.importpartsspec.com/ or 1-800-897-7278. Highly recommended; great service.
   - Foreign Car Parts of Groton, CT: http://www.fcpgroton.com/ Great prices. Their other site: http://www.foreigncarpartsonline.com
   - GAPA in California: http://www.gapa.com/vol.html
   - http://www.europeanautomotive.com/
   - http://www.importeccatalog.com
   - http://www.thepartsbin.com
   - http://www.alloemvolvoparts.com
   - http://www.voluparts.com/ [sells both new and used parts]
4. *Canadian Sources:*
   - In Ontario: Precision Auto Parts 1 800 361 3334
   - Montreal: Stephane at http://www.vlvworld.com specializes in used parts, but also sells many new maintenance items as well. Useful website; ships to US.
   - Vancouver: Don Docksteader Motors http://www.dondocksteader.com
   - Great Bilstein prices: MacNeil at: http://www.weathertech.com/
5. *UK Sources:*
   - EuroCarParts: http://www.eurocarparts.com/
   - German Swedish and French Car Parts: http://www.gsfcarparts.com/
6. *Swedish Sources:*
   - Many retailers purchase from ScanTech (a Swedish aftermarket manufacturer with a distribution center in Minnesota.) Visit their on-line catalog for excellent parts diagrams: http://www.scantechsweden.com/
   - More Swedish connections: Sam Steffanson at http://www.samsteffansson.com
7. *Lighting Parts:*
   - Frank's Foreign Auto: http://www.lampsandlenses.com/
8. *Miscellaneous Parts Sources:*
   - *Metric and Specialty Fasteners*: Maryland Metrics at http://mdmetric.com/
   - *Common Fasteners,* Bolts, Washers, Etc: Bolt Depot at http://www.boltdepot.com/

- *Body Fasteners:* Northland Fasteners: http://www.northlandfasteners.bi

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Used Parts Sources. [Tip from Steve] To determine which parts can be used from different model years of 700 and 900 cars, the salvage yards use a book called the Hollander Interchange manual for auto parts. See their website at http://www.hollander-auto-parts.com/. Ask the yard for it as it is expensive.

US Parts Finders:

- Try CoPartFinder, an automated pay-per-search (around fifty cents) database listing many salvage yards in the US at http://www.copartfinder.com
- Try Car-Part.com, another free car part search engine.

US Sources:

- B+D Used Auto Parts in Shirley/Leominster, Mass, part of Greenleaf Auto, at http://www.greenleafauto.com or call 1-800-752-0146.
- Erie Vo-Vo: http://www.erievovo.com/ near Utica, NY.
- Frank's Foreign Auto http://www.newandusedvolvoparts.com in Orange, NJ
- Strandberg's Auto in Centuria, WI (715-646-2388 or 1-800-448-5121)
- Brian Leppin south of Washington DC: http://www.volvousedparts.com/ Brian's phone number is 1-301-367-2244 (PO Box 1107 Bryans Road Maryland 20616-1107 USA)
- Mark Williams near Schenectady, NY: "runnindeer" at msn.com or 518-865-2254
- Volvo SAAB Auto Dismantlers:916-635-9970 near Sacramento
- Sweden Auto Warehouse: 916-387-6892 in Sacramento

Source of Rebuilt AMM. [Response 1:] Injection Labs in Gardnerville, Nevada remanufactures air mass meters for Volvos. Both my '89 and '90 240DL Wagons are running with their AMM's. They will sell direct. Cost was approximately $150.00 U.S. each (as of April '98). Telephone number is 702-782-8544. Speak to Kevin. Website: http://www.pagekeeper.com/nv/injectionlabs/

[Response 2:] About 18 months ago, I replaced the AMM on my '89 240DL with a re-built unit from the following company: Injection Labs, 1436 Industrial Way, UnitC, Gardnerville, Nevada, 89410, Tel: 702-782-8544 Fax: 702-782-3481.
My unit failed after 15 months and my supplier told me that it had a only a one year warranty. I called Injection Labs directly and spoke to Kevin. He was very helpful and he sent me a replacement right away (no charge). I returned the defective unit. My wife's '90 240 now needs a new AMM. I called Injection Labs and asked if they sell direct, which they will. Kevin quoted me $150.00 U.S., exchange.

Source of FI Computers. A failed ECU forces you to choose among a new, rebuilt or recycled unit. My
preliminary discussions with other list members and my mechanics has steered me into getting a rebuilt for longevity and peace of mind. The Bosch ECUs do deteriorate over time and rebuilders rectify the problems. Most will warrant the unit for two to four years or for your ownership of the vehicle.

A new unit can cost between $800 and $1500 through Volvo dealers or aftermarket resellers of Bosch components. For a rebuilt unit, your first option is to go through the Volvo dealer or contact an independent rebuilder. Independent rebuilders for rebuilt ECUs are listed along with warranties (if known) in Engine: FIComputer.

Source of Rebuilt Power Steering Racks.

- [Tip from Pete Gotseff] Try http://www.jorgenauto.com The Q-list has been using them for years. They are very cheap and price includes return shipping via UPS. These are rebuilt racks and the price justifies having them do it.
- Atlantic Enterprises (South Carolina) Lifetime warranty: http://www.atlantic-ent.com/ or directly from their retailer FCPGroton.

Sources of Aftermarket Air Conditioning Parts. [Inquiry] I need a new evaporator for my 960. The unit in the car reads Harrison France. Where can I obtain one less expensive than Volvo OEM?

- [Tom Irwin] "Import Parts Specialist" in Idaho: (http://www.importpartsspec.com)
- [Rafael Riverol] Try http://www.ackits.com
- [Robert Ludwick] http://www.nostalgicairparts.com "Great service from these folks."
- FCPGroton.com
- http://www.sanden.com/
- http://www.hancockindustries.com/
- http://www.refparts.com/
- http://www.ackits.com/

Source of Rebuilt Air Conditioning Compressors. Automotive Air Remanufacturing (407-265-3100) at http://www.autoaircompressors.com.

Sources of Body Panels and Trim. [Inquiry] [Response: Stoney] US Importer for Veng Body Parts. Please try this company:

ERIK VENG USA INC.
65 VINEYARD ROAD
SEEKONK
MA 02771 USA
Attention: SCOTT EDWARDS
Telefax1: 5083996583
Telefon: 5083996510

Go to the website http://www.vw-parts.com/home.en.html
and get part # and then call/fax Veng USA

Sources of Fasteners. [Tip from Gary Innes] Do yourselves a BIG favor and obtain the catalog from the Gardner-Westcott Co. of Northville, Michigan; 800-521-9805. (http://www.gardner-westcott.com/) They stock standard/metric, chrome/stainless, automotive/hydraulic, grades five/eight and NINE!!! Grade NINE is what we all should be using for head bolts and rod nuts when we rebuild our precious Swedish power-plants!!! Best of all, for us home mechanics--NO MINIMUM ORDER!!! You can order one dollars' worth!!! This sets them apart from firms like MSC, where you must get 50 or 100 of an item. I'm sure that they can ship across The Pond. Their telephone people are always courteous and efficient; shipment is quick; I can't say enough about them.

Volvo Part Numbers: Secret Check Digit. The secret Volvo formula for a check digit is as follows: 1212121 -the next whole number divided by 10. example 6 6 0 8 2 8

multiply each digit, digit by digit, by: 1 2 1 2 1 2

equals: 6 12 0 16 2 16

Then add the resulting digits as: 6+1+2+0+1+6+2+1+6 =25

and subtract from the next closest number divisable by 10 and the remainder is your check digit (5). Hope this helps - I worked at a Volvo dealer for 18-years and found that the Volvo check digit always kept you from accidentally ordering the wrong part (did not keep Volvo from sending the wrong part). Knowing the formula allowed me to order parts that I read about in non-U.S. bulletins.

General Mechanical Tips

Garage Floor Mechanics: Fluid Leak Analysis. [Editor] See this useful chart, copyright by and courtesy of Popular Mechanics Magazine, to help you diagnose fluid leaks on your garage floor.

Socket Sets: Twelve or Six Point? [Editor] When I began working on cars, I considered my Sears 12-point socket set adequate. Many stuck and rounded bolts later, I now use a six-point set almost all the time unless tight clearance demands a twelve-point socket. If the nut or bolt is at all rounded, corroded, badly stuck or worn, a six point socket will grip much better and prevent further rounding. A twelve-point socket or wrench will make matters much worse. Similarly, if you encounter a damaged or stuck bolt head and are using a box-end wrench, consider buying a six-point wrench for the application (Lowe's in the US sells a nice six-point combination wrench set.) This prevents further damage to the bolt or nut.

Flare Wrenches. Flare wrench quality is critical when loosening a stuck brake or fuel line fitting. Cheap flare wrenches are not dimensionally accurate and the jaws can open up under stress. [Tips from Chuck] Craftsman, KD and Easco are the same bunch from Danaher manufacturing; their heads tend to open up under stress. Any other wrench they make is fine, have used them for years. Mac Tools' tend to open up as well. For high-quality flare wrenches, Snapon is not the only choice: SK and Bonney do just fine with their line wrenches.

Loosening Tight Bolts and Studs.

Penetrating and Dismantling Oils. Forget about WD-40 and Liquid Wrench. The only stuff to buy in the US and Canada is PBBlaster, available at IPD, Walmart and other mass marketers. Kroil is another good brand. [Peter Milne] In the UK, try E.A.C.'s PlusGas Formula A, available from tool and engineers' supply shops.

Techniques. [Pat Dwyer] Try TIGHTENING the offending item, just a LEETLE bit, THEN try loosening it. Since learning THAT one, it has come in handy mucho times.

The P.O. thread-locked a carburtor together and I risk snapping off a screw. Any solvent that will dissolve this? [Dave Lot] Usually heat is used to soften up and remove locked fasteners. Then you can use a solvent on the bolt threads to clean the remains. [McDuck] Spec is 400 F; try a soldering iron on the screw, or a torch.

Using Wax and Heat. Heat the area around the bolt with a propane torch, and touch a candle or beeswax to the threads. The wax will be sucked into the opening around the threads, and the bolt can be removed easily. The heating and candle application may have to be repeated a couple times. This works on the same principle as "sweat-soldering" copper pipes, and will work where penetrating oil will not. (Always use care when and where you apply heat). [Art Benstien] In the absence of beeswax, I used Chapstick and it worked well.

Using Cold. Gently heat the area around the female side with a heat gun and then spray the male side with a can of electronics freeze (used to locate intermittent breaks on circuit boards). This may shrink the male bolt enough to break the bond and then allow you to first tighten (as above), then loosen. Spray with PBlaster to ensure that it penetrates into the joint.

Cutting Off the Offending Nut. [Tip from Randy G.] When removing rusted or otherwise stuck nuts or bolts, penetrating oil and impact tools can work, but sometimes just make the job more difficult (as when breaking off a fastener below a point where it can easily be accessed). One of the handiest tools is a "Dremel" type tool (high speed, power rotary tool) . Using the small cut off wheels (approx. 1" in diameter) spinning at high speed (30,000 rpm depending on the tool) these thin, brittle wheels can cut through even the hardest steel. I have used this method to remove a stripped axle spindle nut without damaging the threads of the spindle. Be aware that a full-face protection shield is recommended and that spectators remove themselves from the area. When these little wheels break they can travel some distance. The wheels are available in little containers of 25 (I think) and although they will break quite often until you get the feel for them they are relatively inexpensive.

Loosening Stripped Drain Plugs. For removing stripped transmission and differential drain plugs:

- Try heating area of bolt with a heat gun and then cooling the bolt (see note above on *Using Heat and Cold*). Use a six-point socket after cleaning up the hex sides with a file.
- Try removing the whole cover and then drilling it out, or get another cover from a salvage yard
- Give it a shot of PB'laster and let it sit over night. Then apply a pipe wrench. The pipe wrench will mess up the bolt head but it's shot anyway. The design is such it will grip tighter the more torque you put to it ... and it was made to, among other things, grip round pipe. I've used a pipe wrench with good results on a number of really nasty, stubborn drain and fill bolts on both diffs and trannys. Not an orthodox tool for Brick repair granted ... but it often works in situations like this.

Numerous Techniques. For tips regarding broken stud removal and repair, see the discussions in Exhaust and Turbo.

Welding Technique for Broken Stud Extraction. [Chris Harrison/Jeff Goggin]

The procedure: Using a welder, slowly build up a bead of weld on top of the stud, until it clears the surface of the head. Using vice grips, grab the weld and twist out the stud remains. I used an oxymig at the slowest wire feed, and a medium high setting (110v 30amp welder) - ground clamp to the #1 cam journal.

The patient: Warped exhaust manifold popped #1 and #2 upper and lower studs. This car already had the upgraded studs and washer/nuts found on the later turbo cars.

The problems I encountered: On a couple of them, the weld would break before the stud would break free. I just kept going at it, rewelding until the stud broke free. Some times this took over 6 applications of the weld bead technique.

Suggestions I found that worked:

- On one of the studs, I found that someone had overtorqued the stud so that it ruined the top threads of the hole. I used a drill bit and opened up the hole a bit until it had slightly cut the top threads. Then rocked the stud back and forth (applying some WD) until it cut it's way out of the top threads
- Another stud I found was really in the head solidly. After 6 repeated attempts, I drilled two holes and made a slot in the top of the stud, then did the weld technique again (effectively welding a screwdriver tip into the stud).
- Yet another stud broke free (finger tight) just by applying the first weld bead to it (adding credence to Jeff's surmise that the effect of the weld electrolysis itself loosens the bond between the two materials)
- Using a hammer on the top of the bead each time, I tempered the bead, which appeared to reduce the chances of shearing the bead off the stud.
- Allowing each bead to cool before adding more material, is the key to getting this right.
- If the stud has any length extending above the surface, weld a nut on to the stud. That way, you have a nice big area to build up the weld, and something nice to grab on to once the weld is finished.
- The welding method works best if the head is out of the car.. Flammable things always concern me when welding, even though it isn't a huge concern here. The angle one has to work with is not quite comfortable. Tough to get a good ground sometimes, things like that.

I used the slowest wire feed setting on my welder (mig - med high amp setting) basically dropping weld beads onto weld beads. As this was my first attempt at this procedure, I took the easy route (85 5k fwd) and pulled the head to get the studs out on the customer car. I have no doubt that this procedure can be done in the car, it's just a tougher job, and if number 4 or 5 is toasted, bigger than just removing the head itself. This procedure negates *any* need for the drill and helicoil procedure even the dealer uses. The biggest problem with the drill and helicoil is getting a straight hole, and not going thru to the water jacket beneath.

Broken Headbolt Removal. [Inquiry] While removing the head in my '93 960, one of my head-bolts sheared off right where the threads start (a good 2" below the top of the block). [Response] I had one break in a '92. The furthest one in the back,right. What I did is use a little CRC lube and then used a left handed drill bit, 5/16". After about a 1/4" the drill bit removed the broken bolt.

Broken Screw Extraction. [Inquiry] I have a stripped Torx screw that will not come out. How can I remove it? [Response: Don Foster] Here are some ideas:

- If you have access, try cutting a slot in the head to accept a screwdriver.
- You can try the old trick for loosening/tightening nuts 'n bolts ---- use a hammer and chisel, and hit the side of the head tangentially with the chisel, so as to produce torque. I've done it to remove stripped nuts -- it works, sometimes. Unfortunately, if the bolts were tightened so tight that they stripped, I doubt you'll loosen them this way. [Response] I've NEVER not been able to get one with a chisel. The shock of the blow usually loosens them first shot, then a loose fitting torx or allen finishes the job.
- You can drill deep enough so you can fit a shouldered-type easy-out (the Snap-on style).
- Try grabbing the heads with Vise-grips
- If you cut or grind the heads off, the remaining portion (like a stud) will probably unscrew with your fingers. Unless the bolt has bottomed, the tension is produced by tightening against the head. Cut the sides of the heads back using a 1/4" grinder or Dremel to remove the tension. This will also leave leave something to grab. Hell, maybe you can even grind a hex so you can fit a socket on them.

Stripped Head Bolts. [Inquiry] I have a stripped diesel head bolt, the 12-point triple square bit style. It seems it was damaged already and I finished it off. What can I use to get this out? [Response] The engine's previous mechanic had stripped one bolt on the install, and skipped at least one round of tightening, leading to a coolant to combustion chamber leak down the road. As I took it apart, i found the stripped head bolt, and my triple square tool spun freely. Grinding off the bolt top sounded no fun, so I bought a brand new bit. Set the bit in place, found the best spline alignment, and beat the crap out of it with a 3 LB sledge, forcing the bit as deep as it could go, and hopefully loosening the bolt a bit as well. My impact wrench then removed the bolt no problem. If that fails, I would weld the bit into the stripped hole, the heat will also help to free the bolt. If you can break/file/Dremell/die grind the head off the bolt, the threaded part will usualy come out pretty easily. It should be feasible to plunge cut the head off the bolt with an oxyacetylene torch if you are good at that kind of thing. Don't those bolts make the darndest noise as they break loose? I use a 3/4" drive breaker bar with the handle of my floor jack as a 30" cheater bar.

Plug Those Engine Ports While Working on The Engine! [Tips from R. Haire and Don Foster] Last week my '90 780T started knocking badly during a mild acceleration. The knock persisted. Seemed odd given the low miles and first rate history of the car, but realistically things can fail in the best engines. Still we decided on a staged tear down. Step one was a cam check and then a valve examination through the intake ports. All seemed OK there. Step 2 was pull the head and hope for something to fix. If not, pull the engine for rebuild. The car is just way to nice to consider anything else. There it was, one of those little clips that are fitted to the turbo hose clamps. Probably it was in the system from a turbo swap about 7 years ago. The overlooked piece in an otherwise first rate job at a good shop (PO had it done). The clip made it past the throttle plate and into the intake and cylinder. It was being hammered into the head by the piston. Literally driven 1/4" edge-wise into the aluminum. This is a good lesson for us all. When working on the engine, remember to carefully plug any ports into the engine to prevent dropping that little screw into an inaccessible spot. And remember to unplug all those same places during reassembly.....

Torque Wrench Purchase and Care.

Types of Wrench Options. [Larry Carley, Tire Review, October 2003] A torque wrench can accurately measure the amount of torque being applied to a fastener, displaying the value in SAE or metric units or both. Torque wrenches come in various styles. The simplest and least expensive version is a "beam-style" torque wrench. You’ll find them in the automotive section of many hardware stores, as well as DIY tool racks at parts stores. This type of tool has a long pointer beam that runs parallel to the handle shaft. When you apply force on the handle, the handle deflects, but the pointer remains straight to indicate how much torque is being applied. The pointer scale typically has calibration marks every at 5 pounds. To read the scale accurately, you must look at it straight on. You may also have to estimate the actual reading if the pointer is between lines. Provided the tool isn't abused or damaged, it should remain accurate almost indefinitely. Another style is the "dial indicator" torque wrench. On this tool, the beam is enclosed in a housing and operates a dial indicator to show how much torque is being applied. The dial indicator is more precise and is easier to read. Some are available with a light or buzzer to indicate when a preset torque value is achieved. There are also digital versions of the dial indictor torque wrench. Instead of a mechanical analog gauge, a LCD or LED display shows the exact torque value. Most digital wrenches also offer the capability to switch from SAE to metric units of measurement. Another popular style is the micrometer or "click-style" torque wrench. With this design, the tool makes an audible click to let you know when a certain torque level has been achieved. Inside the handle is a compression spring that exerts pressure against a lever held against a notch. The tool is adjusted by turning a threaded adjuster sleeve on the handle. When the desired torque is achieved, the lever jumps from the notch and makes a click – which you can also feel in the handle. Many technicians prefer this type of tool because it's fast and easy to use. You just pull on the handle until you hear or feel it click, then move on to the next fastener. One thing to keep in mind about adjustable click style torque wrenches is that you should always reset them back to zero after use. If a torque wrench is put away with the value set to a high reading, it can affect the accuracy of the compression spring over time, causing the tool to go out of calibration. One item that is a must with all types of mechanical torque wrenches is an "angle gauge." This is a small metal or plastic wheel that mounts on the socket or tool drive to tell you how far around the wrench handle is being pulled from a particular point. The idea behind angle torquing fasteners is to eliminate variables in torque caused by dirty or damaged bolt threads. With this method, the fastener is usually tightened to a low value, then turned an additional number of degrees to achieve final loading.

Accuracy Issues Any tool or instrument calibrated to a specific standard may go out of calibration over time or as a result of misuse. Torque wrenches are no exception. A simple beam-style torque wrench is pretty reliable, but it's not as accurate as the dial- or click-type torque wrenches. If you drop a beam-style torque wrench and bend the pointer or scale, it obviously won't read accurately. You can bend things back to their original position, but that may not restore the tool's accuracy. The same goes for all types of torque wrenches. They are not designed to take a lot of abuse. Dropping the tool may knock it out of calibration. Misusing the tool can also affect its calibration. Never use a cheater bar on a torque wrench. Most experts also advise against using a torque wrench to break loose fasteners because the sudden shock when the fastener breaks free may affect calibration. Most experts say torque wrenches should be checked and recalibrated every six to 12 months, depending on use. The more frequently the tool is used, the more often it should be checked to make sure it's properly calibrated.

More Tips for Accurate Use. [Motor Magazine, Feb 02; Bruce; et al]

- Set it back to zero before you put it away to reduce spring fatigue and help to maintain accuracy.

- Don't drop it, pitch it into a toolbox drawer, slide it across the floor, leave it unprotected or hurl other tools on top of it.
- Never use a torque wrench as a breaker bar for loosening fasteners.
- Don't try to tighten a fastener beyond the range of the wrench
- Never use a "cheater pipe" on a torque wrench.
- If you have a click-type torque wrench and you haven't used it for several weeks, then "prep" it for use by getting its parts moving again. Adjust the torque setting to the middle of its range (for example, about 50 ft-lb on a 100-ft-lb wrench). Next, put it on a fastener and make the wrench click five or six times at the 50-ft-lb setting. Then adjust it to the required torque for the job at hand and you're ready to go.
- Always torque fasteners with a smooth, steady pull of the wrench. Never jerk or snap the handle abruptly; smooth and steady does it.
- Always position a torque wrench so you're constantly pulling in a level plane, not upward or pushing downward on the wrench as you pull the handle.
- Always avoid the uppermost and lowermost ranges of any given torque wrench. Staying within the middle 60% of a wrench's range yields the best and most accurate results.

For torque wrench calibration and maintenance, try Ben Spurlock at Angle Repair and Calibration in Beckley, West Virginia (304-253-5720, www.anglerepair.com) If you use a torque wrench three to four times a month, you should have it checked at least once a year. Angle Repair charges $25 to calibrate any 1/2-inch drive or smaller torque wrench, 45 bucks for 3/4-inch jobs. Shipping is extra, and the turnaround time is usually a couple of days.

Torque Charts. Courtesy of Precision Instruments, the File shows torque standards for various metric and SAE fasteners as well as conversions from in-lbs to N-m, etc.. If you do not have the Volvo factory torque recommendation, use this chart.

Digital Multimeter Tips.
1. *Basic Diagnosis.* For a superb introduction to basic automobile electrical diagnosis using a digital multimeter and accessories, see Fluke Corporation’s website reference at http://www.fluke.com/application_notes/automotive/beatbook.asp?AGID=1&SID=103

2. *Diode Diagnosis.* [Eye On Electronics, Motor Magazine,Mike Dale, Sept 2001] Another easy yet very useful test for the AC section of a DMM is determining if the alternator diodes are bad. With the meter on the AC scale, the lights on and the engine at approximately 1500 rpm, measure the AC voltage present between the output terminal of

the alternator and ground. If the diodes in the alternator are good, this reading will be less than 500mV. This ripple voltage rides on top of the DC output from the alternator. When a diode is bad, the ripple voltage will be higher because one or more of the pulses was not rectified. Even the simplest DMM can perform this test in less than a minute.

One of the common uses for diodes on a vehicle is to clamp inductive loads. Door lock solenoids, compressor clutches and relays use electromagnetic coils. When these coils are turned off, the electromagnetic field collapses around them exactly the way it does in an ignition coil. While we're glad for that spike in an ignition coil, in a solenoid it's a threat to the power driver that controls the coil. A typical unclamped door lock solenoid may generate as much as 75 volts, while an a/c compressor clutch may generate 1200 volts.

The way to prevent this is to use a reverse-connected diode in parallel to the coil. When the coil is turned on, current flows through it in a direction opposite to that which the diode would conduct. When the coil is turned off, the current reverses and flows through the diode before any major voltage spike can develop.

If a coil driver is destroyed, the clamping diode must be checked to make sure that it's present and working properly. The diode test feature of a DMM offers a controlled current to the diode and measures the voltage drop across it. For the typical silicon diode, this should be about .6 volt. If no voltage drop is seen, reverse the leads and try again. If you still don't get a readable voltage drop, the diode is open and responsible for killing the power driver.

Another feature you can use to make sure a clamping diode is working is glitch capture. Here, the meter is set up to catch the spike that will be created on turnoff if the diode is shot. While most coil drivers are wired between ground and one side of the coil, some circuits have the driver between B+ and the coil. If the circuit you want to test has a feed control style driver, connect the meter's red lead to the control side and the black lead to ground. Reverse the connections for ground-side controlled coils. Activate the coil with the meter set on DC volts, using the highest scale available. Then press the appropriate buttons. When you turn off the coil, the meter will record both the minimum and maximum values. If the driver-killing spike is there, you'll see a value greater than ±30 volts, depending on how the diode is wired.

Crimping Wire Connections. [Rob Bareiss/John Horner/John Orrell] To achieve a good crimp using the average hand crimp tool (Craftsman, et al) you must properly hold and position the barrel of the crimp lug and be consistent about the pressure you apply to each crimped joint. Insufficient crimp pressure, improper sized terminals for the wire size, rotation or misplacement of the crimp force, and just plain cheaply made terminal lugs will all result in poor connections and wires pulling out of terminals, sometimes with minimal force applied.

Tips. See Tyco's page on their crimping tool, most especially the instruction sheet, for good tips on how to achieve a reliable crimped joint.
Failed crimps are usually due to too large a connector for a too thin wire. I n a pinch I'll cut the protruding conductor double-long, then fold it over. That gives a thicker conductor that fills a larger size connector if that's all I have - or if the other wire is thicker. After you make the crimp, hold the connector in one hand and the wire in the other. Give a good tug. A correct crimp will hold tightly while a marginal one will come right apart.I also find that nearly any connector will take a wire one step thicker than what its rated. So a connector spec'd for 14-16 ga. wire will do fine for 12 ga., as long as the wire ends are cleanly bundled together and you slide them into the connector nice and straight so they go in without fraying. If you use plastic sleeved crimp connectors, you may find that you crimp them hard enough that the metal protrudes through the plastic, requiring additional insulation. Some people insist on both crimping and soldering the connection, although a good crimp will be gas tight and not as subject to cracking as solder.

Electric Impact Wrenches. [Stoney] For those without air supplies, electric impact wrenches make sense for loosening and tightening bolts. I had the opportunity to run some tests on a variety of electric Impact wrenches. I had to test several TC Guns used on Steel erection jobs to tighten the TC style A325 3/4" dia bolts, and when we were done a couple of the other trades came over and asked if I could test some of their tools to settle a running bet. A Skidmore Wilheim gauge was used to verify all results. Max measure ment 100 Kips (100,000 lbs of torque) and gauge was calibrated on 11/03 by the maker. Verifivation was via a Proto 3/4" drive model 6020 600 ft lb torque wrench. 3 tests were done of each wrench with a new bolt each time. bolts were IFC/Vermont A325 3/4" 2" length new from a sealed can. Here are the results:

- Milwaukee 1/2" wrench avg of 3 415 ft lbs
- Dewalt 1/2" wrench avg of 3 385 ft lbs
- Hitachi 1/2" wrench avg of 3 270 ft lbs
- Chicago Electric 1/2" avg of 3 250 ft lbs (Chinese-made Harbor Freight unit)
- Ingersoll Rand 1/2" wrench 390 ft lbs (unit was over 15 years old!)
- No Name 1/2" wrench 225 ft lbs (typical EBay unit Red body)
- No Name 1/2" wrench 215 ft lbs (typical EBay special Blue/Green body)
- Sears Craftsman 1/2" Professional 235 ft lbs
- Sears Craftsman 1/2" wrench 250 ft lbs (plain-jane model)

So if you are in the market for a new tool, remember these results and remember that price and name mean nothing in results.

Using a Dial Indicator to Minimize Brake/Wheel Pulsation. [Courtesy Brake and Front End Magazine, Dec 2006, by Andrew Markel]

Runout in the Bearing Face

Rotate the hub bearing assembly by hand. Any roughness, looseness or noise from the bearing is an indication of damage.

To check a hub bearing assembly's internal clearance, use a dial indicator. To obtain accurate readings from the dial indicator it is important to thoroughly clean and smooth the surfaces where the dial indicator base and tip will be placed.
The dial indicator base should be placed or clamped rigidly a secure portion of the suspension. Position the indicator tip perpendicular on the wheel pilot as close to the center of the hub assembly as possible.
Grasp the wheel flange at the 3 o'clock and 9 o'clock positions, and push while oscillating the hub bearing assembly approximately 90° side-to-side at least five times. Set the dial indicator to zero. Next, pull while oscillating the hub bearing assembly approximately 90° side-to-side at least five times.
Mark the high and low spots of the runout on the face.
Observe the total indicator movement. If it exceeds the specs, replace the bearing assembly.

Runout in the Rotor

Tighten down the rotor with the correct conical washers and torque.
Using a micrometer to check parallelism. Measure rotor thickness at six equally spaced points around the circumference of the rotor. More than .0005 in. of variation means the rotor needs to be resurfaced.
Check the taper with the micrometer. Rotor taper (the difference in thickness between the inner and outer edges of the rotor face) should not exceed .003 in.
To check lateral runout, the dial indicator's tip of the indicator against the rotor's face in the center.
Mark the high and low spots of runout in the rotor.

Matching the Hub to the Rotor

By measuring and marking the high and low spots of

runout in the hub and rotor, it is possible to match the high spot of runout in the hub with the low spot of runout in the rotor.
Match and measure.
This technique can be used to minimize the amount of material removed with a on-the-car brake lathe.

Jacking Your Car and Jack Points. [Inquiry] Where do I apply the jacking if I'm going to place the jack stands at the four jacking points specified in the owner's manual? Responses: Chris Herbst and Bram Smits]

Possible locations for your floor jack:

- center of front (engine) crossmember (this is true for the 700, 900 and 960/90 series)
- jack points themselves (use a piece of leather or foam to keep from chipping the paint)
- rear axle (bottom of the differential)

Use a decent quality floor jack to raise the car, but use only jack stands to support it. NEVER use the factory car jack to do anything other than change a flat tire, and use it only at the factory jack points..

Possible locations for jack stands:

- rear axle tubes (but be careful with the rather flat type of jackstands that it doesn't slip off)
- The four jacking points (according to the owner's manual):
  - front - just behind the fore wheels underneath the doors
  - rear - just in front of the rear wheels again underneath the rear doors.
- chassis rails slightly front of front jack points (this is actually a suggestion in the Volvo and Haynes manuals).

If you're doing rear bushing work (assuming rear axle/suspension bushings) you obviously don't want the weight of the car resting on the rear axle, so you place your floor jack under the rear axle and put the jack stands under the jack points, leaving the axle to hang free (and able to be supported/lowered/raised with the jack).

Contamination Caution: Silicone-Based Products. [Editor] Silicone in any form will contaminate your oxygen sensor and quickly render it worthless. Don't spray any silicone-based lube around the engine. If you use silicone-based RTV gasket material anywhere on the engine, especially in manifolds or valve covers, make sure the tube says "sensor-safe RTV compound". Silicone from the gasket can likewise contaminate your oxygen sensor.

Sealing: Fastener Lube and Gasket Surfaces
[Excerpts from Motor Service Magazine, Feb 2002, "The Sweet Science of Sealing", by Greg McConiga]

Thread Lubes:
You'd better be aware of the effect whatever you're putting on those threads has on bolt stretch and clamping force. You don't want to snap one off or over-crush the gasket. In all cases, if the manual states to install the fastener dry, then install it dry. If a lube, sealer or thread locker is specified, then get the right one or its equivalent. Small changes in friction between the ramps that form the threads will result in huge changes in fastener stretch - and using the wrong material in the wrong spot will often result in a comeback..... If a bolt's supposed to be lubricated, don't forget to do the underside of the head. That little bit of friction makes quite a difference in bolt stretch....Head bolts used against aluminum often have a hardened washer to help distribute the load. Make sure the rounded or chamfered side of the washer is facing up.

Cements, Adhesives, Sealants:
Speaking of the wrong materials, other things to avoid are the universal stick-ems we used to coat gaskets with in days gone by. Careful surface preparation and thousands of hours of gasket engineering are wasted if you're using half a pound of goop on every gasket and O-ring. Contact cements, lacquers, copper coating glues, RTV, etc. can cause gasket slip, plug drain and supply holes punched in the gasket, impede heat transfer, make a gasket stick and tear, or soften the gasket's surface enough to cause premature failure. In engine sealing, the mark of an expert is decidedly not a big wad of hardened silicone squeezed out of every joint, but proper preparation of sealing surfaces.

Surface Preparation:
Speaking of surface prep, the use of 3M-style abrasive disks for cleaning them is an absolute no-no. Contrary to popular belief, even the new designs with the abrasive encapsulated in plastic are not safe and will destroy an engine. Clearances are tighter today than ever before, and even the slightest silicate contamination in the oil will wipe out a set of bearings. Plus, abrasive disks will remove significant amounts of metal. They'll even do a job on cast iron (if you doubt this, grab an old rotor and your disc cleaning tool and lean into it - the flying sparks show you what's happening). They are especially bad about removing metal from around holes, creating a concave depression. Use a scraper and chemical gasket removers.

Properly prepped mating surfaces should be clean and dry, with no oil, fingerprints, solvent residue or antifreeze remaining. The surfaces must, of course, be flat. Measure for waves and warpage end to end at the top, middle and bottom, and diagonally in both directions. That means both the part and the surface it mounts to -- add readings to get the total. The total across the width of the cylinder head should be less than .002 in. for all engines. Along the length, not more than .003 in. for a V6, .004 in. for fours and V8s, .006 in. for inline sixes. [Volvo spec for B230F: max 0.5mm/0.02 inches lengthwise, 0.25mm/0.01 in crosswise] Just remember the max is one one-thousandth per bore, over the length and across the diagonals.
Then there's finish, which can be checked with a comparator gauge, an item that should be in every major man's tool box. It's a lot cheaper than a surface profilometer! A finish rougher than 113 RA (roughness average) or 125 RMS (root-mean-square) has too much variation between the peaks and valleys to allow a proper seal, and may have enough "tooth" to grab the gasket and cause it to tear. Too smooth can be a problem as well - surface finishes below 54 RA or 60 RMS may not secure the gasket properly. With MLS (Multi-Layer Steel) head gaskets such as those found on Ford Modulars, however, an almost mirror-like 20 RA or 22 RMS is ideal. In all cases, refer to the manufacturer's recommendations. [Volvo provides no surface finish spec.]

Cooling System Crevice Corrosion:
Crevice corrosion occurs in cooling systems where a tiny quantity of coolant gets trapped in a stagnant area, and the additives are depleted because they can't be renewed from the main body of coolant. If you see etched aluminum intakes or coolant passages on aluminum heads, or if you see rotted hose necks, that's what's happening.

Engine Dissassembly:
Always disassembly bimetallic engines after they've cooled down completely. Taking them apart hot is just asking for trouble. If you're in a hurry, grab a fan and lay it on top of the engine to force the cool down.

Use of RTV Silicone as Gasket:

To reliably seal metal-to-metal joints, RTVs must be applied to clean, dry surfaces and allowed to cure before the vehicle is placed in service. Chemical gasket removers and aerosol solvents like brake cleaner can be used to prepare the surface for an RTV application. Without adequate surface preparation, formed-in-place RTV gaskets can be a gamble, so the proverbial ounce of prevention is, in this case, worth a pound of cure.

Using Antiseize on Threads. [Editor] Torque settings are always (except on bicycles) specified "dry": no lube. The few exceptions include head bolts. Antiseize, beneficial though it may be, is still a lubricant and as a result you have to adjust the torque spec

DOWN by between thirty and forty percent when using antiseize. This is not universal, just a rule of thumb, and will vary by fastener and material. It is especially important for threads inserted into in soft materials, as with spark plugs and manifold studs.

Plastic Part Repair Tips.

Adhesives. [Tips from Randy] Over time you will find that, no matter how careful you are, you will end up with a broken mounting tab on a piece of plastic somewhere. I have recently made two repairs to plastic parts that worked out quite well so thought I would share:

On my 960, the door speaker grillwork is a slide-snap fit. The rear end being two tabs that slide into slots, and the front end has two hollow, cube protrusions molded into the back of the grill that fit over two plastic “T studs” that protrude from the door panel that get captured in the two slotted cubes. All it takes is one idiot trying to remove the grill by pulling instead of sliding to break or crack the mounting 'cubes.' As my grill had gotten to the point of falling off at will I figured that I had little to lose, so I did the repair this way-

All you will need is an old floppy diskette and a tube of “Grip-Ton-Ite” super glue for plastic from Devcon (or equivalent). I got mine at Lowe's. This stuff, from what I can tell, is superglue with a solvent in it. The theory seems to be that if it can't melt it together, it can glue it together, and I will say that from my various experiences with the stuff in the garage and in the home is that it really works, even in small surface area, medium-high stressed parts.!

Split the floppy case into its two halves and discard all the innards including the white slippery stuff that lines the halves. Cut two large strips about an inch wide from one half and chuck them in a vise with about half in the jaws and half protruding. Use a heat gun and gently heat the area of the plastic closest to the vise. When they seem soft enough, use a piece of sheet metal or equivalent and bend them to a 90 degree angle to the vise. Let them cool for a minute then remove from the vise. You now have two “L” shaped pieces of thin, strong plastic.

Using a sharp pair of scissors you can trim the pieces to fit over the contour of the broken plastic. Now, using what good plastic is left, or the other grill from the opposite side of the car, trace the keyhole opening using a bent paper clip, sharpened at one end, onto the parts you just made. I used a Dremel to carve the openings as close as possible, and tested them on the “T” studs on the door panel before gluing them into place. If too much of the plastic is missing, some creative cutting and gluing can fabricate what you need. If too much is missing, find some thicker plastic to work with.

The other repair I made was to the plastic stone guard panel under the radiator. The two tabs on the forward edge that hold it to the back of the bumper (as I remember) were both broken off, and at high speed the panel was flapping and making a racket. I made two replacement tabs from scrap of a corner guard- the 90 degree stuff that you put on corners of walls to protect the wallpaper from wear (also from Lowe's). I cut it to shape with sharp scissors much the same way that I did for the speaker grill. With some care and patience, these sorts of repairs can be easily accomplished, and save the unnecessary replacement of expensive parts. You will find this super glue for plastic to quickly become a staple of your repair kit!

Hot Glue Gun and Colored Glue Sticks. [Mike Niotis] I have found black matte "Glue Sticks" which resemble the plastic bumper material very useful. Some of the repairs I have made using the "HGG" are the following:

- Repaired a nasty cut In my front bumper after a guy backed off with his hitch. The repair is almost 100% undetectable, you have to use your touch to feel the difference
- Glued one of my reverse Lenses that fell off.
- Repaired the black trim above the bumpers. By using a razor and sanding down the material you get everything back to stock condition. If you paint it..you can't really tell the difference.
- Glued the glovebox door cap and preventing it from rattling
- Fixed a broken PCV valve after a piple fell off.
- Fixed a crack around the fuel sender unit exit port.
- Fixed cracks on the dashboard and vinyl, then painted it saddle brown. It almost looks like NEW. The cracks are invisible.

Buy the matte non-shiny sticks for best results.

Homemade Tools from Brick Owners

The thumbnail images below link to larger images to save download time: click the image to open the link.

Tool Sources. See the following links for a variety of special-purpose tools for Volvo cars:

- Schley Products, Inc. tools: http://www.sptool.com/
- Baum Tools: http://www.baumtools.com/
- ETools: http://www.etoolcart.com/
- OnTool: http://www.ontool.com/
- Tool Discounter: http://www.tooldiscounter.com/
- Skyway Tools: http://skywaytools.com/
- SPX/OTC Tools: http://www.spxkentmoore.com/ (makers of Volvo special tools, available through

dealers)

Homemade Cooling System Pressure Tester. Here's what I've rigged up for both pressure testing the cooling system and bleeding the clutch and brakes: I found an old bottle cap that has the same threads as the coolant reservoir. Then I bought $1.00 worth of tank valves and screwed one into it. If you don't have such a cap, then an old coolant reservoir cap should work even better. When I need to use it, I take the gasket out of the coolant reservoir cap and use it in my "pressure cap". I connect a $5.00 bicycle pump (with built in pressure gauge) to the cap and presto. Since the brake reservoir has the same type orifice, it can also be used to pressure bleed the clutch and brakes.

Homemade Exhaust Gas Leak Detector. If you suspect a head gasket leak resulting in combustion gases entering your coolant, you can test for this using special test fluid which turns from blue to yellow in the presence of exhaust gases. Mityvac has a fluid transfer bottle in their vacuum pump kits (pictured) or you can make one using a small jar and a lid with hoses through it. Fill the bottle part way with Lisle testing fluid 75630 for gasoline engines. Place one vacuum tube on your Mityvac or on a source of engine vacuum to pull gases through the bottle. Place a short tube on the other side of the bottle cap to extend down into the fluid to force the gases to draw through the fluid. Seal the coolant reservoir top with an old reservoir cap through which you have glued the sampling hose. Run the engine and draw vacuum: gases will rise from the coolant in the reservoir, exit via your hose through the reservoir cap, enter your test chamber by bubbling through the fluid, and if it turns yellow you have an exhaust leak into the coolant.

Fluid Transfer Bottle

Heater Core Unclogger Tool

Homemade Heater Core Cleaner. [Eric Mollerstuen, courtesy of IPD] If you fail to change antifreeze, your heater core can clog with deposits. For clogged heater cores, you can fabricate a PVC pipe, one end of which contains a "Drain King" pulsating drain declogger and the other end fits into the heater hose. Buy the parts (Drain King, 2 inch PVC pipe about a foot long, a 5/8 inch short pipe, a joining fitting and a tube of adhesive) at a local hardware store. Glue the parts together so that the open 2 inch pipe terminates in the 5/8 inch pipe. Insert the small pipe in the heater inlet hose, place the Drain King in the open end of the pipe, and turn on the water. If your core is badly clogged, it will take a few seconds for the pulsations to blast away the deposits. For Eric, this worked fine and eliminated the need to replace the core. [Editor's Caution] If your core is corroded, this may be enough to cause it to fail and leak. View it as a last resort only.

B230F Crank Holder Tool-Method 1. [Don Foster] Here is the design for the tool used to secure the crank pulley to remove the bolt while changing the timing belt. [Editor's Note: You can purchase this tool number 5284 from Volvo dealers and from IPD for about US$39; see the FAQ section on Timing Belt Tips]

Rear View:

Crank Holder Rear View Plan

Detail of Rear and Front Views:

Crank Holder Detail View

Side View:

Crank Holder Side View Plan

B230F Crank Holder Tool-Method 2. [Dana Manner] Here is another device used to immobilize the crankshaft by holding the flywheel gear in place.

Flywheel Holding Tool from Bar Iron

Manufacture. Make a simple tool from 1/8" thick, 1" wide flat iron bar stock (available at any hardware store or Home Depot in about 4' lengths). Heat the bar stock with a propane torch (or MAPP gas, in the yellow tanks, which burns hotter) until glowing red at a point about one inch from the end of the length of bar stock. Place it in a bench vise and bend it over slightly beyond 90 degrees, so that it forms a shape that is "more" than an "L" and "less" than a "J" shape (see photo). Now, cut the bent portion you just formed in the end of the original long piece of stock with a hacksaw, so that it has a lower leg approximately that is 1" in length and an upper leg approximately 1.5" in length (see photo). Grind or file the edges and corners smooth with a slight bevel.

Use. To use this tool, remove the two bolts that attach the starter to the engine, and withdraw the starter, exposing the flywheel gear teeth. Insert the tool into the round opening of the starter hole, and engage the lower leg of the tool in between two teeth of the flywheel gear, with the bend in the tool resting on the inside of the starter hole against the engine block, and the upper leg of the tool pressing against the flywheel. Once engaged in the teeth of the gear, rotate the crank slightly to wedge the tool in its position. Now both hands are free to use

Starter Hole

to loosen/tighten the crankshaft pulley and harmonic balancer bolt (a huge benefit)! When loosening the crankshaft pulley and harmonic balancer bolt you will install the tool against the top of the starter hole in the engine block, and the tool will jam the flywheel "rock-solid" from rotating counterclockwise. Install it against the bottom of the starter hole (opposite direction), to prevent the flywheel from rotating in a clockwise direction, for retightening the same bolt. This tool and method works better for me than the various other belt/pulley holding/jamming techniques, and the tool is easily fabricated from inexpensive, widely available materials, by anyone with a propane torch, bench vise, hacksaw and file.

B6304 Cam Cover Compressor. [Tips from Nathan Gundy] A good (and cheap!) solution to the volvo cam squeeze tools on B6304 engines is to use two 2 inch wide by 1 inch thick by 1 foot long(or so) pieces of hardwood to go across the cam cover. Hold these pieces with 4 four-inch C clamps, rooted just under the cam cover on the head. As you tighten the clamps down evenly, the cover will squeeze down the cams so you can safely put in all 48 cam cover bolts. Be sure to use hardwood; a lighter wood would probably crack, as it requires pretty strong pressure. Here's a picture:

B6304 Cam Cover Compressor

Valve Spring Compressor. [Tip from Warren Erickson] I don't want to pay Volvo prices for tools, so I made a valve spring compressor out of a large C-clamp and a brass 1/2" to 3/8" reducing coupling. The C-clamp has a six inch opening and is four inches deep. Cut two good size slots 180 degrees apart, on the 1/2" side of the coupling. That's where your valve keepers can be removed. Grind off all burrs and wrap black electric tape around the two legs so it doesn't score the aluminum bores if it shifts to one side. Lay the cylinder head on its side with the coupling windows facing up and down. After compressing, the keepers will fall out with a little help from a small screwdriver. Or you can use a magnet. To reassemble, compress the spring then turn the head flat on wooden blocks. Drop the keepers through the windows. They'll fall right into place. I'm sure there are better ways, but this arrangement worked for both my B230FT and my D24T.

Coupling Showing Cutout Slots

Coupling Mounted in C-Clamp

Valve Spring Compressor in Use

Vacuum Leak Checker. [Tip from Paul Kane] A good vacuum leak check device is a butane charcoal lighter. Don't light it, just use it for 'sniffing' around the suspected leak. Apply the butane to the potential leak- if RPMs change - you've found the leak.

Fuel Pressure Test Tool.

In-Line Pressure Tester Adapters. At last check, Volvo wanted $600 for the pressure rig to test fuel pressures. Here are plans for three designs for much less. Parts needed:

1. Using Banjo Fittings:

> 2 Banjo 'nut' fittings (the ones that actually look like a banjo). Hack apart old fuel lines from an Audi, VW, or BMW from the wreckers to get the ones with the small nipples. Make sure they're the same diameter as your Volvo *(see the tip below for Volvo parts needed.)*
> 1 Brass Tee , 3/8" NPT=18 tpi
> 1 Brass Valve, 3/8" NPT
> 1 150 psi gauge
> 2 2.5" 3/8" NPT brass extender (pipe w/ both ends threaded)
> 2 3/8" NPT brass nipples
> 2" vacuum hose
> 4 small tie wraps (zip ties)
> 1 nylon spacer, 2" long, that will accept the 'bored' banjo bolts
> some telfon tape for sealing

Now, hook them up in this order:

Banjo Nut - 1" vacuum hose - nipple - extender -tee -valve -extender-nipple-1" vacuum hose - Banjo Nut

Use the tie wraps to clamp the vacuum hose onto the banjo nuts and the nipples. Vacuum host isn't ideal for this, but the tests are short term and a short piece of the hose holds the pressure just fine. The gauge goes on the top of the tee. Be sure to use teflon tape to seal all connections.

One of the banjo bolts goes where your control pressure feed line connects to the fuel distributor. The other one gets bolted into one end of the nylon spacer. The other end of the spacer has the control pressure feed line bolted to it.

Now, follow your Bentley or Haynes directions to test... when placing the tester into the fuel circuit, be sure to orient the valve on the correct 'side' or else you'll only be able to measure system pressure.

2. Using 3/8 NPT Plumbing Fittings:

The Volvo fuel line threads (14mm by 1.5mm pitch) are very close to the National Pipe Thread 3/8 by 18 tpi. Go to a good plumbing supply store with a rack of brass NPT fittings and buy:

- Male 3/8 NPT with barb fitting on the end
- Female 3/8 NPT with barb fitting on the end
- "T" insert
- Hose to fit and six worm clamps to fit the hose.
- Male 1/8 NPT with barb fitting on the end

Assemble so that the male and female 3/8 fittings go into the fuel line fittings (use teflon tape to fill any thread gaps and don't strip any threads) with the T in between, connected by hose and secured by hose clamps. Add the extender hose to the side of the T, terminating in the male 1/8 into which your fuel pressure tester fits. If you want to be clever, you can use a terminating schraeder valve at the end too.

3. Using the Volvo Tester Fitting:

Special Volvo Fittings to Make Connection. [Tip from Neal] Here are the Volvo part numbers for two hard to get parts needed to build a fuel pressure gauge assembly:

9995265-23 Nipple $40.00
9995116-2 Hose $ 9.30

The nipple is the fitting that connects between the rubber fuel line and the fuel rail. The threads on this nipple are 14mm by 1.5mm pitch, almost identical to 3/8 NPT by 18 tpi. The hose includes the banjo fitting that attaches inline with the nipple. The other end of the hose is an unusual fitting that I imagine could connect only to a Volvo fuel pressure gauge. I cut that fitting off, and installed a 1/8" male pipe thread with barbed fitting pressed onto the hose. The 1/8" male pipe screws into almost any fuel pressure gauge found at any auto store. Make sure you get a gauge that goes to at least 100psi.

Adapter Using an Old Fuel Rail. [Randy Starkie] If you have an old LH fuel rail handy, you can build a pressure tester using connectors and other parts from the rail per the thumbnail picture shown at the right:

Click for larger view

Fuel Pump Starting Device. Instead of removing your fuel pressure relay and jumping terminals 30 and 87/2 with a large wire (which if installed incorrectly will fry your ECU), build your own pump activator. Using the base of a non-functioning fuel injection relay from which you have removed the electricals, solder a large wire between the tops of those same terminals, making absolutely certain you've picked the right ones as they are labelled on the bottom. When inserted in place of your relay, this will activate the fuel pumps without turning on the engine. Remove it to stop the pumps.

Large Gauge Wire Crimper. [Tip from Tom Harper] Ever needed to get a solidly crimped electrical terminal on larger cables (8 - 4 gauge), but found the cost of crimp tools in that size to cause "sticker shock"? Here's something I've been doing - it works for UNinsulated terminals.
1. Measure the OD of the uninsulated terminal barrel you need to crimp
2. Find (or buy - a dime or so) a nut with a thread size (thread OD - not ID) equal to or slightly smaller than the size in step 1
3. Drill out the nut to match the terminal OD
4. Cut the nut in half, across opposing corners (NOT across the flats). Your Dremel tool will come in handy for this - a hacksaw will do it also, just takes more time.
5. Find a piece of round stock about 1/8" - 3/16" (3-4 mm) diameter, about 3/8" (1 cm) long (you can cut the head off a screw for this - the threads won't affect anything.) You now have a "saddle" and a "punch" (halved nut & screw/round stock piece).
6. Put the terminal in the "saddle", and the "punch" lying lengthwise on top of the terminal, opposite the "saddle" - you'll probably want to tape the assembly together, otherwise it takes 3 or 4 hands.
7. Put the cable end into the terminal, and crimp the whole works together using a bench vise, Vise-Grips, or equivalent. The "saddle" supports the bottom of the terminal, while the "punch" crimps everything nice & tight.

I've gotten really tight & secure crimps on up to 4 gauge cable by hand with this method. After a dozen or so uses, the nut may crack & start to spread; no problem, since you have the other half, and making new "saddles" is easy & cheap anyway.
Make sure your terminal barrel ID is close to the wire OD - this method doesn't do too well if there's a lot of empty space between the wire and the terminal. You may be a bit clumsy at first, but once you work out a way to keep everything aligned as you start the crimp, it'll go really well. The new Vice-Grip adjustable wrench is ideal for this - the "V"-shaped jaw is ideal for supporting the "saddle".
Volvo content - used this trick yesterday when making some "overkill" (4 gauge) engine-to-body ground and alternator-to-starter terminal cables.

M-46 Overdrive Tools. The following are useful tools for manual transmission overdrive maintenance and rebuild tasks.

1. Pressure Relief Valve Tool. [Duane Hoberg] Here is a tool I designed for removing the Pressure Relief Valve (between numbers 22 and 23 on the diagram of the overdrive overhaul procedures.

M-46 Overdrive Pressure Relief Valve Tool

Overdrive Spanners

2. Top Nut Removal Wrench. [Randy Starkie] A cutoff 11mm box-end wrench/ spanner is able to fit in the limited space to remove the top two nuts on the Laycock overdrive unit. See the photo to the right.

3. Pan Caps Removal Pin Spanner. [Randy Starkie] To the right is a pin spanner used to remove the caps under the pan on the Laycock unit. The 3/16" bolts are through a square tube positioned on 5/8" centers with the end of the bolts ground to a radius. This tool eliminates the common practice of using a punch/drift and a hammer to turn the caps.

Engine Lift and Support. See the photo and planform for Dick Riess' and John Vilas' design for an engine lift and support, useful for changing motor mounts and oil pans. It is made of 2x6 lumber and mounts on the fender channels.

Engine Lift Photo

Engine Lift Plan

[Art Benstein] Another version uses two-inch rectangular metal channel stock as the support.

Lift Using Metal Channel Stock

Note the use of the hook and nut. Get a hook with threads long enough to take up the engine sufficiently to remove engine mounts.

Distributor Drive Pin Remover Tool. [Tool design by John Vilas] This tool may be used with a vise or hammer to remove the shaft pin holding the distributor together. You will need it should you ever decide to change the inner o-ring seal on this shaft. You can purchase this from:
John Vilas
Vilas Motor Works
901 S. Texas Avenue
Bryan, TX 77803-4554 Cost is $25 (at 6/6/00)

Distributor Pin Tool Mounted in vise

To use it, see John Sargent's excellent procedure in the FAQ.

Distributor Drive Pin Remover 1

Distributor Drive Pin Remover 2

Timing Belt Tensioner Lock Tool. Use this to secure your tensioner pulley out of the way when installing a timing belt in B21/23/230 engines. Purchase it from:
John Vilas
Vilas Motor Works
901 S. Texas Avenue
Bryan, TX 77803-4554 Cost is $12.50 (at 6/6/00)

Timing Belt Tensioner Lock Tool

Rear Engine Seal Installer Press. Use this press to correctly install your engine rear main seal on B21/23/230 series engines. Purchase it from:
John Vilas
Vilas Motor Works
901 S. Texas Avenue
Bryan, TX 77803-4554 Cost is $35.00 (at 6/6/00)

Rear Engine Seal Installer Press

Pre-Pump and Fuel Tank Sending Unit Removal Tools. [Special bonus for 200-series owners!] Use this lock ring remover to take out your sending unit on 200-series cars. Purchase it from:
John Vilas
Vilas Motor Works
901 S. Texas Avenue
Bryan, TX 77803-4554 Cost is $25.00 (at 6/6/00)

Fuel Tank Sending Unit Removal Tool

Pre-Pump Removal Tool. [Tip from Ross Gunn] Anyone have a Prepump tool they used when they removed the pump from the tank? Volvo has one of these tools, anyone have one they wouldn't mind loaning out? I'm afraid of taking screwdrivers to it as I might break something. Any ideas?

I made one out of 1/8"steel plate which I shaped like this:

```
__________^________ _
|                   |
|   _____________   |
|__|             |__|
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Using vice grips as a handle at ^ , it was quite easy to remove the level sender/pump unit.

Another version for 240 cars by Don Foster:

Fuel Tank Sender Removal Tool

Yet another version for 700/900 series cars by John Sargent, using 3/4" x 1/8" angle iron and an old socket to make the tool. The tape measure shows 5-3/8" between the pieces of angle iron.

700-900 Fuel Sender Bung Nut Tool

Transmission Rear Bushing Remover. You can buy this from Ramac Industries.

Home-Made Pressure Bleeder. [TV Pierce] You can make your own pressure bleeder. Power Motive's is nothing more than a garden sprayer with a brake reservoir cap attached to the end of the tube instead of a spray nozzle (they also add a pressure guage -- but it's not really necessary). The sprayer is about $10 at Home Depot, and a new reservoir cap should be $2-$3 at FCP Groton. Drill a hole through the cap, epoxy a tube fitting through the hole, then cut off the spray nozzle, and attach the reservoir cap. [Gary Gilliam] I made mine out of a cheap all plastic 4 liter (about $13) garden sprayer, and an old master cap. I cut the hose just above the sprayer wand, attached a 5/16" brass fitting that is commonly used for repairing air lines: it is barbed on one end to stick inside the hose and has 1/4" NPT threads on the other. This was secured to the hose with a stainless hose clamp and a 1/2" hole was drilled in the extra master cylinder cap to receive the other end of the fitting. The fitting was secured to the cap with a 1/2" long brass NPT straight connector, adding a rubber washer on both sides coated in RTV for good measure. I was going to add a pressure gauge, but never got around to it. It seems to work fine with just enough pumps to get things moving a bit.

Brake Master Cylinder Bench Bleeder. [Rob Bareiss] Because many master cylinders are mounted at an upward angle that encourages accumulation of air in the upper ends of the cylinder's bore, bench bleeding a new or remanufactured master cylinder is always a recommended procedure. Buy short lengths of European ISO double-flared brake line and bend to fit as per the photo to make a bench bleeder. The tubes are connected from the lower ports back into the fluid reservoir.

Turbo Intake System Leak Tester. [Tips from Josh Wingell/Brent Cook] To assemble a device to locate leaks in your turbo intercooler or intake hoses, try this. Parts Needed:

- A 4 inch long piece of 2.5" O.D. (outside diameter) hose. (I used some radiator hose I got at NAPA)
- 1.5" I.D. (inside diameter) PVC end cap.
- 2 band clamps that will fit around the 2.5" pipe above.
- A schraeder tire valve stem

Intake System Pressure Tester

Note that if you have a larger turbo, the sizes of the end cap and hose may need to be larger in order to fit the turbo inlet. To use it, just remove the intake pipe from your turbocharger inlet, and attach this in its place. If you have a manual boost controller hooked up, you might want to plug off its intake hose, as they leak a lot of air, making it hard to pinpoint the real leak. Pressurize the tester using a bike pump or an air tank. Pressurize the system, and listen all over for leaks. You might want to have a friend check out your boost gauge while you are pressurizing things to make sure you don't put too much pressure on things. (20 psi should be safe, or whatever you run safely for boost) Make sure you or a friend listens under the bumper too, wherever there is intercooler piping. A leak will be obvious, they make a loud hissing sound.

Brake Bleeder/Turbo Hose Pressure Tester

[Randy Starkie] I used my brake reservoir cap/schraeder valve combination that I have made up to also test a turbo intake hose for leaks and cracks. I normally use it to pressure bleed my brakes with a bicycle pump. As luck would have it the size of the cap is almost a perfect fit when clamped into the end of the turbo hose. I turn my compressor regulator down to about 15lbs pressure and use a tire chuck to pressurize the system. Leaks are instantly found with sound of escaping air. The center hole is drilled to 9/16 inch.

Turbo Torqueing Tool 5411. To replace your pre-1991 turbo unit on to the manifold, you need to tighten the manifold-to-turbo bolts which are difficult to reach between the turbo and manifold. Volvo offers a special tool number 5411 used with an angled torque wrench to tighten these nuts to 30 Nm or 22ft-lbs. It looks like an 13mm open end wrench on one end with a 1/2" drive hole on the other for the torque wrench, which is held at a 90 degree angle to the tool while tightening. Make such a tool by welding a 3/8 or 1/2 inch square drive end (to fit your torque wrench) on a 13mm open-end wrench. The distance between the center of the wrench flats (where the center of the nut will be) and the center of the square drive is 6-3/8 inches. Tighten to the torque spec while the wrench and tool are kept at a 90 degree angle. Use new nuts. [Dave Stevens] Note that when a force is applied at 90 degrees to a torque wrench extension then the torque remains the same at the end of the extension. That's how the Volvo special tool is designed to be used. Any home made wrench that can duplicate that right-angle orientation will work just as well, as long as it is held at a 90 degree angle. The length is immaterial.

Turbo-to-Downpipe Nut Wrench (5411) (used with a torque wrench at 90 degree angle)

Turbo Nut Installer 5411

Diesel Tools. [Ross Winberg]

Hazet 2574 Valve Tool

Valve Adjustment. You should adjust your valves every 15,000 miles. To do the adjustment you neet Hazet tool 2574. Be careful as there are several variations on this tool. The one you want is pictured. Some variations are too small to fit the camshaft and are meant for gas VW motors while others are not as ergonomic.

Micrometer

You will also need a supply of VW diesel valve shims. It is also helpful to have a micrometer to verify shim thickness if the numbers have worn off.

To remove the shims use either the VW tool or a shot of compressed air in the notch on the valve depressor.

Valve Shim Pliers

Do yourself a favor and draw a diagram before you start showing the 12 valves and which are exhaust and which are intake valves. Your valve clearances will most likely be SMALLER than spec so you will have to put in thinner shims.

Cam Locking Tool

Timing Belt. To do the timing belt, you will need a camshaft locking tool, which fits into a slot on the back of the cam to keep it stationary.

Injector Adapter for Compression Test

Compression Testing. You will need a serpentine belt tool (the cheapest is from Sears), a compression gauge reading up to 500 psi (very difficult to find) and an injector hole adapter into which you fit the gauge.

Serpentine Belt Tool

Ultraviolet Leak Detectors. [Editor] To detect fluid leaks in engines, transmissions, power steering units, air conditioning systems and the like, get an Airmax LED penlight for UV leak detection from http://www.keep-it-kool.com/ (costs about $40) and a set of UV-enhancing glasses from JC Whitney for about $5. You can purchase engine and transmission fluid dyes from NAPA stores for about $4 each, and air conditioning dye injectors from NAPA as well. The glasses are necessary to see the dye. This works best in a darker garage, unless you purchase a larger and more expensive lamp.

Short Circuit Detectors. [Editor] Both macro (wiring harness) and micro (circuit board) short circuits can be very, very time consuming to diagnose. Here are two tools designed to make the process simple and fast.

Short Locator

Wiring Harness Short Locator. [Tip from Don Lewis] Available over EBay, this tool eases the task of locating wiring harness shorts, especially under trim panels. The gadget really works well. You plug one side into the blown fuse negative side and the other into the positive battery terminal; you must remove the positive cable from the battery. When you plug this thing in it fires up with an internal light and buzzer so you know you're on the right circuit. You pull the little magnetic dial indicator from its pod and run it along suspected harness areas. If you're on the right harness, when the console pulses - every ten seconds - the indicator needle jumps in the direction of the short. As you get closer to the short the needle jumps further. If you pass the short the needle stops jumping because all the current is going through the short into ground. The short was a pinched wire under the rear rocker panel trim where the trunk harness runs up along the rear wheel well. I would have never found it without this tool. Great gadget. It really works well and saved me many hours of work.

Printed Wiring Board Short Locator. Electronic Design Magazine (July 1997,ED Online ID #6386) has a schematic and instructions for a short locator to be used on PCBs: http://www.elecdesign.com/Articles/Index.cfm?AD=1&ArticleID=6386 The battery-powered short-circuit locator uses the small but measurable resistance of circuitboard traces themselves, in combination with a low-voltage excitation current, to directly sniff out bad connections. Useful for engine computer boards, instrument panels, heater control boards, relays etc.

Crank and Cam Seal Installers

Volvo Special Tool Images. Below are some images of Volvo special tools to help you construct your own versions.

Cam and Front Crank Seal Installer.

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700/900 Series Model Identification

Version 7.5

Model Year Changes and Features. See http://www.swedishbricks.net/ModelFAQ/700model.html for more information about the sequence of 700/900/90 carline changes.

What Do the Numbers Mean? Back in prehistoric Volvo time, the factory badged cars with numbers defined as Series +Cylinders+Doors. Hence, a Volvo 264 was a 200-series car with a PRV-6 6 cylinder engine in sedan format with four doors. A 142 was a 100-series car with four cylinders and two doors. A "5" at the end meant five doors or a wagon. This began breaking down when the middle digit was used for the 760 to refer to trim line instead of cylinders, e.g., a 764 sedan may have a turbo-four or six-cylinder engine, but has in both cases a more extensive trim package. In later years, the factory stopped badging the cars in this way and only the owners refer to their cars so. Hence, a "940" sedan is unofficially a 944; a 960 wagon is in the eyes of owners and mechanics a 965. this system was formally abandoned with the newer five cylinder front drive cars in 1993.

Bosch or Rex-Regina Systems? [Inquiry] How do I identify my fuel injection and ignition system? [Response: Chris Mullet/Chris Herbst] Many 1990+ non-turbos have Rex/Regina systems; most turbos seem to have Bosch. Between 90 to 92, all non-California non-turbos were Regina cars. There were some 89s and there were some at least until 1993 if not later. The Regina cars are anything but rare. Regina systems are characterized by:

- Only one fuel pump which is in the tank, without a pre-pump; and this fuel pump is not as high a quality as Bosch
- Ignition coil is a wierd sort of amplifier-looking thing on the LH strut tower, versus a standard looking cylinder-shaped coil.
- Uses an intake air temperature sensor and a MAP sensor, instead of the mass airflow meter.

Vehicle Identification Number Coding. The VIN number (stamped on a plate next to the driver's-side front windshield) for the 700/900 series cars can be decoded as follows: (those listed are common in US and Canada applications)
A. 740/

Digit #	Description	Code	Definition: <=1991	Definition: >1991 if different
1,2,3	Manufacturer:	YV1	Volvo	
4	Model:	A	240	
		B	260	
		F	740	
		G	760	
		H	780	
		J	940	
		K	960	
5	Safety Equipment	A	3-pt seat belt plus SRS	3-pt seat belt plus SRS
		S	4-door with SRS	4-door with SRS
		W	Wagon with SRS	Wagon with SRS
		T	4-door with seat belt only	4-door with seat belt only
		X	3-pt seat belt only	3-pt seat belt only
6,7	Engine	69	B280F	
		74	D24 TIC w/EGR	
		75	D24 TIC w/oEGR	
		76	D24T	
		77	D24 (81-84)	
		80	B230G	
		81	B234G/B230FK	
		82	B230GT (LH 3.1)	
		83	B230FD	
		84	B230E/B230GK	E=elektronisk K=karburator
		85	B230FB	
		86	B230FT	
		87	B230FT	
		88	B230F (LH 2.4)	
		89	B234F	
		92	B6244F	
		93	B6254F	
		95	B6304F w/o catalytic converter	
		96	B6304F w/ catalytic converter	
		98	B6304G w/o catalytic converter	

		99	B6254G	
8	Doors	0	-	Basic engine
	(1992+: emissions)	1	4-door with SRS	Engine with EGR
		2	2-door	
		3		Alternative fuel/ignition system
		4	4-door with seat belt only	
		5	5-door wagon	
9	Check digit		Computed as error check	
10	Year	D	1983	
		E	1984	
		F	1985	
		G	1986	
		H	1987	
		J	1988	
		K	1989	
		L	1990	
		M	1991	
		N	1992	
		P	1993	
		R	1994	
		S	1995	
		T	1996	
		V	1997	
		W	1998	
		X	1999	
11	Factory	0	Sweden (Kalmar)	Sweden (Kalmar)
		1	Sweden (Torslanda)	Sweden (Torslanda)
		2	Belgium	Belgium
		3	Canada	Canada
		4	Thailand	Thailand
		5	Malaysia	Malaysia
		6	Indonesia, Australia	
		7	Sweden (Uddevalla)	Indonesia
		A	Sweden (Uddevalla)	Sweden (Uddevalla)
		D	Italy	
12-17	Chassis number		Unique 6-digit chassis number	

Example:	YV1JS8315S3210849		Volvo 940 4-door with SRS	
			B230FD engine	
			4-door	
			with EGR emission control	
			1995	
			Made in Canada	
			Chassis number 210848	

Product Plate Number Coding. The Product Plate is located on the passenger's side of the front radiator cross brace and has the following additional information in the five lines on the right of the label:

Line	Digit	Description	Code	Definition
2	2	Transmission	2	M46 (4 speed+o/d)
			3	M47 (5sp)
			5	ZF22
			6	AW 70L/71L/72L with lockup
			7	AW 70/71/72 without lockup
3	Last	Steering Rack	2	Cam Gear
			3	SZF
4	First	Brakes	2	Girling front, ATE rear
			3	DBA/Bendix front, ATE rear
5	All	Paint Code		http://www.vlvworld.com/

Service Label Number Coding. The Service Label is located on the driver's door (B) pillar or in the trunk and has the following additional information:

Line	Description	Code	Definition
5	Fuel pump type	2	Pierburg
		3	Bosch
		4	AC-Delco
		5	Sofabex
7	Clutch Type	2	Fichtel/Sachs
		3	Verto/Volvo
8	Alternator	1	Bosch
9	Steering Gear	#	1= Koyo; 2=Cam Gear
		#	3=SZF; 4=TRW

Other Identification Locations. Other identification labels are located as follows:

Engine:

- B230 and 234 series have labels on the timing cover and stamps in the left block below the head.
- B280F have stamps on the block, either between cylinder banks toward the rear (early) or on the right front between inlet manifold and water pump.
- B6304F have labels on the timing cover and stamps in the left block.

Transmission: Metal plates affixed to the left-hand side of the transmission, just above the pan

Rear Axles: Labels on the left side of the axle housing, as follows:

- 1030: Standard rear axle
- 1031: Heavy-duty version of standard solid axle with limited slip mechanism
- 1041: Heavy duty solid axle with automatic locking mechanism
- 1035: Multi-link rear axle
- 1045: Multi-link rear axle, with automatic differential lock

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Transmission Model Information. See this list for automatic transmissions used in recent Volvo RWD cars:

FOR REFERENCE ONLY - USE TAG NUMBERS FOR POSITIVE ID

Model	**Years**	**Transmission Type**	**Engine Type/Size**	**Transmission Model**	**Remarks**
90 SERIES	97-98	4 SPEED RWD	L6 3.0L	AW 40 (A341E)	AW 30-40LE
240	85-92	4 SPEED RWD	L4 2.3L	AW 70	03-70
240	92-93	4 SPEED RWD	L4 2.3L	AW 70L	03-70L
740	85-89	4 SPEED RWD	L4 2.3L	ZF 4HP22	4HP22
740	85-90	4 SPEED RWD	L4 2.3L TURBO	AW 71	03-71
740	85-91	4 SPEED RWD	L4 2.3L	AW 70	03-70
740	90-92	4 SPEED RWD	L4 2.3L	AW 70L	03-70L
740	90-92	4 SPEED RWD	L4 2.3L	AW 72L	03-72L
740	90-92	4 SPEED RWD	L4 2.3L TURBO	AW 71L	03-71L
760	85-90	4 SPEED RWD	L4 2.3L TURBO	AW 71	03-71
760	85-90	4 SPEED RWD	V6 2.8L	AW 71	03-71
780	87-90	4 SPEED RWD	L4 2.3L TURBO	AW 71	03-71
780	87-90	4 SPEED RWD	V6 2.8L	AW 71	03-71
850	93-97	4 SPEED FWD	L5 2.4L/2.3L	AW 50-40	50-40
940	91-97	4 SPEED RWD	L4 2.3L	AW 72L	03-72L
940	91-97	4 SPEED RWD	L4 2.3L TURBO	AW 71L	03-71L

960	93-97	4 SPEED RWD	L6 2.9L	AW 40 (A341E)	AW 30-40LE

List of Paint Color Codes. [Tip from Volvoworld] See http://www.volvoworld.com/ for a comprehensive list of paint codes.

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Volvo 780

Information. I found a new 780 site (by far the best 780 site that I have seen) at: http://www.geocities.com/MotorCity/Garage/6570/ Anyone with an interest in the 780 will definitely enjoy it.

See this forum for more Bertone information: http://wave.prohosting.com/vbertone/

Considering Purchasing a Volvo 780? [Tips from Fitzgerald/Paul Demeo] All the sheet metal on the 780 is custom for only that car. With only 4,000 to 5,000 vehicles imported to the US, they are scarce, but I do know of a few scattered around in salvage yards across the country. I have a pair of 780s, one with the B280F (PRV-6), and the other with the B230FT (turbo-4). The 4-cylinder engine is easier to work on and has a higher peak-horsepower, but the 6-cylinder engine has better low end torque. The PRV-6 is unique, with its own problems, and finding someone knowledgeable enough to work on it can be a challenge.

Headlights, tail lamp assemblies, corner markers, grill, airdam, various other parts etc, are all custom to the 780 and therefore either not available or very expensive. The car chassis and suspension is exactly the same as a 760 GLE for their respective model years (imported to the US from '87 to '91). They only come in automatics, and the interior is hand stitched Italian leather. The interior dash and door trim panels are real birtch wood (not fake plastic), and the sound system is second to none for it's era. If you want to add a CD changer to the factory radio system without any major work, you can swap out the radio head unit (keeping the EQ and amps the same) with a later Volvo CR-814 that they started using in the '91 and up Volvos. The CR-814 is compatible with Alpine's M-Bus system and thus allows for you to add a CD changer in the trunk. (FYI, much of Volvo's audio equipment came from Alpine and bears the respective tags.) While the 780 is a very unique car (and the last 2-door coupe of the RWD Volvos), many of the design features that the Itialians used were copied by Volvo in their 960 series. Comparing a 780 to a 960 side by side, you will find many similarities, expecially in interior layout and door height design (both of which have low cut door sills and provide a great arm rest while driving and lots of visibility). By the time you get through reading the following website, you'll probably be thinking really hard about trying to talk the dealer down on the 780. -and besides, a car that cost $40K 15 years ago typically has lead a sheltered & pampered life. If you consider owning one of these cars for awhile, consider also buying a wrecked one just to have parts on hand if you get in a fender-bender.

When negotiating a price with the seller for your 780, look closely at:

- the air dam assembly and the rear side windows (at the base). The air dam on these cars is VERY expensive and is easily damaged by parking barriers because it is so low. My '88 is missing about 25% of it's air dam, and the '89 is missing the whole thing. I know someone who just recently had his air dam replaced on his '91 780 and had it painted to match for about $3,200.
- broken interior trim, cracking dash, de-laminating wood panels, broken headlights/taillights/turnsignals outside. Check to see if all the doo-dads like trunk poppers (there's two), power seats/mirror/sunroof all work.
- the hand-stitched leather on the seats is softer than typical Volvo leather and is prone to splitting if not cared for with regular leather treatments. You can re-cover the front seats with donor upholstry from a 760, but you must reuse the original seats to retain the function of the folding seat to allow access to the rear seat (the 780 is a 2-door coupe for those not familiar with it).
- rear side glass. This is probably the only significant rust spot on the car to worry about, but when it rusts, it rusts badly. There are some concealed drains and tubing to remove the water from the base of the window glass, and if these become clogged it can turn disasterous very quickly. If any evidence of rust is

showing at the window base, ask the dealer if you can pull the interior rear panel for futher inspection. What you will find will either convice you to look elsewhere or give you a big bargaining chip in price negotiation.

Source for 780 Trim Parts. [Tip from Steve Seekins] If anyone is looking, you can contact them directly. I know that some of these are now difficult to get.
VOLVO 780 (39K) Bertone. The original stainless steel trims for:

A-pillar left and right,
Roof left and right,
C-pillar left and right

H. Bauer Kfz. has purchased the entire stock of the manufacturer at prices of 1 piece DM 100.- or 1 set (6 pieces) DM 500.- If you have interest, please contact :

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Rust Warning. [Tip from Patrick] In the process of fixing up my 780, I have found what could be a characteristic problem - rust around the rear windows. When I bought mine, there was a little surface rust around the rear window trim. I found that this is evidence of serious rusting beneath. There is a drain system for the rear side windows. If you pull the rear inside panel, you will see this drain and also any rust problems. There are several plastic hoses that run from the window frame to the bottom of the car. The rust occurs when the hoses become clogged so that the window doesn't drain. The window assembly comes out as a unit. Mine was so eaten up with rust that if we tried to dissassemble it to sandblast it, it would have fallen completely apart. I encourage you all to at least blow air through the drain system to keep it clear. If you are really industrious, pull the inside panel and take a look. You might even pull the window and check it out completely. Especially if you are keeping the car long term.

To remove the interior panels to gain access to the rear window: If yours has never been apart it is quite possible to break something. Treat them gently; these pieces dry out over time and become brittle. The back seat has to come out first. Then the insert has to be gently pried out of the handle and two screws removed. There is a screw where the panel attaches to the floor under the seat, a screw under the little cap on the door threshold and an allen or torx screw just toward the rear from that one. Then you can pop the panel off - GENTLY - because all that should be left are the pop in retaining clips. Some ot those will probably stay with the car. There are a lot of them.

Once you get the panel off, the rust should be evident - if you have it. There is a piece with three screws in it that runs across under the window. If it is real rusty, you should probably pull the window. To do that, you will have to pull the rear shelf and the trim panels around the window. After you remove the trim around the window there are about 12 screws that screw into the window frame all around. Remove them and you should be able to pull the window out. After you get it out you will see the holes to the drain system. Blow some air throught these to clean them out.

Removing Wood Dash Trim. [Tip from Olle Holmstrom] Remove the instrument cluster, the panel under the steering wheel, the glove compartment and the ECC controls. Then you can remove the small nuts that hold the wood trim to the dash.

Maintenance:

Engine Problems:

Transmission Problems:

Other Concerns:

[Editor's Note: See specific functional areas for more information about particular 960/90 systems, including automatic transmission and heating-air conditioning.]

Maintenance:

Checking Transmission Fluid. [Inquiry] How do you check the transmission fluid level on a 1997 Volvo 960? (I've looked everywhere for the dip stick) [Response: Warren Bain] It's accessed from below on the drivers side. I had this problem at first as well. It's a small yellow 'dipstick' that's way down there, if looking from above.

Coolant Replacement. [Editor] Lots of reports of leaking, porous blocks are appearing in Vovo enthusiast sites such as Brickboard. Many of these failures are in low mileage, late model B6304 engines. Consensus opinion is that these are due to failure to change coolant regularly and to use the proper coolant. Contrary to your owner's manual, the coolant is NOT "lifetime" and has to be replaced. This aluminum engine is subject to electrogalvanic corrosion and coolant breakdown, so make sure you **change the coolant every three years or so. Use ONLY Volvo Type C blue coolant and distilled water.** Do not under any circumstances use orange Dexcool or "all applications" coolants. For more information about leaking blocks, see the link.

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960 Spark Plug Removal. [Inquiry] How do I change the spark plugs on my 960? [Responses: Carlos Torres/Tom Irwin/Warren Bain] The plugs are on the middle of the engine.

- Remove spark plug access cover. (Black cover on top of engine.)
- Once you have the black plastic cover off, number the coil packs with a magic marker 1 - 6 front to back so you can correctly replace them.
- Coil packs are held in with a pair of 10mm bolts (A and B in the illustration. Later 960s have only one bolt at A).
- Once you have the bolts out the pack should just pull out. A little twisting may help as there is an "O" ring seal at the top of the valve cover and a big boot at the spark plug.
- Remove coils from spark plugs. Do NOT disconnect coil wires. (VERY IMPORTANT)
- Inspect the condition of the wiring going to the coil pack. Look for crumbled insulation or charring. See 960 FAQ file for information on failing engine wiring harnesses.
- If you have comprssed air blow out the plug cavity before you take the plug out. As an alternative use a vacuum cleaner and brush to clean any "stuff" out of the hole to avoid having it fall into the cylinder.
- Remove spark plugs. Use a good quality, rubber insulated spark plug socket. Once they are unscrewed, you have to haul them up out of the hole.
- Check and adjust spark plug gap to: 0.030" (.75 mm)
- Install clean, "un-oiled", spark plugs and torque to: 18 ft. lbs .
- Refit ignition coils.
- Reinstall spark plug access cover.

B6304 Coil Pack

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960 Parts Sources. [Tips from Rafael Riverol] Don't pay dealer prices for parts such as rebuilt heads, pistons, piston rings, and the like that are sometimes necessary for your 960 after a timing belt failure or overheating incident. Check the following for exceptional prices, service, and willingness to source in Sweden if necessary:

- Import Parts Specialists (Idaho) http://www.importpartsspec.com
- Foreign Car Parts of Groton (Connecticut) http://www.fcpgroton.com

[Note from Tom Irwin] There is some evidence that Volvo OEM brake rotors for 960/90 cars are of lesser quality; buy aftermarket for better quality and lower prices from reputable suppliers such as IPS, FCP, IPD, RPR.

Online Maintenance Manuals. For online 960 Volvo maintenance manuals, see: http://caunter.ca/volvo960/

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960 Flame Trap Maintenance. See Flame Trap in B6300 Engines for more information.

Serpentine Belt. [John Shatzer] Just a cautionary note to check your serpentine accessory belt for inside edge fraying. Apparently when you begin to accure higher milage (in exess of 100K), the tensioner begins to sag, it will cause rubbing along the inside edge (toward the engine) of the belt surface. Replacement of the tensioner is called for. We've heard about at least one (rare) instance of a broken serpentine finding it's way into the timing belt housing, and the rest, as they say, is history.

Timing Belt/Tensioner Changes. See 960 Timing Belt Change for important information regarding the timing belt change interval - which varies by model year for the 960 series - as well as the tensioner and idler pulleys which, upon failure, will destroy the belt and the cylinder head at great cost. More and more reports of pulley and tensioner failures are being heard, even as low as 95k miles. So the importance of changing these components cannot be overstated.

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960 B6304 Cam Gear Timing. [Inquiry: JT] I removed the cam gears from the head of my 960 and now can't figure out how to get the gears back on with correct alignment so the cams and valves are timed right.
[Tip: Tom Irwin] Make sure and scribe the bolt positions on the gears before removal. There is an awful lot of adjustment in there.
[Self-Diagnosis: JT] I took a look at the 960 again last night and I cam up with a way to solve the problem. The problem was that I took the cam gear off of the camshaft and did not know that it was not pinned or marked. This meant that it could go on the camshaft one of 3 ways at 120 degrees out of phase. With the intake manifold and exhaust manifold off I could see the valves. Had to use a mirror for the exhaust side. The spark plugs were out also. I set the timing marks and hoped for the best with a 1 in 3 chance of getting it right. I did not get any interference when I slowly turned the crank by hand, so feel will not work. I checked the firing order and compared the exhaust valves openings to the intake. Used a flashlight to shine in the plug holes and look in the ports to see when the valves would open. I found that the cam gear was off, making the intake and exhaust valves open and close at the same time. This is why there was no interference. So the intake valves were opening to soon. So I went back 120 degrees to the next

hole and retested. This time the timing was correct. I then marked the cam gear to the camshaft so I would not have this problem again. So all you 960 owners out there be careful with the cam gears. I do not know but the 850s may be the same way.
[Response and Caution: Jim Bowers] The Volvo tools to set the cams cost about $250. There is a tool for locking the crankshaft in position, about $50, and one that attaches to the back ends of the cams, almost $200, and puts everything in sync. In addition to the three possible choices with the holes in the gear/pulley, the holes are elongated so you still have several degrees of choice once you get the correct holes lined up. The car will probably run, but will not be set at factory settings if you don't use the tools. Maybe you can find a place to borrow the tools? Or, once you have it in running condition get to a dealer and have the timing set. I just ordered a set from Kent-Moore, the Volvo tool supplier. Same tools are used for the 850 and probably for the S40? All that having been said, you would have saved your self a lot of hassel if you had spent the few $ to get the Volvo Service manuals for the engine. One of the books I have (TP31714/2) takes you, in pretty good detail, through changing a head gasket.
[Tip from Tom Irwin:] I've heard the following is critical to re-assembling the head: bottle of gasket goo, rollers and tension spreaders? The stuff I have is "Volvo #1161059-3, High Temperature, Chemical Gasket", it comes in a 50ml tube.

Engine Problems:

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960 Valve and Head Problems.

Sticking Valves. [Summary of tips from Tom Irwin] To avoid the sticking valve problem in the B6304 engine which causes valve and piston collisions and consequent head meltdown, follow carefully this advice for 960 owners from Mr. Barrington of Barrington Engine of LA, rebuilders of many toasted 960 heads:
1. The Abe Crombie Tune-Up is a GOOD thing!
2. Put a fitting behind the AMM for occasional, brief WATER introduction to the Hot engine... while
running Shatters and blows away the carbon build-up.
3. ALWAYS ALWAYS use PURE SYNTHETIC OIL! VERY insistent on that one!

Failure of Timing Belt and Bent Valves. If your timing belt in the B6304 engine fails, your engine almost certainly has experienced major damage including multiple bent valves, cracked valve guides, possible damaged pistons, and head damage. This will cost a fair amount to repair since it is both labor and skill intensive. Some tips: [Chuck Jeckell] Any guides that need to be replaced CANNOT BE HAMMERED OUT AND BACK IN!. The head must be heated and the guides cooled/frozen to replace them properly. Volvo has had a problem with people experiencing oil leaks when their valve guides leak after being installed incorrectly. Most machine shops are not set up to install them properly: ask around (and see the note above). Once the head is off, the broken guides will obvious to the shop. Be aware that piston damage is possible, but not likely. Use the orange glue/sealer with a roller when reinstalling the head:

nothing else will do.

Oil Leaks: Diagnosis

General Diagnosis. When diagnosing engine oil leaks on the B6304, first make sure the flame trap and all associated vacuum lines connected to it are clean. Then consider the following sources:

- [Warren Bain/Jim Bowers] The oil filter cooler/adapter O-rings may be leaking. If the oil filter gets stuck at oil change, the oil cooler can loosen. Remove the belly/splash pan to check this area. If the "O" rings have been disturbed, they may need to be replaced to get a perfect seal. This shouldn't be more than .5 hours of labor and $2 in parts. (Then tell your "oil change mechanic" to lubricate the filter gasket and hand tighten only.)
- The rear cam seals can leak, especially if the flame trap was clogged.
- The rear engine seal can leak.
- The oil fill cap gasket can harden and allow blowby.

Clean off your engine and carefully trace the oil leak before concluding the worst.

Cam Timing Sensor. [Inquiry] The cam timing sensor on my 960 is leaking oil when the engine warms up. I have checked the location with a telescope mirror and is not from the seal around the block. Could it be an inside seal? [Response: Abe Crombie] There is a seal deeper in from cam sensor. It is a bear to reach. Go to dealer, they have a tool that presses it in. There is no room to tap it in with engine in car. The shutter wheel must be put back correctly also.

Valve Cover Top Recesses. On removing the valve cover, I discovered oil pooling on the spark plug cover. It turns out the screws holding the cover were loose and mounted in holes drilled too deep into the head (a manufacturing problem from Volvo). I reinstalled them with Teflon sealant tape and that solved the problem. Note that you have to re-tape the bolt threads every time you remove the plastic cover. You may want to replace the torx bolts with regular hex bolts to make removal easier. The torx heads can't take the torque of repeatedly rotating a stud with the tape on the threads. [David Hunter] Those bolts can leak even when not stripped. There is oil under pressure very close to the 4 bolts around each of the plug holes. If the sealant used between the upper and lower head fails the oil will run up the unthreaded portion of the bolt and out under the its head. Then some ham handed "mechanic" comes along and says "oh better tighten that" and he strips it. Before it is stripped though it is quite easy to withdraw the leaking bolt a bit, apply a sealant under the head and retighten to 13 ft/lbs. [John Roberson] If a previous owner has stripped these bolts, here is how to solve the problem of continual oil leaks. You will need a couple of 7x1.0mm bolts about a 1/2 inch longer than the bolts that are in the head now. They should be full threaded parts. You will need a few washers of good strength as well as a couple of hex nuts. You will also need a 7x1.0mm tap. Get them at Fastenall or a machine supply store.
Take the bolts out and retap the holes as best you can and as deep as possible. Clean everything with brake cleaner. Using a Dremel tool, cut the heads off the longer bolts you

bought. Wrap the side going down into the hole with teflon tape, put two of the hex nuts at the top of the other side of the bolts and jam them together tight and then run the bolt down till it just bottoms out, but do not overextend and possibly crack the aluminum casting. Do this on each bolt, then take the hex nuts off and use the bolt now as a stud with a washer under the hex nut and tighten down. By the way, you can use knobs instead of nuts to hold the cover down: Monroe Engineering

Mix up some JBWeld epoxy and apply to the leaking area and let set up over night. I would also use the JBWeld around the hex nuts and washers to make sure it doesn't leak through again. If necessary, you may have to retap with an 8mm tap and install a larger 8mm bolt instead of the loose 7mm OEM bolt.

[Caution: David Aidnik] The oil you are seeing in #5 plug well is creeping across the interface between the upper & lower head sections that is supposed to be glued together with chemical gasket. It is creeping past the o-ring seal around #5 plug well indicating that the upper head section is lifting and also that the o-ring gasket is probably brittle & hard. I would estimate the longevity of any fix other than the correct fix by removing the valve cover and helicoiling all loose holes to be temporary at best. The fact that you are seeing oil seepage means that the chemical gasket is compromised (seperated). This is not going to be fixed by tightening bolts. I'm not a fan of funky fixes, so I would recommend the removal and proper fixing with helicoiling.

Vacuum Leaks: Diagnosis. [John Roberson] I had a difficult-to-trace vacuum leak in my 960. I finally found the last of my leaks--and the last one was a doozy-- on the backside of the intake manifold. On the driver side is a vacuum block that has 6 vacuum hoses coming off it. I found two hoses that were cracked by taking a tube and putting it to my ear, I could hear air hissing. Found the two hoses that were cracked--but the interesting thing was after doing the fix --put the tube back to my ear and could still hear air moving. Unhooked everything and took the vacuum block off-it's held on by one 10mm bolt. I pulled the block out of the intake. At the base there was a disintegrated rubber O ring. A new number 30 o-ring from Lowes hardware and the fix is now complete--no air leaking now.

Porous 960 B6304 Blocks. [Tip on used car purchase: Kelvin Kean] We purchased a 92 960 station wagon in 1985 with about 30,000 miles from a Volvo dealer. In the summer of '98 the coolant started needed topping up about once a week. By October, it needed two quarts a week. After removing the exhaust manifold our mechanic found the leak, a line of pinholes in the side of the block. He attempted to seal the leaks using a compound often used by truckers to seal small radiator leaks. The fix lasted a week. From then until January, we used the car but had to add increasing quantities of coolant to the radiator. In January we took the car into our mechanic and went through five gallons of water keeping the radiator from boiling over. When the mechanic looked over the engine block again, oil was now bleeding from an identical line of pinholes on the same side of the block and parallel to the line of pinholes leaking coolant. The engine block is defective. There is no fix short of replacing the entire block, which means an entirely new or rebuilt engine. [Editor: See Repair Notes Below] And this failure is a fundamental failure in manufacturing or design. No engine block should ever leak coolant or oil short of a million miles! We've contacted Volvo of North America and their position is that the warranty has expired and that besides we did not have the car serviced at an authorized Volvo dealer. We are now in the process of filing a formal complaint in court against Volvo and its dealer. Within the last month, our Volvo mechanic has had another 960 station wagon towed in that was leaking coolant even worse than ours. Volvo has also given that owner the run-around, but he did get a member of the staff of Volvo North America to admit that they had heard of "... four or five..." 960's having the same problem. [Response: Tim] Click and Clack the tappet brothers had a caller a few weeks ago with a similar problem. Seems there are problems sometimes with the castings on the 960 engine. [Editor's Note: Too many reports of casting porosities in 92-95 B6304s have appeared on the Brickboard to dismiss these as related to a short run of early blocks. If you are considering buying a 92-95 960, do some serious investigating and take a hard look at the engine block for coolant leaks, patches, attempted repairs, service records, etc. to pin down whether the car has this problem.] See the notes above regarding the requirement to change the coolant regularly and use proper coolants.

Where They Fail. [Tip: Tom Irwin] The 960 failures always occur directly beneath the exhaust manifold. Go outside and jack up the R/F corner, pull down the splash shield and look under the exhaust manifold, between ports #4, 5 and 6. Thats where your porous block will present itself. But really, it's not all that common. Don't confuse it with other potential leaks nearby: check the coolant return pipe under the front of the exhaust manifold; if it leaks, the o-ring could be bad.

Which Engines Are Subject to This Problem. [Tip from Tom Irwin] The early run '92's, maybe 10,000 units worldwide had metallurgical and dimensional deviations. That was corrected quickly and all subsequent castings have been more or less to print [**But see the update below!**]. Having said that...let's address the coolant. I have been told by reputable sources at Volvo that anything other than Volvo Blue, Type C coolant could begin to attack the block alloy with time. This reaction is accelerated as the coolant degrades. (Note, this applies to aluminum, modular engines, B6304, etc.) Naturally, if you have one of the early 92's this chemical reaction could damage the block faster. The same source also cautions against using anything but Volvo Brake Fluid due to the potential for reactive damage within the ABS pump. **The only constant that remains is that in EVERY case of porous blocks, the owner followed the Volvo guideline of NEVER changing the coolant.**

[**Update Notes** from Tom Irwin: There are two TSBs addressing this issue, 221943 in March, 1997 and 221945 in June 1997. The one from March 97 was superceded by an internal document dated November 1998, that was a Service Bulletin, titled as a "troubleshooting procedure". Here is the BAD NEWS guys...it covers 960 from 1992 through 1994... they went cheap even at that stage and authorized only a block swap with some incidental parts...the original engine gut pack had to be swapped. They called it a "defect" and allowed 20.4 hours for the swap. [Further reference:] Internal Volvo Warranty Claim Documents address block casting porosity issues in one document as a 1992 ONLY issue. The second internal document, Volvo tech paper 2120-001, covers block replacement, under warranty for 1993, 1994, and 1995+ 960's. This references block numbers 25000 to 52873.

[Finding the Block Number: Tom Irwin] Under the exhaust manifold in the webbed casting. Use a mirror and light. Or, Underhood, front body stretcher in front of radiator on your left. Riveted aluminum placard, Right column, top line, last 5 digits.

Preventive Maintenance. [Tip from Tom Irwin] Flush and change your coolant regularly and use **only** Volvo Blue, Type C on these engines.

[Repair Notes from Tom Irwin] I've seen 3 of these buggers come through the shop in 2 weeks. Guess what? They are 94, 95 and 96 Model years!! But.... we have had VERY good luck using "JB Weld" (heavy-duty epoxy) after very careful surface preparation. My "Mad Genius" boss has perfected THAT treatment... So, this doesn't necessarily mean a $5,600 short block... more like $3.99 at Pep Boys. To get good access, you must either go topside and pull the exhaust manifold out, or, go underneath and drop the subframe. Once in there, hit it good with solvent and clean it up with a wire brush. Some guys still peen it up first, but the mad genius strafes the surface with an abrasive flexible wheel in a die grinder.. Criss-Cross, buffet, tap-tap-tap, til it is crosshatched enough to anchor the goo. Mad Genius uses JB Quik, I would prefer the 15 hour cure stuff, but, time is money! The one today, was actually a comeback... not that the repair failed, but because another leak sprung up, missed it the first time. I found it down in the gulley of a casting extrusion, easy to miss when looking upward at it. So, learn a lesson and use a mirror to see what you might be missing.

Cracked Blocks. [Inquiry] My 92 960 block cracked just below the exhaust manifold. Is this repairable? [Paul Golden] I have about 24 cracked B6304 engine blocks on the back scrap pile and they range from 92 to 97. They all cracked in the same place. I also cracked one when I did a headgasket. I have tried welding, however, with very little success. The aluminum is a cast, so it makes it difficult to weld a nice pretty bead. I only got about 8000 miles out of the engine before the oil and water started mixing. I would not weld another one. You would be wasting your time and money. The engine blocks are hard to find, but not impossible. Look for a 6304s block instead of the 6304f block. The s has a beefier web and a better breather box. The only bad part is the main bearings are different from the f on the lower half of the block. Look for a block with less than .006 of wear in the cylinder. Try to find a c marked on the piston, or an A. These are the smaller pistons. Then you can use the f or k pistons and will be able to hone and fit pistons to new tollerance. A new set of oversize pistons and rings will set you back 800.00, plus the cost of machining. By looking in the different core piles, you will be able to piece together a great engine for less than 300.00 with no cracks. Soak the old pistons in carb cleaner with the rings still on, wash in warm water and then dry, wipe them down with a transmission oil soaked rag so they won't rust. A steam cleaner works perfect to get all the old gasket material off the engine mating pieces, other wise you will spend hours scraping. Resurface the cylinder head and torque the new head bolts to only 45 degrees at a time. Do each headbolt three times. Don't torque the bolts to the final factory spec. It is too tight and tends to crack the blocks. I have a customer that has my first 960 engine job. It is still going strong with 109,000 miles on it since the rebuild with a 100.00 core from Muse Core Suppliers. That was 5 years ago. I do about 1 every 2 months now and so far have only cracked one block. I am always amazed how little these engines wear with the proper oil changes. I hope this helps you decide what to do.

B6304 Compression Test. [Inquiry:] Anyone know the correct procedure for disabling the electronic ignition and whatever else is required to check compression w/o damaging anything. [Response: Abe Crombie] There is a terminal in that electrical box on driver's side under hood. It is a single terminal that points up with nothing plugged to it. 12V will trigger starter. w/o key on and all coils and plugs removed and throttle opened while cranking you will safely, accurately get a comp test result that is valid. Warm engine also.

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960 B6304 Intake Manifold Gasket.

Diagnosis. [Tip from Jim Bowers] My '96 960 with 66K developed a rough idle last week. My friendly Volvo service mechanic suggested it was most likely a bad intake manifold gasket when I took it in to have the codes pulled. I fashioned a diagnostic tool for pressurizing the intake system with 4 psi and the problem was easily confirmed to be the intake manifold gasket. When I took the manifold off I found several of the bolts to be less than finger tight!!! The gasket had sucked in and bulged out at the number 1 cylinder. I may have avoided the considerable project if I had tightened the bolts when I first got the car last summer at 58K! With that background I also pulled back the heat shield on the exhaust side and tightened the nuts on the exhaust manifold nuts as well. Most were still tight but 3 or 4 turned up some. One turned up a full half turn! [Mark Stites/David Aidnik] First make sure you actually have a leak at the intake manifold. The easiest test method for this is to spray the region of the intake manifold & rubber sleeves with brake cleaner or propane while the car is idling. Do it when the engine is stone cold as the leak will be worse at that time. Don't look for a rise in RPM as it is not going to happen: instead, the engine will stumble. The worse the leak, the worse the stumble.

Parts Needed. [David Aidnik] You'll need a new manifold gasket; new rubber sleeves, new non-resuable Oetiker clamps for the rubber sleeves (12 clamps); Oetiker clamp pliers. (Although see the notes below about reusing these clamps). The flame trap has an Oetiker clamp, but you might want to change this to a screw type band clamp as the Oetiker clamps are not re-usable. You might also pick up a few throttle body gaskets, and clean the throttle body while you have everything out. Order the parts from Volvo, then you would be sure to get the right size Oetiker clamps & the OEM rubber sleeves. You can buy the pliers on Ebay as I did for ~$20.

Replacing the Gasket. [David Hunter] The gasket is easily replaced by removing the 9 or so manifold bolts, pulling the manifold away from the head slightly and inserting the new gasket. Some bolts are a bit difficult to access, so I used a 1/4" drive set with a universal joint. It would not be necessary to undo the hard to reach lower support bolt as it is on a rubber bushing that will easily flex. The job looks like it should be a one day type job the first time.

Tips. [Mark Stites/David Aidnik] If the manifold gasket is failing it will usually do so at the #1 or the #3 cylinders in that order. I have replaced the gasket both ways: removing the entire intake assembly, or just pulling it back a little. I prefer the former method. A few things to pay attention to if you remove the whole manifold:

1. If you do decide that you must change the manifold gasket and the rubber sleeves, consider getting the Volvo manual on the B6304 engine. The procedure is about 4-5 pages long with good pictures.
2. The outer manifold with the big plenum chamber has a "bottom mounting screw"

underneath next to the motor mount which is not obvious except from the OEM manual.

3. First remove the EGR pipe from the rear/center of the manifold to the EGR valve.
4. While you can do without replacing the special holders to keep the injectors in the rail, it might be good to replace them.
5. Reusing Oetiker Clamps. When undoing the clamps an ice pick or similar tool can spread the crimped feature enough to un-hitch it so as to be able to reuse it. Once off, use two pliers to reform the bent features and open up the crimp features some more. I use a pair of end cutting electrical cutters for the crimp tool.
6. Only disconnect the outer end of the hoses and use a suitable pry tool to maintain control over the manifold as it takes some force to break it free.
7. Make sure that you have all six of the rubber hoses back onto the manifold and none are crooked on the bottom. It is very easy to get one crooked and then clamp it down. Put a light coating of Never-Seize on the inside of the hoses and a little on the manifold to ease the re-assembly process. Use a light and an inspection mirror on every inch of all six of them to make sure before you use that single-use Oetiker clamp.
8. Iif you do pull the entire manifold make sure that you improve the ground for the black wire that mounts onto the engine mount bracket. Consider relocating it to the back of the starter and put a star washer on it to ensure a good ground.
9. I use a magnetic socket when pulling the actual manifold bolts. Loosen, but don't remove, the lower bolts on the inner manifold section; they have slots for the screws on the bottom and are slotted into the manifold itself. It makes for a handy situation when you can install the lower bolts and gasket and then carefully set the little short manifold in against the head. Torque is 15 ft-lbs on the bolts.
10. Make sure that you route the oil trap/breather hose through the manifold runners BEFORE you get the main manifold installed. Have the correct Oetiker clamps for the connection on the top of the oil trap. Inspect that oil trap closely as they are known to leak and now is a good time to replace it.

[More Intake Gasket Notes] I elected to try the shortcut procedure for replacing the intake manifold gasket described by David Hunter elsewhere in this section without disturbing the Oetiker clamps or rubber sleeves. It involved removing all nine cap screws holding the manifold to the head. Upper screws were not difficult; some of the lower ones were hard to access. I would not have been able to loosen some of the screws without a 1/4 inch swivel 10 mm socket - that's the key to this approach.

I removed the MAF assembly and the throttle assembly for easier access. Then I removed the fuel rail, forgetting to relieve fuel pressure. The rail came off the fuel injectors, and I was able to pry out the two fuel feed line fittings after removing the retainer clips. I left the injectors in the engine. The job may have been a little easier if I had removed the injectors, but I didn't have any replacement o-rings, so I didn't want to risk disturbing the seal.

Even though I couldn't see some of the lower bolts, I knew where they were because of the pattern in the replacement gasket. By threading an extension with the swivel socket to where I thought they should be, I was able to get the socket on the bolts and loosen them. One word of caution, though: I dropped one of the wire clips on the fuel injector, plus a couple of bolts, while removing them. They disappeared somewhere in the lower (inaccessible) part of the engine. I found all parts except one and was able to retrieve them with a two foot extension claw.

The manifold could be pulled back about an inch and a half on the rear side, and only a quarter inch or so on the front because of interference with the coolant fitting. I considered removing the fitting, but didn't want to go to the trouble of draining the cooling from the system. The original gasket was red and stuck to the manifold when I pulled it back. It came loose from the manifold with a little encouragement from a scraper. Fortunately, it all came out in three major pieces. I did not have room to fit a scraper back there in the event that little bits needed to be scrapped off.

I was able to carefully work the replacement gasket behind the manifold and hoped that the surfaces were clean. I didn't use any adhesive to hold the gasket in place. Rather, I put two of the top bolts back to hold everything in alignment while I finished with the other seven bolts.

I stuffed some rags underneath the manifold to catch anything I dropped, since it would be next to impossible to find a bolt that fell back down into the abyss. I didn't have a magnet to hold bolts in the socket, so I folded little bits of Duct tape inside the socket, sticky side out, to retain the bolts while trying to get them started. This seemed to work well to keep from dropping the bolts.

Someone suggested that the manual says to only loosen the lower bolts, since the manifold flanges are slotted on the bottom. This may be helpful in removing the manifold, but the gasket required that the bolts be removed completely so they can be threaded through the holes in the gasket.

I snugged everything back up, and the car is running well again. I was a little concerned about reassembly of the fuel rail, though. I couldn't find the proper procedure anywhere in the FAQ. Each of the six fuel injectors pokes into the hole of the fuel rail and is secured only with an o-ring to prevent leaks. The injectors didn't want to go back into their holes. I sprayed a little WD40 to lubricate the seals. Then I snugged down the rail to provide some pressure to the injectors, and was able to individually work each injector back into its hole. The o-rings barely cleared the outer edge of the hole. I'm not sure how far into the holes the o-rings should be seated.

I carefully inspected for fuel rail leaks, both at cold idle and after running the car up to temperature. I'll continue to monitor for leaks and/or fuel smells to err on the side of caution. All in all, a successful procedure, thoug

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960 B6304 Head Gasket Replacement . [Tips from Tom Irwin] If this is your first time replacing a 960 head gasket, then plan on a full day for takedown. Then however long at the machine shop. This is a good time to at least check out the exposed parts while the head is out. Then plan on 2 full days for buildup.

Tips. See Engine: Mechanical for detailed tips on head gasket installation on 960/90 cars. For a homebrewed cam cover compressor tool, see the FAQ Section in Special Tools.

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960 B6304 Fuel Rail Leakage Problems. [Editor's Notes] If this condition occurs on your car, GET IT FIXED IMMEDIATELY since you are driving a potential bomb. [Tip from Tom Irwin re: 1992+ 960] I've been trying to trace the source of a raw fuel smell coming from my car. It always got too hot and evaporated before I could find the liquid. This morning, I found it alright. Front of the fuel rail, there is a plug, steel or aluminum which is inserted sometime after the machining process and a flange of excess extruded aluminum from the body of the fuel rail is sort of 'stretched' and crimped over the plug, thus forming a "permanent seal". The pressure test fitting is installed and crimped in much the same way.

Fuel is simply POURING out of that plug. Because the engine is tilted slightly backwards, the stream rolled back down and under the fuel rail where it disappeared due to evaporation. Go check that manufacturing plug in the front of the injector rail for leaks... remember, the system won't pressurize until it sees a spark impulse, so run it first. This sucker spews liquid fuel... FORWARD INTO THE COOLING FAN... WHICH VAPORIZES IT... AND BLOWS IT BACK ONTO THE MANIFOLDS AND CAT!!!!!!! Repair tip: use JB Weld epoxy repair for a very temporary fix, and replace the fuel rail for a permanent repair. [Tip from Neil Noonan] Mine was leaking at the plug on the very end of the fuel rail towards the front of the car and could be seen dripping at start up.

Repair Notes from Tom Irwin: After I finally received all the correct parts, it would appear that Volvo has known about this possibility for some time as the Fuel Rail Ass'y for 92-97 has been pulled from inventory and superceded by the 98 up design. Looking at the two, side-by-side, it would appear that this plug failure was thought to be caused by excess transmitted vibration. The new version has no direct contact with the manifold. Instead, you must thread in two wide shoulder spacers into the foremost and rearmost mounting holes and the rail then bolts to the top of the spacers. It ends up being rather suspended, over the intake runners, instead of being bolted to it. You will need at least two of these spacers, not 1 like the parts guy swears it calls for. Get three since they are cheap and VERY easy to break off. I broke one. Had to drill and retap the hole.

Also, when mounting the injectors into the rail, the retainer strip no longer will wrap around each injectors body. Instead it slips in to the slots up near the tail of the injector. There are two slots on each injector. LEARN FROM MY MISTAKE. Align the strip with the lower most slots, nearest to the injector tail. If you align with the upper one there will not be enough reach for the injector noses to seat firmly within the runner(s). Then, if you are dumb, like me, you will turn each spacer a few more times to grow some clearance and you will snap it right off.

Once done, it ran great! No Leaks, No Problems.

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960 Gas Smell After Fillup. [Inquiry] I get a very strong gas smell right after I fill the car up, seems to come through the vents. Lasts just about 5 minutes or so then slowly goes away. [Response: Tom Irwin] This happened to me when I first got my 95 960. It was a bitch to find and fix too! There is a rigid plastic pipe that ties into the fill neck, behind the opening where you stick the nozzle. It is only accessible from underneath and by tearing out the lining on the left side of the trunk. It cracks. I'll just bet you $50 bux when you top off the tank you have a puddle of fuel under the center/rear of the car! Also, expect it to set a "Check Engine" code real soon. Get it fixed. You are a road hazard. [Response: R.W. Reagan] I had a similar experience with the 94 960. Except mine wasn't a cracked plastic tube. There's also a rubber hose that looks similar to a radiator coolant hose that connects the rigid filler tube to the inlet on the gas tank. You can see it by removing the access hatch in the trunk floor underneath the hat rack. This hose is about two inches in diameter, but has a smaller hose coming out the side - sort of in a "Y"configuration. It also connects to a fitting on the tank in the single most inaccessible part of the car. The small part of the hose had split where it connects to the tank. I was able to locate the leak by pressurizing the gas tank with a compressed air hose inserted into the filler tube and sealed with plumber's putty. I could hear the hiss of the leak, but couldn't see where it was because of the location. I used a short length of hose as a stethoscope and probed around until I located the problem. I'm guessing that filling up the tank displaces the fumes in the tank out your leak and causing the smell. Filling up to the neck also will cause a puddle to appear under the car

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960 Fuel Filter Change. [Inquiry:] Can someone outline the procedure for changing the fuel filter on a 1995 960. I plan to remove the fuel pump relay, run the car till it dies replace the filter, and put the relay back. Does that sound about right? I noticed what appears to be some sort of pressure relieve valve on the line in from the tank to the filter. Is this valve used when changing the filter? If so how? Also do I need a special tool for disconnecting the lines from the filter? [Response: JT Charger] Leave the fuel pump relay alone. After unbolting the fuel pump bracket, simply squeeze the rubber connectors back while holding the fuel lines. Its like connecting an airhose to an airgun, spring loaded, compression fitting. The other fitting you see in the fuel line is for us superstar technicians to check fuel pressure with. Leave it alone. Put rags under the old fuel filter before disconnecting the lines, to soak up the normal spillage, perhaps use a pan.

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960 Temperature Too High or Low: Stuck Thermostat. *Symptom: Overheating:* [Tip from Bruce White] 1992 and up some 960's are starting to have overheating problems. I have seen about 4 in the past 2 months that have overheated and warped the cylinder head. The problem appears to come from a failing thermostat that sticks closed. Had one yesterday that came in overheated and blowing water out of the coolant bottle. The t-stat was stuck closed and replacing the t-stat fixed the problem. No major engine repair was needed. **I would highly recommend that all 960 owners have your t-stat replaced immediately.** There are others reading this that have had 960 heads warp and major repairs were needed. Don't let your repair center tell you that the t-stat does not need to be replaced. Don't take a chance. I would replace the t-stat every 60K miles. *Other Symptoms: Too Cold.* Symptoms My '93 960's engine was very slow to warm up in cold weather. The colder the ambient temperature the colder the gauge indicated. The interior heater was also not very functional at these times as the ECC system sensed the cold coolant and would not start the system. I deduced that the thermostat was staying open and allowing coolant through the motor even when the motor was cold.

Replacing the Thermostat. [Procedure from Randy G.]

Remove the Old Thermostat. Remove the splash pan under the radiator and remove the coolant overflow tank cap. Place the cap on top of the upper radiator shroud so you don't forget it. Drain sufficient coolant to below the thermostat level. The radiator drain is on the bottom, rear of the right-side tank. Remove the three phillips-head screws on the plastic protective cover under the air conditioner condenser in front of the radiator. This makes it easier to access the drain valve on the radiator. Place a short length of hose on the drain valve and put the hose into a clean drain tank. Drain about 1 to 1.5 quarts (or liters) of coolant out of the radiator. It doesn't have to be empty. Close the valve and tighten it CAREFULLY! DO NOT OVERTIGHTEN! It doesn't take a lot of torque! On the right side of the block under the exhaust manifold, near the front of the engine is another drain. Place the drain hose on this valve and drain about one pint or so. Close and tighten the drain valve. This one is metal and can take a bit more torque. The thermostat housing is at the motor end of the upper radiator hose. Using a T-40 Torx tool, loosen and remove the two bolts that hold the thermostat housing to the block. If you drained a sufficient amount of coolant there should only be a drop or two left in this area. There is a little bypass valve in the thermostat itself that allows air to flow out of the thermostat. Lift the thermostat housing upwards with the radiator hose attached. Do so carefully so as not to stress the radiator's upper hose bib. The thermostat can now be lifted out of the block along with its gasket. There is no paper gasket for thermostat in these engines. After doing this, I found that the thermostat metal strap had failed and caused it to stick open.

Install the New Thermostat. Check the mating surfaces to be sure they are clean. Clean the two retaining bolts with a fine wire brush and coat them with some quality anti-seize. Check to see that the gasket is properly installed on the thermostat and drop it into the block with the curved retaining strap upwards. The thermostat upper housing will not go into place if you put the thermostat into the block upside down. Make sure the little valve is at the top of the thermostat to allow air to bleed. If there is an arrow, it means water flow out of the head to radiator. Replace the thermostat housing over the thermostat (again being careful of the radiator's upper hose bib) and start the two bolts into the block with your fingers for the first three or four turns. After that, use the Torx tool to finger-tighten the two bolts, turning them evenly until the housing is seated. Torque to specs (Chilton's states 7ft/lbs - 10Nm for the 960's 2.9L motor). That's not much!

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960 Coolant Loss: Coolant Reservoir Cap at Fault. See link.

Coolant Loss Behind Water Pump. [Inquiry] I've got a coolant leal at the connection of a "U" pipe and the back of the water pump. I unbolted the branch that runs to the cylinder head, between the exhaust manifold and timing belt cover. Now it can rotate within the water pump connection, but it won't come out. How do I remove this? [Response: Jim G and Tom Irwin] Remove the exhaust manifold heat shield (8 bolts, 12 mm). You'll need to move the secondary air pump out of the way. You don't need to remove the exhaust manifolds (so long as you don't need to the "U" pipe completely out). There's a bracket on the back extension of the U-pipe. It's under the back manifold, next to cylinder #5. (This is why it wouldn't come out.) Unbolt this bracket and the 2-bolt connection to the front of the cylinder head. Disconnect a compression-type coolant hose connection, just below the "U" pipe (22mm compression nut). Take all the hoses off the "U" pipe. It should pull out of the back of the water housing: it's a tight tolerance interference fit; no snap rings or retainers. It will rattle around underneath the exhaust manifolds. (If the "U" pipe must come out to be repaired or replaced, the manifolds must come out.) There is an o-ring in the block opening that the "U" pipe fits. I replaced the o-ring since it seemed to "take a set", with flat spots. (Please forgive me, all you Volvo purists) I matched the o-ring size at local auto parts store. The size I used is OD=39mm ID=33 3mm thick, BUNA N. I used a small amount of RTV as the lubricant to noodge the pipe back into the socket. Clean off any crud or corrosion on the pipe ends. Clean up the mating surfaces very well with a wire cup brush chucked in a drill motor.

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960 B6300 Leaking Oil Cooler Fitting. [Inquiry] My '96 960 Wagon has a slight oil leak at the oil cooler. It's been weeping ever since I bought it. Is this a common problem? Do you use some gasket sealant when replacing the sealing rings? Does anyone know what the torque specs are on that HUGE bolt that holds the oil cooler in place? [Response: Tom Irwin] VERY common problem. Count on it every 50k or so. There is a repair kit with one large block cut o-ring and one smaller, corded o-ring.   Pull the whole damn thing out, with the filter attached. Change the coolant lines too. To re-torque the large bolt, set your big-ass channel locks on about 2nd position from maximum. And tighten until you fell a reasonable amount of give in the o-rings as they squeeze. [Tip] The oil cooler o rings can fail over time and need to be replaced. The first time I did this I put a little oil on the o-rings and buttoned back up; they always seeped thereafter. The last time I cleaned the surfaces really well, oiled the small o-ring and applied a thin coat (very little so you hardly know it's there) of RTV silicone to the edges of the larger o ring (gasket) where they mate with the surfaces; tightened the large bolt and no more seepage. I also hand torque the filter now so as not to stress the large o-ring. [Response: Warren Bain] If you are going to replace only the two lower hoses it won't take too long. If you are going to replace all the hoses, it can take a while. The heater hoses at the back of the engine have their clamps aligned for easy assembly at the factory, but not replacement. They are aligned 90 deg. to the engine and you have to use a universal joint, and a 7 mm socket. I realigned then to a 45 deg angle so it will be easier the next time. Also the lower radiator hose had the clamp aligned so the frame rail was blocking it. Use a 7mm box end wrench to loosen it. I realigned that one too. Get a new thermostat too. You will need Torx bits, an oil pan for the adapter, and a catch pan for the anti freeze. Don't tighten the radiator hoses too tightly or you can break the inlet/outlets.

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960 Rear Cam Seal Repair. [Long, Involved Tale from Tom Irwin] First, many thanks go out to Steve, Abe and the other generous tipsters without who's help I would have had a bit more difficulty. .

OK, the heater hoses are in the way so in preparing to disconnect and remove them I drained ~6 litres of coolant from the petcock on the Ex. side of the block. Make sure you have a jug of Type C Blue sitting around before you start, if you choose to do it this way. Well, then I noticed that with the coolant drained, the hoses became soft and flexible enough to be squished back/down out of the way. So I did that and left them connected.

Don't even think of doing this job without a telescoping inspection mirror, preferably a self-illuminated one.

The 2 T-40's that hold the cam sensor housing to the head...these are BIG mamajama's! They are made of soft metal and are easily deformed. And I promise you, they are frozen in their threads. Breakaway torque is considerably stonger then the set torque values. **CAUTION** if you strip or otherwise wreck the bottom T-40 fastener, you will likely have to PULL THE ENGINE to complete the job...'Nuff said.

Also, DO NOT use an El Cheapo T-40 driver bit either...if it comes out of a kit with a bazillion other parts...uses different adapters to connect it to a plastic handle and says "made in China"... GET THEM OUT OF THE WORK AREA..
Luckily, I went after the top T-40 first and the bit yielded under load and wrecked the head of the T-40!! Because it was the TOP one I was able to grab it hard with a monster vise-grip and bust it loose, after which it spun right out, no problem. My wife went out and got me a hardened, impact grade T-40 x 3/8" ratchet drive bit. Made ALL the difference! Even after I cheezed up the lower one a little, this quality bit grabbed it's target and brought the lower bolt out.

The Cam Sensor cover may be a bit gummed up with oil residue, so it may want to rotate a bit instead of withdrawing from the head. Fine! Rotate it CCW a bit and you can tap the upper and lower mtg. ears with a drift and light hammer alternately, until it walk's out. Set this aside.

Remove the 10mm bolt that retains the "shutter wheel" this is kinda like taking out a rotor from a distributor housing. no problem. Set the shutter aside. Wipe out the pooled oil.

If you are smart you'll have a seal picker kit with many different parts to make many different articulated angles...you will need them. If you are *me* you'll waste an hour sacrifice two craftsman screwdrivers in a vise with an Acetylene torch, trying to fabricate the same thing. For the record, the smaller one worked better. Use a Dremel tool or equiv. to de-burr and hone the business end of this thing so as to not damgage any sealing surfaces.

Now is when you MUST have an inspection mirror. Get on back there, work carefully as you are working a mirrored image. Hook that sucker under the garter spring + up behind the metal ring and it pops right out real easy. Wipe the cavity out again and reinspect the sealing surfaces for damage.

Lube up the new seal with... I dunno...I used heavy weight petrolatum..and ease it over the cam shaft. Try and jam several fingers back there and push evenly on different point on the seal. Make sure it doesn't cock in the bore. Stop and use your inspection mirror frequently to check it is even. To bring it home...again, if your smart, you'll find a way to get a hold of Volvo Tool P/N 999-5450. It has a perfectly dimensioned steel cup with a hole in the back to put your cam shaft shuter bolt thru temporarily to tighten the cup down and push the seal in to place. If you are me, you'll hack a piece of nylon bar stock at work and while the prototype machinists are on break and "borrow" a CNC Vertical Mill and fabricate same based on Seal dimensions and your best guess from a picture in the service manual.
Anyway, my best guess was about .250" off, but before I ran off to get a longer bolt, I put both hands on it and squeezed it against the head and ... "Whump" it popped right in. Check it again with the mirror for even seating.

Put the shutter + 10mm bolt back in. Fit the tabs squarely in the milled slot on the end of the cam. Tighten.
Clean the rim on the sensor cover and gently fit it over the shutter wheel being careful not to

damage
the magnetic pick up chingas inside. Align the holes and replace the T-40's.

Fill-up your coolant. Take a Prozac. Start your engine. Check your work.

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960 B6304 Leaking Rear Main Seal. [Inquiry:] It appears the rear oil seal is leaking on moms 95 960 65k. This appeared all at once. It seems to be coming down from the flywheel ispection cover. I cant identify a drip while running but it pools while sitting. She just had the oil changed then this happened. [Tip from Rob Bareiss] The reason for the sudden blow out is... it's the same rear main seal as an 850 engine. Which is to say, subject to unexplained and sudden oily failure. I dunno, I can't really adequately explain it. They just let go, it seems completely at random. We've just done our 5th 960 rear main seal in the last 6 months, and I don't even want to think how many leaky 850 rear mains we've seen- it's gotta be 30 in the last year. At the minimum. I had 4 850's we sold this summer, everything from 48K to 114K miles, and we bought the cars because they were blessedly dry at the engine/trans split... and they came back, from 1-week to 2-months later, well within our warranty period (lucky us!) having sprung leaks. And I've had 150K mile 850's and 960's which have never leaked. I do not understand it, or know of a fix or cure for it. I'm sorry it happened to you- hope it doesn't dim your opinion of an otherwise great car. If you were to bring it to my shop, you'd be looking at ~$21 for the part, and about 6.5 hours labor. And, be glad that went instead of the catalytic converter.... [Tip from Tony Symons] Flywheel bolts on this engine are drilled all the way through the crank flange and can leak oil. Seal their threads on installation with Hylomar or Loctite sealant that will prevent oil leaks and keep the bolts adhered in place.

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960 B6304 Oil Pressure Problem: O-Ring Problems. See link.

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960 Oil Pressure Problems: Failing Oil Relief Piston. [Tip from JT] As you know I have had some problems with no oil psi after I got the 2.9l back together. I thought that the oil pick-up was plugged with sludge or something. I know I did not want to drop that oil pan so I figured that I had nothing to lose by trying to clean the sump. I put in 6 quarts of the gunk parts cleaner (comes in 3 qt cans) thru the dipstick hole and let it set for 2 days. When I drain it the oil sump was spic & span! I flushed it with oil, then tranny oil, and then with oil again. I then filled two caulking tubes with mobil-1 0w-30 oil and with a rubber stop (with a center hole) pressurized the oil system thru oil filter inlet. I put the filter on, filled the sump with oil, and cranked the engine. No oil psi! I had to know what the heck was going on with this no oil psi. Still not wanting to drop the pan I went after the new oil pump. When I got the pump off it did not look right to me. What I thought should be the oil psi relief valve looked strange. Never seeing one of these before in the new Volvo engines I was not sure how it was suppose to work. What I found was a cylinder in a cylinder with a spring going thru it. I went to Volvo and ordered everything I could (except the pump) that was associated with the pump. It was clear when I got the new parts. The inside cylinder used to be a piston. The wire snapring chipped away at the piston top everytime it would hit the stop. Since the relief valve is made out of PLASTIC with the force of the spring behind the piston top, it was chipped away until the spring blew the top on the piston off! No oil psi. The new piston is made out of steel. So this will not happen again. This was a new oil pump that had this plastic piston in it. I am told that the 850's use the same pumps. My sisters 850's oil pump took the big vacation about 2 years ago and I wonder if this was the cause. The casting date stamp on the oil pump in the 960 with the plastic piston was 98. So formational purposes, the next time you do a timing belt, you may want to check to make sure you do not have a plastic piston relief valve.

Techniques: [From JT] The good news is that you do not have to take the oil pan off to check/replace the relief valve piston. I never took my pan off. I am really happy that I did nót have to take that step. I do not know how many oil pumps came with plastic pistons or when there was a change to metal ones, but I say rather safe than sorry. If you are coming up on a timing belt change, pull the crank pulley and the crank timing belt gear. You will see four Torx head bolts that hold the oil pump in. Remove the bolts and the pump slides straight out. The piston was about $12 and the oil pump kit was about $23 (including front seal, oil pump seal, oil pump gasket). If you have a plastic piston in the relief valve you will have to separate the oil pump by removing the back gasket and removing 2 small hex head screws. Push the piston out and put the new one in. That's all. When you get ready to install the oil pump back into the engine you will need a special tool to get the front seal over the crankshaft. I used a thin walled piece of pipe but I think the book called for Volvo tool #5455. It makes the job real easy to get the oil pump back on.

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960 Engine Won't Start: Sticking Valves. [Inquiry:] We have had two instances of sticking valves preventing the engine in our 960 to start in the past two years. This has caused the engine to flood, fouled plugs, and with several attempts to start, gas in the oil. It is getting expensive at $500 a pop to "fix". Our dealership recommended several things:

Changing to synthetic oil

Rinsing the engine with a Blistein cleansing/filtering system

They also stated that these cars were meant to be driven hard (o.k.), as on the autobahn (Montana here we come!). So I guess my wife will have to become a bit more agressive on the trips to the grocery store... What gives? [Editor's Note: see 960 Valve and Head Problems above.]

Abe Crombie Tuneup Solution:

The 4 valve/cylinder engines use small valves and the accompanying lighter valve springs. The exhaust valves will on any engine get some accumulation of deposits, primarily from fuel combustion with some portion from oil that seeps through guides for valve stem lubrication, that in some situations can cause the valve to slightly bind in guide. On a cold engine the guide-valve clearances are reduced due to temperature and the fact the metals of guide and cyl head shrink more than the metal of valve stem. You attempt to start engine and the oil system can and does build oil pressure on these engines in one crank revolution. This leads to the hydraulic valve lash adjusters ("lifters") filling and extending ("pumping up") while the sticky valve is closing sluggishly and not following the cam profile.

A strong contributing factor is excessive fuel system cleaning additives. I know this flies in the face of what has been said loudly and often for the last few years but it is the truth according to a recent study on this very no-start, low compression problem. The additives used for fuel system cleaning make the deposits on exh valve stems worse. If you don't have a fuel system problem with symptoms then don't add anything to tank in the form of a cleaning additive.

Premium fuel has lower volatility and is harder to ignite in cold weather. This can make engine not fire as strongly on initial cranking and less than stellar starting performance give the "lifter" pump-up problem time to occur. If the engine fires off and reaches speeds over 600 RPM the lifter filling time is lessened enough to diminish the odds of the pump-up. Cold weather also reduces the need for higher octane anyway as spark knock is less likely in colder air temps.

Regular operation of the engine at eng speeds over 4500 RPM for 5 minutes or more will cause valve rotation that will clean stems of valves somewhat. This can be done by driving with cruise set in "L" position on gear selector at 55 MPH. THIS WILL NEVER HURT THE ENGINE! QUITE THE CONTRARY, IF YOU DO THIS, I GUARANTEE YOU WILL NOTICE A SMOOTHER IDLE WHEN YOU STOP AFTER THIS EXERCISE OF ENGINE!!! I was amazed at the difference when I tried this on my parents' 95 960.

If the no compression, no start condition occurs you can usually get it to start if you will keep your foot on throttle 1/4 open and operate starter for 30 seconds at a time with a 1 minute rest. Keep throttle open until it starts. If 6 attempts (3 minutes starter time) have been made and it is not running then you will have to have a tow to a service shop. If cranking speed becomes slow during this time indicating you have a severely weakened battery, stop and charge battery or give in and have it towed to service shop.

[TSB Reminder from Jim] Volvo TSB #TP 31714/2 "Deposits on Exhaust Valve Stems" "M/Y 1992 960's [dated 8/93] which are subject to driving conditions consisting of short, low speed trips may experience reduced performance or vibration as the engine warms up. Another possible symptom may be a sensation that the transmission lock-up is engaging and disengaging. In most cases, this is caused by sticking exhaust valves due to deposits on the exhaust valve stems. This condition, in most cases, can be solved by replacing the engine oil with synthetic oil (see Service Manager Bulletin 22-3) and driving the car at a high RPM (5000-6000 RPM) for 12 minutes in low gear. This test drive will remove the deposits from the exhaust valve stems. The synthetic oil will help prevent new deposits from being formed on the exhaust valve stems." [Editor's Note: probably applies to every B6304 ever made, not just model year 1992.]

Deposit Removal Methods. See the FAQ section on Fuel Intake Carbon Removal for some techniques.

Don't Do Short, Cold Runs. [Tip from Abe Crombie] There have already been a few postings about turn over, won't start, has no compression on five and six cylinder Volvo engines. This always surfaces in cold weather. The thing that almost always precedes this no run condition is that the car was started and run a couple of times, each time for less than a minute. These short runs do two things: 1. they set the stage for fouled spark plugs, and 2. normal exhaust valve stem lube oil deposits get partly dissolved and form a sludge (GOO) that makes the valve just sluggish enough to allow the hydraulic tappets the opportunity to fill ("pump up") and hold the valves off seat 1 mm or so as the cams rotate and move the valves up and down.
Starting an engine and running it for a brief period IS NEVER GOOD! The engines are punishing you for doing this by not running. If you need to start a car to move it in the driveway then start it and let it run for several minutes until it is warm. Better would be to start it and drive it a few miles if you have any reason whatsoever to do this. I had a 96 850 do this to me once

when I had mistreated it to a couple of very brief crank-up-and-move cycles. It failed to run the next morning when I was in a rush to get to work. I deserved it. That was outright abuse. Volvo and many other car makers with 4 valve per cylinder hydraulic tappet engines (Volvo quit using hydraulic tappets in 2000) have had this phenomenon in their cars. They started using more foul-resistant spark plugs to better allow the plug to fire when the compression is low , just barely averting this trouble. Most of us will not have it happen, but if it happens to you then you caused it. The car didn't just up and decide to not to have compression enough to run that day for absolutely no reason............ Enjoy and be kind to your motor and it will be kind to you.

If Your Car Has Had This Problem: Check Exhaust Manifold Pipes. [Tip from victim Tom Irwin] As a result of a sticking exhaust valve, the exhaust pipe broke, internally, just inches below the cylinder head. The resulting backwash of resonating exhaust caused symptoms of lost performance/compression. Symptoms of break: radial cracks around the pipe.

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960 Engine Stalls and Won’t Restart: Wiring Harness. *These brief notes are in honor of Tom Irwin, who suffered more grief from the engine wiring harnesses and connectors on his 1995 960 than any one person should bear! All of us 940 owners salute you, Tom, for extraordinary patience and hard diagnostic work, much done late at night.* [Inquiry from Tom Irwin:] I stranded in 100 degree heat. Got the car 4 blocks to home (thanks Triple A). Ran the codes and came up with DTC's 113 and 115. This points to Injector groups 1 and 2. Twice before, only 113 came up. I've done everything I reasonably can. Checking all connections and ohm specs. I greased the 55pin connector at the ECM. [Responses: Abe Crombie, Tom Irwin, Rafael Riverol, DanR]

Removing Intake Manifold to Access Harness. Unfortunately you have to remove the intake manifold to get access to the wire bundle. It is pretty straightforward in removal on the top side, but the one nut at the bottom of the ball-like part of the manifold is a bear to get to. In order for me to get at it, I had to kneel on top of the engine (careful not to break the plastic cover) to get my hand contorted to get a box end wrench under there. The nut only needs to be loosened, it does not have come off.

Wiring Bundle Chaffing at Manifold: Check the wiring harness on engine where it comes up through intake between the # 4 and 5 intake runners. It may have rubbed through and grounded to engine. About a .750"d loom. I had just enough clearance to sneak in a bentnose plier and move it around. The loom cracked away like egg shells. I could not see the rub point on the wires, but right at the head casting extrusion was a bright, shiny, rub spot. I pulled the loom/ harness away from the head. And BOOM! Christine sprang to life. This makes total sense. It has always died upon acceleration. The torsional moment of the engine would tend to bite into anything against it. I lost only group one the first time because only one wire was worn through. With time, two wires, thus both groups lost.

Tie Points: This is where all 6 GRN/RED wires join together. It occurs once up on top of the engine and again down the side of the block, under the intake manifold. Both can rot. Both can cause ghost problems in the EFI and ignition. The secondary tie point is buried inder the intake manifold. Must remove for access. The wires were stripped, twisted, crimped and ultrasonically welded. The welds APPEAR to be solid, but microscopic corrosion occurs between the individual wire strands, you know, where the SHOULD BE solder. No easy fix. I literally cut out the whole joint, re-stripped the wires clean. Braided the wires in between with copper rope, twisted tight into a mass. Then I silver soldered the living hell out of it! Heated it thoroughly and just flowed a couple ounces of high grade solder into the joint. I wrapped it in that stretchy, silicone, self-fusing stuff used on Hi -voltage wires, then tape and loom.

Motor Mount Ground Point: While you are down there do NOT miss the chance to clean and tighten the left motor mount ground point, that nasty little ring terminal that bolts on the lower left motor mount. This is ANOTHER source of impossible electrical problems. And clean and protect the connections to the knock sensors.

Coil Pack Connectors: [Tip from Rafael Riverol] If you have a 960, I please take off the plastic cover atop the engine that reads "24 valves" and examine the female connectors at each of the six coils. I suspect you will likely find crumbling insulation, brittle barrels and poor connections. I can tell you these can fail you anytime. You will also likely find crumbling wire sleeves that will allow wire chaffing againt the engine head. Parts Source: [John Randstrom] Borton Volvo gave me this Volvo part #3523813 (List $6.10ea, net $2.76) as the replacement ignition coil female terminals for my '93 960. These have the rubber isolators on them. You need two per housing. The connector socket housing Volvo part # 9144275-6 is $1.25 Experience with Radio Shack and other sources is not good: the female connectors de-tension and fail to maintain contact.

Cam Carrier Ground Leads: De-ox and dress the two ground leads atop the cam carrier edge. Both, if corroded or broken, will kill an EFI system right quick. I cut mine off and soldered in some solid copper lugs.

MORAL: If you own a 960, watch your engine wiring harness, connectors, leads and all other electrical components very carefully. If you suffer from unexplained driveability problems, start with a careful check of every bit of harness and every connector near the engine. If the wiring is failing, you may want to consider a new engine harness.

960: Transmission Lights Flash, Engine Stalls: Bad Ground. [Steve Wilson] Symptoms: Transmission mode selector lights would start flashing as soon as the key was turned on; the up-shift arrow on the dash would flash on & off; and occasionally the engine fails with no spark on 2 adjacent cylinders at the same time. Diagnosis: Since the ignition control modules for the even & odd cylinders are separated, that eliminated that possibility. The only thing those have in common are the ECM & a ground connection at the left (driver's side) motor mount just above the steering rack. There are 2 black wires (the individual grounds for the separate ignition control modules) that exit the harness approximately 3 inches long with a crimped terminal on each. The fixing bolt also acts to secure a corner of a plastic shield for the wire harness. I had checked continuity previously from the bolt to ground and gotten a good reading. This time I removed the bolt and connected both ground wires to a common ground back to the battery negative terminal. As soon as I turned the key and the transmission mode lights didn't flash I knew I was on to something. The 2.9 sprang to life on 4 cyl, the 2 plugs were still removed and were firing like crazy. This is the ground Volvo identifies in their schematic as a "power ground".

If your car just sputters and dies and won't restart, look here before buying any parts.

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960 Sudden Idle Surge: ECT Sensor Failure. Symptoms: sudden very high idle surges (2500-3000 RPMs) while sitting at idle and hot-start problems. See the fix.

Changing Engine Mounts on 960/90 Series Vehicles. See the link to the Engine: Mechanical file.

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960 Engine Swap. [Inquiry] I just purchased a 1995 960 with a B6304 engine 150,000 miles. The block is leaking coolant and is clearly porous. I'd like to swap this engine with one from a 1998 S90. Will this engine be a direct replacement or will it need modifications or not fit at all? [Jim Bowers] The S90 engine will be a direct bolt in for you. Just keep all the electronics and wiring harnesses from your present '95. 19'95 was the last year they made any "improvements"/ changes to the engines they put in the 960 chassis. '96 got the OBD-II electronics but no other changes. The S/V90 got another external ambient temperature sensor for helping optimize control of the AC but no other engine related stuff. [Patrick McGinnis] I have pulled the 960 motor three times and always with the transmission...up and out of the top of the hood opening.

Transmission Problems:

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960 Automatic Transmission Questions. ***See the FAQ file for Auto Transmissions AW 30/40 for more info.*** 960 cars have experienced a far higher rate of transmission troubles due to overheating.

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960 Won't Restart: PNP or Harness? [Inquiry] My '92 960 wagon will not start after short trips. The gear shifter will lock when placed into "park" and the car will not make a sound (other than the "click" when I turn over the ignition) when I attempt to re-start it. Usually, after sitting for about an hour, the car will start normally. However, today it refused! Could this be the PNP switch? [Response: Etherman] Put the trans in PARK. Turn the key to #2. Step on the brake and attempt to shift out of Park. Does it happen? I think it will. If so, your PNP is working. In this case, look to a bad battery and/or voltage drop in the batt cables which may or may not exhibit signs of corrosion. Check the voltage drop on both cables. Greater than .40 volts is bad. $5.00 says your positive cable needs to be spliced or replaced. [Quick Fix Tip] Cycle yourshifter back and forth a bunch of times (I did it with the engine off) to clean the PNP switch contacts. It works!

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960 Flashing Transmission Lights. [Inquiry] After selecting low gear and accelerating, I get a series of flashing lights: the instrument panel arrow flashes, the lights alternate between "E" and "W" on trans selector, switch positions "E" and "S" will stay depressed when depressed, but "W" will NOT stay depressed. The tranny shifts normally. What is wrong? [Response: Tom] You have a faulty gear position sensor. I had mine replaced at around 68000 miles, but some last longer. It is on the right passenger side of the tanny, next to the fluid cooler line.

Other Concerns:

Unexplained Driveability Problems: Rotten Battery Cables. [Tips from Tom Irwin]
Symptoms: No Hot Restart
My '92 960 wagon will not start after short trips. The gear shifter will lock when placed into "park" and the car will not make a sound (other than the "click" when I turn over the ignition) when I attempt to re-start it. Usually, after sitting for about an hour, the car will start normally. Is this my PNP switch? [Response: Etherman] Put the trans in PARK. Turn the key to #2. Step on the brake and attempt to shift out of Park. Does it happen? I think it will. If so, your PNP is working. In this case, look to a bad battery and/or voltage drop in the batt cables which may or may not exhibit signs of corrosion. Check the voltage drop on both cables. $5.00 says your positive cable needs to be spliced or replaced.

Symptoms and Problem Diagnosis.Stalling and Random Electrical Problems
960 showed occasional cutting out, complicated by intermittent ABS warnings without any codes set. Engine dying at intersections, etc. Apparently "ABS WARNING" when translated from Swedish means "Low Voltage". As with the FWD Volvo's, the battery cables rot inside the crimps, where it's not visible, and they exhibit voltage drop across the length. Volvo knows about this and specs a max drop of 0.09v end to end. Beyond this limit everything gets squirrely.. the ECU turns inside out, etc. Below 10volts, the ABS trips out and sets a code that's the Swedish way of suggesting you have a battery problem. This will kill your voltage regulator too. My Red cable was showing 0.34v drop, four times the limit. I touched the negative battery clamp, it was cool. Then I touched the positive clamp and it was HOT! Looked real good... clean and tight and whatnot... but that internal ROT is blocking most of my current, so the voltage drops... My friend, the master tech says he replaces them all the time on 960's and 850's. But, he added, the part that goes bad is always at the terminals, inside the crimp. So a repair in situ was in order.

Repair Procedure for Battery Cable Ends
Procedure 1: I bought a Pep Boys 25 inch "NASCAR" Battery cable with two ends crimped on it. I cut it to about 12", then I put red shrink tube around all three conductors, boom! Instant

positive cable. Outside I cut the battery cable on the 960 and instantly, this powdery, fluffy powder fell out. It was greenish white and several of the conductors inside were clearly over heated and discolored. I noticed that the Volvo cable was a very fine grade wire filament, braided like a rope, whereas my "NASCAR" cable had much thicker conductors bunched up inside the jacket. But 2" down, the wire was in good shape. So I stripped both ends and took 2 small fuel injection line hose clamps and slipped them over each end of the cable. Then I I fanned out the conductors and smooshed them together at equal length. Using both hands, I twisted the cable ends together into a more or less even mass of perfectly meshed wire. Now the trick... I slipped the EFI clamps down over the repaired section, about 1 inch apart, and tightened them, forming the repaired section in to a tight mass of copper. With the clamps in place I lit my torch and adjusted it so that about 1/2" of inner, light blue flame was present. I preheated the repair section and gently flowed in enough silver solder to petrify this repaired section into an impenetrable mass. The solder flowed smooth and perfect underneath the EFI clamps.   After about 5 minutes of cooling I loosened the EFI clamps and remove the screws. The clamps can now be peeled away from the repair section because the galvanized coating resists the solder mass. Once removed... a solid, cylindrical mass of copper and silver solder is there. I slipped a pre-positioned section of shrink tube over this and heated it up. I added multiple layers of red tape, then stuffed into two sections of loom.   I repeated this procedure on the two adjacent branch circuits from the battery to chassis electrical and EFI. Smaller gauge wire, same process. The car acts very diferently now. It cranks over like a spastic rabbit. Whereas before, it sounded like an old tired V-8. The cold idle RPM's are much higher, but settle right down to 850 when warm. Overall, better performance and pickup. Also, I took apart the alternator connection, de-ox'ed and sanded it, then flowed a solder joint into it as well. This problem is very widespread and was at the root of many vague problems the car has had for over a year. Worth checking out.

Procedure 2:   [Rafael Riverol] Let me suggest a repair for voltage drop from corrosion inside battery cable connectors. I has worked perfectly for me and it can be done with things that a DIY generally has ready at hand. So he need not go anywhere or spend any money. Take battery cable out of the car. Drive a small drill bit into the cable strands along the direction they enter the connector. Do not drill through the connector or make any holes in it. Push solder flux down the cable strands inside the connector. Hang the cable from your work bench or other place so that you will be able to apply a blow torch to heat the connector where it holds cable strands. Do so until flux boils over. Continue to apply heat and put in solder until it fills space around strands inside the connector. The flux cleans the cable stands and inside of the conector. The solder fills all empty space around cable strands inside the battery connector. Let the cable cool for a few minutes and then put it back on the car. You should have absolutely no voltage drop between cable and connector. This has worked very well for me and it takes only a few minutes to do and no money.

Painted Bumper Cover Repair. See Painted Bumper Cover Repair for more information.

Headlamp Wiper Motor Removal. See Headlamp Removal for more information.

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960 Brake Pulsations. 960/90 series front brakes are sensitive to rotor runout: see the FAQ

Section describing this.

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960 Driveline Noise: Failing Grease Seal at Rear of Driveshaft. [The Tom Irwin Chronicles, Ch 47: Tom finds a "tink-tink" sound coming from somewhere under the 1995 960. After repairing a cracked exhaust manifold, he starts examining the drive shaft and multi-link suspension.]
Continued: THEN, at THE VERY END OF THE DRIVESHAFT, just before it mates to the Rear end... I push up and down on it..... "TINK-A TINK-A TINK-A TINK"... and it moves a bit... That's "TINK-A TINK" under ONE 'HAND POWER'... start applying HORSEPOWER to it and the sound might EASILY sound like what I'm getting.... YES, this is it... Now... WHAT's Going on??? This driveshaft end looks different from the book, it tapers down from a tube to a solid rod, then it terminates at a LOBRO-looking joint with 6 or 8 HEX Screws and a few shims... it's only when in motion, or rather under acceleration.. REALLY LOUD "TINK-A TINK-A" noise. Like an exhaust pipe... But I just replaced EVERYTHING North of the Resonator... This end of the driveshaft SEEMS to be a tube welded around a shaft rod, like a modified Constant Velocity Joint, with a rubber boot and the works..?? What's inside the cadmium-plated cap? A Bearing/Bushing? Did something possibly break in there? Do you just need to re-pack the grease sometimes? There is a LARGE AMOUNT of dried, caked grease all over all around this thing and the gas tank tunnel where that bugger sticks out... Looks like it has been SLOWLY losing a bit of grease every so often over 5 year and 125k miles. The boot looks ok... probably out of the end cap... I'll use the RTV.. Interestingly the spray pattern of the grease is fairly widespread, fore and aft span totals about 18 inches. I'll bet tomorrow I'll find it dry as a bone... hope there is no galling or pitting of the balls. THIS appears to be the cause of the "TINK-A TINK-A TINK-A" sound, previously blamed fully on the broken cat pipe..... That little burp up to 6,200 RPM dropped me crisply into 1st gear and must have WAILED the shit out of that shaft, displacing enough grease to allow the bearing to slap. The noise of course would be amplified by yet ANOTHER STEEL sleeve tube over an inner pipe/shaft...
[Comments from Abe Crombie] The end of the shaft is welded to a splined shaft to accept the joint. It is a CV joint with the inner 6 slot hub driving the outer 6 slot housing via 6 10mm +/- ball bearings. The grease can dry out and the joint will wear a bit and the driveshaft will actually begin to move axially and make noises. If you are lucky the grease will fix it indefinitely. Does the grease deposit line up with the CV joint-pinion flange joint or does it look like it escaped through the boot? The boot on those should last almost forever unless road crap maybe damages it. If it looks like it seeped through the cap then seal it with silicone sealer on outer perimeter to prevent this loss of lube again.
You can remove rear section of shaft from pinion flange via the 6 Allen bolts. Tap the end cap off the joint. Once the shaft is removed at rear you will see the back end of this joint is closed by a cadmium-plated cap. You should be able to tap around the edge of the cap and get it off. Wipe out the grease and then pack it full of wheel bearing grease and then place cap on and reinstall shaft on pinion flange. Oh, BTW if it's not too late you should mark the joint to the flange to preserve balance if it was dynamic balanced. It will be paint-marked if the paint has lived this long.
These assemblies have no history of failure so piece service parts aren't available. The whole shaft would need to be replaced. The CV-jointed rwd driveshafts like this are rarely serviced on any of the Euro (Volvo,Benz, or BMW) models.

[Comment on Grease from Jim Bowers] I believe the grease for CV joints is something more than axle grease. Years ago, I used to get some special stuff from the dealer for the CV joints on the axles of my Porsche. It looked like it was loaded with Molybdenum Disulfide. Anyway, I think the parts store should have something recommended specifically for CV joints.

Removing the Camshaft Position Sensor. [Inquiry] How do I remove the exhaust camshaft position sensor (CMP) sensor? [Response:DanR] I had to remove mine once and it was a bear to get out. Use a high quality T-40 bit (the T-45 is too loose); you want the tightest fit possible. I ended up botching the top bolt and having to saw it off. [David Aidnik] Get a ratcheting 1/4 inch box end wrench. Snap On makes one which is 1/4 & 5/16 and is a short flat thing about 1/4 inch thick and about 4-5 inches long. The wrench flips over to select tightening or loosening. Mount in the 1/4 drive end a short (less than one inch long) T-40 Torx bit. Hold the bit firmly in the Torx screw with the end of your finger while you carefully crack the bolt loose with the wrench.

Camshaft Position Sensor Connector. [Inquiry] My connector disintegrated; can I obtain another? [Response] Volvo sells most of the connectors used on the car. Look it up in the dealer's parts diagram and visually identify the one you need. You can order it separately. If the wires have come out, the colors from left to right, with the two bumps or notches and spring clip on the connector up, are: grey (ground), green (+5V), red (+12V).

OBD Code 2-1-2 for "Faulty Oxygen Sensor" in 960 Cars. See the discussion regarding cleaning the connector.

OBD-II Scanner for 96+ 960/90 Cars. See the FAQ section under Engine and OBD Diagnostic Codes.

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960 Fuel Tank Hose Failure. *Symptoms*: When the tank is filled all the way up gas can be smelled inside the car and sometimes there is also a leak. [Diagnosis: Walt Poluszny] The rubber hose from the filler to the tank has a "Y" in it, which sometimes cracks at the "Y" or where it connects to the tank, and leaks fuel. You can view the rubber hose by taking out the carpet in the truck and removing the 4 bolts that hold the Fuel Pump/Level Sending unit access hatch on the rear uppser level of the trunk. [Repair Tips: Michael Diamante] The small hose was torn at the clamp close to the fuel tank. The clamp uses a small torx screw. The head was facing the body of the car and was not accessible. Out of desperation I tugged on the hose and it came right off. Without lowering the fuel tank, I wasn't able to reinstall the clamp as it came from the factory.

When I changed the hose I first thought that I could do the job entirely from the top. I soon discovered that I needed to be under the car to see the small hose connection. I put a jackstand under the right rear jack point and was able to see the access hatch and hose connection. I used a torx bit on a ratchet with extensions to remove the screws to the valve that hangs down in the way on the right side. I disconnected the small hoses surrounding the fuel filler hose. I disconnected the hoses from the valve and set it aside. I disconnected the fuel filler hose from the fuel sending unit. Using a combination of offset screwdriver and flexible driver, I disconnected the fuel filler hose from the fuel filler tube. I then discovered that I couldn't unscrew the clamp to the small hose and thought that I might be able to cut it off. As a last attempt before cutting, I tugged on the small hose and it easily came off. If I had to do it again, I would tug on the small hose before disconnecting anything else. Installing the new hose wasn't the easiest thing in the world. The large section of hose fits tightly. Fit the hose over the fuel sending connection. Leave it loose so that you can twist it into position to slip over the fuel filler tube. I had to wiggle and push and finally got the hose to fully cover the fuel filler tube. When replacing the valve, attach the hoses before tightening the screws. There isn't clearance to attach the hose at the front of the access hatch if you tighten the valve bracket first. I would consider using a different type of clamp for the small hose. Something easier to tighten and loosen. When I was attempting to attach the small hose and clamp the first time, I discovered that the body dips down and gets in the way of the clamp. A thinner clamp would be good. The hose was about $45.00 + tax from the dealer. The part number on the new hose was the same as the original. On my 93 960 there is a valve of some kind on the right side under the lip of the access hatch. Its bracket is attached with two torx screws. I removed it to ease access to the small hose connection.

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960 Air Conditioning Failure Points. [Rafael Riverol] See the discussion on steel bolt-to-aluminum tube corrosion leaks in 960 air conditioning compressors. See the separate discussion on 960 air conditioning compressor clutch failures.

Torque Values for B6244, B6254, and B6304 Engines. [Alex] See note below on bolt sealing requirements.

Components	Nm (ft. lb) or degrees
Exhaust manifold, at cylinder head	25 (18)
Exhaust manifold, at heat shield	15 (11)
Cylinder head, stage 1	20 (15)
stage 2	60 (44)
stage 3 (angle tightening)	130°

Cylinder block, intermediate section, stage 1 (M10)	20 (15)
stage 2 (M10)	45 (33)
stage 3 (M8)	25 (18)
stage 4 (M7)	17 (13)
stage 5 (M10) (angle tightening)	90°
RPM Sensor	5 (3.5)
Intake manifold	20 (15)
Camshaft carrier cover	25 (18)
Camshaft pulleys	20 (15)
Timing belt, tensioner pulley	25 (18)
Timing belt, tensioner mounting	25 (18)
Timing belt, idler pulley	30 (22)
Knock sensor	20 (15)
Coolant pump	20 (15)
Carrier plate, stage 1	45 (33)
stage 2 (angle tightening)	50°
Torque arm, stage 1	50 (37)
stage 2 (angle tightening)	90°
Torque converter	40 (30)
Flame trap	15 (11)
Oil sump plug	35 (26)
Oil pump	10 (7)
Oil sump	20 (15)
Oil pressure sensor	25 (18)
Flywheel, stage 1	45 (33)
stage 2 (angle tightening)	65°
Vibration damper, center nut	300 (221)
Vibration damper, flange bolt, stage 1	35 (26)
stage 2 (angle tightening)	60°
Spark plugs (do not oil)	25 (18)
Conrod bearing caps, stage 1	20 (15)

stage 2 (angle tightening)	90°
Gearbox, to engine	50 (37)

Hermetically sealed bolts are used where a perfect seal is required. Replace bolts once undone or seal with new sealing compound: HYDRAULIC THREAD SEALING COMPOUND part number 1161056-5; follow instructions on pack. The service bulletins include a list and illustrations of hermetically sealed bolts on the B6304 engine. Click on the thumbnails below to see the list and illustrations of sealed bolt locations on these engines.

Intake Side Sealed Bolts	Exhaust Side Sealed Bolts	Front-Rear Sealed Bolts

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Notes on Cleaning Up Fuel System Deposits

Injector Deposit Problems. [Import Car Magazine, Mar '03 by Larry Carley]

To save a few pennies per gallon and to increase the competitive and/or profit margin of gasoline, some suppliers have cut back on the amount of detergent they add to their fuel or have switched to cheaper and less effective additives. Commonly used deposit-control additives include polysibutylamine, polyisbutylene succinimide and polyisobutylene phenylamine. But these same additives also can build up on intake valve stems causing them to stick. To prevent this from happening, additional additives called "fluidizers" must also be added to the fuel. But, over time, these can contribute to the formation of combustion chamber deposits that raise compression and the engine’s octane requirements. Dirty injectors lean out the fuel mixture and contribute to lean misfire, hesitation and even detonation.

Cleaning should restore like-new performance. One of the best additives is polyetheramine. It keeps injectors, valves and combustion chambers clean without the help of any additional fluidizers - but it costs more than twice as much as the other commonly used additives. How much additive does it take to provide an adequate level of protection? Industry sources say the recommended level is about 1,000 parts per million (ppm) of dispersant-detergent in the fuel - which costs the gasoline supplier less than a penny a gallon. Even so, as much as 85% of the gasoline that’s being sold contains only one-tenth of the recommended dosage, or only 100 ppm of additive. Consequently, using cheap gas contributes to the formation of injector deposits. .. The classic symptoms of dirty injectors include lean misfire, rough idle, hesitation and stumbling on light acceleration, a loss of power, and higher hydrocarbon (HC) and carbon monoxide (CO) emissions.

Gasolines with Detergents. In the United States, the new Top Tier gasolines are certified to have adequate detergent levels to remove intake system deposits as determined by the Top Tier group of GM, BMW, Honda, and Toyota. Since the minimum additive performance standards were first established by EPA in 1995, most gasoline marketers have actually reduced the concentration level of detergent additive in their gasoline by up to 50%. As a result, the ability of a vehicle to maintain stringent Tier 2 emission standards has been hampered, leading to engine deposits which can have a big impact on in-use emissions and driver satisfaction. Top Tier fuels are recognized by the vehicle manufacturers as having the most effective additives and in the highest concentrations. Gasoline retailers must meet the high Top Tier standards with all their grades of gasoline (not just premium) to be designated a Top Tier supplier. In addition, all the gasoline outlets carrying the brand of approved gasoline also must meet the same standards. Gasoline retailers who are currently on the Top Tier list include Chevron, Chevron-Canada (B.C. only), Texaco (Chevron supplied only), Conoco, Entec Stations, Kwik Trip/Kwik Star, MFA Oil Company, Phillips, QuikTrip, Shell, The Somerset Refinery and 76. See their website at http://www.toptiergas.com/

Fuel Additives [Mark Burns]

Some of the high end aftermarket fuel additive packages are very effective at removing deposits in the fuel injectors, intake ports, intake valves, combustion chambers, and exhaust valves. One of the best products available is the STP Complete Fuel System Cleaner. It can out perform Techron and other Techron-based products like Slick 50 and Gumout Regane with respect to intake valve and combustion chamber clean up. These aftermarket packages can remove any and all deposits in the system if used at sufficiently high or repetitive dosages although there is some risk of crankcase lube contamination. All deposits in the system are carbonaceous. The structure of the deposits in the injectors is different from the structure of the deposits on the valves is different from the structure of the deposits on the combustion chamber, but all are carbon based. The chemistry that is able to remove each type of deposit depends on the temperature profile that each area sees and the thermal stability of the detergent in the additive package. Since October 1, 1993, all gasoline marketers are required by the federal government, according to the Clean Air Act Amendments, to deliver a minimum level of deposit fighting additives in their fuel. Up to that time, deposit control additives had been used to differentiate branded gasoline. The major gasoline marketers usually added at least a competent package to all of their grades. The lesser known brands rarely added any additives at all. About thirty percent of the gasoline sold were not additized. The minimum level of deposit control performance that all gasoline must meet are two standard deposit control tests-the ASTM D 5500-97 BMW intake-valve deposit test and the ASTM D 5598-95 Chrysler 2.2-liter port-fuel-injector test using a test fuel that encompasses the sixty-fifth percentile of U.S. fuel severity parameters. This federally mandated requirement for gasoline has established a lowest common denominator for deposit control performance.

Gasoline additive suppliers have found ways to minimize additive dosage and "beat" these two tests. The result has been an overall reduction in the deposit control performance of U.S. gasoline. While a fuel marketer may have data demonstrating that their specific additive package once passed the BMW intake valve test and the Chrysler port fuel injection test, there are no guarantees that the gasoline they are marketing will provide adequate performance in any consumer's engine. There are many commercial gasoline, available in the market today, including some major national brands, that, when tested in fleet test vehicles representing various drivetrain configurations, have developed more than 1000 milligrams on the intake valves. This is ten times the maximum amount of deposit allowed for passing the BMW intake valve test. There is even some evidence that the very low levels of deposit control additives being used by some gasoline marketers actually make the base gasoline create greater levels of intake valve deposits in the average engine than the unadditized gasoline would. It could be suggested that more consumers on the road today could benefit from the occasional use of a high quality aftermarket additive package than ever before. In some gasolines on the market, use of a high quality gas treatment package would certainly be advised if a driver wants a greater degree of certainty that their engine will be kept clean.

[Paragraph from Dave Stevens:] The prevailing wisdom seems to be that BG44K is an excellent, but very strong cleaner, really only appropriate for use on badly carboned/neglected engines, especially considering its cost. I mean, you don't need oven cleaner to do the dishes. You can try getting it through a friendly shop or auto supplier or you can try getting it from one of the auto e-tailers. Other top end/injector cleaners you may want to try are AMSOIL PI (through distributors like our Paul S), Chevron Techron (concentrate) and Redline SI. That's more or less the order of preference I've seen. Some of the house branded injector cleaners (like GM and Mazda) are reportedly as strong as BG44K. There are many other injector cleaners out there, some may be okay, especially for routine use. Just be sure to avoid the cheaper, older solvent based cleaners that might attack the fuel system and injector seals. Periodic use of additives (like every year or so) should be the most that's necessary if you use quality gas, your engine is properly tuned and you do a reasonable amount of highway driving. If you buy cheaper gas with minimal additives or lower octane than the engine requires or if you do strictly stop and go driving, then more frequent use (like every few months) may be required.

Other Approaches to Deposit Control

There are other approaches to the fuel system cleaning besides adding aftermarket fuel additives. One is to use water as described in the FAQ link, one is the fuel tank/vacuum induction fuel system cleaning approach that many quick oil change places use and one is the high tech, expensive (some of these machines cost $4000), and complicated machine approach. Water is a great deposit remover. It is just like steam cleaning the combustion chamber.

Unfortunately, the heavy components of fuel and fuel additives are liquid during the combustion process and don't get completely burned. About 25% of the active fuel additive components (the oligimeric detergent and fluidizer components) end up in the crankcase. These components may or may not be compatible with the oil. As you can imagine, water does not burn. It may leave through the exhaust valve as steam or it may end up in the crankcase. Do you want 25% of the total amount of water used in the cleaning process to end up in the crankcase? You can change the oil right away or you can run the engine long enough and at a sufficient speed to distill off the water. After any of the serious fuel system cleaning, the oil should be changed anyway. You can draw your own conclusions about the effects of water in the crankcase and the prospects of getting all of it out, but you can clean up the engine just as effectively without the use of an oil insoluble actor. There are some systems out there that use water in the fuel system cleaning. I think these systems usually employ some kind of very expensive machine. I don't think they clean more effectively than the fuel tank/vacuum induction fuel system cleaner. Cars are sensitive to deposits, but not that sensitive.

The fuel tank/vacuum induction fuel system cleaner cleans injectors, intake valves and the combustion chambers through the action of the bottle of additive poured into the fuel tank. The vacuum inducted intake system cleaner is added through a vacuum line behind the throttle plate. The purpose of the intake system cleaning is to remove deposits left by the PCV and the EGR as well as aiding in cleaning up the intake valves, ports, and combustion chambers. One brand that is very effective and provides a high quality product is C.A.T. Products makers of Run Rite.

The tool used to induct the intake system cleaner into the vacuum line is usually a metal bottle with a tube in it that connects to a hose with a fitting on one end to connect to a vacuum line close to the throttle plate on the vacuum side. There will be no problem as long as the engine is running, it will suck in the cleaner. If the engine stops but the fluid keeps flowing, you can hydrolock the engine and damage valves, rods, pistons and gaskets. These tools often have a valve in line and a clear portion in the hose after the valve to adjust the feed and monitor the flow so that it is a steady drip. The fluid usually used in the bottle is an air intake/throttle plate cleaner package. Only the additized fuel in the tank goes through the injectors. Based on what I have seen, this should work as well as any injector cleaning scheme on the market. Fuel injectors deposits are not as much of a problem now as they were a few years ago. New injectors are more resistant to deposits and most gasolines, as poor as they are at controlling most deposits today, still can keep injectors (and carburetors) clean. STP Fuel System Cleaner works very, very well. Two bottles should have them spotless and will clean the valves, ports, and the combustion chambers. The fuel tank/vacuum induction fuel system cleaning makes an immediate difference in the way the car runs. It must have something to do with the EGR and PVC deposits. You can also try to replace the PCV. The beauty of the vacuum induction fuel system cleaner approach is that it doesn't require a degree in mechanical engineering and a master mechanic certification to operate: pour a bottle in the tank then find a vacuum hose and suck a bottle of the intake system cleaner into the intake. I don't think the systems that utilize the expensive machines actually clean the fuel system any more thoroughly.

The problem with the machine systems hooked up to the fuel rails is that they can not clean the parts of the system that the fuel does not get to. Cleaning through port fuel injectors can clean the injectors, intake ports, intake valves, and combustion chambers. Cleaning through the vacuum line cleans the entire intake manifold, intake ports, intake valves and combustion chambers while the fuel additive added to the tank cleans the injectors, intake ports, intake valves, and combustion chambers, albeit at a slower rate as the fuel in the tank is burned over about 350 miles. I think the fuel tank/vacuum induction fuel system cleaner approach may, in fact, provide a more thorough cleaning. I personally do not believe that the expensive and complicated machine/high pressure systems have any advantage over the simple approach that we are using. They do, however, have a major drawback in that there are more things to go wrong. The technician has to disconnect the fuel pump and connect to the fuel rail. There is big potential for disaster with this approach if the technician is not highly trained. It is pretty easy to pull off a vacuum line and suck in the cleaning solvent. If the vacuum line is not reconnected properly, the car will not run, but it is easy to diagnose and fix. It is also unlikely to burn the car up if the technician doesn't do something right.

The walnut shell blasting can be done without removing the head. It is a fairly difficult operation and requires the right equipment. You also have to make sure you remove all of the residual walnut shell. All in all, the aftermarket fuel additive packages or the fuel tank/vacuum induction fuel system cleaning are probably the least intrusive approaches.

Coolant Information Links. Here are some links to informative sites about coolant and antifreeze topics:
http://www.team.net/sol/tech/coolant.html This comes from the Triumph Car Club and discusses basic coolant information.
http://www.texaco.com/products/ This is the Texaco Dexcool product information site.
See the following reference web sites for information on automotive coolants:
http://www.vanagon.com/info/articles/coolants.html
http://www.eskimo.com/~dalus/bmw/all/misc/all_antifreeze_info.html

Notes from the Jaguar Lovers Club by Jim Crider. Here's a response from someone who designs vehicle cooling systems for a living ...... (that would be me):

Strictly looking at the heat transfer coefficient, straight water is the way to go.   HOWEVER... straight water has its problems, notably a lack of certain additives that prevent cavitation of the water pump at high speeds; corrosion of the various metal bits present in all engine cooling systems; surfactants to lower the surface tension of the coolant (allowing it to "wet" the surfaces of the coolant passages better); anti-foaming agents to keep the surfactants from making big bubbles; and freeze point and boiling points that are closer together than a mix of coolant and water.. All these are present in antifreeze/coolant. The surfactants and anti-foaming agents are present in Redline Water Wetter. Water Wetter has limited to no benefit in a system using a commercial coolant -- it's simply adding more of something already present in sufficient quantity.

There are two types of base coolant stock available right now: Ethylene glycol (EG) and propylene glycol (PG). Currently, no engine manufacturers selling product in the US recommend PG (sold by Arco as Sierra brand coolant), most caution against it (check your owner's guide). PG has a higher boiling point than EG (straight), but has a lower heat-transfer coefficient. EG coolants also come in several flavors, depending on the additive package (more below). BTW, PG isn't truly non-toxic. It's LESS toxic than EG, but PG coolant contains various and sundry additives that aren't really good for you. Basically, the less-toxic claim only applies if you pour the stuff straight out of the bottle and onto the ground. Don't bother with it. And treat *any* used coolant as low-level hazmat. Small amounts can be disposed of in sanitary sewer systems, but you're better off making nice with the operator of the neighborhood quickie lube place, who will be able to take it off your hands and get it into the recycling stream, sometimes for a nominal fee.

The green-dyed EG "conventional" coolant we all know and love has an additive package based around a silicate (and sometimes also phosphate) based anti-corrosion additive. It's well-established and does a good job. It can go 5 years/50K miles without worry.
A few years ago, someone thought a long-life coolant (original plan: life of vehicle) would be a Good Thing. This lead to Organic Acid Technology coolant (OAT), which is marketed as "DexCool" by GM and has been factory-fill in their products (except C4 Corvette -- not sure about C5 Corvette) since 1995. It's the orange or orangy-red stuff. Someone along the line decided the word "acid" was a Bad Thing to try to sell, so OAT was recursively changed to Organic Additive Technology. It can go 5 years/100K or 150K miles -- provided it's not mixed with other coolant. OAT has less cavitation resistance than silicate-based coolant, and can

attack certain sealing materials, so it's not a good idea to convert a green-coolant car over to OAT unless the manufacturer says it's okay. OAT also has a tendency to stain translucent plastics in things like overflow bottles and pressurized de-gas bottles with a funky brown crud. Oh, and OAT from one manufacturer isn't necessarily compatible with OAT from a different manufacturer. Texaco is GM's OEM supplier and is licensed to use GM's "DexCool" trademark on their aftermarket packaging. I'm not aware of any other company being licensed to do so.

Many European automakers use a hybrid of OAT -- HOAT (Hybrid Organic Additive Technology -- clever, huh?), which is the OAT package with a small amount of silicates added to increase the cavitation resistance and make it less aggressive against those seals and gaskets. This is often pale yellow in color. DaimlerChrysler is using it in several car lines now, too, notably the LH sedans and the new minivans and PT Cruiser. This stuff seems to offer pretty much the best of both worlds -- it's not quite as long-lived as straight OAT, but it is much better behaved in operation than OAT, much like conventional coolant. It is now sold by Valvoline under the Zerex G-05 label and by Texaco as Havoline Custom-Made.

Note that these three different additive packages are not really cross-compatible. No, they won't eat the insides of your radiator if you mix a little of one in with another in a pinch, but you'll be better to get the system flushed out and a fresh mix of 50/50 whatever your car needs put back into it. In my own cars, I run a 50/50 EG/W coolant mix. I happen to own cars that take conventional coolant, but if I owned a car that came with OAT or HOAT from the factory, I'd likely stay with it. The anti-corrosion additives, in particular, leave residues on the walls of the various coolant passages (that's how they work -- the residues coat the base metal and prevent corrosion), and it's tricky to convert an engine that's been run with one style of package to use another package and get the full benefit. Switching from conventional to OAT, for instance, requires a mild acid flush of the cooling system after removal of the conventional coolant and before pouring in the OAT if the long-life corrosion benefits of the OAT coolant is to be realized. Just pouring the OAT in after draining the conventional won't gain the full measure of added coolant life the OAT marketers (notably Texaco) like to use as selling points. [Note from Texaco regarding rumored incompatibilities:] "We have seen the statement many times that "On '93 and older GM models, use of this antifreeze is discouraged because its chemical ingredients can interact with the copper-soldered joints inside the radiator." It was even in Motor Trend recently, which has spread the rumors further. The statement is not true. Havoline Extended Life Antifreeze DEX-COOL can be used in any car including 93 and earlier model GM cars without any problems.

It is true that some older GM cars used a high lead solder in copper brass radiators where their newer cars are all aluminum. However, Havoline Extended Life Antifreeze DEX-COOL protects the high lead solder very well, there is no detrimental interaction with the solder or radiator, and there is no need to be concerned. Indeed, although GM decided to be conservative in not recommending DEX-COOL for all older cars, Texaco has recommended Havoline DEX-COOL for ALL cars, and stands behind the product in ALL cars. "

[Stephen Goldberger] It is claimed by the manufacturer to leave a thinner inhibitor layer on the metal, resulting in improved heat transfer, and it is claimed to be less abrasive to the water pump seals. The inhibitor in "DexCool" is a non-silicate formulation, more along the lines of the European sebacic acid practice, but it is not the same. The 100,000 mile or 5-year recommended change interval is only true for vehicles which had "DexCool" as original fill; otherwise, it is recommended that the original factory change interval be adhered to.

[Notes from Underhood Service Magazine, Oct 2005] There are essentially three basic types of coolants:

> Traditional North American "green" antifreeze, the original "universal" formula that everybody used until the introduction of extended-life coolants 10 years ago. The fast-acting silicate and phosphate corrosion inhibitors provide quick protection for bare iron and aluminum surfaces, and have a proven track-record of providing trouble-free service in virtually any vehicle application (domestic, Asian or European). But the short-lived nature of the corrosion inhibitors means this type of coolant should be changed every two to three years or 30,000 miles (though some products now claim a service interval of up to 50,000 miles with improved chemistry).
>
> OAT-based extended-life coolants. OAT stands for Organic Acid Technology, and includes such ingredients as sebacate, 2-ethylhexanoic acid (2-EHA) and other organic acids, but no silicates or phosphates (except in the case of Toyota's pink extended-life coolant, which adds a dose of phosphate to its extended-life OAT-based antifreeze). OAT-based coolants are usually (but not always) dyed a different color to distinguish them from regular North American green antifreeze. GM's OAT-based Dex-Cool is orange. Volkswagen/Audi uses a similar product that is dyed pink. But Honda has an extended-life OAT coolant that is dyed dark green and does not contain 2-EHA. The corrosion inhibitors in OAT coolants are slower acting but much longer-lived than those in traditional North American green coolants. Consequently, OAT coolants typically have a recommended service life of five years or 150,000 miles. OAT corrosion inhibitors provide excellent long-term protection for aluminum and cast iron, but may not be the best choice for older cooling systems that have copper/brass radiators and heater cores. It depends on the formula. One ACDelco spokesman said they do not recommend Dex-Cool for older vehicles with all-iron engines and copper/brass radiators.
>
> Hybrid OAT coolants, also known as "G-05." This formulation also uses organic acids, but not 2-EHA (different organic acids are used). Hybrid OAT coolants add some silicate to provide quick-acting protection for aluminum surfaces. Silicate also helps repair surface erosion caused by cavitation in the water pump. Hybrid OAT coolants are currently used by many European vehicle manufacturers as well as Ford and Chrysler.

[*Notes from Motor Magazine, Aug 2004*] The "DexCool" designation means the coolant passes General Motors performance testing. Although DexCool is not a specific formula, all three brands that have the label (Texaco Havoline, Prestone Extended Life and Zerex Extended Life) are somewhat similar. In particular, they're OAT coolants, but the similarities go beyond that basic description. All DexCool-approved coolants to date use two organic acid rust/corrosion inhibitors, one called sebacate, the other called 2-EHA (which stands for 2-ethylhexanoic acid). These organic acids are very stable and last a long time, although they take thousands of miles to become fully effective in protecting coolant passages. GM recommends a DexCool change every five years or 150,000 miles, whichever comes first. Because most people drive 15,000 to 20,000 miles a year, that translates to a five-year replacement interval. As noted, the thousands of miles required to protect metal is an important trade-off for that longer life. Although like conventional coolants, OATs also contain other inhibitors, for targeted protection. The inhibitor 2-EHA works well in hard water and is more effective than sebacate at lower pH levels (when the coolant moves from the alkaline end toward the acid side), particularly for cast iron. Well, GM has a number of cast-iron engines. When there's a low coolant level in the coolant passages, the exposed cast iron rusts. Apparently, that rust is washed away later by flowing coolant, and is deposited in the heat exchangers. It eventually produces the rust powder problems that have been so widely observed... The inhibitor 2-EHA poses another issue: It's a plasticizer (softens plastic), so it has been blamed for coolant passage gasket leakage. Softening (and the resulting distortion) was reported by Ford, which encountered gasket leakage problems when it tested a DexCool-type formula on its V8 engines. Ford also saw similar issues with other gasket materials... Ford and Chrysler Group use G-05, a low-silicate, no-phosphate formula long specified by Mercedes, even for its passenger car diesels. What is G-05? It's called a HOAT (for hybrid organic acid technology) that today serves for extended intervals, typically 5 years/100,000 miles. Like conventional Euro coolants, it's a low-silicate, no-phosphate formula designed to pass European hard water tests. The reference to OAT in HOAT is for an organic acid inhibitor called benzoate, which actually has been used for many years in almost every American, Japanese and European conventional coolant except what we now call OAT. Honda and Toyota use a new extended-life OAT coolant-made with sebacate as the only organic acid and no 2-EHA. Sebacate isn't quite as effective in combating corrosion at lower pH levels, but because that's more of a cast-iron issue, it apparently didn't concern the Japanese. Both Honda and Toyota do continue to avoid silicates, but add a dose of phosphates to provide fast-acting aluminum protection, particularly to recoat the water pump after cavitation erosion/corrosion.... One of the issues that may arise is the use of an aftermarket replacement radiator or heater core made of copper-brass with lead solder. We have in previous articles pointed out that today's coolant inhibitor packages contain a small amount of copper-brass protection, but may provide little protection if a radiator is made with high-lead solder. Results of industry standard tests of the new Toyota extended-life coolant now show a substantial weight loss (corrosion), both in a 50-50 mix and in a 33% coolant mixture (solder corrosion is much greater in this more diluted solution). If you have to change a radiator or heater core, use aluminum. Or, if it's an older car and the owner wants the lowest-cost radiator, you might procure a soldered-together copper-brass unit. Conventional American coolant should provide better protection against solder corrosion, which can result in radiator tube restrictions and leaks. But no coolant provides perfect protection.

Makeup Water. [Tip from Prestone and consistent with other manufacturers' recommendations] We would consider the order of preference for water to be as follows:

1. 1st choice: Type IV water- Both demineralized & deionized.
2. Next choice: Distilled water
3. Next choice: Bottled water (like the type at a grocery store)
4. Last choice: Tap water

Note that the "deionized" water available at the supermarket may be merely softened with sodium replacing some of the other ions. While this is OK, distilled is a better choice. Note as well that a prevalent urban legend cautions against "distilled water as too aggressive"; in a coolant mixture this assertion is ridiculous.

Lubricants:

Oil Information Links. Check out these great links to find out all/more than you ever wanted to know about oil:

> http://bobistheoilguy.com/

Two excellent book references are:

- Synthetic Lubricants and High-Perfomance Functional Fluids, 2nd Edition, Leslie R. Rudnick and Ronald L. Shubkin, editors, 1999, published by Marcel Dekker, Inc. New York
- Automobile Engine Lubrication, Alphonse Schilling, 1972, Scientific Publications Ltd., Broseley, Shropshire, England translated from French.

Synthetic Oil Notes. [Tips from Geoff Williams, edited] I have spent the last 6 months learning about which oils will work best in my new VW TDI engine. In that process I have come across a wealth of information. I'll state the following hopefully in a straight forward manner (BTW my wife is now the primary driver of our '86 240 wagon).

1. Oil Groupings. American Petroleum Institute (API) has defined five groups (I through V) of base lubricating oils. The system established three groups (I-III) of paraffinic base oils based on levels of saturates, sulfur, and viscosity index (VI), as well as PAO-based oils (IV) and ester, PAG and other oils (V). Recent developments include the informal (non-API) addition of "+" subcategories and a new Group VI:

- Group I. Mineral oils refined using the historical techniques (i.e., solvent extraction of aromatics, solvent dewaxing, hydrofining to reduce sulfur content). This processing produces mineral oils with sulfur levels typically greater than 0.03% with viscosity index (VI) of less than 90.
  - Group I+: Still have high sulfur and low saturates, but processing conditions have been adjusted to make higher VI. This higher VI, in the range of 100-105, gives better cold cranking and Noack performance, enabling these base oils to be used in 10W-30 engine oils with minimal Group III or Group II+ correction fluids.
- Group II. Mildly hydrocracked mineral oils with conventional solvent extraction of aromatics, solvent dewaxing, and more severe hydrofining to reduce sulfur levels to less than 0.03%, as well as removing double bonds from some compounds. Viscosity index is approximately 90-100.
  - Group II+: There is now an informal Group II+ (not an official API definition) which emerged out of the need to describe base oils with a meaningfully higher viscosity index than the 100 than is typical of most Group II base oils. Group II+ base oils, produced through altered refinery processing conditions, typically have VI in the range of 108 to 115. These base oils offer performance advantages over Group II in some passenger car motor oil applications, specifically related to balancing volatility with low temperature

viscometrics.

- Group III. Severely hydrotreated mineral oils with sulfur content between 0.001 and 0.01%; VI in excess of 120. These are considered VHVI (very high viscosity index) mineral base stocks. They behave like synthetics in VI but have much higher pour points (-20C versus -54C for PAO) which must be modified with pour point depressants for lower temperature use. They have lower oxidation stability than Group IV or V oils. These are made in proprietary processes by Chevron, Shell, Exxon, and others.
    - Group III+: New Gas-to-Liquid base stock lubricating oils are being developed for market introduction in 2005 that will compete with Group III and PAO at costs similar to Group I. These will enter the passenger car motor oil market in response to demands for more 0W oils. They are created using catalysis of natural gas and have properties similar to PAO. They will have VI's exceeding 140 and will be used for 0W-XX and 5W-XX engine oils and super-premium transmission fluids.
- Group IV. Poly-alpha-olefin (PAO) synthetic oils with VI of 125-150. PAO significantly outperforms Group III in low temperature applications without the need for pour point depressant additives.
- Group V. Everything Else: Esters, polyethers, polyalkylene-glycol (PAG) synthetic oils with various VI ranging between 100 and 175. Group V can include quite low quality base stocks, like naphthenic base oils as well as very high quality base stocks like esters
    - Esters are hygroscopic, causing water to enter the oil; and reactive, adding natural detergency, seal swell, and additive solubility to oil characteristics.
- [Europe Only] Group VI oils. These are polyinternalolefins (PIO) somewhat similar to PAOs. These oils are not readily available at present anywhere outside of Italy.

2. *Synthetic Base Stocks*. Group IV base stock is made of PAO and was for a while the only base used in synthetic oil until Group V (Esters) came along. PAO has a property of shrinking rubber gaskets, and when older cars were switched the leaking was generally due to this fact. Cars with new gaskets that used PAO-based oils from the beginning did not encounter shrinkage or leakage. The newer and the better synthetic oils began to incorporate a new base stock (group V -Esters) that helped to keep the rubber from shrinking. True synthetics are generally Group IV (PAO) mixed with Group V (Ester) base stocks, like Amsoil. Mobil began using straight PAO, switched to a very good blend of PAO and ester, then in their new Supersyn went back to all-PAO. Their additive package seems to be among the best. [Email from Mobil Products: Mobil1 Supersyn motor oil is not a hydrocracked oil, it is a group IV basestock which is a PAO base motor oil. It also has proprietary anti-wear synthetic package which is a group V basestock. The Mobil1 Supersyn is a fully synthetic motor oil with no petroleum additives.] [Comment from Geoff Williams: The first component (alkylated naphthalene) has the advantage over PAO and esters in that it has the best additive solubility and the best seal compatibility of the 5 most common engine lubricants (PAO, esters (2 types) and mineral oil). This is great news for older cars, with brittle seals that might be more suceptible to shinking with a PAO and ester-only based synthetic motor oil.]

3. *Is it a "True Synthetic"?* Prompted by a challenge to Castrol's use of hydrocracked Group III base oils in its Syntec product, the National Advertising Division of the US Council of Better Business Bureaus in 1999 allowed the definition of "synthetic lubricant" to include Group III-based oils. This decision resulted in a quick replacement of PAO by Group III oils due to $1.50 to $2 per gallon cost savings: most oil producers (with the notable exception of Mobil) made the

switch in their synthetic products. There is some controversy about claiming VHVI Group III base oils as "synthetic". According to an unnamed PAO expert quoted in Lubricant World magazine, "The quality of Group III products is inconsistent, and their physical properties are different from one manufacturer to the next." Marketers using G III VHVI base oils in their "synthetic" lines include Castrol (Syntec), Valvoline, and Petro Canada. Those using Group IV or V oils include Mobil. According to Lubricant World magazine, "The synthetic market in general has seen ... new blends, new product releases, and formulation changes" and this continues to the present. Because marketers do not freely disclose oil formulations, *caveat emptor* prevails.

4. *Oil Longevity*. Synthetics are designed to last longer than conventional oils. Changing the oil every 3000 miles with synthetic oil or even Castrol Syntec is a complete waste of money. IMPE, using Castrol Syntec (what was provided during the free service period) in my VW TDI Turbo Diesel for 10,800 miles (the recommended change interval) it was found through oil analysis of the oil taken out of the engine when it was changed that it hadn't broken down, and the additives were not depleted enough to warrant changing. That was after nearly 11,000 miles in a turbo diesel. Your Volvo puts less demands on an oil than my TDI running up here in Michigan at below freezing temps, and the oil still lasted that long. A 3,000 mile oil change does not make sense for any car unless you are racing it or you drive less than 10,000 miles a year. For $15 you can have your oil analyzed to determine if you are changing it too soon or waiting too long.

5. *API Standards*. The standards set by the API are very easy to meet. Look for the Chevy Corvette standards (GM 4718) if you want a good oil. Or if you want the best protection against wear use an API CH-4 rated synthetic oil. Anyone can make an oil meet most standards, but the standards don't look at the amount of caking or sludge deposits. The additive package and the Viscosity Improvers have more to do with longevity and do not affect the passing of tests but do affect the long term health of your engine.

6. *ILSAC Standards.* The latest standard from ILSAC is GF-4, a 2004 standard developed to meet tougher emissions and fuel economy standards mandated by the U. S. Government. Automotive OEM's need better fuel economy to meet Corporate Average Fuel Economy (CAFÉ) limits. They also need their catalytic converters to provide reduced emissions for 120,000 miles. Higher quality base oils are an important part of the solution to GF-4.

7. *Viscosity*. Per the SAE (Society of Automotive Engineers), viscosity is a measure of an oil's thickness, or resistance to flow. Lower numbers indicate thinner oil and higher numbers indicate thicker oil. There are two types of motor oils, single grade and multi-grade. Multigrade oils such as a 10W-30 are designed to have the viscosity of an SAE 10W oil at cold temperatures combined with the viscosity of an SAE 30 oil at engine operating temperatures, The "W" or "Winter designation indicates that the oil meets viscosity requirements for low temperatures (below 30°F). At the Chevron site http://www.chevron.com/ there is a nice SAE Viscosity Grade guide.

As an illustration, the Kinematic Viscosity is measured in centistrokes, the higher the number the thicker the oil (65 is thicker than 55) The Viscosity Index can be interpreted as an indicator of how thick the oil is, the LOWER the number the thicker or more viscous it is. The Viscosity Index of the base oil is a good measure of the oil's quality between 40 and 100 degrees C. At lower temperatures, some base stocks (Groups I-III) require pour point depressants and viscosity improvers which can break down over time. Hence, in comparing two base oils with the same VI, the better oil is the one with a lower pour point.

The following is for a 5w30 and a 0w30 made by the same manufacturer (synthetic based oils: Group IV and V blend)

Kinematic viscosity @ 100C cST (ASTM D-445 test) 11.5 and 11.3
Kinematic viscosity @ 40C cST (ASTM D-445 test) 66.00 and 57.3
Viscosity index (ASTM-D2270 test) 170 and 196

Now if we compare Castrol and look at the 5w30 compared to the 10w30 (Group I base stock nonsynthetic:)

Kinematic viscosity @ 100C cST (ASTM D-445 test) 10.7 and 11.3
Kinematic viscosity @ 40C cST (ASTM D-445 test) 63 and 80

Now in the same line of oils, a "monograde" SAE 30:

Kinematic viscosity @ 100C cST (ASTM D-445 test) 11.2
Kinematic viscosity @ 40C cST (ASTM D-445 test) 93

Quite a bit of difference there. . .

Here is some data from Chevron on their Supreme Motor oil (all Group II base, just like Syntec except they also sell a true synthetic:)

(numbers below are for 5w30 and 10w30 and 30, respectively)
Kinematic viscosity @ 100C cST: 10.4 and 10.4 and 11.5
Kinematic viscosity @ 40C cST: 62.5 and 69.8 and 101
Viscosity index: 155 and 135 and 101

Again the oil is thicker as the first number increases.
Here is QuakerState: 5w30 and 10w30 and 30 (all Group II base, just like Syntec except they also sell a true synthetic)

Kinematic viscosity @ 100C cST: 10.7 and 11.0 and 11.2
Kinematic viscosity @ 40C cST: 67 and 73.2 and 90.5
Viscosity index: 155 and 140 and 113

Here is Penzoil: 5w30 and 10w30 and 30 (all Group II base except for the straight 30 weight which is a Group I or solvent refined oil)

Kinematic viscosity @ 100C cST: 10.5 and 10.5 and 11.5
Kinematic viscosity @ 40C cST: 60 and 67.0 and 98
Viscosity index: 160 and 140 and 105

Remember that the 5 is just for start up and gives you better protection if you start you car often, and the last number is what your car sees in operation, But it is possible for a 30 to be almost as thick as a 40 weight oil. The 30 will in some cases give you better fuel mileage than a 40 weight.

The heavier weight synthetics are designed for cars that are burning or leaking oil not for properly running cars. There is a market because some folks have been running synthetic and recognize how superior it is but wind up with a slight oil leak. Switching to a heavier weight synthetic will help reduce oil consumption. But using a 5w50 has some other problems besides creating a thick film of horsepower-robbing resistance, it stretches the limits on stability over time. The viscosity improvers needed to have a 5w50 (the w stands for winter) displace some of the lubricating molecules and are the first component to break down and create deposits in your engine.

Volvo does not recommend a single grade motor oil; they recommend multi-grades for their engines. Single grades should only be used as per manufacture's recommendation.

Viscosity Index improvers are mentioned at Lubrizol in a New York taxi test: http://www.lubrizol.com/ This test was much different than the Consumer-sham-Report/Review test on NYC taxi cabs, the results are more meaningful. In summary, "the New York City taxicab fleet test provides persuasive evidence of the outstanding performance of Lubrizol viscosity modifiers. Despite the severe operating conditions, Lubrizol viscosity modifiers, combined with the Lubrizol performance package, provided superior engine cleanliness and durability. Further, they maintained their remarkable rheological characteristics over the extended drain intervals of the test, providing consumers with additional confidence that their cars will start and operate reliably in all weather conditions.

8. *Break-In Period*. The issue of using a dino/mineral oil as a break in oil is somewhat overblown. And since you are using Syntec, you are still using a mineral oil, NOT a synthetic oil. Like I said before, Syntec is a highly refined and stabilized MINERAL oil, it is not a synthetic in the terms you are thinking. Regular oils, Dino - mineral - petroleum - whatever you call them, are most commonly solvent refined, a process that leaves many impurities in the oil. Castrol and many other companies now are using the hydrocracking process that refines the crude oil without using solvent separation, resulting in an ultra clean pure product. BUT IT IS STILL A REGULAR OIL. If you want to switch to a synthetic oil wait till you have 10-20k miles on the engine. At that point your car should be 'broken-in' enough for you to feel comfortable about using a REAL synthetic.
A couple comments about break in myths and synthetic oil consumption after switching: Most break-in periods in new engines will be accompanied with some oil consumption. If this is not the case for a particular engine switching to synthetic early will not prevent normal break-in. The extra slipperiness of a synthetic might prolong the period but it will provide extra protection and as long as you don't beat up the engine by over revving it too much or loading the car up and climbing a mountain before it is broken in you should be fine.

9. *Switching to Synthetic Oil.* As far as switching from normal oil to synthetic I think that it is better to change over all at once, but you will need to make two or three changes before resuming or beginning normal change intervals. I would put a full crankcase of synthetic in, drive it for 1000 miles, change the filter, drive 2000 miles and change the oil and filter, and then change both after 3000 miles then begin either 5, 7.5 or 10k mile oil change intervals. The filter changes are important because the new oil will be removing lots of deposits and sludge and you don't want to overload a filter. The extra cost and time spend with the first few changes will be

rewarded with a smoother running car, lower costs (extended drain intervals, and if the proper viscosity is chosen fuel savings) and a nice clean running engine. [Added Remarks from Mr. Lube] The synthetic will clean a great deal of gunk out, which will plug the filter quickly. I have seen it happen at my oil change shop over and over and over. I tell people to bring the car back after a month to change the filter only. It can and will cause some damage. I do not think it is a matter of preference or choice really. Rather, the $4.00 filter will become plugged with the switch, and it is left to the wise to follow past experience and advice from the ample evidence. Get it changed, and you will be surprised how dirty the filter will be.

Check out these sites for more info on oil:

- Specifically this one for VW TDI engines:

  http://tdiforums.abahn.bc.ca/NonCGI/Forum5/HTML/000625.html
- Try this too:

  http://www.vtr.org/maintain/lubricants-redline.html
- Lubrizol Lubricant Data and lubrication theory: http://www.lubrizol.com

The Mobil and Chevron oil corporations sell synthetics and have good information on their sites.

10. Fuel Economy Issues. See Lubrizol's discussion of the effects of base oil on fuel economy at: http://www.lubrizol.com
[Williams:] My personal experience is in line with this and I have seen an increase in Fuel Economy of 10% (24 mpg to 26.5 mpg) since switching from a Group I 10W-30 to a Group III/IV/V 0W-30 blend.

11. Synthetic ATF. [Editor] In the Lubrizol "knowledge Base" site at www.lubrizol.com, they note that two European commercial vehicle automatic transmission makers have posted specs for mineral oil versus synthetic automatic transmission fluid lifetimes. Voith allows 60k km drain intervals on mineral oil and Group III (hydrocracked semisynthetics) ATFs and 120k km intervals on full synthetics, both in Dexron III specs. ZF allows 30k km for mineral oil, 60k km for "part" synthetic, and 120k km for full synthetic, again in Dexron. This is an indication of the value of synthetics in normal use. Mobil 1 ATF is a full synthetic.

Oil Filter Information Links. [Tip] For a comprehensive (but very much embryonic) study on common brands of oil filters, see:
http://www.scuderiaciriani.com/rx7/oil_filter_study/
This study was written by Russ Knize and may be found, if the link is broken, by searching on "Minimopar" and "oil filter".

Nitrile anti-drainback valve

For information on filters and filtration media, see: http://www.filtercouncil.org and look for "technical bulletins."

Kane Leung deconstructed a Mann W-917 filter, used on B230 series engines, to find:

Filter image

- Overall inner dimension of 3-1/4" diameter.
- Metal caps on both ends (unlike Fram which uses cardboard).
- An anti-drainback check valve, consisting of a full circumference nitrile rubber flap.
- A strong, spring loaded bypass valve with nitrile rubber seal.
- 90 pleats, pretty evenly spaced, each glued down very tightly. The paper is ribbed to keep the pleats separate.
- The filter pleat measured 2-1/4" tall, with 89 of the pleats measuring to 25/32" deep. The pleat at the crimp measured to 3/4".
- Each pleat offers 2 sides, for a total of 180 sides of filter surface. (2.25*0.78125*178) + (2.25*.75*2) yields just over 316 sq.inches. By comparison from the other oil filter study out there, the gigantic Ford/Motorcraft FL-1A offers 400 sq. inches of filtering area. In this same size, the Fram PH8 offers just 193 sq.inches. With the Volvo filters being shorter, you can imagine how little filtering area the Fram will offer.

Oil Additive Information Links. Thinking of using Slick 50 and other additives? Check out these references for more information:

> The Federal Trade Commission article on Slick 50 is here: http://www.ftc.gov/opa/1996/9607/slick.htm

Overall good advice is: always use high-quality lubricants at the proper viscosity range; never use additives, especially PTFE-based oil "enhancers."

Fuel:

Gasoline Information Links. See for gasoline information:

http://www.repairfaq.org/filipg/AUTO/F_Gasoline.html

Gasoline Recommendations for Turbo Engines. [Inquiry] What octane requirements work best with a turbo? Around here, 90 grade with ethanol is widely available; 92 is more expensive; Will 87, 90 or 92 work?

[Response 1: Bernard] The B230FT engine is set up for the North American market to run without problems on 87 octane engine (ROZ = MOZ :2). In today's view, that might not have been the wisest decision. Most drivers would appreciate a few horsepower more (maybe on B230ET-level) and rather spend 10 cents a gallon more on gas. Anyway, if knocking is detected on a late model 700 or early 900 car, the Bosch Motronic will retard ignition automatically. However, as with many other cars from other manufacturers, it might very well be that someone experiences knocking when buying no-name 87 octane gasoline. Many of turbo Pilots have therefore decided to run at least 89 octane, many even 91octane gas all the time, myself included. [Response 2: Phil] I'm stuck with that ethanol gas also. I can't run 89 so I'm stuck with the more expensive 92. When I can get undiluted gas it makes a noticeable difference in performance. If you can't get anything but the ethanol you'll probably need to use the 92. [Editor's note: using lower octane will cause retarded timing, lower power and higher engine operating temperatures. Use your own judgement.]

Reformulated (Oxygenated) Gasoline Areas. This map from the EPA shows reformulated gasoline areas in the US: Several reports have been received about poor quality reformulated gas causing valve seizures in B230 and B6300 engines driven on short trips with old gasoline.

Replacement for Leaded Fuel. [Editor] If you have an older engine (e.g., many EU cars through 1989) requiring leaded fuel, now unavailable in many countries, check this link from the UK Volvo Club for information from Volvo about dealing with your fuel needs.

Sulphur or "Rotten Egg" Odor. [Excerpt: Volvo Tech Tip 4/6] Hydrogen sulphide is created in the catalytic converter from sulfur in fuel. Its likelihood increses during short trips in stop-and-go traffic, hot climates, and winter fuel formulations. A sulfur concentration of 0.03% can cause the odor. Many regular-grade fuels contain well over 0.1% Replacing the converter will not solve the problem: only a low-sulfur fuel such as premium grade will work.

Car Storage, Fuel Degradation and Engine Deposits. [Based on Tips from Chris Herbst] If you store a car for long periods, be sure to use a fuel stabilizer to eliminate varnishing and deposit formation. There is some evidence that use of ethanol-based fuel in stored cars will result in serious valve damage: the fuel tank is coated with gummy precipitate, valve stems gum up with deposits and the head requires complete cleaning. See Car Storage Tips

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Volo 700\900 Hot Start Problem Diagnosis and Repair [FAQ Home]

Quick Reference Guide: Volvo 700\900 Hot Start Problem Diagnosis and Repair (by Mark Berglund)

Abbreviations:

AMM	Air Mass Meter
ECT	Engine Coolant Temperature sensor
ECU	Engine Control Unit computer (either fuel injection or ignition)
FI	Fuel Injection
FPR	Fuel Pressure Regulator
IAC	Idle Air Control solenoid valve
TB	Throttle Body
TPS	Throttle Position Sensor
VSS	Vehicle Speed Sensor

Overview

This diagnostic and repair tool was created to help individuals identify the cause and repair of the more common hot start problems in 700/900 series Volvos. Hot start problems have been well documented on the Brickboard. It is from this source that most of the information used to create this reference tool was gathered. As such, credit must be given to those individuals whose contributions made this reference tool possible. Regrettably, the names of all the individuals are not available to accomplish this so I can only give credit in blanket form. This work is not intended to be the final word on hot start problems. Rather, it is viewed as a work in progress needing continual additions and refinements to make it more useful to Volvo owners. Comments are welcomed and encouraged and should be directed to

Diagnosis

For the most part, the cause of hot start problems can be attributed to a component that is easily fixed and/ or replaced. It is divided into two sections based on the general nature of the hot start problem. The answer to the following questions will direct you to the appropriate section relating to your specific situation. Furthermore, when answering the questions, it is given that the vehicle had been driven for some time, the engine is at or slightly above normal operating temperature and has not been running for 2 to 10 minutes (hot soak) and subsequently starts fine after cooling down.

Question A: The engine cranks but does not start regardless of how long the starter is engaged or how much the accelerator is depressed?

If the answer is "YES" go to Section I   If the answer is "NO" go to Question B

Question B: The engine spins but only starts after prolonged cranking or the accelerator has been pressed and continues to run only if engine RPM remains above idle speed for 1-3 minutes.

If the answer is "YES" go to Section II

Section I: No Start After Crank

This type of hot start problem is almost always caused by intermittent failure (due to high temperature) of the Fuel Injection Relay (FIR), RPM/Crankshaft sensor (if equipped, RCS), Hall Sensor (if equipped), Radio Suppression Relay (RSR) and to a lesser extend the Engine Coolant Temperature sensor (ECT) and Power Stage. Statistically, the FIR, RCS, RSR and the Hall Sensor account for the majority of hot start problems. For this reason, it is suggested that diagnostic efforts concentrate on or eliminate these items first before moving on to the ECT and Power Stage. For the average do it yourselfer, exact identification of the defective part is limited to replacement with a new or known good unit. With more experience and a Volvo "Green Manual," advanced diagnostic techniques can be used to eliminate different components before spending money to replace them. If the vehicle experiencing the problem is a high mileage vehicle, it is best to replace these parts. Given the well documented nature of 700/900 Volvos, it is only a matter of time before they give up the ghost. The exception to the previous statement is the FIR. The FIR often fails because of cracked solder connections on the relay's circuit board. Below is a part by part guide to location, function, testing (if possible) and correction procedure.

Fuel Injection Relay

- Location: Relay tray, center of dashboard console behind ashtray. It is the tall white Hella relay on left in back row.
- Function: Supplies power to main fuel pump when key is turned to the "ON" position or position "II".
- Test Procedure: Place finger on relay and turn key to "ON" position or position "II". A click should be felt and the main fuel pump under the car, beneath the drivers seat, should cycle for approximately 1.5 seconds.
- Correction Procedure:
    - Replace with known good unit.

    - Resolder. See “Testing or Repairing Bad Fuel Injection Relay” heading in Engine: Fuel Injection section of 700/900 FAQ for instructions on resoldering the FIR.

RPM/Crankshaft Censor (if equipped)

- Location: On top of bell housing below the distributor (B230f and B230ft motors).
- Function: Tells the ECU where the crankshaft is and how fast it is spinning so correct ignition timing and fuel flow can be computed.
- Test Procedure: Replace with known good unit.
- Correction Procedure: Replace with known good unit.

Radio Suppression Relay

- Location:
    - Between power steering reservoir and strut tower. If located here it will be next to the cooling fan relay which is sometimes identical.
    - Various locations on passenger side of engine compartment.
    - Inner fender wall, driver’s side between battery and power steering pump reservoir.
- Function: Supplies power to fuel injectors when key is turned the “ON” position or position “II”.
- Test Procedure: Replace with known good unit. On some models, the RSR is identical to and located next to the cooling fan relay. If this is the case, the cooling fan relay can be substituted for the RSR to test.
- Correction Procedure: Replace with known good unit.

Hall Sensor (if equipped)

- Location: Inside distributor underneath rotor.
- Function: Tells the ECU where the crankshaft is and how fast it is spinning so correct ignition timing and fuel flow can be computed.
- Test Procedure:
    - Replace with known good unit.
    - Use a DVOM to test voltage at Hall Sensor. See “Testing Hall Sensor “ in Electrical: Ignition System section of 700\900 FAQ.
- Correction Procedure: Replace sensor or distributor. It is advisable to have the Hall sensor replaced by a professional due to the way it is secured to the distributor with steel rivets or replace the entire distributor.

Engine Coolant Temperature Sensor

- Location: Cylinder head, under the intake runner to cylinder #2. This is the rear-most sensor (the front sensor is the coolant temperature guage sensor, the angled one is the knock sensor.)
- Function: Supplies ECU with engine temperature information so various engine parameters can be adjusted for optimum performance.
- Test Procedure:
    - Replace with known good unit.
    - Use a DVOM to test voltage at ECT. See “Diagnosing ECT Failures” in Electrical: Engine Sensor section of 700\900 FAQ.
- Correction Procedure: Clean connector and/or replace.

Turbo Boost Overpressure Switch: Turbos Only

- [Dan Ridenour] The Boost Overpressure Switch is “normally closed” and is designed to “open” if the turbo-boost pressure exceeds some preset limit. This function is designed to protect the engine from a runaway turbo or a stuck waste-gate.
- On my 1988 760 Wagon, the boost overpressure switch is mounted in the engine compartment, on the right front strut tower, and is effectively “just above” the turbo. High underhood temperatures can cause this switch to fail and shut the engine down.
- To confirm switch failure, disconnect the waste-gate controller and wire the waste-gate fully open, effectively disengaging the turbo. Then short the boost overpressure switch. If the car starts while hot and runs without incident, then you've found the source of your hot-restart problem. Don't drive this way as you may overboost your engine.

Section II: Engine Starts Only After Prolonged Cranking

Hot starting problems addressed in this section are characterized by an engine that starts only after long periods of cranking and/or depressing the accelerator pedal with the engine not wanting to hold idle for a few seconds to a few minutes after starting. Possible causes of this situation include malfunctioning fuel pressure regulator, in tank pre-pump, slow responding Idle Air Control Valve, and to a lesser extent a faulty gas cap.

Fuel Pressure Regulator

- Location: On forward end of fuel rail. It is a cylindrical vacuum operated valve that has a small vacuum hose coming out of the front side and a larger fuel hose coming out of the back side.
- Function: Maintains proper fuel pressure in fuel rail based on vacuum signal

from intake manifold. Excess fuel is routed by the FPR back to the main fuel pump.

- Test Procedure:
  - While engine is running (exercise extreme caution when performing this test to prevent explosion and fire) After hot engine has been setting for approximately 10 minutes, remove the FPR vacuum hose where it attaches to the intake manifold. If gasoline is present in this hose, the FPR is defective.
  - Remove fuel return line from the rear of the fuel rail. Attach one end of a long length of hose to the end of the return fuel hose coming off the end of the fuel rail; place the other end of the hose in a suitable container away from the car. Start the engine. Fuel should immediately come out of the hose in substantial quantity. If only a little fuel is coming out, or in sporadic spurts, the FPR is defective.
- Correction Procedure: Replace with known good unit.

In tank Pre-Pump

- Location: In fuel tank.
- Function: Supplies fuel to the main fuel pump.
- Test Procedure:
  - With engine running, remove gas cap and place ear next to opening to fuel tank. If the pre-pump is working, a faint or not so faint buzzing should be heard.
  - Gain access to fuse tray by removing ashtray assembly. Start motor. While motor is running, remove fuse for the pre-pump. When fuse is removed, the engine should run rougher and main fuel pump noise should noticeably increase.
  - Connect fuel pressure gauge to fuel line between intake pre-pump and main fuel pump. Start motor. Fuel pressure gauge should read somewhere between 5 lbs. and 8 lbs. If pressure is below this range, the in tank pre-pump is not pumping enough fuel due to wear, leaking rubber hose connecting pre-pump and float assembly, or the filtering sock on fuel pickup is clogged.
- Correction Procedure:
  - Replace pre-pump with known good unit.
  - Replace rubber hose
  - Replace or clean filtering sock.

Slow Responding Idle Air Control Valve\CIS Motor

- Location: Under Intake Manifold. It is a cylindrical metal part with a 5\8 inch to 3

\4 inch hose connected to the forward end, wires connected to the rear facing end and another 5\8 to 3\4 inch hose coming out of the lower side that faces the motor block.

- Function: At idle, the IAC valve opens and allows the necessary amount of air past the closed butterfly valve in the Throttle Body so the engine will idle properly. Note: It is possible that the IAC is responding slow due to a faulty signal from the ECU.
- Test Procedure: Replace with known good unit.
- Correction Procedure:
  - Clean air passage in IAC with carburetor cleaner.
  - Replace with known good unit.

Gas Cap

- Location: Behind fuel door at rear of vehicle.
- Function: Prevent fuel from escaping tank, prevent outside materials from entering tank and maintain proper pressure inside tank.
- Test Procedure: After hot engine has been turned off for several minutes slowly remove cap. If a hissing or rushing air sound is heard then the vent mechanism in the cap is defective.
- Correction Procedure: Replace with known good unit.

Abbreviations

DVOM: Digital Volt Ohm Meter
ECT: Engine Coolant Temperature Sensor
ECU: Electronic Control Unit (engine\fuel injection\ignition management computer)
FIR: Fuel Injection Relay
FPR: Fuel Pressure Regulator
IAC: Idle Air Control Valve/motor (also called CIS motor)
RCS: RPM/Crankshaft Sensor
RSR: Radio Suppression Relay

Volvo 960 Mass Air Flow Meter Cleaning

In later year 90 series cars (after 1996), the mass air flow meter uses a hot film sensor that can become dirty. To clean this sensor, remove it from the air box outlet and follow the instructions in the photos below.

1. Unscrew with T20 Security Torx

2. Dip this end in Simple Green 1:1 solution

3. Clean gently with q-tips

4. Shake off and dip into 99% alchohol

5. Dip mesh end in Simple Green and then Alcohol

6. Screw clean sensor back into tube

Now reinstall it back into the car.

[Volvo Maintenance FAQ for 7xx/9xx/90 Cars] [Top of Page]

Volvo Oxygen Sensor Replacements

FAQ Home

Volvo Maintenance FAQ for 7xx/9xx/90 Cars Version 7.5

Here is a list of generic replacements for Volvo 7XX/9XX oxygen sensors:

740T/760T:
➝13913 Bosch 3 wire Universal (under 40$ at Autozone)**
➝13942 Bosch 3 wire (92 V8 Mustang, 8.5" long wire, 39$ @ Autozone)
➝13953 Bosch 3 wire (92 V8 Mustang, 16.5" long wire, 40$ @ Autozone)**

740NA (LH):
➝13913 Bosch 3 wire Universal (under 40$ at Autozone)**
➝13942 Bosch 3 wire (92 V8 Mustang, 8.5" long wire, 39$ @ Autozone)
➝13953 Bosch 3 wire (92 V8 Mustang, 16.5" long wire, 40$ @ Autozone)

740NA (Regina):
➝25003 NGK/NTK
can be obtained from NTK web site or www.oxygensensors.com or sparkplugs.com

940T:
1991 through 3/31/1993
➝13957 Bosch 3 wire Direct fit
➝13913 Bosch 3 wire Universal (under 40$ at Autozone)**
➝13942 Bosch 3 wire (92 V8 Mustang, 8.5" long wire, 39$ @ Autozone)
➝13953 Bosch 3 wire (92 V8 Mustang, 16.5" long wire, 40$ @ Autozone)
➝15735 Bosch 3 wire Universal **

4/1/1993 +
➝13381 Bosch 3 wire Direct fit (# 0 258 003 381, Volvo# 9135794)
➝15735 Bosch 3 wire Universal **
➝13913 Bosch 3 wire Universal (under 40$ at Autozone) **
➝13942 Bosch 3 wire (92 V8 Mustang, 8.5" long wire, 39$ @ Autozone)
➝13953 Bosch 3 wire (92 V8 Mustang, 16.5" long wire, 40$ @ Autozone)

4/1/1993 + with California emissions (EGR)
➝13376 Bosch 3 wire Direct fit (bosch# 0 258 003 376)

→15735 Bosch 3 wire Universal
→13913 Bosch 3 wire Universal (under 40$ at Autozone)
→13942 Bosch 3 wire Universal (92 V8 Mustang, 8.5" long wire, 39$ @ Autozone)
→13953 Bosch 3 wire Universal (92 V8 Mustang, 16.5" long wire, 40$ @ Autozone)

940NA (LH):
→13034 Bosch 3 wire Direct fit
→13913 Bosch 3 wire Universal (under 40$ at Autozone)
→13942 Bosch 3 wire Universal (92 V8 Mustang, 8.5" long wire, 39$ @ Autozone)
→13953 Bosch 3 wire Universal (92 V8 Mustang, 16.5" long wire, 40$ @ Autozone)
→15735 Bosch 3 wire Universal

940NA (LH)+ with California emissions (EGR): Bosch Direct fit or OEM sensor

940NA (Regina):
→25003 NGK/NTK
can be obtained from NTK web site or www.oxygensensors.com or sparkplugs.com

940SE: See 940 Turbo

960NA:
→13119 Bosch 3 wire Direct fit ('92-'95)
→15098 Bosch 4 wire ('95-'98 before Cat)
→15099 Bosch 4 wire ('96-'98 after Cat)

Other:
→15727 Bosch 4 wire
Not sure what this would specifically be applicable to, but should work in place of any car that specifies the 15735, though you may have to hook up the 4th wire (ground).

VOLVO AC R134 refit kit instructions for the 700 series

Volvo Maintenance FAQ for 7xx/9xx/90 Cars: **FAQ Home** Volvo Maintenance FAQ for 7xx/9xx/90 Cars: **Heating-Air Conditioning R134 Home**

CFC-Free A/C Retrofit Kit for Pre-1993 Volvos

Introduction; Kit Contents: Page 1

Written by Dave Urban. Caution: This information is giving for purely information only. No Warrantee is either given or implied. Only people who have the correct equipment
should perform this task.

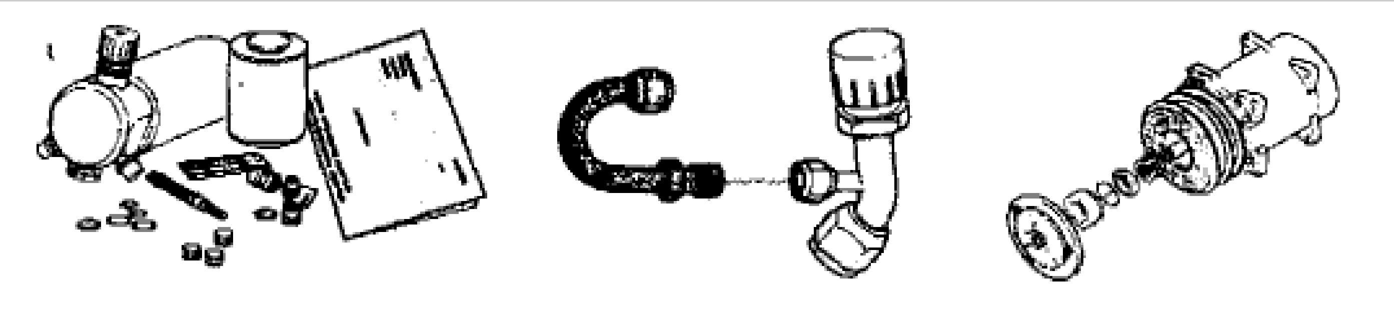
Years ahead of legislation, Volvo first introduced CFC-free air conditioning on all of its U. S. and Canadian 1993 model cars.

With the public's increasing concern about the environment, Volvo released a retrofit kit for older model Volvos in the spring of 1993. The kit allowed Volvos with existing R12 freon based air conditioning systems to be converted to use a CFC-free refrigerant. Volvo was the first automobile manufacturer in the world to offer such a conversion kit for older model cars.

When I purchased my kit from my local dealer, I was shocked to find that it did not include any type of instructions. They were kind enough to fax it to me. This is a web version of the instructions that I received. I have added some of my own comments in *italics.* This is not a job for the weekend mechanic . It does require special tools. Some of those tools can be used at the shop then the work done at the house.

[Editor] When the instructions mention "torque joint to 12 Nm" this means to tighten until snug. Don't overtighten: the seal is made by the o-ring, not the threads. Lubricate the o-ring before installation with compressor oil; use a backup wrench on all fittings; and test with soap solution (which will bubble in the presence of a leak) after.

	Supplementary Kit 1 Mainly for cars not equipped with,factory-fitted valve, with pipes or where pipe has been removed as a service fix	Supplementary Kit 2 Shaft seal kit for cars equipped with Sandan Compressor



					Replaces 9145664-0			
740/940		9145660-8	9145661-6		9134032-3		9134344-2 (SD-510/508)	9134345-9 (SD-709)
B23F	-	*	-		-		-	-
B230F	-92	*	-		*		-	-
D24T	-87	*	-		*		*	-
B234F	-	*	-		*		-	-
B230FT	940SE USA Turbo 1991	-	*		-		-	-

The basic kit comes with

- *New receiver/Dryer*
- *R134a filler valve*
- *Ester Oil*
- *O-rings*
- *R12 Filler permanent Caps*
- *Circlip*
- *Kit costs: 9145660-8 - $57.00*

- *Supplement #1 - $30.00*

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Replacing Vacuum Servos in ACC/ECC-Equipped 700/900 Cars

OEM Manual Procedure for Replacing Vacuum Servos. See the FAQ file for a large .pdf describing the official procedure with diagrams, courtesy Volvo Car Corporation (copyright; all rights reserved).

Replacing the Vacuum Servo on 700/900 with ACC/ECC Double-Acting Servos. [Procedure from Dick Riess, to whom thanks are given; some notes from Dan]

The following is a shortcut for installing the replacement vacuum valve involved with this problem. It is assumed that the old valve has proven faulty. Tom Irwin led me through my replacement and I feel the information can save much time and money. Tom Irwin did his on a 960 and I did mine on a 940 se. Basically it will include most 7 and 9 series that have that double acting valve. Believe this tends to be in the automatically controlled heating-ac cars. They all look alike from my studying the manuals. Warning! You cannot overestimate how long this job will take you. Leave plenty of time to go to stores for extra bits and pieces. Do not attempt with a sore back or hangover.

Tools required

- Small hacksaws. Pointed saw works best for starting cuts.
- Drill, approximately 1/8 inch.
- 10-mm socket to disconnect old valve and install new valve.
- Sidewinder 1/4-inch drive socket.
- Mirror to see where mounting nuts are located.
- Masking tape to line inside of 10-mm socket to hold nut in place.
- J-B Weld or similar substance.
- Black silicone RTV for caulking.
- Black or other color duct-tape.

Arrange car with the seat back. Pad the area with blankets to prevent bodily injury. Remove under-dash cover and bolster.

Picture #1 - Mark the area to be cut. Note the box in the picture and chalk marks. These are on the left side of the box. Drill 1/4-inch holes at the top left, top right, going diagonally up at approximately 45 degrees. Drill another hole, bottom left and another hole on the right side of the box. Cut across side-to-side. Next, make a vertical cut, and swing the plastic flap to the right side. [Note: I would enlarge the hole in the photo downward another 4 cm to have more room to maneuver.] Picture 2.

.]The plastic is quite flexible and may crack, but should not break, thereby creating a hinge. Note: if it cracks off, use duct tape and epoxy to repair. Take the hacksaw and cut to the left, horizontally, on both top and bottom, and swing the plastic flap to the left. Place a rag in the bottom of the hole to prevent "bits" falling down.

Picture #3 - You now have access to the inside of the box. The vacuum valve is located on the left outside of the box and has two hose connections.

Remove the hoses, and mark them for re-assembly. Next, using a 10-mm deep socket, and the Sidewinder ratchet, remove the two mounting nuts. These were a pig to get off. I used a 1/4" ratchet with a universal joint extension stiffened by wrapping it in duct tape. Next, remove the press-on retainer from the air-diverter post which holds the vacuum valve: this requires pushing and pulling with a screwdriver. Remove the vacuum valve.

Pictures #4 and #5 - In this picture, you can see the valve attachment to the air-diverter and the valves without hoses.

This is also a picture of the new valve installed. Before installing the new valve, install the nuts on the valve to cut threads into the plastic stud. Don't break off the studs, which are brittle. Now install the new valve, without the nuts. Attach the valve to the air-diverter post and replace the lock piece. Next, replace the nuts on the new vacuum valve. You may need to use some masking tape inside of the socket to hold the nuts in place to prevent them from falling out. Be careful putting these nuts back on as the plastic studs may break.

I am now going to assume that you have broken one or both plastic studs on the vacuum valve. You will need to fabricate a bracket, as noted in picture #4. Bracket material is the same material as used to mount car radios. This has multiple perforations and is fairly easily bent. Tom Irwin experienced breaking both studs and fabricated a bracket which held the valve on by going over the vacuum valve. The bracket had a hole in the center, which was enlarged, to go over the center hole of the vacuum valve. The bracket was attached to the air-box by using small screws. The bracket I used had a small bolt going through the box. Make certain that wherever you mount the screws that they cause no interference with the movement of the diverter in the air-box.

Attach vacuum hoses. Start the car, and check that the valve works properly by moving your heating-air-conditioning controls. If all is well, clean up the edges of the flaps which were cut, bend them back into position, and use J-B Weld or a similar product to hold in position. Next, use the black RTV-silicone sealant. Do not use too much as it could interfere with inside air-flap movement! After the sealant is dry, you may desire to put duct-tape over the entire incision. You will note in Picture #6 the reassembled unit minus the duct-tape. This has worked well for us during the past months.

Replace the bolster and any other parts that were removed. Enjoy your air-conditioner.

Alternative Technique for Replacing Vacuum Servo

Similar symptoms in my 940SE: very little was coming out of the "face vents" during acceleration. I pulled open the inside panels and tested all accessible vaccuum motors with the pump and meter and found the double acting motor (the only one with two hoses) was leaking on one side. This motor is according to the manual the foot/defrost motor (part number 9463042).

This is how I replaced the vacuum motor:

Tools good to have were: Screwdrivers Torx T15,T20,T25, Phillips #2, Long nose pliers for the washer thing, mirror and flashlight, 1/4" Ratchet and spinner sockets: 7,8,9,10,12 mm, 6" extension, and for the nuts on the motor .. 4" flex extension bar (Steel cable type from Craftsman) together with a kind of "thumb wheel" spinner (Snap-On)

1. Turn power seats as far back as possible.
2. Remove ground terminal from battery (You do have the radio code later?)
3. Remove “knee” covers on both sides.
4. -Remove glove compartment (4 screws)

5. Remove knee bolster at driver’s side (2 screws , 2 nuts)
6. Remove knee bolster bracket (2 bolts)
7. Remove ashtray -Slide parking brake cover back 4-5" (6 screws)
8. Remove "switch cover" right of steering wheel (disconnect switches and light)
9. -Remove radio, compartment under radio and the whole radio compartment (4 screws, wires for cig lighter + 2 panel lights)
10. Lift relay assembly to right side (plastic inhex screw)
11. Remove the ECC control console (4 screws)
12. Remove driver’s side “side feeding” duct (round 90 degree behind radio compartment driver’s side)
13. Slide off duct feeding passenger side ("carefully with force")
14. Remove duct coming from “air distribution housing” to “upper face and side vents”.
15. Remove air grilles (both sides) from floor distribution box (2 #2PH screws per grille).
16. Disconnect temp sensor at driver side heater housing, disconnect one connector passenger side and check for others obstructing floor distribution box.
17. Remove fixing screw for floor distribution box
18. Driver side floor duct was soft and tin plastic and could be "bent" enough (again "carefully with force") to get it off the floor dist. box.
19. Once driver side of floor dist. box is loose it can be pulled back and slightly right.
20. Now the double acting "motor" can be accessed through a down facing opening.
21. Pry washer off lever (washer will brake) unscrew the two nuts and vacuum motor comes out.
22. Mount new motor and test them all with pump and meter.
23. Reassemble in reverse order.

Well I'm not sure which one is faster , easier or better but I had hard time getting the motor out and back in again even if I had an opening about 4*5" to work through. It took me 4 hours work to get it done. Care should be taken not to break many of the numerous plastic clips and tabs that keep everything fixed. Most time went to find replacement lock washer and to puzzle the ducts back together (a lot harder then to get them out). The procedure is not to recommend for people with bad backs, short nerves, or large hands. Noticed also that this one was the easiest to change , the other two (single action) would require the complete air distribution box to be taken out.

Heater Core Replacement. [Procedure by Dave Stevens] It's absolutely no fun driving on a cold, rainy day with a couple of inches of slush on the road, the windows fogged up, the heater off, a rag in one hand, the windows half down, and a pool of anti-freeze building up on the passenger floor tray. If you have a fluid leak in the cabin area that means the heater core has failed as there are no hoses (those nipples you see sticking out through the firewall are part of the heater core). Presumably you've either just had a rad flush or you've been ignoring your rad fluid change for too long (or both, in my case). Most good anti-freeze fluids will have a certain degree of leak stoppage ability so if you've just changed fluids and it's only weeping it may "heal over", but don't get your hopes up. Although they might work well for a case like yours, I would be *very* hesitant to use any of the aftermarket stop-leak treatments (Bars being one of the more infamous). You might run the risk of plugging up or at least restricting your heater core or rad. Note that these magical fluids work when exposed to air and there can easily be pockets of air at the top of the cores. Perhaps others will differ on this, but the decision is yours.

As for dealing with this, it's going to be a tedious job and it sure wouldn't hurt to have Harry Potter -The Sorcerer's Illustrated Guide to Volvo Heater Replacement (aka. the Volvo green Heater Manual). A quick look at my Haynes manual (the 740 '82-'88 edition will do fine) revealed some of the basic steps and invaluable diagrams. Also, a quick look in my AllData CD gave only a few additional cryptic steps for replacement (very poor content on this as AllData is really only good for powertrain topics). If you don't go for the Volvo manual then at least get your hands on a Haynes (try your local library) and checkout chapters 2 (secs 21-23), 11 (secs 33-37) and 12 (secs 33, 35). Note that Haynes tells you to discharge the air conditioning system, which is NOT required.

Here are the guidelines I've developed so far:

1. You're going to be working primarily from the left footwell (orient vehicle for good access and lighting)
2. Prepare yourself: Verify sufficient inventory of favourite brew. Brush up on four letter word vocabulary. Make reassembly easier by using masking tape to label each screw, bolt, plastic retainer etc with a number to indicate order of removal. This assists reassembly.
3. Loosen rad expansion tank cap then clamp off heater hoses and disconnect at firewall (old hoses can be a real pain to get off; nipples are delicate; be prepared to catch fluid when you succeed). To be able to drive the car without the heater, simply join the two hoses (a 1/2" i.d. copper pipe 90 deg coupler works well)
4. Disconnect battery as a precaution when working around dash accessories and the relay tray.
5. Remove ashtray (and holder), lighter (pull lighter plastic bezel straight out) and storage box (remove two screws and swing out at left).
6. Remove shifter console: Two screws under plastic clip in bottom of storage box. Remove plastic cover below brake handle and pry off metal clip at front of console (under ashtray area) to allow centre section of console to be spread and moved around shifter column. Disconnect seat heater switches and swing entire centre console back up out of the way.
7. Remove left under dash panel: Note Torx head screws. Disconnect and remove air duct under steering column.
8. Remove right under dash panel: Carefully work plastic covering around heater fan motor.
9. Remove glove box: Note two nuts on either side.
10. Remove radio: Flat retaining clips hold side edges. Remove knobs (pull/pry straight out). Clips should be visible behind outer edges. Insert hooked wire through knob openings (upward and outward). Grab clip and pull in slightly to release clip as you work console out. Remove radio compartment (held by screw in tab at upper rear).
11. Remove left and right console side panels: Remove side panel bolts (1 at lower front behind carpet, 2 at lower rear behind carpet, 2 at upper front inside console at radio slot area). Detach lower crossbar (pull both panels forward slightly to allow screwdriver access from rear; loosen screws; bar is slotted on both ends).
12. Remove heater control panel: Remove surround trim (carefully snap out trim with protected blade gently prying inward and outward; note the metal retaining clip holding the middle of the trim panel to the right of the electrical switches - release clip from behind dash by pushing toward switch; disconnect switches). Remove metal bracket below heater controls. Remove heater control panel and swing out of the way to the right.
13. Remove ducting: Remove right and left outside face vent ducts (behind glove box and behing instrument cluster over steering column). Remove centre panel vents (remove short duct then push out vents). Disconnect floor vent ducts (peel back carpet; remove tunnel duct screw; reef out plastic stud; pull back rear floor vent ducting and wiggle off floor distribution box outlets. Remove floor distribution box from under main distrbution box (release relay tray and swing out of the way to the left; remove relay tray frame; remove centre screw securing floor distribution box to main distribution box; remove floor distribution box sliding out to right side). Remove main defroster duct to allow access to upper distribution box cover screws (unfortunately this duct is secured with grip clips on plastic studs that will seemingly break off during any attempt at removal; in order to gain restricted access to the upper distribution box screws you can try just removing the foam collar from the base of the duct and working through that restricted gap).
14. Remove air distribution box cover: Remove the *12* screws securing the distribution box cover (including two in middle of

top -a diagram really helps here). Separate the cover from the box by prying with a blade (putty knife) inserted into the mastic (starting at the lower right and prying up the right seam) allowing you to remove the cover by hand (don't be too forceful once you get it started in case you've missed a screw). Note the locations of the four coloured vacuum servo hoses connected to the cover then remove them (unclip the tab then slip off).

15. Remove heater core: simply held in by the two long side clips.
16. Mop up spilled anti-freeze: The tunnel carpeting, passenger footwell and left rear footwell are the prime target areas. Extract the excess from any soaked carpets (a carpet shampooer is ideal; a wet/dry vac is the next best; blotting with old towels will do; rinse and repeat). Peel up all wet carpet areas, blot up any excess including foam side of underpad). Leave carpet up until areas are dry. Dispose of liquid anti-freeze and contaminated rags properly.
17. Visit chiropractor

Total time for removal is somewhere in the 5-10 hour range. Replacement heater cores are available from Volvo (p/n 1308374, for all 700/900) and on-line from places like ipdusa.com, AllOEMVolvo.com, carparts.com and global4auto.com. Brands are 4-Seasons (variously as p/n 94734 and p/n R3000-62353) and Everco (p/n H5121) with prices between U$100 and U$250. Used heater cores are probably NOT a very good buy when you consider you're paying the labour to have a used one removed and the labour you may soon have to repeat if it also fails.

Manual Climate Control System Components:

MCC Climate System

Volvo 760/780 Nivomat Shock Conversion

Nivom Shock

This step-by-step guide was written and photographed by 2LT Jonathon Belmont, USA. Conversion of the Independent Rear Suspension found on some 700 series cars from a Nivomat (self-levelling) setup to a conventional shock and spring setup is neither overly difficult or prohibitively expensive. IF you have the right tools, time, and know-how. This step-by-step guide will cover required materials, parts, labor, procedure, and expected results.

Nivomat Installed

Tools. You will need a lift that will support the vehicle by the chassis, not by the tires. You will need at least one coil spring compressor, the type that goes inside the spring and has two sets of flexible jaws... two is highly recommended. Air tools will be a big help as well, as it can get mundane and difficult to compress the springs by hand. Also in the air tool department, a cut-off tool to cut the pigtail off the rear springs (get to that later). You'll also need a socket wrench set to remove a few bolts securing the brake caliper (to move it out of the way so you don't rupture a brake line... learned that the hard way) and the bolts that secure the shock. You'll also need a block of wood that will keep the trailing arm extended while you compress the spring. A large pry bar may also come in handy.

The notes below include two different procedures: wedging the spring out with the trailing arm in place, or unbolting it instead. The latter is much easier. However, unbolting would have been difficult if not impossible had I not had access to the auto shop on base, complete w/ air tools, press, cutoff wheel, grinder, lift, and hydraulic tranny stand. If you have none of these, then you will need to compress the spring and wedge it out.

Shocks and Springs. As for the parts themselves, I got two Bilstein B46-1662 shocks.

Bilstein Shock

I got them for about $120 for the pair (I think) from shox.com. I also got IPD overload coils for a 200-series... wagon preferred, because you will then need no spring spacers. When you cut the pigtail off the springs, they're a good fit. I cut it off right where it started to resume normal circumfrence, it was exactly one turn. Finally, you'll need something to spread the rear springs about an inch or so... I got the kind that twist into the coils (two on each side) from auto zone... any discount auto chain should sell something similar. If you use the sedan springs, the only difference in the back between lowering and just converting is the size of the spacers you must put in the rear springs when you're done. If you use about 1" spacers and cut the front springs like I did, the car will ride level at about 1 to 1.5" lower than stock. If you don't cut the front coils, you'll need to spread the rear springs at least 2"... I wouldn't try it; get some springs custom made instead.

Lower Mount. The lower mount must be either fabricated or cannibalized from the old nivomat.   I went with the fabricated route last time (see below for illustrations), and tried the cannibalization route the next time. Why? Because I spent about 4 hours trying to make my own mounts, only to discover when I went to install them that I had drilled the holes slightly off and a bit too far out, and they were too long in general and therefore wouldn't fit. Rather than leave the car in the shop, I took the old Nivos and proceeded to press out the metal center of the bushing. Naturally, the rubber was destroyed, so I just saved the center metal portion. Now here's the trick: the Bilstein already has a metal sleeve just the right size OUTER diameter in the middle of its rubber bushing. The metal sleeve is VERY firmly fixed to the rubber bushing. Fortunately, the rubber bushing is NOT very firmly fixed to the rest of the shock, and therefore can be pressed out without totally destroying it. At this point, I was running short of time, so I cut the bushing down one of the seams and used liquid wrench and a screwdriver to separate the rubber bushing from the metal sleeve. I then pressed the bushing back into the shock and the center metal portion from the nivomat back into the bushing. Seems to work fine. Next time, I'll look for a comparable bushing ahead of time, so I don't have to worry about saving the one I extricate from the bilstein.

Nivomat Lower Mount

If you fabricate your change to the lower shock mount... a machine shop should be able to do this for minimal cost, or if you have access to the right tools, it shouldn't prove too difficult to fabricate. It's simply a piece of steel tubing that's passed through the lower mount, crimpedtogether, drilled, and then slightly bent upwards. Once you get the parts and have a close look at the old lower mount on the Nivomat, this cryptic description will become much clearer.

Installed Lower Mount

Procedure: Removal. The procedure should take a full afternoon... probably 8-10 hours. I started in the front and worked my way back, because I wanted the car lowered about an inch and not just converted to a conventional setup. I removed the front springs and cut off about a coil and a half... this lowered the car about an inch and a quarter, and made the suspension a bit stiffer. I'm sure 700 series lowering springs would also do the job but I'm cheap and cutting the coils worked just fine.

You've got to remove the Nivomat shock first, then put in the wood block to keep the trailing arm fully extended. I think I stuck the one I found between the top of the fender well and something else off to the side, I really don't remember. Just make sure that it is sturdy (I used a 4" by 4") because when you compress the spring and remove it, the trailing arm is going to want to retract, seriously limiting your room to work. If you do not have a jack to raise and lower the trailing arm, then remove the brake caliper so it's not in the way, and so you don't bust a brake line by mistake.

Three bolts secure the nivomat- one up top and two through the bottom of the trailing arm. Remove them. Three bolts and a nut secure the mounting point of the trailing arm (towards the front of the car) to the frame. [If you have a lift and are using a jack to support the trailing arm: I chose to remove them, because the way I had the car jacked up didn't allow easy access to the one bolt which went through the trailing arm bushings and secured to the mounting point.   I had the car up on a lift when I did this, and used an adjustable hydraulic tranny stand to support the trailing arm as I undid the bolts & nut, then I lowered the tranny stand and the trailing arm to remove the old spring and drop in the new one.]

If you don't have it on a lift, then compress the spring and get it out of the top spring seat so that you can pull it towards the fender well opening and out to freedom (this is the tough, time consuming, and quite frankly DANGEROUS part). I put two spring compressors up inside the spring with one end of each one clipped as high up on the coils as they could reach, and the other ends dangling loose below the trailing arm. Then, I placed two sturdy wrenches across the hooks that were hanging below the trailing arm... that way, when I began to compress the spring compressors, the wrenches prevented the bottom end of the spring compressor from retreating back up into the trailing arm hole. When they stopped at the bottom of the trailing arm, the compressors began to pull the top of the spring down towards the bottom of the spring, gradually unseating it from the top spring seat. Unfortunately, as I compressed the spring compressors, the long bolts will ran up into the hole for the shock, preventing me from tilting the whole damn thing over to the side and freeing the spring. This is why it's nice to have TWO spring compressors... Once the spring was fully compressed by both compressors, I let up on the outboard one (closest to the wheel well), pulled the spring towards me so that part of it was outside the spring seat, and then reinstalled the one I loosened with its bolt on the outside of the shock hole this time. This allowed me to compress it enough to get it more than halfway out of the shock hole at the top... then I released the spring compressor that was still sticking its long bolt up into the hole, and I pried like hell to get the whole spring out.

Procedure: Installation.   Installation is the reverse of disassembly. Get the spring back in, then put in the shock. Next, put in whatever spring spacers you decided to use.[Note: not needed if you used the IPD wagon overload springs] .. that'll keep the car from riding on the bump stop. Don't install the spring spreaders before you put the shock back in, because you need to be able to see where the spring's maximum clearance is. Depending on what type of spreader you get, you may hear an occasional "thump" as the spreader whacks up against the shock tube going over a bump or around a corner.

Installed Bilstein Replacement Shock

[If you are using a lift and a tranny jack: Jack the trailing arm back up and hope that the bolt holes line up and you can get a few in. I ended up getting one or two started, but the big nut in the center wouldn't go, so I jacked the stand up a bunch more to lift that corner of the car off of it's lift support (VERY CAREFULLY), then moved the lift support from the jack point to underneath the trailing arm itself. Then, I lowered the tranny stand. This way, rather than the tranny stand pushing up on the trailing arm, I had the weight of the whole car pushing down on it. This provided a bit more compression and allowed me to get all bolts and the nut started sufficiently that I could crank them down securely. Now put in the new shock and you're all done! I previously suggested removing the caliper so it wasn't in the way, and as it turns out, dropping the trailing arm makes removing the spring so easy that the caliper removal step can be eliminated.]

Installed Bilstein Lower Mount

All in all, my car is about an inch and a half lower, and once I got it aligned, it was extended to the maximum camber capacity (if you find a way to overcome this, let me know) and the tires still "squat" a little. Ride is noticeably improved and so is handling and even gas mileage a bit. The car loves to corner, and dampens out small and large bumps with little complaining. It doesn't roll as much in the corners and traction is better. This may seem like a daunting task, but I'd take it on again in a heartbeat... well worth it!!!

Volvo B6304 Oil Pickup Tube Repair

B6304 Engine Oil Pickup Tube O-Ring Replacement [Procedure from David Aidnik]

Symptoms: Noisy "ticking" hydraulic valve lifters caused by leakage of crankcase air past the oil pickup tube o-ring into the oil stream.

Repair: Oil pan must be removed to replace the o-ring at junction of the oil pickup tube & the block.

Parts: Four O-Rings total ($6); One Tube Volvo Chemical Gasket ($16); Oil Filter; Seven Qts. Oil

Time Required: 10 to 12 hours (first time)

Special Tools: 24 inch socket extension with a 17 mm flex joint socket. A universal joint should work, but the more compact flex socket is preferable. Dense urethane foam paint trim roller; approx 2 inch wide. I got one of these at the local harware store with replacable rollers for $5.

Step by Step Procedure:

1. Front end of car must be elevated; front wheels need to be approx. 4-6 inches off the ground. Car must be solidly supported on jackstands.
2. Drain coolant. Use of a short hose on the radiator fitting will allow draining directly into gallon bottles.
3. Drain crankcase oil & put the drain plug back in. Note: Front axle crossmember must be dropped down. It can just hang from front suspension, but use of floor jack is helpful to drop it down in a careful stepwise fashion.
4. Support engine at harmonic balancer. I used a screw type house jack and a piece of dense packing foam to conform to the shape of the balancer & keep the top of the jack located. Use of mechanical non-hydraulic jack is preferable so as to be certain that the engine does not "drift" downwards in position.
5. Loosen engine mounts at interface with front axle crossmember. Three screw

connections on each mount; two are nuts on studs & one is screw from underside of car. Remove the nuts & the screws, leave the studs for the nuts alone.

6. Raise engine slightly using jack under harmonic balancer to confirm that mounts are lifting off the axle crossmember. Once you have this, you know that you've got the engine weight off the crossmember & can now drop the crossmember down.
7. Disconnect the two power steering hydraulic lines from the steering unit on the axle crossmember by removing the banjo bolts; make sure to get the copper or aluminum sealing rings on BOTH sides of each fitting (2 sealing rings for each bolt). Note that the ATF/Power steering fluid is going to drain here, so have your oil drain pan handy when you remove the banjo bolts.
8. Position steering wheel in the "straight ahead" position. This will allow easy access to steeing knuckle u-joint clamp bolts underneath. Remove steeing knuckle u-joint clamp bolt on axle end of u-joint. You will have to remove safety clip from threaded end of bolt. It may be convenient to rotate steering wheel 180 degrees to remove clip, then rotate the wheel back to the straight ahead position to remove the bolt.
9. Carefully mark the steering u-joint clamp on the axle end & the splined shaft of the axle-mounted steering unit to enable getting these pieces back together in "exactly" the same position; a tiny line on one side & a tiny line or arrow on the other. This part is very important.
10. Remove the four bolts fixing the anti-sway bar to the car body subframe. Two bolts on each side near the bushings at the ends. Take note of the orientation of the spacer plate between the bushing & the subframe. The anti-sway bar will just hang down.
11. Support the axle crossmember with a floor jack under the center (it doesn't weigh very much).
12. Remove the four large bolts (10 mm bolt; 17 mm head) fastening the axle crossmember to the body subframe. The heads of these can be easily seen on the passenger side of the engine compartment. They go straight thru the box sections of the subframe & thread into nuts welded in the crossmember. The bolts on the drivers side WILL require a flex joint type of socket & about a 24 inch extension to reach the heads without removing stuff on the drivers side of the engine.
13. From the underside of the car, lower the axle crossmember slowly. Some jiggling loose of the steering u-joint may be necessary as well as pushing the power steering lines upwards out of the "hole" in the crossmember. This stuff around the steering should be all that is "holding" the crossmember from dropping down. Once the splined shaft comes out at steering u-joint connection, the crossmember should just drop down about 8 inches. It doesn't fall because there is a lot of friction in the rubber bushing connections in the axle & steering. Pull the crossmember down as far as it will go. Now you have the working

clearance to get the oil pan out.

14. Remove the oil filter housing/oil cooler. This has one very large banjo bolt (42 mm head). This must be removed as one of the oil pan screws is INSIDE it and another is under it!
15. You are now ready to begin removing the oil pan bolts. Note that the bottom three bolts in the front mount of the transmission to the engine are threaded into the oil pan. You will need to take these bolts out, so you should support the transmission somewhere near the front of the pan. I used a hydraulic floor jack (the one I no longer needed under the axle crossmember) & just jacked up enough so that I saw the back of the engine start to move upwards. Then I knew that I wouldn't be stressing the transmission/engine interface too much when I took out those bottom three bolts. Remove these three large bolts.
16. Now loosen all the small bolts attaching the oil pan to the engine (10 mm hex head). There are some at the back where access is not easy. I used a general loosening pattern of loosening the perimeter ends first; working toward the center & loosening the center ones last. If all the bolts are loosened, the oil pan should crack loose and now your almost done with the diassembly. There are a few different lengths in these bolts, about 75% are all short approx 1 inch & identical; the other 25% are longer & varied in length. I marked the position of each of these longer ones on a couple of sheets of paper and put these bolts on the paper to keep everything straight.
17. The oil pan comes out towards the back & off to the driver's side; it can't go straight back because of the jack under the transmission. Remove the pan, pour out the residual oil & rough clean it with something like paint thinner & an old toothbrush; NO wire brush, steel wool or abrasives allowed here. The baked-on varnish-like oil is not a problem. Remove the plate attached in the oil sump area to enable cleaning of any crud here. There are lots of corners because the pan has internal buttresses to add stiffness to the block when assembled.
18. Zen and the art of using a single edged razor blade is what the next phase can be called. This is where you CAREFULLY shear off every square millimeter of the chemical gasket material, which should be almost all on the oil pan. This process will take maybe 1.5 hours; you don't want ANY gouges in the sealing surfaces of the aluminum pan or the block; this stuff is only maybe 5 mils thick or less. After you finish the pan, you can check for any remnants on the bottom of the block after you remove the oil pickup tube. When you see the shape of the oil pickup tube, the weird "jock strap" protrusion in the front of the oil pan makes a lot more sense.
19. There are two o-rings on the bottom of the block which you should/will replace. There is also one on the oil dipstick tube. After the razor blade cleaning, wipe off the mating surfaces with a non-greasy solvent to make sure the mating surfaces are impeccably clean. I had to wipe out some of the oil in the cavities where the main bearing bolts were as oil kept oozing out onto the mating

surface of the block.

20. With everything perfectly clean, you are ready to reassemble. Put the plate back in the sump area of the oil pan. Re-install the oil pickup tube with a new o-ring. When I put this in, I noted that the new o-rng was significantly tighter than the old o-ring. The o-rings on the bottom of the block can be tricky. Gravity is against you here & you don't want them falling out as you try to put the pan on. I used some of the chemical gasket stuff in the counterbores of the block where the o-rings go. Put a little bit in; put the o-rings in & let them sit a little while you continue to make sure they won't fall out later at an unwelcome time.
21. Now in the re-installation, you must get the prepped pan under the car without touching or getting any dirt, etc on the prepped surface. You must also get it angled up a bit in front to clear the axle crossmember without touching or scraping anything on the sealing surface. I did a trial run at this time before prepping the pan with the chemical gasket, just going to the point where I was ready to push the pan up on to the block and no further as I did not want to disturb the two o-rings on the block which were still sticking in the chemical gasket stuff. So far; so good. I took the pan back out for the final prep.
22. Apply the Volvo chemical gasket to the oil pan. I put a bead all the way around & used the 2 inch wide urethane foam roller to even it out. The roller really helps to get the chemical gasket coat thin but even; that's the way it works best. I touched up the amount wherever it needed it so that I had an even thin coat; there is at least 1.5 times as much as you need in the one tube of the chemical gasket material. Note: This also brings to mind a dilemmna I faced at this stage in putting the pan back in. There is a crankcase breather tube fitting on the driver's side of the pan which makes it pretty difficult to get access to a screw or two on the perimeter of the pan at the back. In re-installing the pan, I figured to leave this tube off until after I got the pan back in. I discovered later that the hex on the breather fitting proved quite difficult to access as well after the pan was in. I put some of the chemical gasket material on the cleaned threads of the fitting and screwed it in as tight as I could by hand. Then I managed to get it turned maybe a quarter of a turn afterwards with great difficulty. The gasket goop seemed to set, and I put a better hose clamp on the fitting to prevent any turning. A deep socket should have worked, but the cylindrical part of the fitting was too big to fit in the bore of the deep socket. . . You decide your best approach on this one.
23. Now the pan goes in for real. Be sure to have the four center screws for the pan handy down there as well as a 10 mm socket driver that you can manipulate with one hand only. Two screws in the mouth, like a carpenter with nails, socket driver ready; one last look at the two o-rings on the bottom of the block; this is it! Clearing the front mount of the transmission with the back of the pan is the last hurdle, then up & back against the transmission at the same time. Hold tight & get two of the center screws in & hand snugged so the pan cannot pull back away. Now you can breath; it's almost all downhill from here.

24. Get all the oil pan screws back in & just snugged including the special lengths. Install the 3 bolts that anchor the transmission to the oil pan & just snug these as well. The spec torque of the oil pan screws is 15 ft-lbs. I tightened in a general pattern fron center-middle to perimeter-ends in a couple of stages. After the first stage, I tightened the 3 transmission bolts about halfway as well. There are about 50 screws in this oil pan. Get all the screws & bolts torqued. The bolts from the trans into the oil pan should be tight; 40 ft-lbs. Floor jack inder the trans can now be removed.
25. Re-install oil filter housing/oil cooler. I used a little bit of the gasket sealant at the top with the neoprene gasket. Put a new oil filter on.
26. Re-installation of the axle crossmember & anti-sway bar is pretty straightforward except that is must be taken stepwise with the floor jack to get the splined steering unit shaft engaged in the delicate aluminum clamp (which is easily damaged) in exactly the right rotational position and keep from pinching either of the power steering lines under the motor mount on the driver's side. Tighten axle crossmember bolts 70 ft-lbs. Fasten anti-sway bar to subframe.
27. Get steering u-joint bolt back in & tightened. Don't forget the safety clip. Get power steering lines connected to axle mounted steering unit with the banjo bolts. Don't forget the copper sealing rings on both sides of the fittings.
28. Get the nuts & bolts back in the engine mounts. Don't forget to get the clips which anchor the power steering lines under the motor mount nut on the driver's side. Lower the engine down on to the axle crossmember & tighten the motor mount nuts & bolts.
29. Get the coolant back in the engine. Put about 6 qts of oil in the engine. Remove the spark plugs; cover the plug area of the head with the plastic cover (coils off to the side) & crank engine with the starter until you get oil pressure. This takes a bit of cranking as you have to fill up the new oil filter. I took this in a couple of steps; the oil light icon DID eventually go off.
30. Re-install spark plugs & start motor. Go back under & look for any leaks. Keep pumping (squishing) upper radiator hose to get air out of coolant system.

The ticking of the hydraulic lifters didn't disappear right away, but was less. After I got the plastic covers on the underside; got the back on the ground & drove the car, I drove it in Low for a few miles around town with some periodic accelerations especially in the 4000-5500 rpm range. This pumped out all the air from the hydraulic lifters and the car ran "so so so sweet". Only then did I realize how much the air content in the valve lifters caused assymmetry in the valve openings; before the o-ring replacement, I could feel that assymmetry in the exhaust stream at the tailpipe with my hand; it was subtle, but it was there. The car will run with this condition, and will run reasonably well, but will NOT run "RIGHT". After the job, the exhaust stream at the tailpipe felt like sweet perfection. This engine was at 112k miles and had never been overheated.

Volvo B230 Connecting Rod Bearing-Oil Pump Replacement

[Courtesy of Dick Riess]

Replacement of Connecting Rod Bearings, Oil Pump and Oil Pan Gasket. See also the FAQ file section on oil pump wear and replacement.

1. It is wise to clean the engine first or at least the areas where work will be performed. You will be under the car and dirt and oil falling in your face and on clean surfaces to be reassembled is not desirable.
2. Place car on jack stands so that there is no danger of the car falling on you. This includes using emergency brake and chocking the rear wheels.
3. Remove the front license plate and bracket. This is to reduce gouging your body parts as I have often done..
4. Depending upon the model and year of the car, certain engine parts need to be disconnected and loosened. The fan shroud needs to be loosened as the engine will be raised and the blades may run into the shroud itself. Turbo hoses may need to be removed partially if any strain is placed on them.
5. Disconnect the battery ground.
6. Pull dipstick out and cover the opening.
7. Drain oil and remove filter. Replace drain plug after oil is out. Keeps things much neater.
8. Remove the engine to transmission bracket (6 bolts).
9. Steering: Remove the bottom bolt and pin holding the steering shaft to the rack and pinion. Remove the top pin and loosen the bolt. Slide up the coupling so it is free of the rack and pinion. The steering shaft will be loose and can be tucked toward the fender wall.
10. Mount the engine lift so the lift feet are in the area where the fender bolts are located. The lift hook should be over the hook by the thermostat housing where it can be attatched. I have made lifts from heavy duty wood and presently am using one from Harbor Freight which is a significant improvement.
11. Remove the belly pan.
12. Motor mounts: Lift the engine to take the weight off the engine. Drivers side: remove the three nuts holding the base of the mount to the axel. Remove the one nut holding the mount on to the engine bracket. Passenger side: remove the top two nuts holding the mount to the axel. Under the axel remove the one

bolt holding the mount. Remove the top nut holding the mount to the engine bracket. You can now remove the mounts from the axes providing you have lifted your engine clear of the axel.

13. Remove the bolt holding the clamp retaining hoses on the front of the axel. Check other straps as you lift the engine and drop the axes so there is not strain that will break or tear wires and hoses.
14. Loosen completely the 4 bolts holding the front axel. Two on each side. These do not need to be removed. You can now push down the axel and may have to block it between the frame to hold it.
15. Remove the pan bolts. You will have to turn the fan approximately 90 degrees to the rear to get it clear of the oil pump. It may take a couple of tries to get it down.
16. Clean all surfaces of the pan and bottom of the block. This is a good time to clean the inside of the pan completely. I have used Simple Green to dissolve the crud.
17. If replacing the oil pump, remove the two bolts holding it. First study the location of the hose draining the oil trap and the finger on the oil pump holding it in place. Also note the location of the little metal bracket holding the hose. Mark the pipe feeding the block from the pump. Mark it so you know which end goes where when you reassemble. Clean the pipe thoroughly and make sure the O rings are out of the block and pump locations.
18. Rotate the engine so two of the connecting rods are fully down where you can get to them.
19. Remove the rod bearing caps. You will need a 10 mm 12 point socket to remove them. Perhaps a different size on earlier engines. Not the marking on the cap. It will have a number 1 through 4 and this number points toward the exhaust side. The connecting rod will have a like number on the same side. Get acquainted with your engine and make notes if you are in doubt. The engine does need to be put together as you found it. Once the nuts are off the cap, you may need to tap the sides to loosen it. Push the piston up enough to remove the insert bearing. Coat the new insert with a light coat of assembly grease on the face toward the crankshaft. Make sure the small tang on the insert fits into the rod properly. Pull the rod down to the crank. Clean the rod cap and mount a new insert with assembly grease on the surface toward the crankshaft. Make sure the tang goes into the portion designed to receive it. Assemble the cap on the connecting rod and be sure the numbers are on the exhaust side. Tighten the nuts to 18 lbs. Angle tighten each nut to 90 degrees. Repeat this on all four connecting rods. You can easily turn the engine if you have a wrench on the crankshaft bolt holding the harmonic damper on to the crank.
20. Reassemble the oil pump using new O rings on the pipe and make certain everything is in its place as you took it apart. Lightly lubricate the O rings with vaselene before inserting into the oil pump and engine block. Tighten the two bolts holding the pump to the block. In my experience I find original Volvo parts

best when it comes to bearings and gaskets. Good fit and no leak. I confess I have used the aircraft grade Permatex on the oil pan gasket. Oil pumps: I use febi-Bilstein as they are higher pressure and I run turbo engines. I have had to replace pan gaskets because they were aftermarket and leaked by acting as a wick. You do now want to do this twice.

21. Mounting the gasket to the engine is a pain. I have used small plastic zip ties to loosely suspend the gasket from the block while I fight the pan into place. It usually takes me awhile to get the pan on as the oil pump must fit into the sump and then the pan must be turned. Once you do this and hang the pan loosely by a bolt or two you can remove the zip ties. Pan bolts are tightened at only 8 - 12 lbs. Tighten them each a little at a time.
22. Finish your reassembly of the car.
23. PUT OIL IN THE ENGINE!!!!!!
24. Remove the coil wires and crank the engine till the oil warning light goes out. 25 Run car 500 or so miles and change oil and filter as you may have loosened up some more crud. Good luck, it has worked for me a few times.

Volvo B230 Distributor Shaft Seal Replacement

FAQ Home

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[Procedure and Photos by John Sargent]

I have done many distributor shaft seal replacements for myself and others. The picture below shows the distributor fixture, three seals which work, and two wrenches. The 8mm ratcheting box end wrench makes quick work of the three screws holding the dap to the distributor. The 10mm ratcheting box end wrench makes quick work of the two bolts holding the distributor to the head. The distributor is the older version with the Hall Sensor and connector. Before you begin this, make sure the distributor is mechanically sound: shaft wobbling is abnormal and indicates wear.

The next picture is rotated 90º, but it shows the distributor in the fixture (which in turn is held in a vise) and I am starting to drive out the pin which holds the drive dog to the shaft. Some of these pins are easy, and others are really tight and have frustrated some very fine mechanics. I always use a tapered pin punch to get the pin started. You will break a straight pin punch of the highest quality on some distributors, and you won't move the pin. I know this from experience.

The picture to the right shows driving the pin out the last little bit. You have to quit with the tapered punch when it bottoms out in the drive dog.

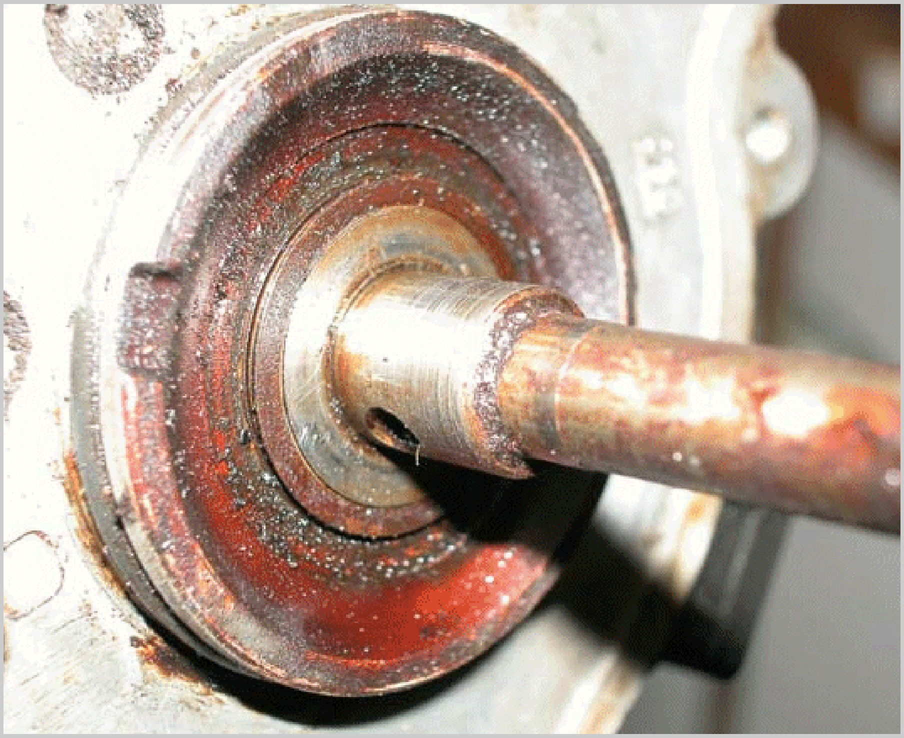
The picture below shows the shaft after removing the drive dog. The shaft is covered with old oil varnish.

You must remove the old varnish with razor blade scaper and ScotchBrite or you break the fiber

washers which cannot be purchased.

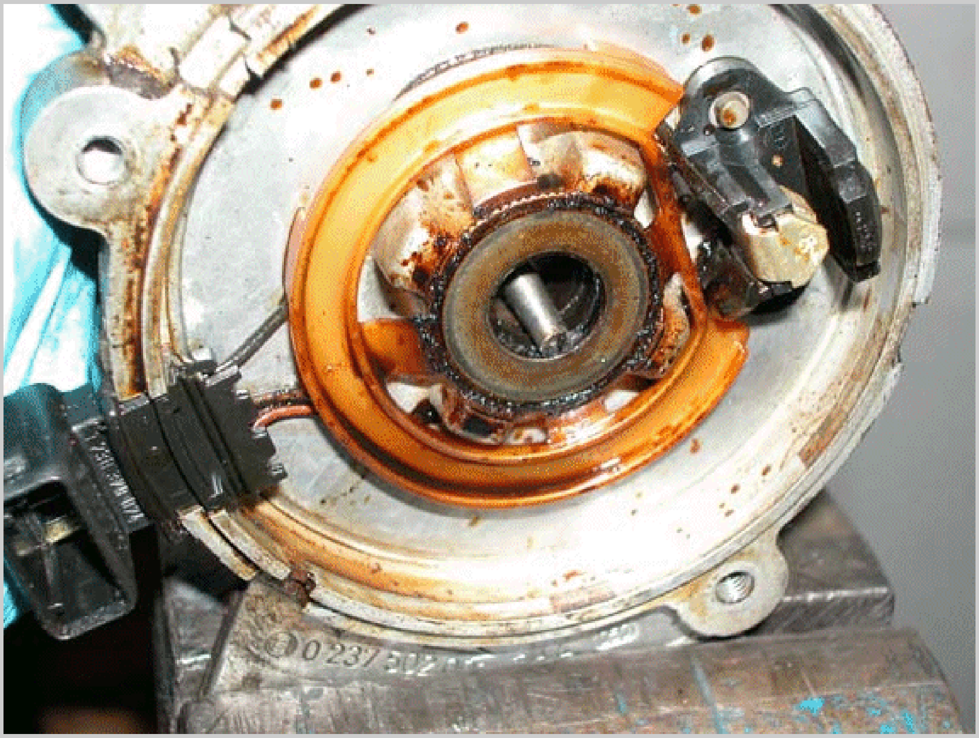
The picture below and to the right shows the shaft cleaned up and ready to be pushed out the distributor

base.



The picture below shows driving out the seal retaining washer with the tapered punch.

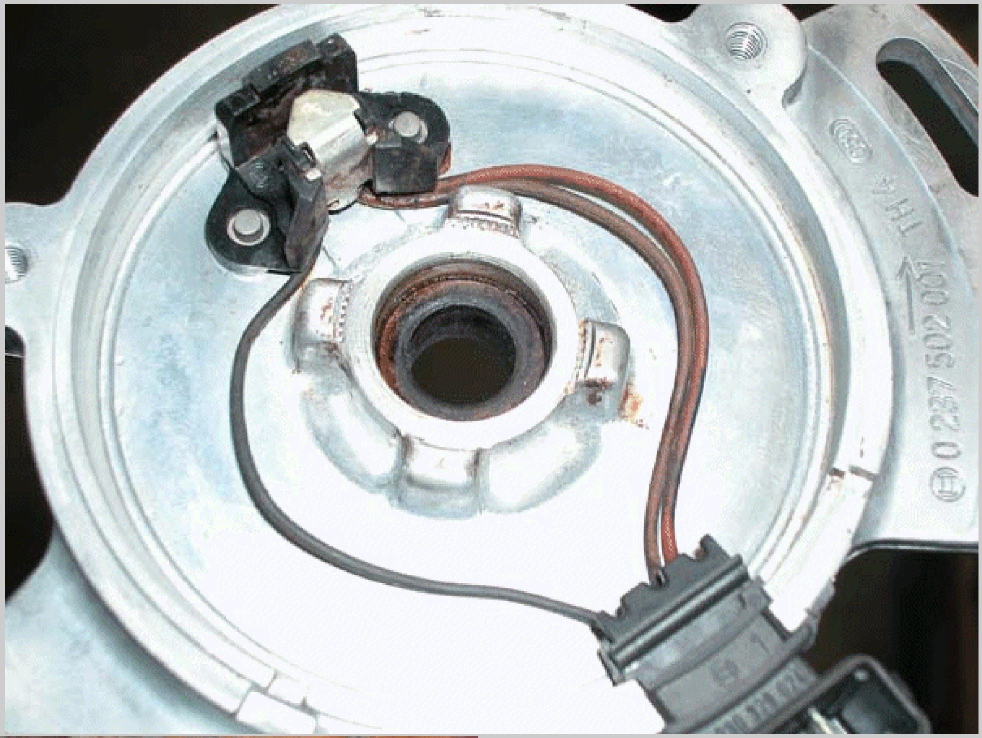
This seal was leaking badly!



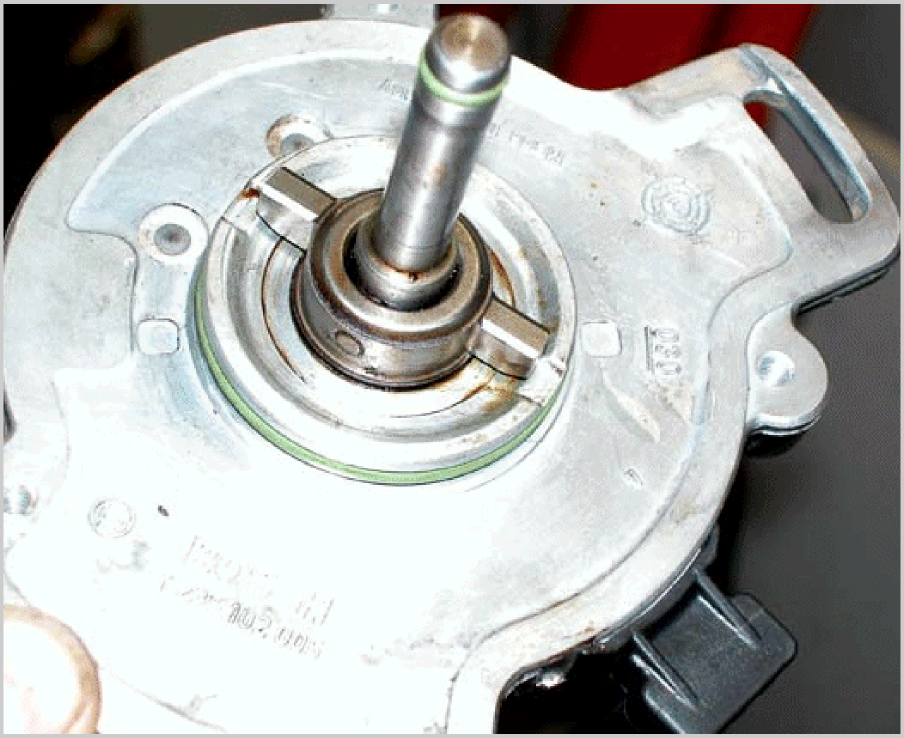
In this picture I have the distributor base cleaned up and ready for the

new s

After pressing the seal in with my fingers I set the seal retaining washer with a socket and a hammer.



Here is the finished product:



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Instructions for Fitting a 900 series with a Remote Locking Device.
[Photos courtesy of Dick Riess]

[Tips from Rob Bareiss] To add a keyless remote system to your 740 or 940, you need to add a lock motor to the driver's door. This lock motor that you add needs a linkage to operate the driver's door lock rod- the rest of the doors operate just as if you pushed the button down yourself. You can make this a bit easier on yourself by picking up the driver's rear door lock motor and a passenger's front door lock motor and linkage from a junkyard. This will give you factory parts that will bolt in directly. You will also need the control box from a keyless kit to make this work. Finally, you'll need to run a power wiring harness to the new motor- try to grab one from one of the lock motors you get in the junkyard. All the parts can come from a junkyard. You can also buy aftermarket, but the "custom fit" actuators often require you to hack up your door skin.

[Dick Riess] The 900 series uses a totally different lock motor system than the 700 series: the 900 motor is not "L" shaped and is directly connected to the lock and the knob. There is no linkage arm.. Finding 900 parts proved impossible, so a 700 series motor and passenger side linkage (shown in the photos) was substituted. You may also use a 200 series motor, but linkage does not work as well. The swivel and linkage were used, but the metal cage normally used to attach to the door was discarded. The holes in the motor, which normally hold screws fastening the cage were bored out, so that metal screws could fasten the motor to the door. Note picture

1. The plastic swivel was mounted on the inside corner of the door. See picture. One linkage rod was run to the motor...the other to the lock switch. Linkage was bent for best fit. The two motor wires were routed through the door with the other door wiring through a piece of shrink wrap. Note picture 2. The shrink wrap was used because there was not room in the factory conduit. Wires were attached in the area of the left kick panel. Wiring of the motor was reversed because of the reversed position of the lock motor. Note approximate position of wires and controller in picture 3. Leave the old door switch (which acts as a switch for the other doors) in place so that the process of unlocking will be as follows: The new motor gets a signal to lock/ unlock the door. This is transfered to the locking unit via the linkage and raises/lowers the round knob. At the same time, the existing drivers door switch is triggered, signaling the other doors to lock/unlock. Comment: My wife likes it!

2. Wires coming through door edge

1. Motor and linkage rod mounted on door

3. Wires running to keyless controller box in kickwell

Installing Power Seats in Car With Manual Seats [FAQ Home]

[Volvo Maintenance FAQ for 7xx/9xx/90 Cars]

Version 7.5

Installing Power Seats in a Volvo 700/900 Series [Jay Simkin]

I. Planning: Parts and Wiring

It is helpful to have the section of the donor car's seat wiring harness that takes power from the behind the central console, to the connector at the outer corner of the seat (near the door). You can use a seat wire harness from a driver side seat in a 940, or either seat in a 960. If you cannot get the seat wiring harness from a junk car, get it from the dealer. You will need the connector block at the end of the harness, to connect to the block at the end of the chair wiring harness.

So far as I know, you cannot install a driver side seat on the passenger side of the car, or vice versa. Any powered passenger seat or switch should work fine, regardless of the model of the car (940/960), in which the seat is installed. A passenger side power seat will NOT have memory functions. You cannot put a driver side power seat switch on a passenger side seat. They are totally different. The driver's side seat switch attaches to a seat computer, from which wires run to the seat mechanism. The passenger side seat switch attaches directly to the seat mechanism. A car that did not have a power passenger seat does not have any connector on the wiring harness inside the front console into which a seat wiring harness can be inserted. When these cars were built, only those ordered with dual power seats had connectors on the wiring harnesses inside both sides of the front console.

Before you begin, check any salvaged seat wiring harness for continuity, to be sure that there are no breaks in the conductors, inside the insulation. To do this, take a test-meter, set it to OHM (continuity), and put one test probe at each end of, say, the black wire. If the needle jumps to the far right, you have continuity. If it does not move, there is break in that wire, and it is useless. Check each wire. Once you know there is continuity - that all wires are undamaged - you may proceed.

At the end of the donor car seat wiring harness that connected to the wiring harness behind the console, remove the individual wires from the connector. You can do this by opening the connector cover. Using a needle nosed pliers grip the connector by its shank (the metal part that grips the wire) and gently wiggle it, will pulling it out of the connector housing. The black wire is, of course the ground. I grounded mine to the screw that secures the emergency brake activation switch (see below). The black/ white or black/red wire is the positive wire. It needs to have a female spade-type connector put on it. Once you do that, it can be connected at fuse #7 on the fuse block. Once this is done, you will have power to the seat.

II. Procedure: Installing Power Seats.

Here are the specific steps.

Removal of the manual seat

Preparations

(a) Cover the inner face of the passenger door panel with a sheet of cardboard. Cover with cardboard the rocker panel section at the bottom of the door opening and the plastic strip on the interior that rocker panel section (the door threshold strip). This will protect them against damage. A power seat is heavy, bulky, and unwieldy.

(b) You may want to remove door threshold strip. To do this, pry up the three plastic screw covers, using the edge of a putty knife, with the blade blunted. Remove the three torx screws. To remove the door threshold strip, you must remove the center column plastic cover (at the top of which, the seatbelt emerges).

(c) To remove the center column cover, two screws, covered by screw caps, need to be removed. Remove the screw caps, using the tip of a small screwdriver. The caps are secured by lugs at the 12 o'clock and 6 o'clock positions. Pry gently. Remove the screws. Then, using the edge of your putty knife, start at the top of the center column cover. Insert the knife at a 45-60 degree angle between the black plastic edging and the edge of the center column cover. Pry gently, to free the cover from the edging. NOTE: be very gentle, as the top of the center column cover is slit on one side, so that the seat belt can pass through. As a result, there is only 3/4 of material connecting the top of the center column cover, to the rest of it. The center column cover is secured by four metal clips, at intervals between the two screws (which you have removed). Thus, the rest of the center column cover can be removed by prying gently, moving from top to bottom. If it does not come free, use the blade of the putty knife for leverage. Once you insert the blade between the black plastic edging and the cover, push the putty knife handle towards the door opening. The cover should then "pop" free of the clips.

Remove the center column cover and the door threshold strip.

(d) Next, remove the plastic covers over the back end of the seat tracks. They are held on by lugs on the tracks, which fit into recesses in the covers. Pull back to disengage the cover from the lug, and then pull up. With a bit of wiggling, they should come free.

Seat Removal

(a) Remove the four seat bolts. Pull the seat as far back as possible, then move it forward 1/4". That will allow the seat track lug to disengage from the "keyhole" in the floor plan.

(b) To remove the seat belt anchor bolt, unscrew the cup-holder at the front of the seat (a single Torx screw). Rotate the cup-holder upwards, to expose the seat-belt anchor bolt. Remove it. This bolt will be tight: be prepared to use muscle on it. Remove the seat belt from the seat.

(c) Carefully lift the seat out of the car.

Running wire for power seat to the fuse block.

Preparation: Accessing the fuse/relay block requires removal of the ashtray, lighter, and storage bin

(a) Remove the ashtray, by lifting the latch at the bottom.

(b) Remove the plastic bezel around the lighter, by prying gently from the right (passenger) side

(c) Remove the two Phillips head screws - one short, one long - that secure the lighter/ storage tray

(d) Gently pull the storage tray - with lighter attached - towards you.

(e) Disconnect the wires from the lighter.

(f) you can now access the fuse/relay block (white plastic) with enough room to work

Accessing the under-side of the fuse/relay block

(a) Release the white clips on the right and left front corners of the fuse/relay block

(b) Gently lift and pull the block towards you: the block has a very large number of wires coming into it, so the wire harness may be stiff. Do NOT yank on the block. If it is balky, pull firmly with one hand, using the other hand to push on the block from behind. If you have to do so, remove relays (when re-installing relays, reseat them fully)

(c) When you have the fuse/relay block through the opening, if there's enough slack in the harness, rotate the front end upwards, so you can see the underside of the fuse/relay block

(d) If there's not enough slack to do that, use a mirror to view the underside of the fuse/relay block

(e) Find fuse No. 7. You may need to move wires aside to see it. You will see a male spade connector. It is to this connector, that you will attach the wire, that will take power to the passenger-side seat.

Running wire from passenger-side seat to the fuse block

Remove the carpet and run the seat harness wire from the fuse block to the front, door-side corner of the seat location.

(a) You will need to roll back the front, passenger-side carpet for about half of its front-to-back length. You need to roll-back the carpet, so you can see the black plastic heating duct that runs from the passenger side of the center console under the front seat. You will need to pull the carpet from under the plastic kick panel on the passenger side of the center console.

(b) Using a piece of soft steel wire (or a coat hanger wire), put a 1/4" loop in one end, using a needle-nosed pliers. Attach a piece of nylon seine twine (string) to the loop. Working from the fuse/relay block opening, "fish" the steel wire inside the kick panel, so it emerges beside the black plastic heating duct.

(c) Grip the seine twine (string) and pull an 18" length. Cut the twine free from the loop in the steel wire. Remove the steel wire (it has served its purpose).

(d) taking the end of the seat wire harness that has a connector on it, tie the seine twine to the end of the wire. Wrap the connection with plastic electrical tape to make a smooth cover.

(e) grip the seine twine where it comes out of the fuse/relay block opening. Gently pull the seine twine upwards, drawing the seat harness wire inside the kick panel, until it emerges in the fuse/relay block opening.

(f) remove the plastic electrical tape and cut the seine twine.

Attaching the seat harness wire to the fuse block

(a) cut off the old connector (the one that used to go into the connector block, and plugged into the central wiring harness), bare 1/4" of wire using a wire stripper, and install a standard female spade type connector (No. 14-16 wire, blue insulation). This connector need not have an insulated shield.

(b) Using a mirror if necessary to view the underside of the fuse/relay block, gently move aside wires so you can see the male spade-type connector at fuse position 7. Press the female connector onto the male connector at fuse position seven. A needle-nose pliers, will be useful to do this.

Completion of running wire from fuse block to front, door-side corner of seat location

(a) Replace the fuse/relay block in its holder, taking care that the new wire is not crimped in the process. When you push the fuse/relay block back into position, do so gently, making sure that the wire harness attached to it is not jammed between the fuse/relay block walls, and the white plastic fuse relay block holder.

(b) If there's excessive slack in the new wire, in the fuse/relay block area, gently pull on the end of the wire, where it emerges from the kick panel

(c) Loosen the plastic wire ties, and thread the new wire through them, beside the existing wire for the seat-belt warning (and/or seat heater) system, until it reaches the in-place connectors for the seat belt warning system (and/or seat heater).

(d) Take the black wire from the seat wiring harness, and thread it through the plastic wire ties, until you near the side of the emergency brake console

(e) Replace the storage bin/lighter, making sure that connections to the lighter are correct. Replace the two Phillips screws that secure this unit. Replace the black plastic bezel around the lighter. Do not replace the ashtray.

Removal of the Emergency Brake Console

(a) Remove the two Torx screws in the black plastic emergency brake "well".

(b) Remove by sliding backwards, the black plastic "L" shaped fitting, at the rear end of the opening, through which the emergency brake handle protrudes (some years may not have this fitting)

(c) Open the storage bin, and remove the panel in the bottom by prying gently, with the tip of a 1/4" wide, flat-bladed screwdriver. Remove the two Torx screws beneath the panel.

(d) Rock the console about 1" front to back

(e) Disengage the black plastic emergency brake handle well from the console housing (which will be colored to match your interior)

(f) If seat heater switches are present, reach under the emergency brake handle well and disconnect the seat heater switch connectors, from the wiring harness.

(g) Remove the emergency brake handle well

Attachment of the Ground (black wire)

(a) Take the black wire from the seat wiring harness [See C (c) above] and run it up to the screw that secures the emergency brake warning switch.

(b) bare 1/4" of the black wire attach a ring connector (No. 14-16).

(c) Remove the screw that secures the emergency brake warning switch

(d) Put the ring connector beneath the emergency brake warning switch

(e) Replace the screw that secures the emergency brake warning switch. You have a good ground. Using a multi-meter, check for power at the connector at the end of the seat wiring harness. If you have power there, proceed. If not, see Section J, below.

Replacement of the emergency brake well and center console

(a) Place the emergency brake well over the emergency brake handle.

(b) Reconnect the seat heater switches. Check for function.

(c) Replace the emergency brake well (do not replace the screws), aligning it with the front of the center console

(d) Re-seat the center console, aligning the holes in the bottom of the storage bin, with the holes in the bracket, to which it is screwed.

(e) Replace the screws in the bottom of the storage bit, but do not tighten fully

(f) Replace the screws in the bottom of the emergency brake well, but do not tighten fully

(g) Align the center console (do not tighten the screws).

Seat Installation

Preparation

(a) Tighten the plastic wire tires, loosened to allow running ground and positive wire from the fuse block/emergency brake switch positions, to the front door-side corner of the seat location

(b) Replace the carpet. Push the edges under the side of the center panel kick panel and the emergency brake console. Lay the carpet flat from the edge of the emergency brake console to the door.

(c) Tighten all four screws that secure the center console

(d) Replace the panel in the bottom of the center console storage bin

(e) Replace the ashtray

Seat Installation

(a) Place the powered seat into the car. Put the stud into the key hole in the floor pan and align the holes in the seat tracks with the bolt holes in the floor pan.

(b) Insert the bolts into the holes, but do not tighten then.

(c) Insert the seat wiring harness connector into the power connector attached to the front right corner of the power seat.

(d) Move the any seat switch (e.g., front-to-back). The seat should move in both directions. Check the other switches.

(e) Insert the four seat bolts, and tighten them. Lift the cup holder, and attach the seat belt anchor. Taking care that the seat-belt is not twisted. Tighten fully. Replace the screw at the front of the cup holder.

Finishing

(a) Replace the center column panel. Start at the top. The upper edge of the panel should be flush with the ceiling. When you press it into place, make sure the edges of the panel fit behind the black plastic. Do not press the bottom of the panel into place.

(b) If you've completely removed the door threshold strip, put it into place, engaging the lugs at the bottom of the center column panel.

(c) Position the threshold strip, so that the holes in the strip align with the holes in rocker panel.

(d) Position the center column panel into the metal clips that hold it.

(e) Press the center column panel into place

(f) Replace the screws that secure the center column panel

(g) Replace the screw covers over the center column panel screws

(h) Replace the screws that secure the threshold strip

(i) Replace the caps over the threshold strip screws.

(j) Replace the front door-side track cap. Tuck the electrical connectors behind the cap. Engage the cap lugs into the edge of the threshold strip. Secure the cap with the torx screw.

(k) Replace the rear plastic track caps. Fit the cap on the lugs on the seat track and push the caps forward. They should lock into place.

Trouble-shooting.

(a) If you do not have power at the seat connector, after you connect the ground, check Fuse #7 to be sure the circuit is live. If the fuse is OK, check to make sure that the connector has not been dislodged from the fuse block. Re-check all wires for continuity. If there is continuity - and there still is no power at the seat connector - there is some other fault, that is not obvious.

(b) If you have power at the seat connector, but the seat does not move, the switch likely is defective. These seats have a relay on the circuit board that wears out. You can bridge this relay out of the circuit or replace it (it is available from the manufacturer). This is a separate procedure. You can also replace the switch with one from a salvage yard, or from the dealer.

(c) Other power seat faults can be diagnosed using the Volvo Technical Manual.

Volvo Third Seat Installation

FAQ Home

Volvo Maintenance FAQ for 7xx/9xx/90 Cars Version 7.4

How to Install Your Wagon/Estate Third Seat [Manual Pages Scans by Kris Carlson]

SVENSKA

OBS!

- Finns skyddsgaller monterat måste det tillfälligt tas bort då extrasätet användes!

ENGLISH

NOTE:

- If a safety net has been installed, it must be removed while the extra seat is in use!

DEUTSCH

ACHTUNG!

- Ist ein Schutzgitter montiert, muß es bei Benutzung der Zusatzsitzbank entfernt werden!

FRANÇAIS

ATTENTION !

- Si une grille de protection est installée, elle devra être provisoirement enlevée pour utiliser le siège supplémentaire.

SUOMI

HUOM!

- Jos suojasäleikkö on asennettu on se tilapäisesti poistettava lisäistuinta käytettäessä !

ITALIANO

N.B.

- Se è montata la griglia di protezione si deve rimuovere temporaneamente quando si usa il sedile supplementare.

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1

SVENSKA

- Palla upp bilen bak.

ENGLISH

- Fold up the rear seat.

DEUTSCH

- Hinteren Wagenteil anheben.

FRANÇAIS

- Mettre le train arrière de la voiture sur chandelles.

SUOMI

- Nosta auton takapää ylös.

ITALIANO

- Sollevare la vettura sulla parte posteriore.

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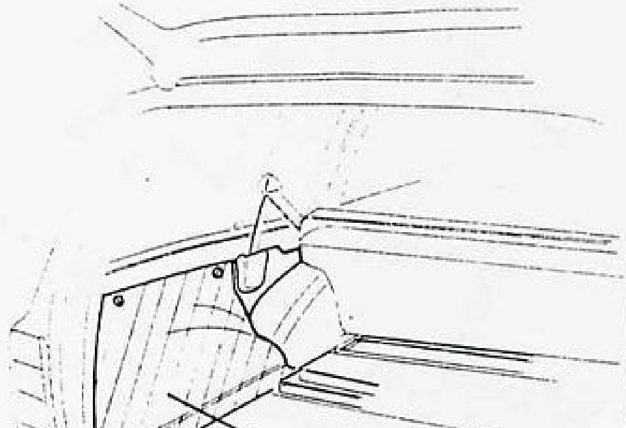
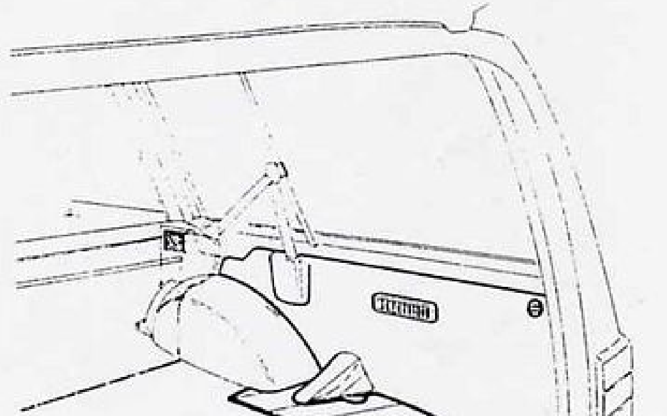
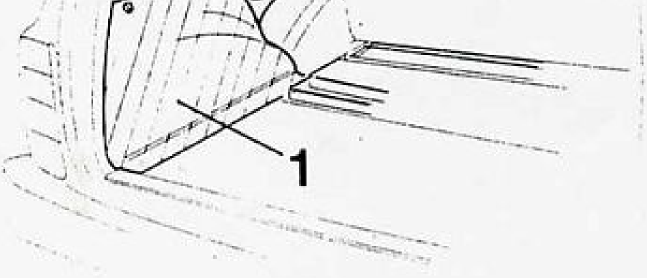
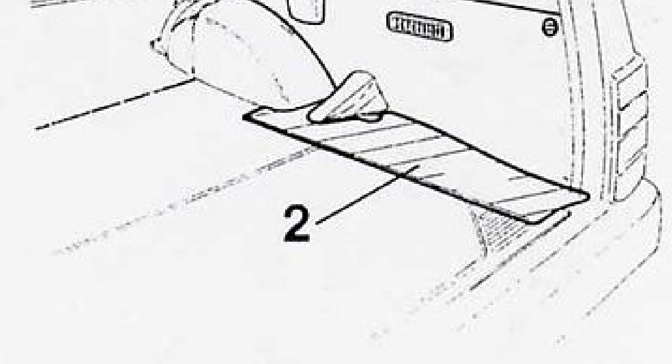
2









—SVENSKA—

- ☐ Ta bort panel (1) och golvlucka (2).
- ☐ Lyft ut reservhjulet.

—ENGLISH—

- ☐ Remove the side panel (1) and the floor panel (2).
- ☐ Lift out the spare wheel.

2

—DEUTSCH—

- ☐ Abdeckung (1) und Bodenklappe (2) entfernen.
- ☐ Reserverad herausheben.

—FRANÇAIS—

- ☐ Déposer le panneau (1) et la trappe de plancher (2).
- ☐ Enlever la roue de secours.

—SUOMI—

- ☐ Irrota paneeli (1) ja lattialuukku (2).
- ☐ Nosta vararengas ulos.

—ITALIANO—

- ☐ Rimuovere il pannello (1) e la botola sul pavimento (2).
- ☐ Sollevare la ruota di scorta.

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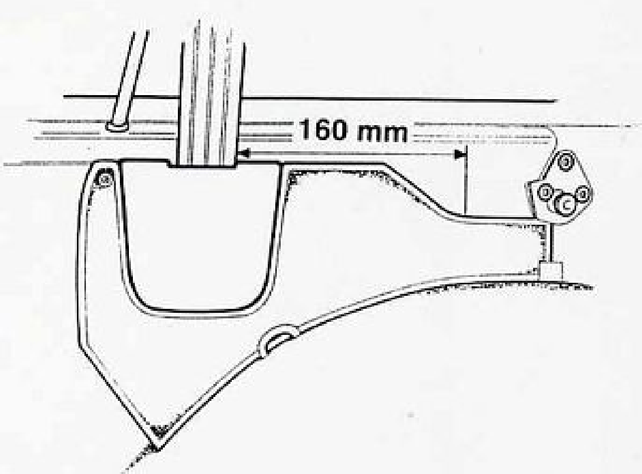
3



—SVENSKA—

- ☐ Mät ut och rita en lodrät linje 160 mm från bakre bilbältet.

—ENGLISH—

- ☐ Measure and draw a vertical line 160 mm from the rear seat belt.

—DEUTSCH—

- ☐ Senkrechte Linie 160 mm vom hinteren Befestigungsgurt ausmessen und anzeichnen.

—FRANÇAIS—

- ☐ Mesurer et tracer une ligne verticale à 160 mm de la ceinture de sécurité arrière.

—SUOMI—

- ☐ Mittaa ja piirrä pystysuora viiva 160 mm takimmaisesta turvavyöstä.

—ITALIANO—

- ☐ Misurare e tracciare una linea verticale di 160 mm dalla cintura di sicurezza posteriore.

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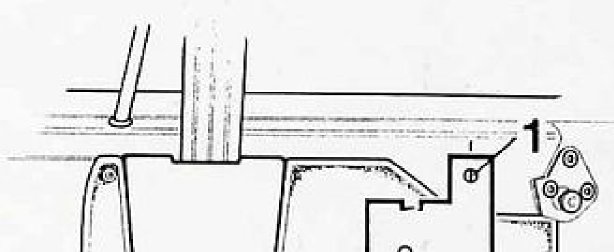
4

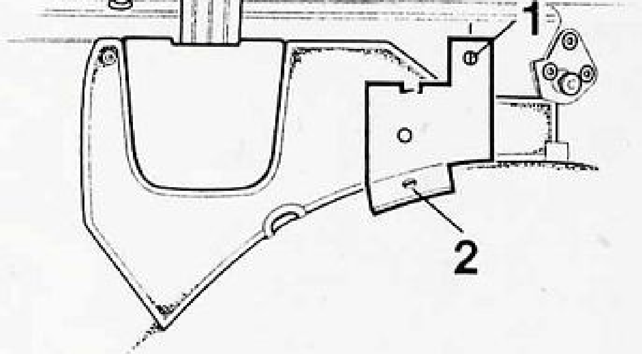


—ENGLISH—

- ☐ Hold the bracket **TIGHT** against the wheelhousing panel and carpet in a vertical position such that the line can be seen through the ho'e (1).
- ☐ Mark through the hole (2).

—DEUTSCH—

- ☐ Konsole so anhalten, daß sie senkrecht steht , die Linie im Loch (1) sichtbar ist und die Konsole **DICHT** an Paneel und Radkastenverkleidung liegt.
- ☐ Loch (2) anreißen.



☐ Konsole so anhalten, daß sie senkrecht steht , die Linie im Loch (1) sichtbar ist und die Konsole **DICHT** an Paneel und Radkastenverkleidung liegt.
☐ Loch (2) anreißen.

FRANÇAIS

☐ Positionner le support pour qu'il soit vertical et que la ligne tracée soit visible par le trou (1). Le support doit venir tout **CONTRE** le panneau et le tapis du passage de roue.
☐ Faire un repère dans le trou (2).

SUOMI

☐ Pidä konsolia paikallaan niin, että konsoli on pystysuorassa, viiva näkyvissä reiän (1) läpi ja että konsoli on **TIUKASTI** paneelia ja pyöräpesänmattoa vasten kiinni.
☐ Tee merkki reikään (2).

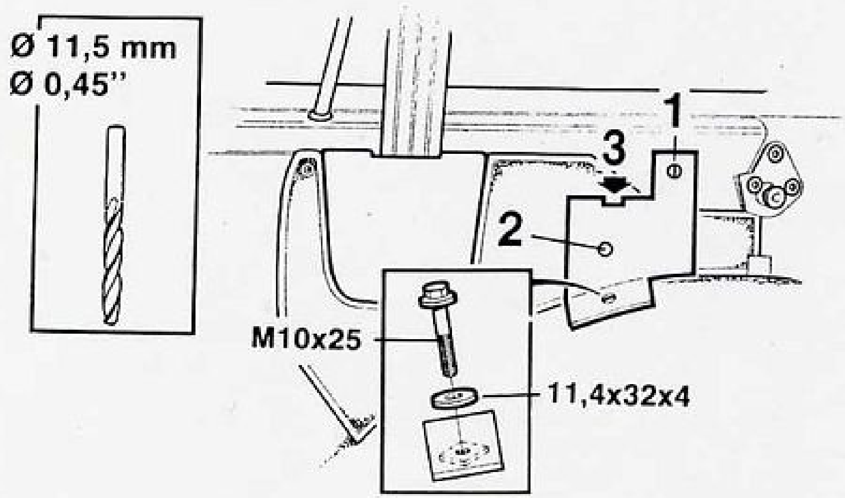
SVENSKA

☐ Håll konsolen på plats så att konsolen står lodrät och att linjen syns i hål (1) och konsolen ligger **TÄTT** mot panelen och hjulhusmattan.
☐ Gör en markering i hål (2).

ITALIANO

☐ Tenere fissa la mensola in posizione verticale e in modo che la linea sia visibile nel foro (1) e che la mensola si trovi **SPINTA** contro il pannello e contro il tappetino sul passaruota.
☐ Effettuare un segno nel foro (2).

5



SVENSKA

☐ Borra hål Ø 11,5 mm i mattan och hjulhusplåten.
☐ Dra fast konsolen i hjulhuset med svart skruv så att hjulhusmattan pressas ihop.
☐ Kontrollera att linjen syns i hål (1).
☐ Gör en markering i hål (1 och 2), märk även ut uttagets placering (3).
☐ Ta bort konsolen.

ENGLISH

☐ Drill a Ø 11.5 mm hole in the wheelhousing carpet and panel.

FRANÇAIS

☐ Percer à Ø 11,5 mm dans le tapis et dans la tôle du passage de roue.
☐ Avec la vis noire, serrer le support dans le passage de roue pour bien comprimer le tapis du passage de roue.
☐ Vérifier que la ligne est visible par le trou (1).
☐ Faire un repère dans les trous (1) et (2), repérer également l'emplacement de la découpe (3).
☐ Enlever le support.

SUOMI

☐ Poraa Ø 11,5 mm reikä mattoon ja pyöräpesäpeltiin.

également l'emplacement de la découpe (3).
- ☐ Enlever le support.

—ENGLISH—

- ☐ Drill a Ø 11.5 mm hole in the wheelhousing carpet and panel.
- ☐ Tighten the bracket to the wheelhousing with the black screw so that the wheelhousing carpet is compressed .
- ☐ Check to make sure the line can be seen in the hole (1).
- ☐ Make a mark in the holes (1 and 2) and also mark out where the cut-out (3) is positioned.
- ☐ Remove the bracket.

—DEUTSCH—

- ☐ Loch Ø 11,5 mm in Verkleidung und Radkastenblech bohren.
- ☐ Konsole in Radkasten mit schwarzer Schraube so fest anziehen, daß die Verkleidung zusammengepreßt wird.
- ☐ Kontrollieren, daß die Linie im Loch (1) sichtbar ist.
- ☐ Loch (1) und (2) anreißen, auch Position des Ausschnitts (3) markieren.
- ☐ Konsole entfernen.

—SUOMI—

- ☐ Poraa Ø 11,5 mm reikä mattoon ja pyöräpesäpeltiin.
- ☐ Kiinnitä konsoli pyöräpesään mustalla ruuvilla niin, että pyöräpesänmatto puristuu kokoon.
- ☐ Tarkista, että viiva näkyy reiästä (1).
- ☐ Tee merkki reikiin (1 ja 2), merkkaa myös aukon paikka (3).
- ☐ Irrota konsoli.

—ITALIANO—

- ☐ Praticare un foro da Ø 11,5 mm nel tappetino e sulla lamiera del passaruota.
- ☐ Fissare la mensola nel passaruota con la vite nera in modo da fissare il tappetino del passaruota.
- ☐ Controllare che la linea sia visibile nel foro (1).
- ☐ Effettuare un segno nei fori (1 e 2). Segnare anche la posizione della presa (3).
- ☐ Rimuovere la mensola.

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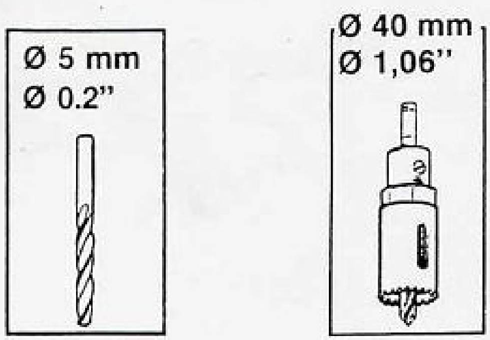

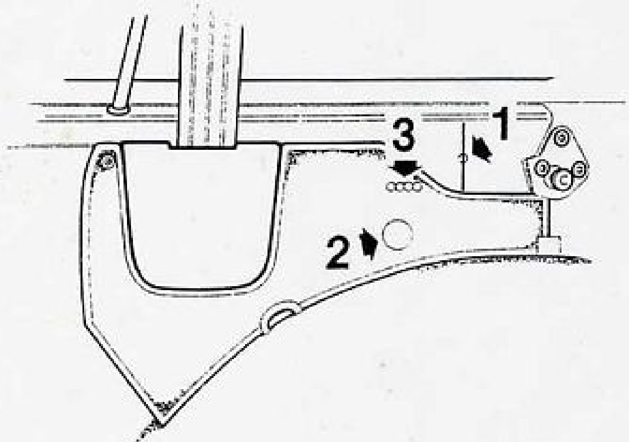

—SVENSKA—

- ☐ Borra markering (1) med ett Ø 5 mm borr.
- ☐ Borra markering (2) med en hålsåg Ø 40 mm.
- ☐ Borra 4 st. hål Ø 5 mm i uttagets markering (3).

—ENGLISH—

- ☐ Drill the mark (1) with a Ø 5 mm drill.
- ☐ Drill the mark (2) with a Ø 40 mm keyhole saw.
- ☐ Drill 4 holes Ø 5 mm where the cut-out is marked (3).

—DEUTSCH—

- ☐ Markierung (1) mit Bohrer Ø 5 mm bohren.
- ☐ Markierung (2) mit Lochsäge Ø 40 mm bohren.
- ☐ Vier Löcher Ø 5 mm in Ausschnittmarkierung (3) bohren.

—FRANÇAIS—

- ☐ Percer avec un foret Ø 5 mm au repère (1).
- ☐ Percer avec une scie Ø 40 mm au repère (2).
- ☐ Percer quatre trous Ø 5 mm dans le repère (3) pour l'encoche.

—SUOMI—

- ☐ Poraa merkintään (1) Ø 5 mm poralla.
- ☐ Poraa merkintään (2) Ø 40 mm reikäsahalla.
- ☐ Poraa 4 kpl. Ø 5 mm reikää aukon merkintään (3).

—ITALIANO—

- ☐ Effettuare il segno (1) con una punta da Ø 5 mm.
- ☐ Effettuare il segno (2) con un seghetto da Ø 40 mm.
- ☐ Praticare 4 fori da Ø 5 mm nel segno sulla presa (3).

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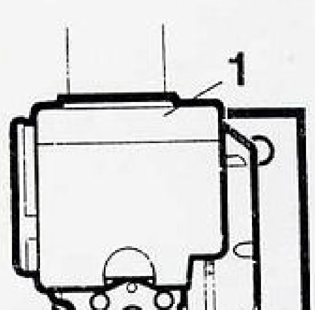


—SVENSKA—

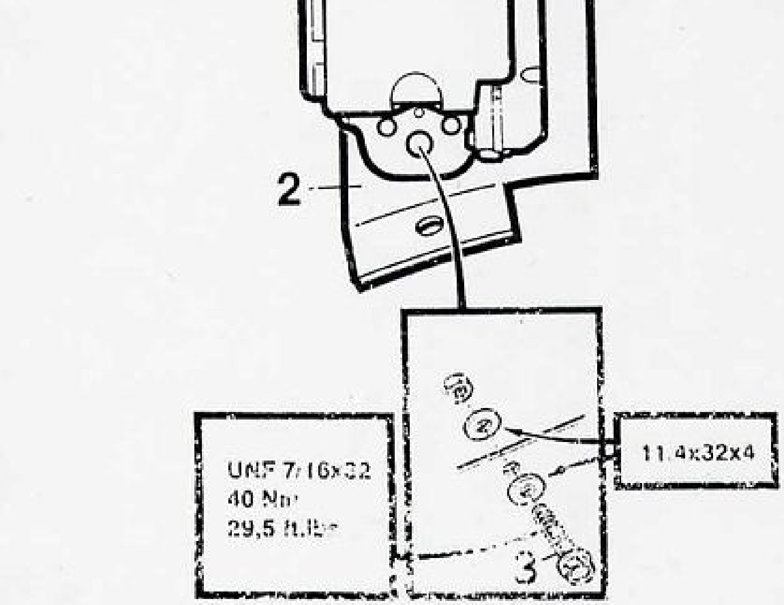
- ☐ Skruva fast extrasätets bältesrulle (1) i konsolen (2). OBS! Skruven (3) skall vara svart och helgängad.

—ENGLISH—

- ☐ Screw tight the extra seat belt roller (1) to the bracket (2). NOTE: Black, full-thread bolt (3).

—DEUTSCH—

- ☐ Gurtrolle (1) der Zusatzsitzbank an der Konsole (2) festschrauben. ACHTUNG! Schwarze Schraube (3) mit vollem Gewinde



DEUTSCH

- ☐ Gurtrolle (1) der Zusatzsitzbank an der Konsole (2) festschrauben.
  ACHTUNG! Schwarze Schraube (3) mit vollem Gewinde anwenden.

FRANÇAIS

- ☐ Visser le rouleau de ceinture de sécurité (1) pour le siège supplémentaire dans le support (2).
  ATTENTION ! La vis (3) doit être noire et filetée sur toute sa longueur.

SUOMI

- ☐ Kiinnitä lisäistuimen vyörulla (1) konsoliin (2).
  HUOM! Ruuvin (3) on oltava musta ja täysin kierteitetty.

ITALIANO

- ☐ Fissare il rullo (1) della cintura per il sedile supplementare nella mensola (2).
  N.B. La vite (3) deve essere nera e filettata.

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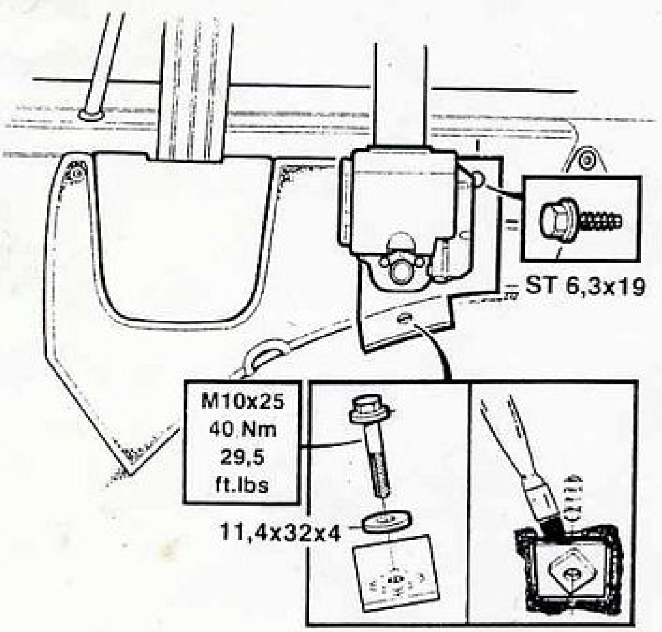

SVENSKA

- ☐ Skruva fast konsolen med bältesrullen i bilen.
- ☐ Stryk underredsmassa på och runt mutterplattan.
- ☐ Utför samma moment på andra sidan.

ENGLISH

- ☐ Screw tight the bracket with the car belt roller.
- ☐ Apply underbody sealant to and round the nut plate.
- ☐ Repeat the above on the other side.

DEUTSCH

- ☐ Konsole mit Gurtrolle im Wagen festschrauben.
- ☐ Unterbodenschutz auf und um die Mutternplatte auftragen.
- ☐ Gleiche Montagepunkte auf der anderen Seite ausführen.

FRANÇAIS

- ☐ Visser le support avec le rouleau de ceinture de sécurité dans la voiture.
- ☐ Passer de l'enduit de caisse sur et autour de la plaque écrou.
- ☐ Procéder de façon identique de l'autre côté.

SUOMI

- ☐ Ruuvaa konsoli ja vyörulla kiinni autoon.
- ☐ Sivele alustamassaa mutterilaattaan ja sen ympärille.
- ☐ Tee sama toisella puolella.

ITALIANO

- ☐ Fissare la mensola con il rullo della cintura nella vettura.
- ☐ Applicare del materiale per il sottoscocca sul e intorno al dado
- ☐ Eseguire la stessa operazione sull'altro lato.

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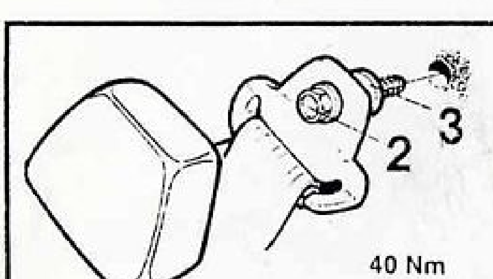
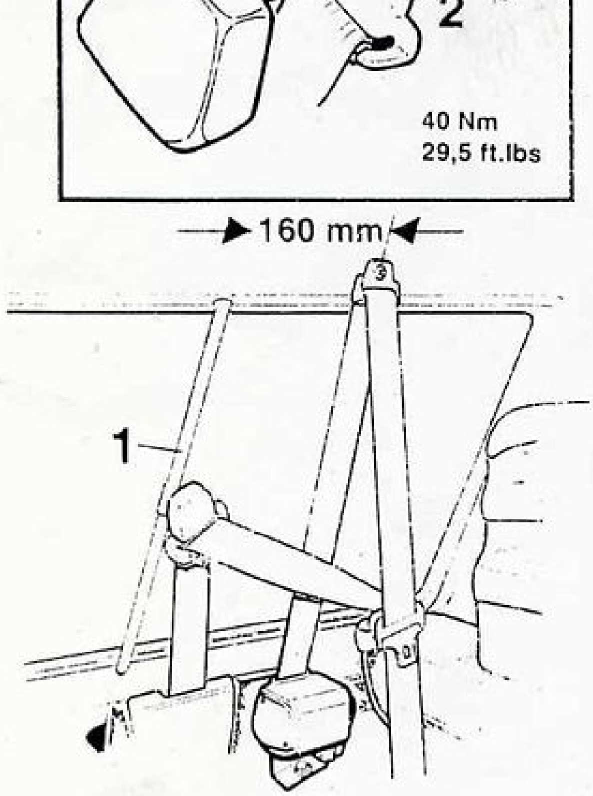


SVENSKA

Utan skyddsgaller

- ☐ Leta upp svetsmuttern i takbalken finns ca 160 mm framför staget (1).
- ☐ Stick hål i takklädseln.
  OBS! Dragningen av bältet.
- ☐ Sätt fast övre fästet med skruven (2) och bricka (3) mellan fästet och takbalk.
- ☐ Dra åt skruven.
- ☐ Sätt dit kåpan.
- ☐ Utför samma moment på andra sidan.



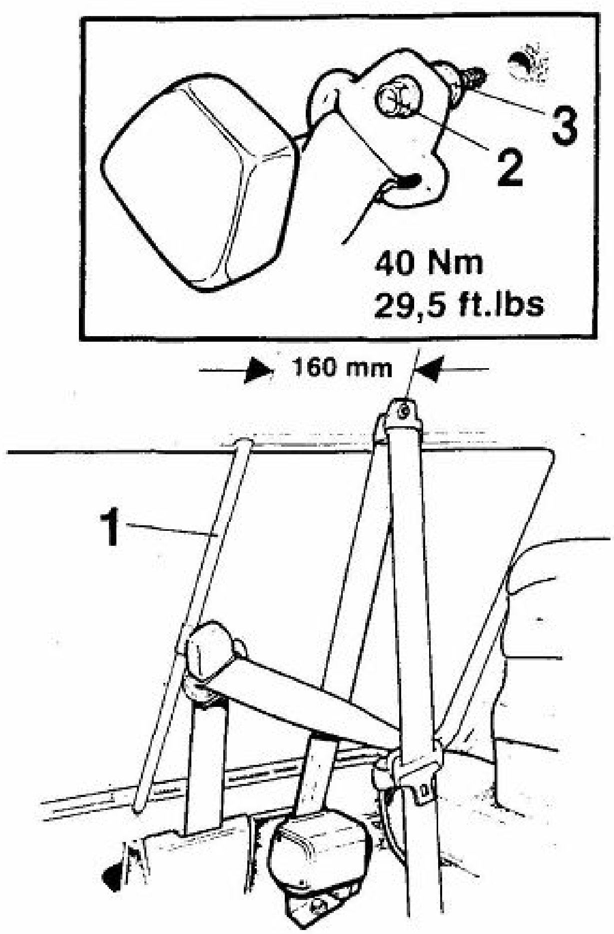
fästet och takbalk.
- ☐ Dra åt skruven.
- ☐ Sätt dit kåpan.
- ☐ Utför samma moment på andra sidan.

ENGLISH

No safety net mounting
- ☐ Locate the weld nut under the headlining about 160 mm in front of the stay (1).
- ☐ Stick a hole in the headlining. Note how the belt is drawn.
- ☐ With the bolt (2) and washer (3) fix the upper attachment between the attachment and roof member.
- ☐ Tighten the bolt.
- ☐ Fit the casing.
- ☐ Repeat the above on the other side.

DEUTSCH

Ohne Schutzgitter
- ☐ Schweißmutter im Dachbalken ausfindig machen (ca. 160 mm vor dem Stag (1)).
- ☐ Loch in Dachverkleidung stechen
ACHTUNG! Einbau des Gurtsystems.
- ☐ Obere Befestigung mit Schraube (2) und Unterlegscheibe (3) zwischen Befestigung und Dachträger anbringen.
- ☐ Schraube anziehen.
- ☐ Abdeckung aufsetzen.
- ☐ Gleiche Montagepunkte auf der anderen Seite ausführen.



FRANÇAIS

Sans grille de protection
- ☐ Chercher l'écrou de soudage dans le profilé du pav
à environ 160 mm devant l'étai (1).
- ☐ Percer dans la garniture du plafond. ATTENTION p
passage de la ceinture !
- ☐ Monter la fixation supérieure avec la vis (2) et la ron
(3) entre la fixation et le profilé du pavillon.
- ☐ Serrer la vis.
- ☐ Positionner le capot.
- ☐ Procéder de façon identique de l'autre côté.

SUOMI

Ilman suojussäleikköä
- ☐ Etsi hitsausmutteri kattopalkista, se on noin 160 mm
(1) etupuolella.
- ☐ Tee reikä kattoverhoiluun.
HUOM! Turvavyön veto.
- ☐ Kiinnitä ylempi kiinnike ruuvilla (2) ja aluslevyllä
kiinnikkeen ja kattopalkin välille.
- ☐ Kiristä ruuvi.
- ☐ Kiinnitä kuomu.
- ☐ Tee sama toisella puolella.

ITALIANO

Senza griglia di protezione
- ☐ Individuare il dado di saldatura sulla traversa del tett
trova a circa 160 mm davanti l'asta (1).
- ☐ Praticare un foro nel rivestimento del tetto.
N.B. Tiraggio della cintura.
- ☐ Montare l'attacco superiore con la vite (2) e la rondell
tra l'attacco e la traversa sul tetto.
- ☐ Serrare la vite.
- ☐ Montare il coperchio.
- ☐ Eseguire la stessa operazione sull'altro lato.

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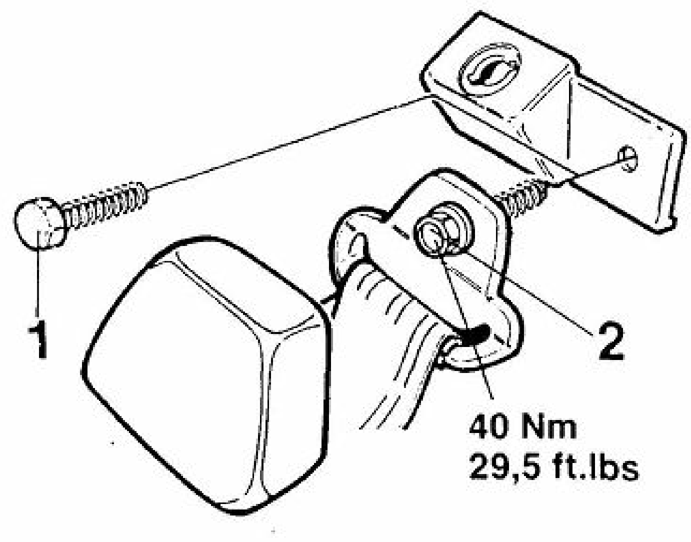

SVENSKA

Med skyddsgaller
- ☐ Ta bort skruven (1).
- ☐ Sätt fast övre fästet med skruven (2).
- ☐ Dra åt skruven.
- ☐ Sätt dit kåpan.
- ☐ Utför samma moment på andra sidan.

ENGLISH

Safety net mounting
- ☐ Remove the bolt (1).
- ☐ Fix the upper attachment with the bolt (2).
- ☐ Tighten the bolt.
- ☐ Fit the casing.
- ☐ Repeat the above on the other side.

DEUTSCH

Mit Schutzgitter
- ☐ Schraube (1) entfernen.
- ☐ Obere Befestigung mit Schraube (2) anbringen.
- ☐ Schraube anziehen.
- ☐ Abdeckung aufsetzen.
- ☐ Gleiche Montagepunkte auf der anderen Seite führen.

FRANÇAIS

Avec grille de protection
- ☐ Enlever la vis (1).
- ☐ Monter la fixation supérieure avec la vis (2).
- ☐ Serrer la vis.
- ☐ Positionner le capot.
- ☐ Procéder de façon identique de l'autre côté.

10

SUOMI

Suojussäleiköllä varustettu
- ☐ Irrota ruuvi (1).
- ☐ Kiinnitä ylempi kiinnike sarjan ruuvilla (2).
- ☐ Kiristä ruuvi.
- ☐ Kiinnitä kuomu.
- ☐ Tee sama toisella puolella.

ITALIANO

Con la griglia di protezione
- ☐ Rimuovere la vite (1).
- ☐ Fissare l'attacco superiore con la vite (2).
- ☐ Serrare la vite.
- ☐ Montare il coperchio.
- ☐ Eseguire la stessa operazione sull'altro lato.

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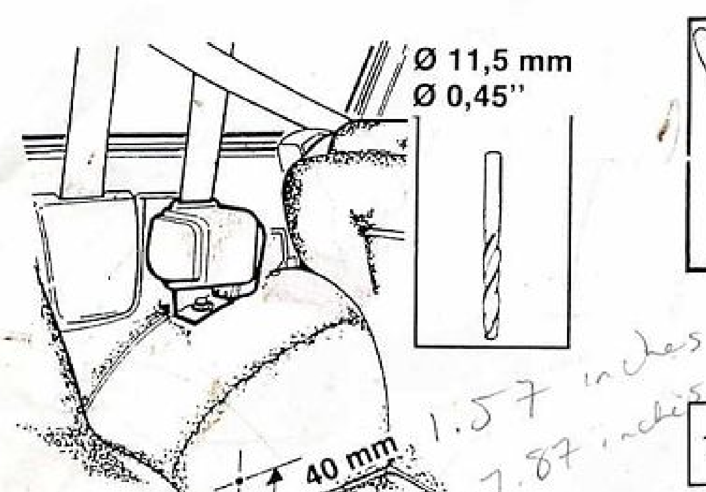

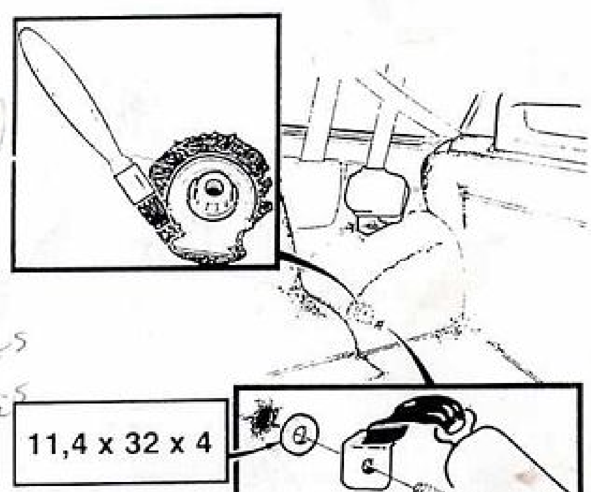

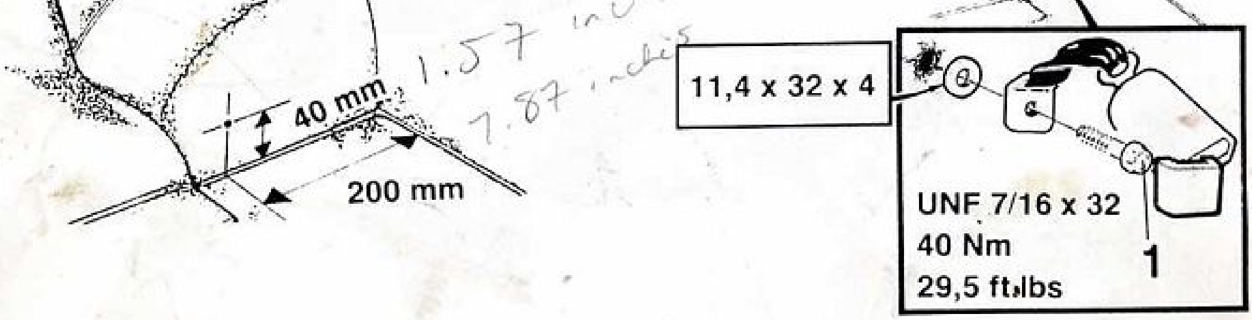

SVENSKA

- ☐ Märk ut och borra hål i hjulhuset.
- ☐ Skruva fast bälteslåset.
  OBS! Använd skruv (1) med ansats.
- ☐ Stryk underredsmassa pa och runt mutterplattan.
- ☐ Dammsug bort borrspanor.
- ☐ Utför samma moment pa andra sidan.
- ☐ Sätt dit kåpan (2).

ENGLISH

- ☐ Mark out and drill a hole in the wheelhousing.
- ☐ Screw tight the belt lock.
  NOTE: Use a bolt of the kind shown in the fig. (1).
- ☐ Apply underbody sealant to and around the nut plate.
- ☐ Repeat the above on the other side.
- ☐ Vacuum-clean drill filings.
- ☐ Fit the casing (2).

DEUTSCH

- ☐ Loch im Radkasten anreißen und bohren.
- ☐ Gurtschloß festschrauben.
  ACHTUNG! Schraube (1) mit Ansatz anwnden.
- ☐ Unterbodenschutz auf und um die Mutternplatte auftragen.
- ☐ Gleiche Montageschritte auf der anderen Seite ausführen.
- ☐ Bohrspäne mt Staubsauger entfernen.
- ☐ Abdeckung aufsetzen (2).

FRANÇAIS

- ☐ Repérer et percer dans le passage de roue.
- ☐ Visser l'attache de la ceinture de sécuruté.
  ATTENTION! Utiliser la vis (1) avec butée.
- ☐ Passer de l'enduit de caisse sur et autour de la plaque écrou.
- ☐ Prodéder de façon identique de l'autre côté.
- ☐ Enlever les copeaux avec un aspirateur.
- ☐ Positioner le capot (2).

SUOMI

- ☐ Merkkaa ja poraa reikä pyöräpesään.
- ☐ Kiinnitä vyölukko.
  HUOM! Käytä laipparuuvia (1).
- ☐ Sivele alustamassa mutterilevyyn ja sen ympärille.
- ☐ Tee sama toisella puolella.
- ☐ Imuroi porauslastut pois.
- ☐ Kiinnitä kuomu (2).

ITALIANO

- ☐ Effettuare i riferimenti e praticare i fori nel passaruota.
- ☐ Fissare con la vite la serrature della cintura.
  N.B. Utilizzare la vite (1) con il blocchetto.
- ☐ Applicare della protezione per sottoscocche sul e intorno alla piastina del dado.
- ☐ Aseguire la stessa operazione sull'altro lato.
- ☐ Rimmuovere le polvere co un aspirapolvere.
- ☐ Montare it coperchio (2).

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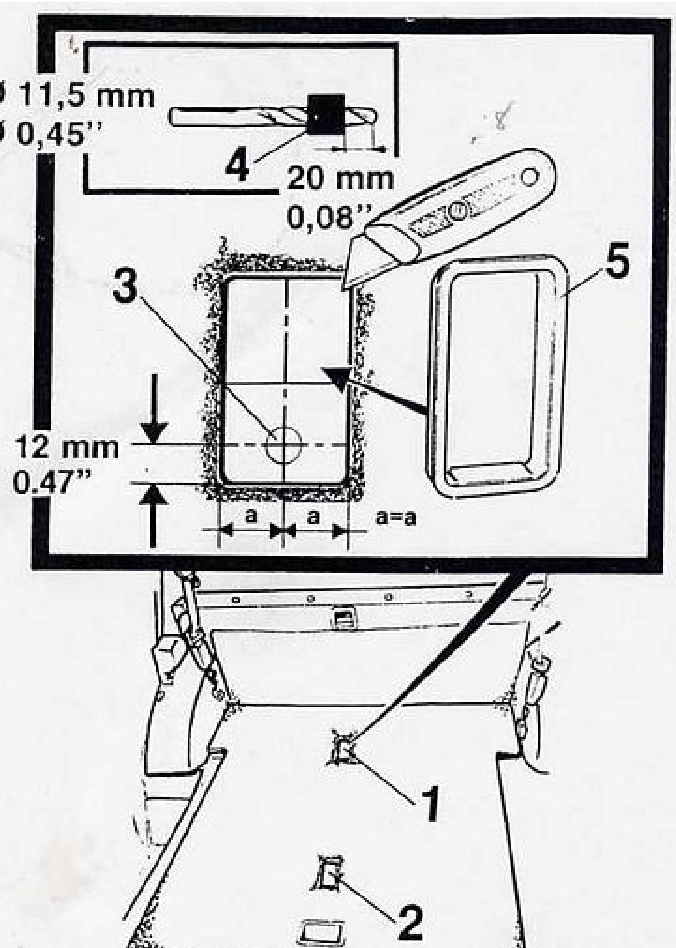

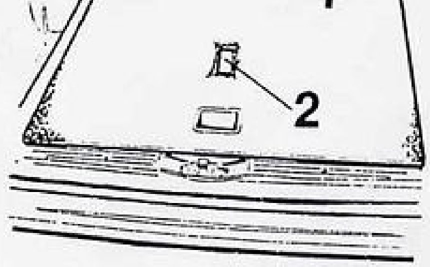

SVENSKA

- Lokalisera hålen (1 och 2) under mattan. Skär ut hålen ur golvmattan med en vass kniv.
- Märk ut i hål (3).
- Borra hål.
  OBS! Borra försiktigt då bensintanken är monterad på undersidan. Montera ett stopp (4) på borren enligt fig.
- Justera träpanelen för hål (2) med kniv så att låsningarna för plastskoningen (5) får ingrepp.
- Sätt dit plastskoningarna (5).

ENGLISH

- Locate the holes (1 and 2) under the carpet. Cut holes in the floor carpet with a sharp knife.
- Mark out a hole (3).
- Drill the hole.
  NOTE. Observe great care when drilling since the fuel tank is mounted underneath. Fit a stop (4) on the drill as shown in the fig.
- With a knife adjust the wooden panel for the hole (2) to enable the plastic lining retainers (5) to grip.
- Fit the plastic lining retainers (5).

DEUTSCH

- Löcher (1) und (2) unter dem Teppichboden ausfindig machen. Löcher mit scharfen Messer aus Bodenbelag herausschneiden.
- Loch (3) anreißen.
- Loch bohren.
  ACHTUNG! Vorsichtig bohren, da auf der Unterseite der Kraftstofftank montiert ist. Bohranschlag (4) entsprechend Abbildung anwenden.
- Holzabdeckung mit einem Messer für das Loch (2) so ausrichten, daß die Führungen für die Kunststoffbeschläge (5) in Eingriff gelangen.
- Kunststoffbeschläge (5) einsetzen.

FRANÇAIS

- Localiser les trous (1 et 2) sous le tapis. Découper les trous dans le tapis de sol avec un couteau tranchant.
- Repérer le trou (3).
- Percer.
  ATTENTION ! Percer avec précautions, le réservoir d'essence est placé en-dessous. Mettre une butée (4) sur le foret comme le montre la figure.
- Ajuster le panneau en bois pour le trou (2) avec un couteau pour avoir un bon verrouillage de la baguette en plastique (5).
- Positionner les protections en plastique (5).

SUOMI

- Paikallista reiät (1 ja 2) maton alta. Leikkaa reiät lattiamattoon terävällä veitsellä.
- Merkkaa reikään (3).
- Poraa reikä.
  HUOM! Poraa varovasti koska bensiinitankki on asennettu alapuolelle. Asenna poraan pysäytin (4) kuvan mukaan.
- Muotoile puupaneelit reikää (2) varten veitsellä siten, että muovireunuksen (5) lukitukset kiinnittyvät.
- Kiinnitä muovirenus (5).

ITALIANO

- Individuare i fori (1 e 2) sotto il tappetino. Tagliare i fori sul pavimento usando un coltellino.
- Fare i segni sui fori (3).
- Praticare i fori.
  N.B. Praticare i fori con attenzione poichè il serbatoio del carburante è montato sull'estremità in basso. Montare un arresto (4) sulla punta come indicato dalla figura.
- Regolare il pannello di legno per i fori (2) usando un coltellino in modo che i fermi del cono di plastica (5) entrino in contatto.
- Montare i coni di plastica (5).

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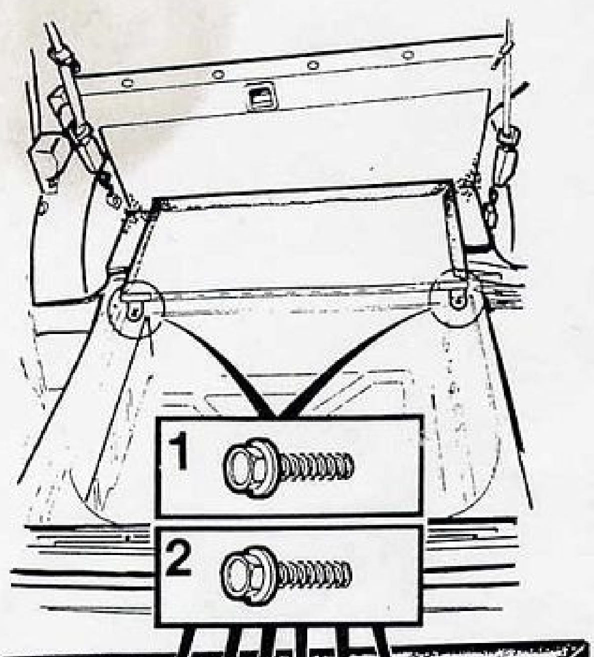


ENGLISH

Removing the wooden floor

- Tilt up the wooden panel and remove the bolts (1).
- Fold up the rear seat cushion and tilt the backrest a bi forwards.
- Remove the bolts (2).
- Lift out the entire floor.
- Remove of the insulating mat on the rear axle tunnel (3).

DEUTSCH

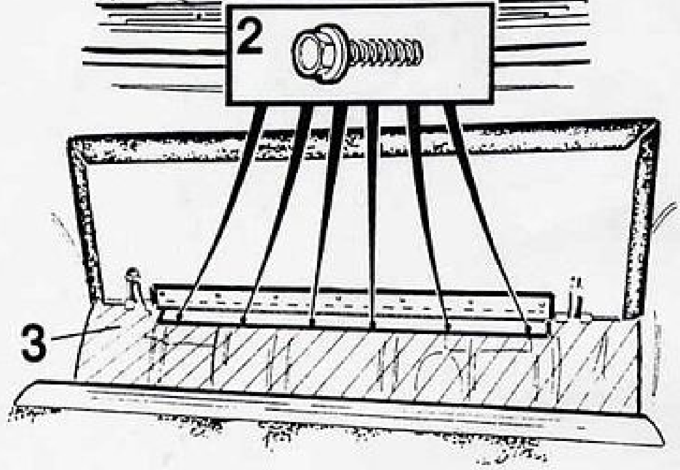
Ausbau des Holzbodens.

- Bodenluke öffnen und Schrauben (1) entfernen.
- Hinteres Sitzpolster senkrecht stellen und Rückenlehne etwas nach vorn neigen.
- Schrauben (2) entfernen.
- Gesamten Holzboden herausheben.
- Isolierbelag über dem Hinterachstunnel (3) entfernen.

FRANÇAIS

Dépose du plancher en bois

- Relever la trappe du plancher et enlever les vis (1).
- Relever la banquette du siège arrière et le dossier légèrement vers l'avant.



—SVENSKA—

Borttagning av trägolv

- ☐ Fäll upp golvluckan och ta bort skruvarna (1).
- ☐ Fäll upp bakre sittdyna samt fäll upp ryggstödet något framåt.
- ☐ Ta bort skruvarna (2).
- ☐ Lyft ut hela golvet.
- ☐ Ta bort isoleringsmattan över bakaxeltunneln (3).

—FRANÇAIS—

Dépose du plancher en bois

- ☐ Relever la trappe du plancher et enlever les vis (1).
- ☐ Relever la banquette du siège arrière et le dossier légèrement vers l'avant.
- ☐ Enlever les vis (2).
- ☐ Déposer le plancher en entier.
- ☐ Déposer le tapis isolant sur le tunnel du pont arrière (3).

—SUOMI—

Puulattian irrotus

- ☐ Käännä lattialuukku ylös ja irrota ruuvit (1).
- ☐ Käännä takimmainen istuintyyny ylös ja selkänojaa hieman eteenpäin.
- ☐ Irrota ruuvit (2).
- ☐ Nosta koko lattia ulos.
- ☐ Poista kokonaan taka-akselitunnelin (3) päällä oleva eristematto.

—ITALIANO—

Rimozione del pavimento di legno

- ☐ Sollevare la botola sul pavimento e rimuovere le viti (1).
- ☐ Sollevare il cuscino posteriore e spostare lo schienale leggermente in avanti.
- ☐ Rimuovere le viti (2).
- ☐ Sollevare il pavimento.
- ☐ Rimuovere il tappetino isolante sopra la galleria del retrotreno (3).

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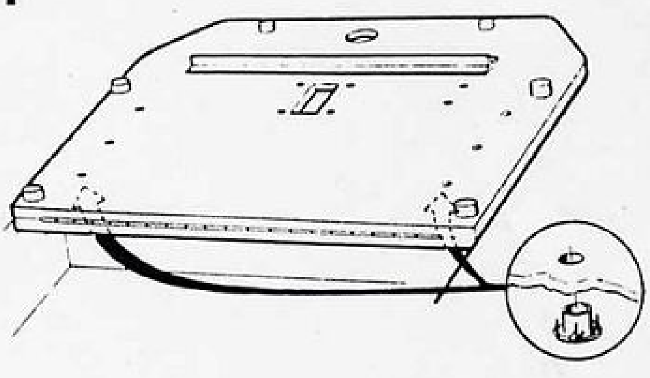

—SVENSKA—

Gäller endast årsmodell 1978-85

- ☐ Markera hålen i mattan, fäll ner luckan och slå i islagsmuttranra i hålen från mattsidan, 12 st.

—ENGLISH—

Applies only to year models 1978-85

- ☐ Mark out holes in the mat and fold down the floor panel. Knock impact nuts (12 nuts) into the holes from the mat side.

—DEUTSCH—

Gilt nur für Modelljahr 1978 - 85.

- ☐ Löcher im Teppichboden markieren, Luke schließen und Einschlagmuttern in die Löcher von der Belagsseite he einschlagen. Gesamt 12 Stück.

—FRANÇAIS—

Concerne uniquement les modèles de 1978 à 1985

- ☐ Repérer les trous dans le tapis, rabattre la trappe e enfoncer les écrous dans les trous côté tapis, 12 écrous

—SUOMI—

Koskee vain vuosimalleja 1978-85

- ☐ Merkkaa reiät mattoon, käa 'uukku alas ja ly iskumutterit reikiin matonpuolelta, 12 st.

—ITALIANO—

Vale solo per i modelli 1975-85

- ☐ Effettuare i riferimenti per i fori nel tappetino, abbassare botola e montare i dadi nei fori, 12 pezzi.

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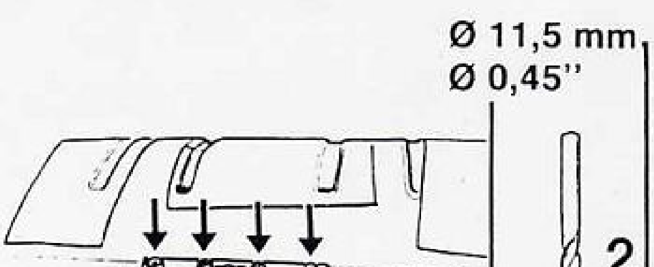
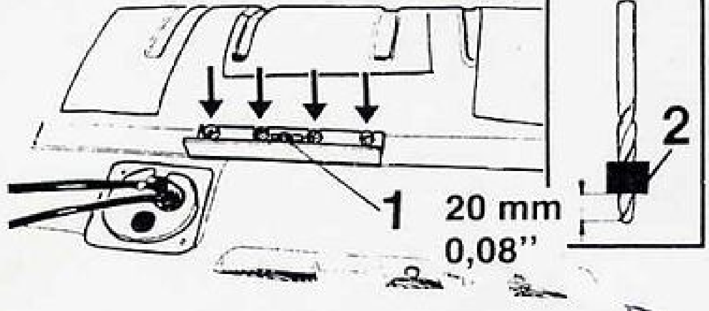


—DEUTSCH—

- ☐ Mutternplatte mit der Oberseite nach unten auf bereits gebohrte mittlere Loch (1) im Bodent auflegen.
  ACHTUNG! Mutternplatte muss gerade aufliegen.
- ☐ Die vier übrigen Löcher anreißen und bohren.
  ACHTUNG! Vorsichtig bohren, da der Kraftstofftan der Unterseite montiert ist. Bohranschlag (2) entspr end Abbildung anwenden.
- ☐ Lochkanten mit Rostschutzmittel behandeln.
- ☐ Bohrspäne mit Staubsauger entfernen.



SVENSKA

- ☐ Placera mutterplattan upp och ner på dct redan borrade mittre hålet (1) i golvplåten.
  OBS! Mutterplattan måste placeras rakt.
- ☐ Märk ut och borra de fyra övriga hålen.
  OBS! Borra försiktigt då bensintanken är monterad på undersidan. Montera ett stopp (2) på borren enligt fig.
- ☐ Rostskyddsbehandla hålkanterna.
- ☐ Dammsug bort borrspånor.

ENGLISH

- ☐ Place the nut plate upside down over the centre hole (1) already drilled in the floor plating.
  NOTE! Make sure the nut plate is placed straight.
- ☐ Mark out and drill the other four holes.
  NOTE! Observe great care when drilling since the petrol tank is mounted underneath. Fit a stop (2) on the drill as shown in the fig.
- ☐ Rustproof round the edges of the holes.
- ☐ Vacuum-clean the drill filings.

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der Unterseite montiert ist. Bohranschlag (2) entspr end Abbildung anwenden.
- ☐ Lochkanten mit Rostschutzmittel behandeln.
- ☐ Bohrspäne mit Staubsauger entfernen.

FRANÇAIS

- ☐ Positionner la plaque écrou sens dessus dessous s trou central déjà percé (1) dans la tôle du plancher.
- ☐ Repérer et percer les quatre autres trous.
  N.B.! La plaque écrou doit être en position droite.
  ATTENTION! Faire attention pour le perçage, le rése d'essence étant placé en-dessous. Monter une buté sur le foret comme le montre la figure.
- ☐ Traiter les bords des trous contre la corrosion.
- ☐ Enlever les copeaux avec un aspirateur.

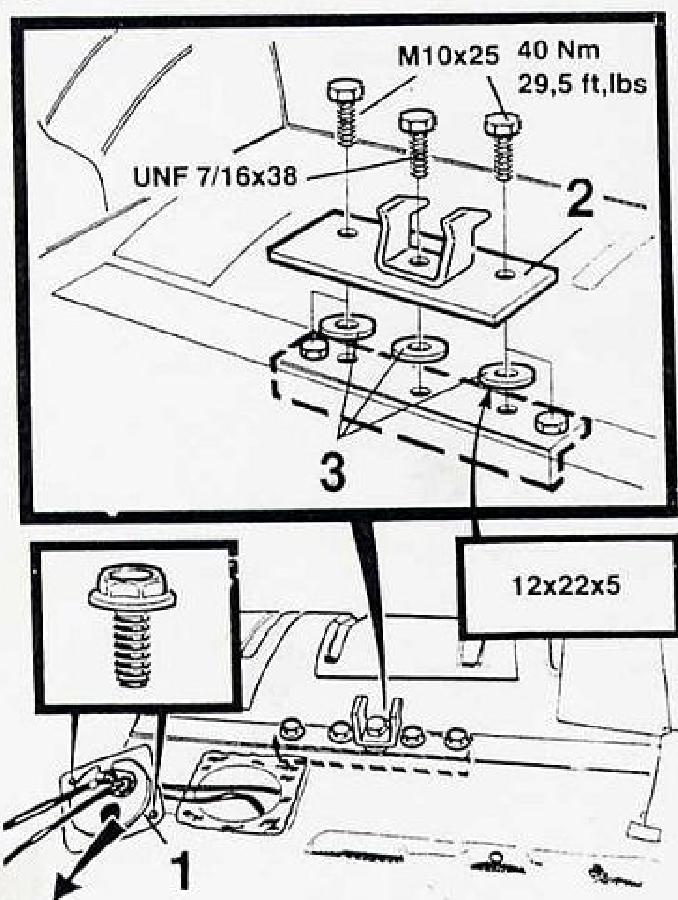
SUOMI

- ☐ Aseta mutterilaatta ylösalaisin lattiapeltiin poratun kes mäisen reiän (1) päälle.
- ☐ Merkkaa ja poraa jäljellä olevat neljä reikää.
  HUOM! Mutterilaatta on asetettava suoraan.
  HUOM! Poraa varovasti koska bensiinitankki on a nettu alapuolelle. Asenna pysäytin (2) poraan ku mukaan.
- ☐ Ruostesuojaa reikien reunat.
- ☐ Imuroi porauslastut pois.

ITALIANO

- ☐ Collocare la piastrina del dadoin senso inverso sul centrale (1) già preforato, sulla lamiera del pavimer
- ☐ Effettuare i riferimenti e praticare gli altri quattro fori
  N.B. La piastrina si deve trovare in posizione diritta
  N.B. Praticare i fori con attenzione poiché il serbatoi carburante è montato sull'estremità in basso. Montai arresto (2) sulla punta come indicato dalla figura.
- ☐ Praticare l'anticorrosione degli angoli dei fori.
- ☐ Rimuovere la polvere con un aspirapolvere.

16



SVENSKA

- ☐ Ta bort skruvarna som håller luckan (1), vik luck sidan.
- ☐ För in mutterplattan genom hålet och skruva fas tillsammans med låshaken (2) och brickorna (3).
  OBS! Låshaken måste sitta rakt.
- ☐ Sätt tillbaka och skruva fast luckan (1).
- ☐ Sätt tillbaka trägolvet.

ENGLISH

- ☐ Remove the bolts securing the panel (1) and mov the one side.
- ☐ Fit the nut plate through the hole and tighten it up to with the hook plate (2) and washers (3).
  NOTE! Make sure the hook plate is fitted straight.
- ☐ Re-install the panel (1) and tighten up.
- ☐ Re-install the wooden floor.

DEUTSCH

- ☐ Schrauben, die die Klappe (1) halten entferne Klappe zur Seite legen.
- ☐ Mutternplatte durch Loch einführen und zusamm Verschlußhaken (2) und Unterlegscheiben (3 schrauben.
  ACHTUNG! Verschlußhaken muß gerade sitzen.
- ☐ Klappe (1) wieder einsetzen und festschrauben.
- ☐ Holzboden wieder einsetzen.

ACHTUNG! Verschlußhaken muß gerade sitzen.
- ☐ Klappe (1) wieder einsetzen und festschrauben.
- ☐ Holzboden wieder einsetzen.

16

FRANÇAIS

- ☐ Enlever les vis de fixation de la trappe (1), repousser la trappe sur le côté.
- ☐ Introduire la plaque écrou par le trou et la visser en place avec le crochet de verrouillage (2) et les rondelles (3). ATTENTION ! Le crochet de verrouillage doit être droit.
- ☐ Positionner et visser la trappe en place.
- ☐ Remettre le plancher en bois.

SUOMI

- ☐ Irrota luukun (1) kiinnitysruuvit, käännä luukku sivuun.
- ☐ Pujota mutterilaatta reiän läpi sisään ja kiinnitä se lukkohaan (2) ja aluslevyjen (3) kanssa. HUOM! Lukkohaan on oltava suorassa.
- ☐ Aseta luukku (1) takaisin paikalleen ja ruuvaa se kiinni.
- ☐ Aseta puulattia takaisin paikalleen.

ITALIANO

- ☐ Rimuovere le viti di tenuta della botola (1). Piegare la botola di lato.
- ☐ Introdurre la piastrina del dado attraverso il foro e fissarla insieme al gancio (2) e alle rondelle (3). N.B. Il gancio si deve trovare in posizione diritta.
- ☐ Rimontare e rifissare la botola (1) con la vite.
- ☐ Rimontare il pavimento di legno.

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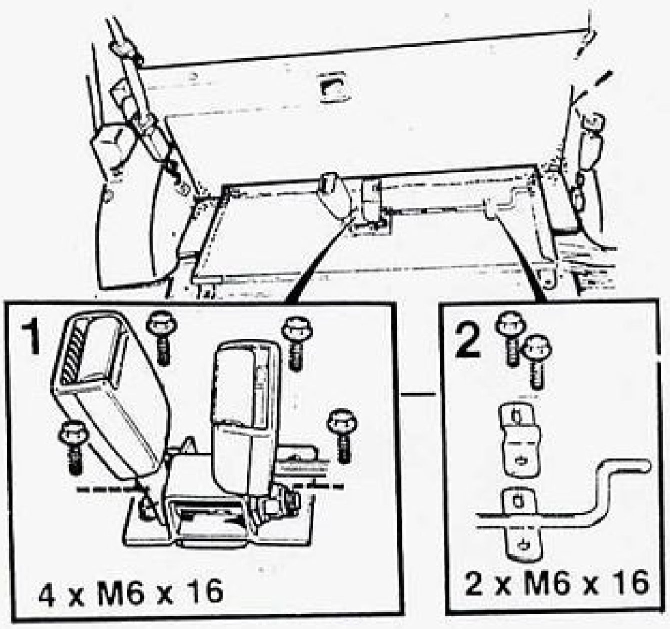

SVENSKA

- ☐ Fäst låset (1) och vridstången (2) löst med **kromade** skruvar.
- ☐ Kontrollera att spärren går i lås genom att dra i bälteslåsen.
- ☐ Dra åt skruvarna. OBS! Om låset ej låser, justera enligt punkt 18.

ENGLISH

- ☐ Loosely secure the belt lock (1) and the twist rod (2) with the **chromed** bolts.
- ☐ Check that the catches lock by pulling the belt locks.
- ☐ Tighten up the bolts. NOTE: If the belt lock doesn't lock, adjust according to point 18.

DEUTSCH

- ☐ Schloß (1) und Drehstange (2) mit **verchromten** Schrauben lose befestigen.
- ☐ Durch Zug an den Gurtschlössern kontrollieren, daß die Sperre einrastet.
- ☐ Schrauben anziehen. ACHTUNG! Rastet das Schloß nicht ein muß entsprechend Montagepunkt 18 justiert werden.

FRANÇAIS

- ☐ Monter l'attache (1) et l'articulation (2) avec les vis **chromées**, sans serrer.
- ☐ Vérifier le verrouillage en tirant sur les attaches.
- ☐ Serrer les vis. ATTENTION ! Si le verrouillage n'est pas correct, ajuster comme indiqué au point 18.

SUOMI

- ☐ Kiinnitä lukko (1) ja vääntötanko (2) löysästi **kromatuilla** ruuveilla.
- ☐ Varmista, että salpa menee lukkoon vetämällä vyölukoista.
- ☐ Kiristä ruuvit. HUOM! Jos lukko ei lukitse, säädä kohdan 18 mukaan.

ITALIANO

koista.
- ☐ Kiristä ruuvit.
  HUOM! Jos lukko ei lukitse, säädä kohdan 18 mukaan.

ITALIANO

- ☐ Fissare il bloccaggio (1) e l'asta di torsione (2) senz[a] serrare, con le viti **cromate.**
- ☐ Controllare che l'arresto entri in contatto con la serratur[a] tirando il blocchetto della cintura.
- ☐ Serrare le viti.
  N.B. Se la serratura non chiude, regolare secondo punto 18.

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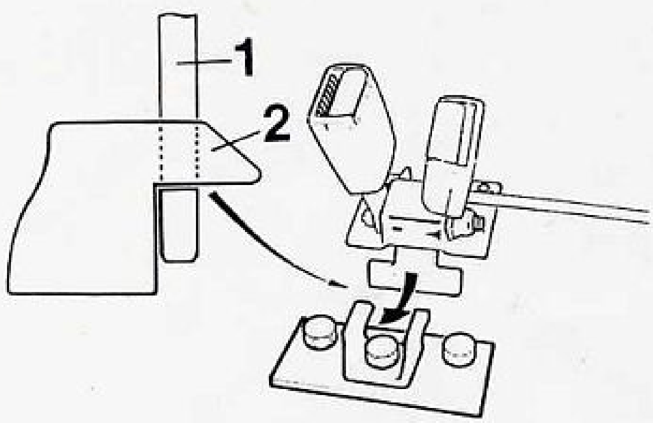
18



SVENSKA

OBS! Det är mycket viktigt att låset låser korrekt mot låshaken.
- ☐ Kontrollera att låsets arm (1) går innanför låshakens ändar (2). Om armen ej låser korrekt **MÅSTE** låshaken justeras så att det låser korrekt.
- ☐ Justera låshaken upp eller ner genom att byta ut de tre brickorna under låshaken till tunnare resp. tjockare brickor, (max tillåtet mellanlägg 10 mm).
  Kontrollera att låsets arm låser mot spärrhaken varje gång extrasätet används.

ENGLISH

NOTE:It is most important that the lock secures correctly against the hook plate.
- ☐ Check that the lock arm (1) goes on the inside of the lock detent ends (2). If the arm does not engage correctly, the detent plate **MUST** be adjusted so that it does.
- ☐ Adjust the detent plate up or down by using thicker or thinner washers (max. thickness 10 mm).
  Check that the lock arm engages the detent catches each time the extra seat is used.

DEUTSCH

Achtung! Es ist von größter Wichtigkeit, daß der Sperrarm einwandfrei unter dem Sperrhaken sitzt.
- ☐ Kontrollieren, daß der Sperrarm (1) innerhalb der Sperrhaken-Enden (2) sitzt. Wenn der Sperrarm nicht richtig arretiert, **MUSS** Sperrhaken oder Sperrarm justiert werden.
- ☐ Einstellung der Sperrhaken nach oben oder unten durch Austausch der drei Unterlegscheiben unter dem Sperrhaken gegen dünnere bzw. dickere Unterlegscheiben. Max. zulässige Zwischenlage 10 mm.
  Bei jedem Gebrauch der Zusatzsitzbank erneut

SUOMI

HUOM! On hyvin tärkeää, että lukko lukitsee kunnolla lukkohakaa vasten.
- ☐ Varmista, että lukkovarsi (1) tulee lukkohaan (2) sisäpuolelle. Jos varsi ei lukitse kunnolla **ON** lukkohakaa säädettävä niin, että se lukitsee oikein.
- ☐ Säädä lukkohakaa ylös tai alas vaihtamalla kolmea lukkohaan allaolevaa aluslevyä ohuempiin tai paksumpiin aluslevyihin, (suurin sallittu välikkeen paksuus on 10 mm).
  Varmista, että lukkovarsi lukitsee lukkohakaan joka kerta kun lisäistuinta käytetään.

ITALIANO

N.B. E' molto importante che la serratura chiuda correttamente sul gancio.
- ☐ Controllare che il braccio della serratura (1) si trovi davanti le estremità del gancio (2). Se il braccio non chiude correttamente **SI DEVE** regolare il gancio.
- ☐ Regolare il gancio verso l'alto o verso il basso sostituendo le tre rondelle sotto il gancio con rondelle più sottili o più spesse. (distanziale massimo consentito 10 mm).
  Controllare che il braccio della serratura chiuda sul gancio di arresto ogni volta che si usa il sedile supplementare.

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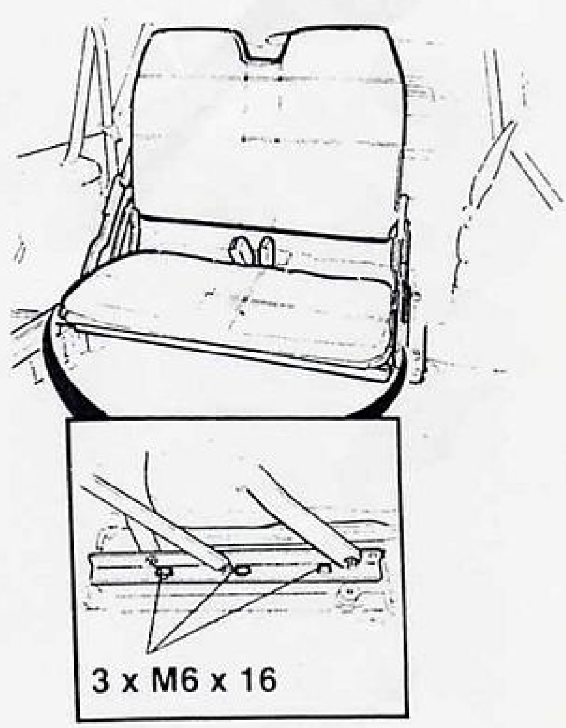

werden.

- ☐ Einstellung der Sperrhaken nach oben oder unten durch Austausch der drei Unterlegscheiben unter dem Sperrhaken gegen dünnere bzw. dickere Unterlegscheiben. Max. zulässige Zwischenlage 10 mm.
  Bei jedem Gebrauch der Zusatzsitzbank erneut kontrollieren, daß der Sperrmechanismus funktioniert.

FRANÇAIS

ATTENTION! Le verrouillage dans le crochet doit être correct.

- ☐ Vérifier que le bras du verrou (1) passe entre les extrémités d[illegible]ochet (2). Si le bras ne verrouille pas correctement, le crochet **DOIT** être ajusté pour avoir un verrouillage correct.
- ☐ Le crochet peut être soulevé ou abaissé en remplaçant les trois rondelles sous le crochet par des rondelles plus ou moins épaisses (épaisseur maximale permise 10 mm).
  Vérifier que le bras du verrou s'enclenche bien dans le crochet à chaque utilisation du siège supplémentaire.

3 x M6 x 16

SVENSKA

- ☐ Placera extrasätet i uppfällt läge på golvluckan oc pressa sätet framåt och dra fast skruvarna ordenlig skruva fast sätet lätt i hålen med svarta skruvar.

ENGLISH

- ☐ Place the extra seat in the tilt-up position on the floo panel and press the seat towards the front of the car. F the black bolts in the holes and tighten up well.

DEUTSCH

- ☐ Zusatzsitzbank aufgeklappt auf die Bodenklappe stelle nach vorn drücken, Schrauben kräftig festziehen ur Zusatzsitzbank leicht mit schwarzen Schrauben in de Löchern festschrauben.

19

FRANÇAIS

- ☐ Positionner le siège supplémentaire en position relevée sur la trappe du plancher. Pousser le siège vers l'avant et bien serrer les vis. Serrer légèrement les vis noires.

SUOMI

- ☐ Aseta lisäistuin avattuna lattialuukulle, työnnä istuinta eteenpäin ja kiristä ruuvit tiukkaan. Kiinnitä istuin löysästi reikiin mustilla ruuveilla.

ITALIANO

- ☐ Collocare il sedile supplementare in posizione sollevata sulla botola del pavimento e spingere il sedile in avanti. Serrare le viti. Fissare il sedile serrando le viti nere nei fori.

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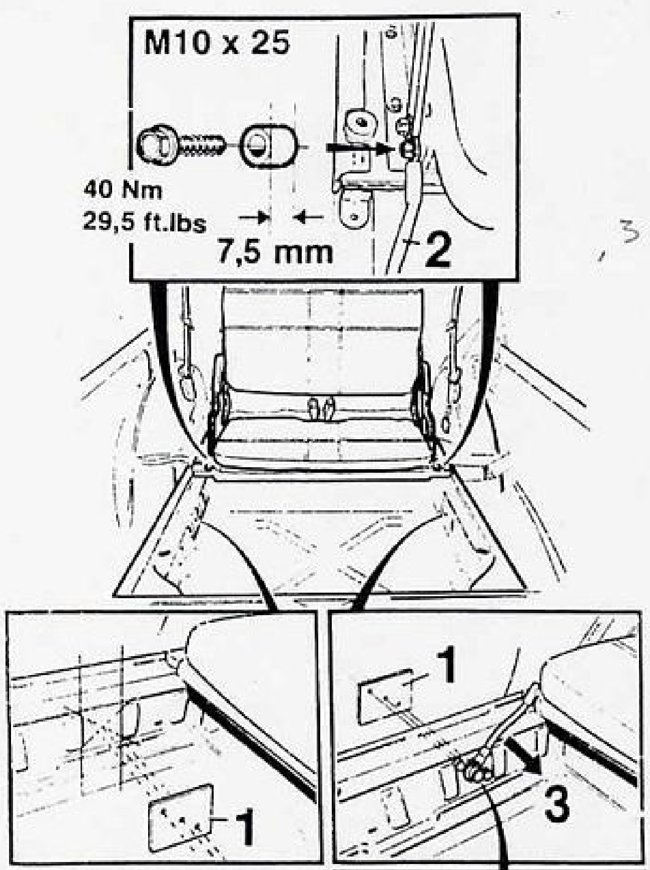


, 3 inch

ENGLISH

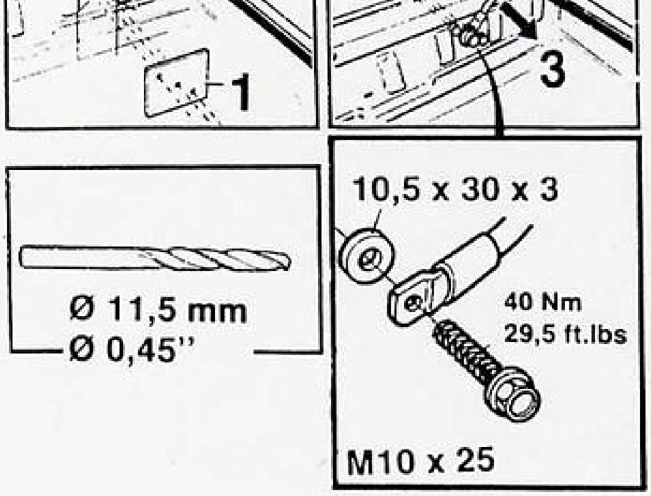
- ☐ Use the nut plate (1) as a template.
  NOTE: Make sure the row of holes in the nut plate face the right direction.
- ☐ Mark out and drill holes.
- ☐ Screw tight the wire (2) on both sides of the seat and then with the nut plate on the rear side at the lower attachment, see fig.
- ☐ Tighten to a torque of 40 Nm (29.5 ft.lbs.).
- ☐ Check that the wire bends downwards (3). If it doesn't, slacken the lower bolt, adjust the wire and tighten up again.

DEUTSCH

- ☐ Mutternplatte (1) als Schablone verwenden.
  ACHTUNG! Richtung der Lochreihe auf der Mutternplatte kontrollieren.
- ☐ Löcher anreißen und bohren.
- ☐ Stahlseil (2) auf beiden Seiten der Sitzbank festschrauben. Dann mit Mutternplatte auf der Rückseite an der unteren Befestigung entsprechend Abbildung anschrauben.
- ☐ Mit 40 Nm (29,5 ft.lbs) anziehen.
- ☐ Kontrollieren, daß das Stahlseil nach unten (3) geschwungen ist. Falls nicht, untere Schraube lösen, Stahlseil etwas nach unten drücken und Schraube erneut festziehen.

FRANÇAIS

- ☐ Utiliser la plaque écrou (1) comme gabarit.
  ATTENTION ! Vérifier le sens des rayons de congé pour la plaque écrou.
- ☐ Repérer et percer.
- ☐ Visser le câble (2) des deux côtés du siège puis avec la plaque écrou sur l'arrière, vers la fixation inférieure,



SVENSKA

- ☐ Använd mutterplattan (1) som mall.
  OBS! Kontrollera mutterplattans hålradsriktning.
- ☐ Märk ut och borra hål.
- ☐ Skruva fast vajer (2) på båda sidor i sätet och sedan med mutterplattan på baksidan vid nedre fäste enligt fig.
- ☐ Dra åt med 40 Nm
- ☐ Kontrollera att vajern böjer sig nedåt (3). Om ej lossas vajerns nedre skruv, vajern vrids ner något och skruven dras åt igen.

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- ☐ Utiliser la plaque écrou (1) comme gabarit.
  ATTENTION ! Vérifier le sens des rayons de congé pour la plaque écrou.
- ☐ Repérer et percer.
- ☐ Visser le câble (2) des deux côtés du siège puis avec la plaque écrou sur l'arrière, vers la fixation inférieure, comme le montre la figure.
- ☐ Serrer au couple de 40 Nm.
- ☐ Vérifier que le câble fait un coude vers le bas (3). Sinon dévisser la vis inférieure du câble, tourner légèrement le câble et resserrer la vis.

SUOMI

- ☐ Käytä mutterilaattaa (1) mallina.
  HUOM! Tarkista mutterilaataan rei'ityssuunta.
- ☐ Merkkaa ja poraa reiät.
- ☐ Kiinnitä vaijeri (2) istuimen molemmalle sivulle ja sitten mutterilaatan kanssa takapuolelle alemman kiinnikkeen kohdalle kuvan mukaan.
- ☐ Kiristä 40 Nm. (29,5 ft.lbs).
- ☐ Varmista, että vaijeri taipuu alaspäin (3). Jos ei, löysää vaijerin alempaa ruuvia, väännä vaijeria hieman alaspäin ja kiristä ruuvi uudelleen.

ITALIANO

- ☐ Utilizzare la piastrina dei dadi (1) come riferimento.
  N.B. Controllare la direzionbe della piastrina dei dadi.
- ☐ Effettuare i riferimenti e praticare i fori.
- ☐ Fissare con le viti il filo (2) su entrambi i lati del sedile e poi la piastrina sul retro all'altezza dell'attacco inferiore come indicato dalla figura.
- ☐ Serrare con una coppia di 40 Nm.
- ☐ Controllare che il filo si pieghi verso il basso (3). Se non si allenta la vite inferiore, girare il filo leggermente e riserrare la vite.

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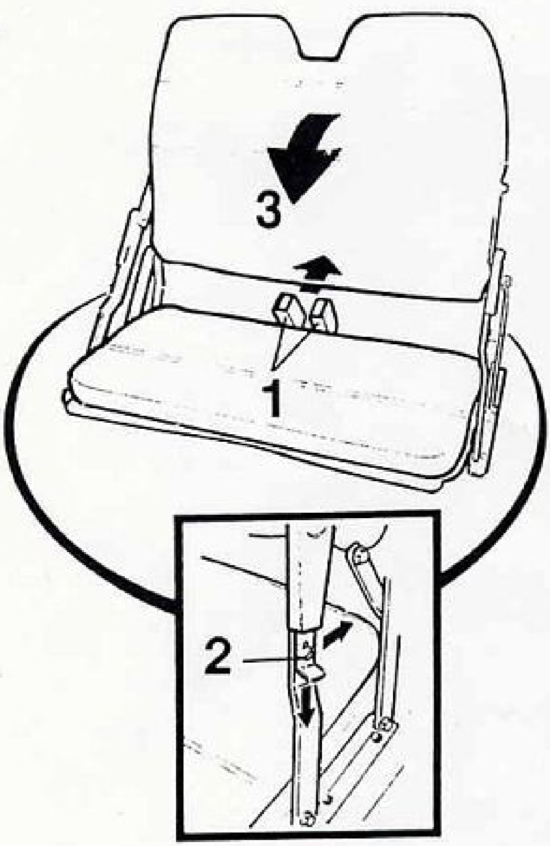

SVENSKA

Ihopfällning av extrasäte

- ☐ Tryck bälteslåsen (1) framåt.
- ☐ Frigör länkarmsspärren genom att trycka ner spärrhakarna på båda sidor (2).
- ☐ Tryck sedan länkarmarna framåt och fäll ihop sätet (3).

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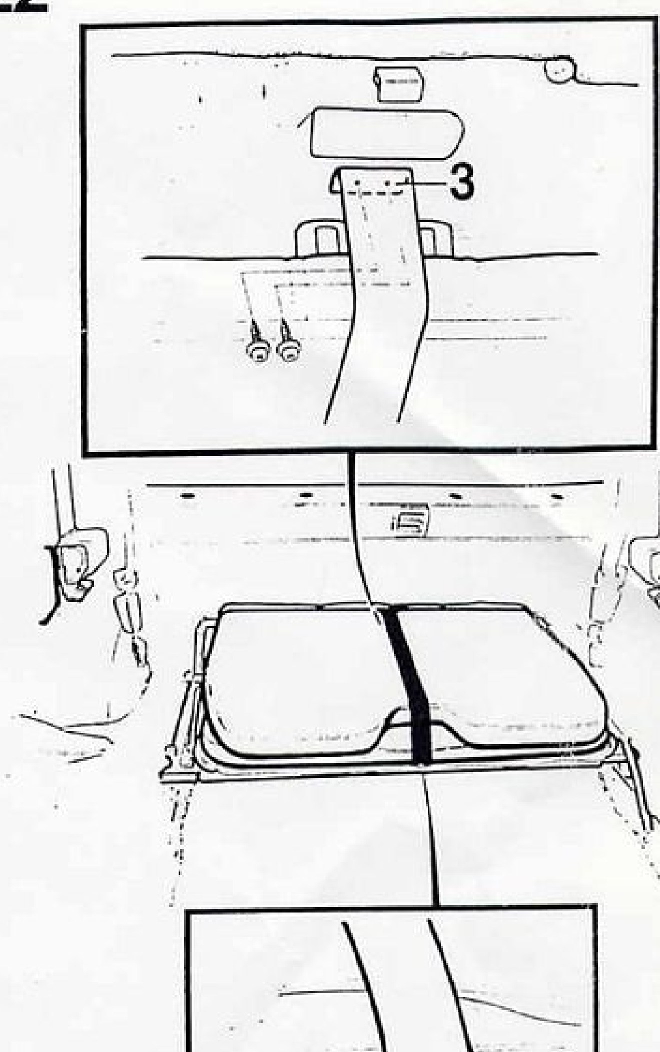

Ihopfällning av extrasäte

- ☐ Tryck bälteslåsen (1) framåt.
- ☐ Frigör länkarmsspärren genom att trycka ner spärrhakarna på båda sidor (2).
- ☐ Tryck sedan länkarmarna framåt och fäll ihop sätet (3).

—ENGLISH—

Folding the extra seat

- ☐ Press forward the belt locks.
- ☐ Release the link arm detents by pressing down the detent catches on both sides (2).
- ☐ Then press the link arms forward and fold the seat (3).

—DEUTSCH—

Zusammenklappen der Zusatzsitzbank.

- ☐ Gurtschlösser (1) nach vorne drücken.
- ☐ Gelenkarmsperren durch Niederdrücken der Sperrhaken auf beiden Seiten (2) entriegeln.
- ☐ Gelenkarme nach vorn drücken und Sitz (3) zusammenklappen.

—FRANÇAIS—

Pour rabattre le siège supplémentaire

- ☐ Pousser les attaches de la ceinture (1) vers l'avant.
- ☐ Dégager les verrous d'articulation en enfonçant les crochets des deux côtés (2).
- ☐ Pousser ensuite les articulations vers l'avant et rabattre le siège (3).

—SUOMI—

Lisäistuimen kokoontaitto

- ☐ Paina vyölukkoja (1) eteenpäin.
- ☐ Vapauta vipuvarsilukot painamalla lukitushakoja alaspäin molemmalta puolella (2).
- ☐ Paina tämän jälkeen vipuvarsia eteenpäin ja taita istuin kokoon (3).

—ITALIANO—

Piegamento del sedile supplementare

- ☐ Spingere il blocchetto della cintura (1) in avanti.
- ☐ Liberare l'arresto spingendo i ganci su entrambi i lati (2).
- ☐ Spingere poi i bracci in avanti e piegare il sedile (3).

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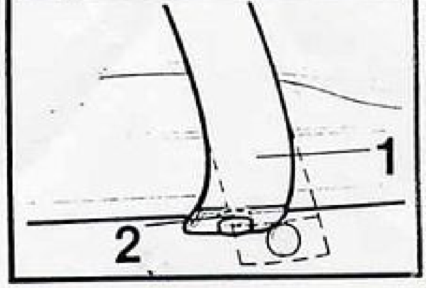

—SVENSKA—

Montering av låsband

- ☐ Sätt dit bandet (1) på tryckknappen (2).
- ☐ Komprimera sätet genom att lägga dig på knä på sät
- ☐ Sträck bandet hårt och märk upp placeringen för skruvar (3) med en rits. Lossa bandet i tryckknapp Skruva fast bandet i luckan enligt markering (ing förborrning behövs).
- ☐ Kontrollera att bandet är sträckt rakt över sätet och dr skruvarna.

—ENGLISH—

Installing the retaining strap

- ☐ Fit the strap (1) to the push button (2).
- ☐ Press the seat together by kneeling on it.
- ☐ Pull hard on the strap and chalk-mark where the screws (3) are to be fitted. Slacken the other end of strap in the push button. Screw the strap tight in recess (no pre-drilling required).
- ☐ Make sure the strap is stretched straight over the s Tighten up the screws.

—DEUTSCH—

Montage des Sicherheitsbandes

- ☐ Band (1) auf Druckknopf (2) drücken.
- ☐ Sitzbank durch Daraufknien zusammendrücken.
- ☐ Band kräftig spannen und Montagestelle für Schrauben (3) mit einer Linie markieren. Band Druckknopf lösen. Band an der Klappe entsprec Markierung festschrauben (vorbohren nicht notwen
- ☐ Kontrollieren, daß das Band gerade über den gestreckt ist. Schrauben nachziehen.

22

—FRANÇAIS—

Montage de la sangle

- ☐ Positionner la sangle (1) sur le bouton pression (2).
- ☐ Comprimer le siège en montant dessus à genoux.
- ☐ Tendre la sangle et repérer l'emplacement des deux vis (3) avec un traçoir. Enlever la sangle du bouton pression. Visser la sangle dans la trappe conformément suivant les repères (aucun pré-perçage n'est nécessaire).
- ☐ Vérifier que la sangle est bien tendue sur le siège et serrer les vis.

—SUOMI—

Lukkohihnojen asennus

- ☐ Kiinnitä vyö (1) painikkeeseen (2).
- ☐ Purista istuinta painamalla polvella.
- ☐ Kiristä vyö tiukalle ja merkkaa piirtopuikolla paikat kahdelle ruuville (3). Lyösää hihna painikkeesta. Ruuvaa hihna kiinni luukkuun merkinnän mukaan (esiporausta ei tarvita).
- ☐ Tarkista, että hihna on kireällä suoraan istuimen yli ja kiristä ruuvit.

—ITALIANO—

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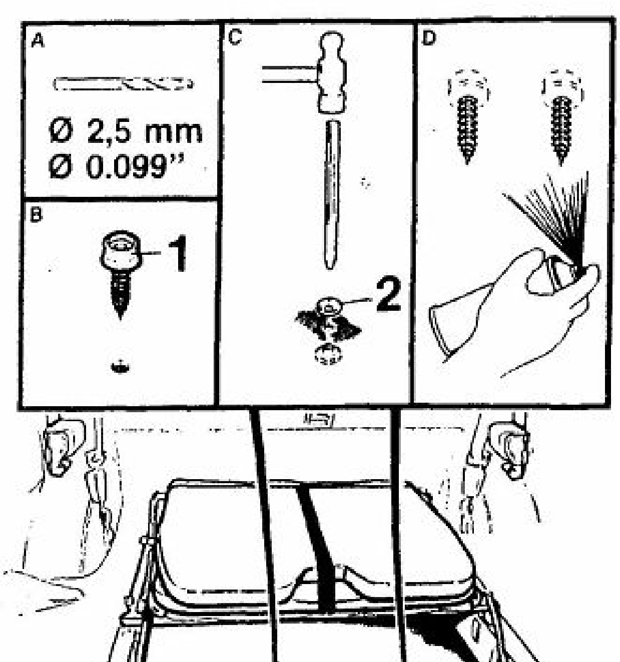

tarvita).
- Tarkista, että hihna on kireällä suoraan istuimen yli ja kiristä ruuvit.

ITALIANO

Montaggio del nastro di bloccaggio
- Montare il nastro (1) sul pulsante (2).
- Spingere il sedile ponendovi in ginocchio sul sedile.
- Tirare il nastro e segnare la posizione per le due viti (3). Allentare il nastro nel pulsante. Fissare il nastro nella botola seguendo i segni (non è necessario).
- Controllare che il nastro sia tirato sopra il sedile e serrare le viti.

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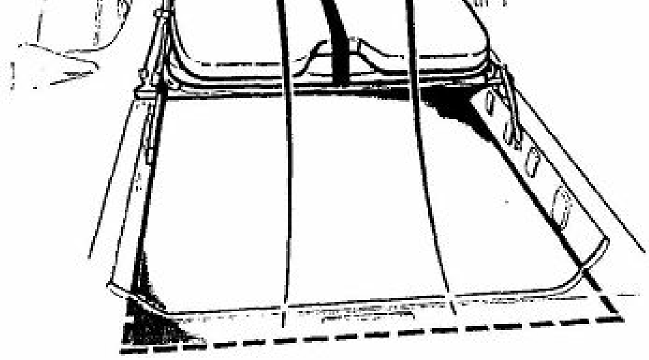

SVENSKA

- Kontrollera att mattan ligger rätt och att ledningsmattan ligger så långt bak som möjligt.
- Fig.A. Borra två hål Ø 2,5 mm genom matta och golv.
- Vik upp mattan.
- Fig.B. Skruva fast fästena (1) i golvet.
- Sätt dit tryckknapparna (2) i mattan, ev. måste hålen i mattan förstoras med skruvmejsel.
- Fig.C. Nita fast tryckknapparna, (verktyg finns i satsen).
- Dammsug bort borrspånor.
  OBS! Rostskyddsbehandla skruvspetsarna på bilens undersida.
- Tryck fast mattan på fästena i golvet.

ENGLISH

- Check that the carpet fits neatly and that the cable harness is as far back as possible.
- Fig. A. Drill two Ø 2.5 mm holes through the carpet and the floor.
- Fold up the carpet.
- Fig. B. Screw the anchorage screws (1) in the floor.
- Fit the push buttons (2) in the carpet (the holes may have to be widened, e.g., with a screwdriver).
- Fig. C. Rivet on the push buttons (the kit has a rivetting tool).
- Vacuum-clean drilling filings.
  IMPORTANT! Rustproof the tips of screws protruding underneath the car.
- Button the carpet to the screw anchorages in the floor.

DEUTSCH

- Kontrollieren, daß der Teppichboden richtig und der Kabelstrang soweit hinten wie möglich liegt.
- Abbildung A. Zwei Löcher Ø 2,5 mm durch Teppichboden und Boden bohren.
- Teppichboden nach oben klappen.
- Abbildung B. Befestigungen (1) auf dem Boden festschrauben.
- Druckknöpfe (2) in den Teppichboden einsetzen. müssen die Löcher im Teppichboden mit einem Schraubenzieher vergrößert werden.
- Abbildung C. Druck knöpfe festnieten (Werkzeug im Montagesatz).
- Bohrspäne mit Staubsauger entfernen.
  ACHTUNG! Schraubenspitzen auf der Wagenunterseite mit Rostschutzmittel behandeln.
- Teppichboden auf den Befestigungen im Boden festdrücken.

FRANÇAIS

- Vérifier que le tapis est correctement positionné et que le faisceau de câbles vient aussi loin vers l'arrière que possible.
- Fig. A. Percer deux trous Ø 2,5 mm dans le tapis et dans le plancher.
- Relever le tapis.
- Fig. B. Visser les fixations (1) dans le sol.
- Positionner les boutons pression (2) dans le tapis, les trous dans le tapis doivent éventuellement être agrandis avec un tournevis.
- Fig. C. River les boutons pression (l'outil fait partie du kit).
- Enlever les copeaux à l'aspirateur.
  ATTENTION ! Traiter les pointes des vis contre la corrosion en-dessous de la voiture.
- Enfoncer le tapis sur les fixations dans le plancher.

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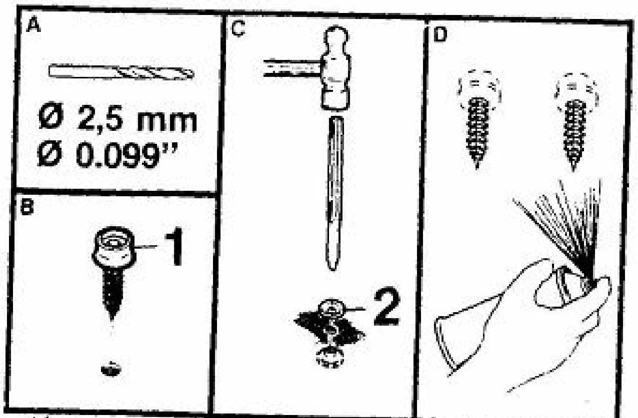
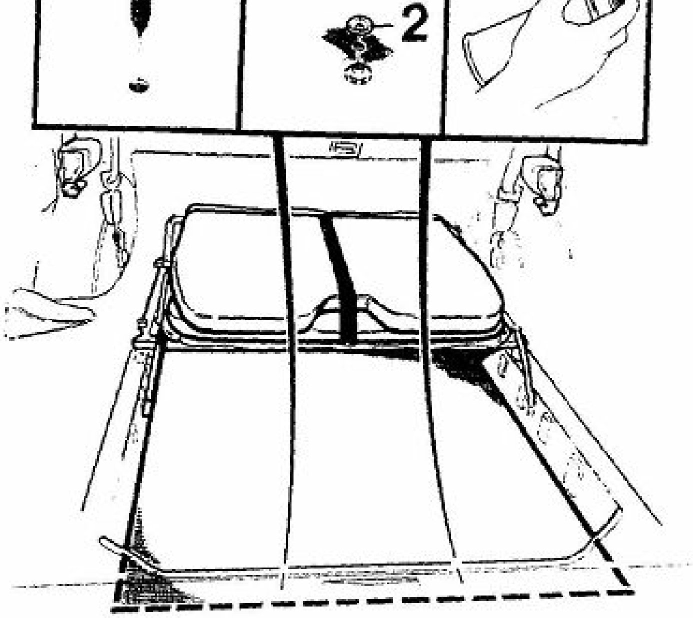


SUOMI

- Tarkista, että matto on oikein paikallaan ja että johdi sarja on niin takana kuin mahdollista.
- Kuva A. Poraa kaksi reikää Ø 2,5 mm maton ja lattian lä
- Käännä matto sivuun.
- Kuva B. Ruuvaa kiinnikkeet (1) kiinni lattiaan.
- Kiinnitä painonupit (2) mattoon, matossa olevia reikiä v suurentaa tarvittaessa ruuvitaltalla.
- Kuva C. Niittaa painonupit kiinni, (sarjassa on työka niittausta varten).
- Imuroi porauslastut pois.
  HUOM! Ruostesuojaa ruuvien kärjet auton alapuolelta.
- Paina matto kiinni lattiassa oleviin kiinnikkeisiin.



Suurenna tarvittaessa ruuvitaltalla.

- ☐ Kuva C. Niittaa painonupit kiinni, (sarjassa on työka niittausta varten).
- ☐ Imuroi porauslastut pois.
  HUOM! Ruostesuojaa ruuvien kärjet auton alapuolelta.
- ☐ Paina matto kiinni lattiassa oleviin kiinnikkeisiin.

ITALIANO

- ☐ Controllare che il tappetino si trovi in posizione corretta e che il cablaggio si trovi il più possibile all'
- ☐ Fig. A. Praticare due fori da Ø 2,5 mm attraverso il tappetino e il pavimento.
- ☐ Piegare il tappetino.
- ☐ Fig. B. Fissare gli attacchi (1) nel pavimento.
- ☐ Montare i pulsanti (2) nel tappetino. Se necessario ingrandire i fori nel tappetino con un cacciavite.
- ☐ Fig. C. Rivettare i pulsanti (gli attrezzi si trovano nel kit).
- ☐ Rimuovere la polvere.
  N.B. Praticare l'anticorrosione sulle punte delle viti sull'estremità in basso.
- ☐ Fissare il tappetino sugli attacchi del pavimento.

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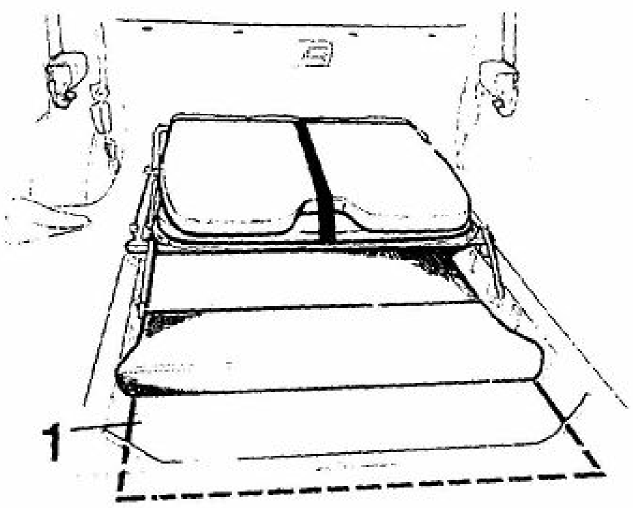

SVENSKA

- ☐ Vid behov ta ur isoleringsmattan (1) under skyddsmattan. (t ex. om nackskyddet skaver mot mattan).

ENGLISH

- ☐ If necessary remove the insulating mat (1) underneath the protection mat (e.g. should the head restraint scuff against the mat.

DEUTSCH

- ☐ Bei Bedarf Isolierbelag (1) unter dem Schutzbelag entfernen (Wenn beispielsweise der Nackenschutz an der Schutzmatte scheuert).

FRANÇAIS

- ☐ Si nécessaire, enlever le tapis isolant (1) sous le tapis de protection (par exemple si le repose-tête frotte contre le tapis).

SUOMI

- ☐ Ota tarvittaessa ulos eristematto (1) suojamaton alta. (esim. jos niskatuki hankaa mattoa).

ITALIANO

- ☐ In caso necessario rimuovere il tappetino isolante (1) sotto il tappetino di protezione, (ad esempio se il poggiatesta non e in posizione corretta rispetto al tappetino)

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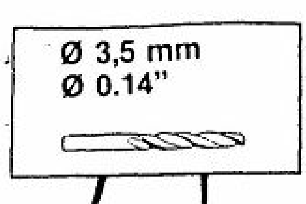
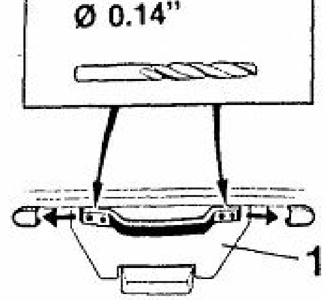


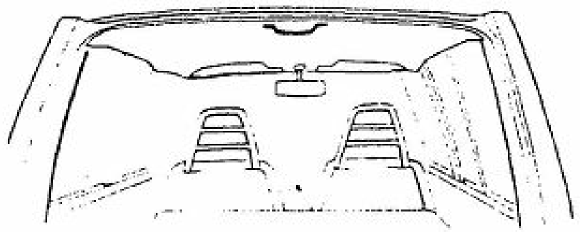
ENGLISH

- ☐ Install the tailgate handle.
- ☐ Place the template (1) against the roof lamp, mark out and drill four holes.
- ☐ Slide off the screw covers and screw tight the handle.
- ☐ Put back the screw covers.

DEUTSCH

- ☐ Montage des Einstieg-Handgriffs.





SVENSKA

- ☐ Montera instegshandtaget.
- ☐ Placera mallen (1) mot taklampan, märk ut och borra upp de fyra hålen.
- ☐ Skjut täckbrickan åt sidan och skruva fast instegs-handtaget.
- ☐ Skjut tillbaka täckbrickan över skruvarna.

- ☐ Slide off the screw covers and screw tight the handle.
- ☐ Put back the screw covers.

DEUTSCH

- ☐ Montage des Einstieg-Handgriffs.
- ☐ Schablone (1) an die Innenraumleuchte anhalten, vier Löcher markieren und bohren.
- ☐ Abdeckung zur Seite schieben und Einstieg-Handgriff festschrauben.
- ☐ Abdeckung über die Schrauben zurückschieben.

FRANÇAIS

- ☐ Positionner la poignée de maintien.
- ☐ Placer le gabarit (1) contre le plafonnier, repérer et percer les quatre trous.
- ☐ Repousser la plaque de recouvrement sur le côté et visser la poignée de maintien.
- ☐ Remettre la plaque de recouvrement en place sur les vis.

SUOMI

- ☐ Asenna kahva.
- ☐ Aseta malline (1) kattolamppua vasten, merkkaa ja poraa neljä reikää.
- ☐ Työnnä peitekansi sivuun ja ruuvaa kahva kiinni.
- ☐ Työnnä peitekansi takaisin ruuvien päälle.

ITALIANO

- ☐ Montare la maniglia.
- ☐ Collocare la sagoma (1) sulla lampadina sul tetto, fare i riferimenti e praticare i quattro fori.
- ☐ Spingere la rondella di copertura di lato e fissare la maniglia con le viti.
- ☐ Rispostare la rondella sopra le viti.

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Engine: Turbo Rebuilding

Volvo Maintenance FAQ for 7xx/9xx/90 Cars

Version 7.5

Volvo Turbo Diagnosis & Rebuild, Boe Kalinoski, ImportCar, December 1999

Fig.1: Inlet and exhaust turbine shaft.

The basic function of a turbocharger today is essentially the same as the one first designed by Alfred Buchi many years ago. Yet the mechanical design is simpler and the size for a given output is much smaller. Volvo pioneered this technology in 1955 when it launched a series production of turbocharged bus engines. Volvo and other car makers started producing their cars with turbochargers in the early ‘80s. They were lubricated with engine oil and also cooled by the oil. Eventually, a water-cooled unit was produced, giving the turbo lower running temperatures and longer bearing/seal life. With the installation of an intercooler, the turbo was able to raise the boost pressure by cooling down the charge. Cooling the charge regains some of the density and brings other benefits, as well.

Some consumers were afraid to purchase a Volvo with a turbocharger thinking that when it failed, it was going to be an expensive repair. But they liked the performance characteristics. As a result, manufacturers came out with multi-valve, higher-compression engines and sophisticated fuel systems trying to squeeze more power out of durable engines. But the turbocharged engines were still in demand. Thus, turbo rebuilds represent solid profit centers for shops that welcome the opportunity. Patience and the proper replacement parts and procedures will go a long way toward securing customer satisfaction and increasing your shop’s profitability as well.

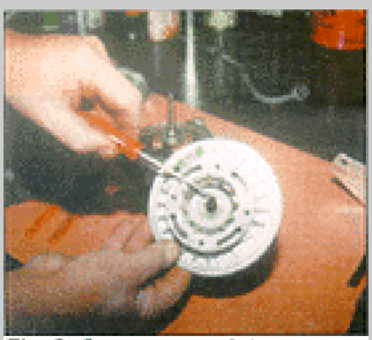

Fig. 2: Compressor plate.

TURBO DURABILITY

A turbocharger lubricated with clean oil at engine pressure can last many years without visible signs of wear on the bearing journals. But if dirty oil, or no oil at all is supplied to the turbo, even for a short period of time, the chances are the unit will be short-lived. We have a customer that comes to our shop who has more than 300,000 miles on his Volvo and it is equipped with the original turbo! What’s the reason for it being so long-lived? It’s because the vehicle was properly maintained: Changing the oil every 3,000 miles and letting the turbo cool down after heavy-driving conditions.

PROBLEM AREAS

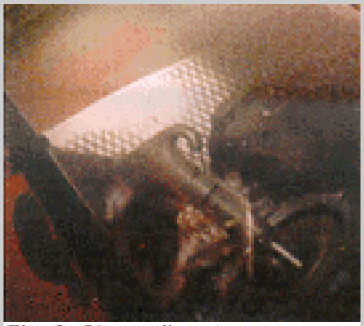

Fig. 3: Clean all parts.

A common problem with a turbocharger is oil passing by the oil ring seals, leaving a cloud of blue smoke coming from the exhaust. The oil drain inside the unit could be plugged with coke/burnt oil deposits, making the only route for the oil is to dump into the exhaust. Oil must be drained away from the turbo faster than the oil being fed to it. Consider the possibility that excessive oil pressure/ volume might be being fed to the turbo, causing the bearing housing to be flooded with oil and the turbo to leak.

Fig. 4: Exhaust turbine seal area.

Turbochargers won't actually blow a seal; the seal on the exhaust side is usually a simple piston ring with a small ring gap. The seal on the compressor side is either the same style or a more positive carbon seal similar to an air conditioner compressor seal, or even a water pump seal. Before you condemn the turbo, consider the fact that even a good turbo will leak oil given certain circumstances. Here are four areas to look at:

• A restricted air inlet;

• A restricted exhaust;

• A physical restriction in the oil drain away from the turbo; and

• An effective restriction to the oil drain away from the turbo, such as crankcase ventilation problems or anything that can cause excessive crankcase pressure, like worn piston rings.

In this article, I am going to try to give you some pointers in rebuilding the most popular Volvo turbo units. Volvo used the Garrett T3 unit for some years with great service results. It was used in the 240 series and the 760, and then the water-cooled units were available.

REBUILD PROCEDURES

1. Remove turbocharger from manifold and place it on a clean workspace.

Fig. 5: Trapped carbon/oil deposits.

2. Remove all hoses from housing; carefully mark position of compressor housing relative to turbine. You want to mark the housing to have the correct measurement for reassembly so all the hoses/connections line up for installation.

3. Remove the compressor housing, and then the exhaust housing. Try to mark the compressor wheel with the exhaust drive wheel so it will be assembled in the same manner as it was balanced from the factory (See Figure 1).

4. Inspect worn areas, such as compressor plate on which the seal ring rides (See Figure 2).

Fig. 6: Reassembly preparation.

5. Clean all parts. Use a glass bead cabinet if one is available. It will pay off in the long run, but it must be fine grit! All parts must be thoroughly rinsed, as residual glass bead will destroy your rebuild in a very short time (See Figure 3). If glass bead is not available, a cold carburetor dip is acceptable.

6. Soak all parts until clean. A soft brush may be used to help remove stubborn deposits. Remember, the cleaner you get the parts, the longer the rebuild will last!

7. Make sure all oil passages are very clean to allow proper oil flow to bearings.

8. Inspect all parts for signs of abnormal wear. All shaft surfaces should be smooth and pit free. Bearing bores in the housing should not be scored. Turbine seal area in housing should be flat — no grooves. Blades should not be bent or broken and should not have contacted the housing. Do not try to straighten out the blades! They will crack and fail under use.

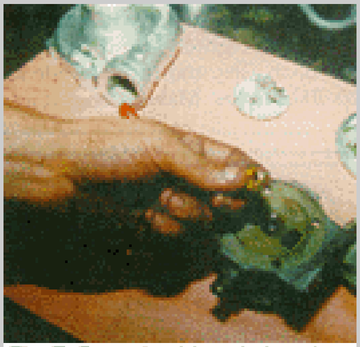

Fig. 7: Brass bushings in housing.

9. Inspect exhaust turbine seal area for worn-out ring groove (See Figure 4).

10. The carbon/oil deposits trapped in the main housing could fool you, as they look like the casting. Poke all around with a sharp object, and scrape away all the foreign particles! This is a very important step, as the oil has to drain through the housing without any restrictions (See Figure 5).

11. Lay out the torn down turbo on a clean area with all the parts ready for assembly (See Figure 6).

12. Replace brass bushings in housing and lube with engine oil (See Figure 7).

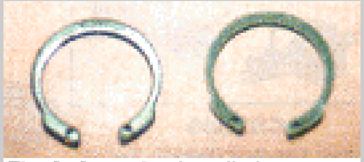
Fig. 8: Snap ring installation.

13. Install the small snap rings the proper way — sharp/square side out (See Figure 8).

14. Install seal rings on the compressor side and the exhaust turbine (See Figures 9 & 10) and lube with oil.

15. Install turbine shaft into housing, not forgetting the heat shield. Make sure the seal is centered in the housing. It will slide in easily when it is in position. Do not apply force, or you will damage the shaft, seal and housing.


Fig. 9: Seal ring installation.

16. Slide the compressor wheel on the shaft. Tighten the nut to 18-20 in./lbs., then add one additional quarter turn or shaft stretch of .0055 in. to .0065 in. At this time the wheels should spin freely and not have excess play.

17. Install housing with clamps and bolts. Tighten compressor to 145-165 in./lbs. and turbine slide to 185-200 in./lbs. Make sure turbine wheels do not contact the housing in any position.

INSTALLATION TIPS

Change oil/filter and clean or replace oil inlet line going to the turbo. Many times the line will become plugged with coked oil, restricting oil flow.


Fig. 10: Seal ring installation.

Do not use silicone sealer (RTV) on oil inlet gasket as it may squeeze out into bearing passages and plug up the turbo.

Do not race engine for 2-3 minutes after start-up.

The TD05 Mitsubishi unit is much smaller in design (See Figure 11) and has lineup pins built into the housing to make things easier to assemble after tear down. This unit has a large snap ring and collar-type clamp holding the unit together.

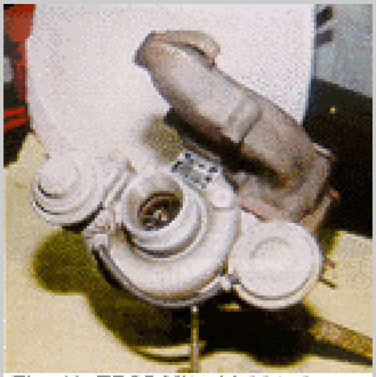
Fig. 11: TD05 Mitsubishi turbo.

The method of rebuilding is similar to that of the Garrett unit. Clean parts and careful inspection of worn areas are the keys to a profitable repair. I have been rebuilding turbos for some time now and have had good results.

My customers have been satisfied with the performance upgrades and price savings I’ve delivered to them vs. purchasing a rebuilt unit elsewhere. I found a real good source for turbo repair kits. This company has been around for 12 years and could help you with all your turbo needs:

United Turbo Co., Spofford, NH, (http://www.unitedturbo.com). Phone: (800) 779-1780.


Fig. 12: Complete turbo rebuild kit.

Unlike what other suppliers offer, they come with bolts, seal rings and all the gaskets (See Figure 12) to help you do your turbo rebuild efficiently and effectively.

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Volvo 700/900 Turbo Identification

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[Photos and Text by John Sargent] The turbocharged B23FT, and B230FT came with several different turbochargers depending on the model year. The Garrett turbos are known to be more robust than the Mitusbishi turbos, and have better metal in the exhaust turbine. The Mitsubishi turbos are easier to remove and replace with the single stainless steel clamp that retains the turbo to the wastegate housing. If you change the engine oil frequently both turbos give good life.

Garrett T3 Water-Cooled Turbo

This Garrett T3 is on a B23FT, and is water cooled. The T3 was used starting on the 240 turbos and continued through the 1989 700 turbo cars. It became water cooled in the 1987 model year and most replacement T3s were water cooled. Note the flat flange oil supply directly on top of the turbo. The CBV (Compressor Bypass Valve) is mounted on the head and is on the far right of the picture.

This Mitsubishi TD05 is on a 1987 B230FT and was used in 1987-1989 model years. Note the wastegate is

Mitsubishi TD05 Turbo

bolted to the exhaust manifold from the back side. This turbo is a factory rebuilt turbo. The original owners of the car didn't change oil very often, sometimes up to 12,xxx miles between changes. This turbo will put out more boost than the later Mitsubishi TD04, and the people who want lots of boost often use it. It has an integral CBV, as all the Mitsubishi turbos used on the 700/900 series do. 8

This is the early version of the Mitsubishi TD04 identified by the integral CBV mounted vertically. The wastegate housing is fastened from the front side of the exhaust manifold, which is a plus if you have to replace the wastegate. These turbos have great street driving qualities. This turbo was introduced in the 1990 model year with an improved exhaust manifold. I'm told the new exhaust manifold gave about a 10HP increase not reflected in the specs. These better flowing later manifolds are prone to cracking, while the early ones generally don't crack.

Mitsubishi TD04 Later Version

This is the later version of the Mitsubishi TD04 which is identifed by the angular mounted CBV. There may be another version (with higher flow ratings) of this turbo used on a few 1995 940 cars. It should look just the same.

Garrett T25 Turbo

This is a Garrett T25. They are very rare. I bought this one from Brian Leppin and he said it is the only one he has ever seen. It has the integral CBV like the Mitsubishi turbos. It was used on the 940SE, and maybe a few other 700s anbd 900s. While the exhaust manifold for this turbo looks identical to the Mitsubishi exhaust manifold, the machined flanges which mate to the turbo and different and the exhaust manifolds won't interchange.

Aisin-Warner AW-7X Valve Body Service in a Volvo 7XX-940 Car: Page 1

All information written by Brad Wightman and used by his kind permission.

The valve body in the Aisin Warner 71L automatic transmission is a very complex piece of kit. Servicing this unit is not a job to be taken lightly. Go about it the wrong way and you could end up with costly repairs. Go about it the right way and the job is relatively simple albeit a bit challenging if it's your first time. Before even considering servicing the valve body there are some considerations: The Volvo Automatic Transmission service manual (TP 31642/1) is an absolute necessity. DON'T attempt this job without this manual. At a minimum, have the following parts on hand: Valve body gasket kit (5 gaskets), 5.5mm check balls (Volvo part number 1377746), transmission fluid, filter and filter gaskets (2), fluid pan gasket. See pics below.

Pan Gasket **Gasket Kit**

It's a good idea to have a plate to hold the accumulator pistons in place in the transmission as you take the valve body out. I've heard of people getting by without one but I felt it was better not to risk having the pistons drop out onto the floor. I made one from a scrap piece of 1mm thick steel plate. Three holes are drilled in the plate corresponding to the pan bolt holes and it is held in place using the pan bolts. See pic below. The arrow points to the correct holes. I had to redrill them because I was slightly off with my measurements, so ignore the bottom holes.

Accumulator piston holding tool

If you are planning to do a full valve body service, allow a whole weekend. This is NOT a job you will do in an afternoon so plan it for a time when you won't need the car for a couple of days. It is possible to replace just the check ball and put everything back together in a day but while you're in there you might as well do a thorough job.

Also have plenty of rags to mop up the fluid off the floor. You WILL lose quite a lot.

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Volvo AW70/71 to M-46 Transmission Conversion

Converting an AW-71 Automatic to an M46 Manual Transmission by Paul Demeo (with thanks to Paul and George Holmer)

This all began about 2 years ago, when I finally bought my ultimate Volvo, a 1990 780 Bertone Turbo. I had been lusting after 780's for a bit, and once I finally came to the realization that they didn't make one in a manual, I bought one. I intended to change it over to a manual immediately, which, of course, took two years and three afternoons…

The first two years were spent gathering parts at a ...ahem… leisurely pace. The parts required are as follows:

- M46 transmission
- M46 transmission mount
- 58-hole Flywheel (more about this later…)
- Clutch, pilot & throw-out bearings from iPd
- Driveshaft, from Jeff Canter's Car World
- U-joints, center bearing, & support

- Master Cylinder, from B & D Used Auto Parts
- Clutch Pedal, also from B & D
- Slave Cylinder, new from Volvo
- Clutch Hose, new from Volvo
- Clutch fork, new from Volvo
- Shift Lever and interior trim bits...
- M46 Overdrive Relay, from Car World

Those are the major bits. Everything else (while a lot) is just little stuff you'd have to pick up from the dealer for any job of this type. (Flywheel bolts, clutch bolts, new driveshaft bolts, new nylon and steel shift-linkage parts, snap rings if you trashed the ones on the junk cars you pillaged, tranny fluid, locktite, grease, etc…) Recognize as well that if you have an LH 2.4 car with a bellhousing-mounted RPM sensor, one key will be finding a later model transmission with the cutout for the crank sensor in the top of the bell housing. Earlier transmissions usually have a relief cast into the bell housing, but do not have it punched out. It can be knocked out with a hammer and chisel or a dremel tool so that you can mount the sensor.

Notes on Parts

- Use the pedal assembly from any manual 700 series. The brake pedal in your auto car is too big to fit a clutch next to it.
- Use the centre consol trim from any manual 700 series. The 760 mk II will not work; I am also unsure if the 780 got the updated interior from 1988 onwards but I doubt it.
- If the donor car is a 240 with NA B230F, then that box will not work, it is too weak for a B230FT. The overdrive unit in the 740 TIC is a stronger type.
- You will need to use the propshaft off a 740 with M46 box. The 240 will not fit nor will your present one.

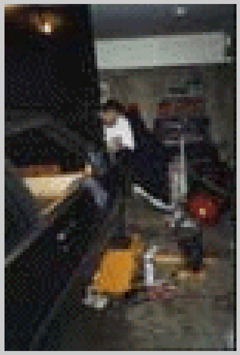
The Driveshaft: The driveshaft for an M46 7-series Volvo connects to the transmission by way of a 3-bolt flange and a big rubber bushing thing. Now, I didn’t think Volvos were that unusual, but every driveshaft shop in the Manchester, NH area that I took it to to have it balanced looked at me like I had brought a live tuna into their shops. None had the equipment to balance a driveshaft that didn’t have u-joints at either end. They couldn’t deal with the 3-bolt flange. Finally, I ended-up driving an hour down to Shrewsbury, MA to have it done.

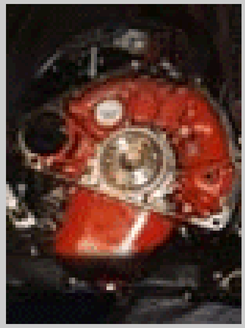
The Swap Itself:

Step 1 : Remove the AW-71. This went fairly smoothly. I unbolted the driveshaft and removed it from the car, disconnected the shift linkage, removed the shifter from the center console, and removed the lines up to the transmission cooler. This was the first thing I wasn’t expecting: I had to remove the intercooler in order to remove the cooler from it’s home. The auto tranny fluid also makes a trip thru the right side radiator tank; after removing the lines I simply plugged up the nipples on the radiator with rtv sealant…

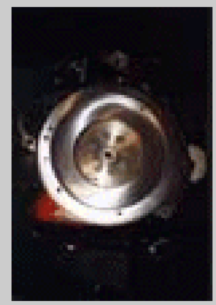
The second thing that threw me was the procedure for removing the torque converter from the driveplate, which involves undoing bolts from the backside (engine side, front relative to the car) of the driveplate. This was only discovered after tugging on the tranny with a confused look on my face, and resorting to reading a shop manual. That done, the slushbox slipped free, and after Andy (RTFM’ing in the photo) cut the dipstick tube off, (which was sticking up into the engine compartment) we slid it out from under the car.

Step 2 : While you've got the tranny out, and the driveplate off, replace the rear-main seal. (No, this is NOT a Batman camera-angle. Note the front-crossmember toward the bottom of the picture, a B230FT is a slant-four, remember?)

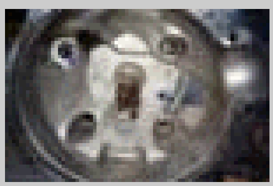




Step 3 : Bolt the new flywheel in place. This was my next big stumbling point. I had taken care to get a flywheel that had the perimeter holes next to the starter ring for the flywheel position sensor found on 1990 and later cars. What I didn't know, and what the dealership didn't seem to know either, was that there was more than one pattern of holes! I had bought a flywheel with 40 holes and two gaps, what I needed was a flywheel with 58 holes and one gap. Sadly, I only came to this conclusion AFTER I had the auto out, and was staring at the 58-hole driveplate. Needless to say, the car wouldn't start. Panic and despair set in. A morning of frantic phone calls led me to Don Weaver at Lamar Automotive in Kansas, who was able to ship the flywheel right away!

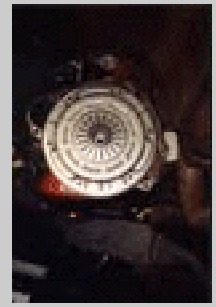


Step 4 : Bolt up the clutch. Nothing exciting here. Use brake cleaner to make sure the flywheel and pressure plate are clean. Use of a clutch alignment tool should be considered mandatory.

Step 5 : Install the clutch-fork and  release bearing.
My bellhousing had been set up for use with a cable clutch, but I wanted to use a hydraulic system instead. If you look at the picture to the right, this meant I had to move the pivot-point from A to B. Simple enough, but it involved removing the bellhousing from the transmission.

Step 6 : Wrestle the transmission up and into place. I usually use the grunting bench-press method, but you can use whatever's good for you. (a jack, some sort of tranny-stand…)

Step 7: Install the driveshaft. With the 780's 21 gallon fuel tank that lives on *both* sides of the driveshaft, this involved bringing the shaft under the front of the car and "threading" it up and thru the fuel tank and it's supports. Thankfully, Volvo was nice enough to put the IRS differential in exactly the same spot as the live-axle car, so I didn't need to go find some ultra-rare IRS/manual driveshaft… (finding a driveshaft that wasn't either buried in mud or mangled by a forklift was hard enough.)

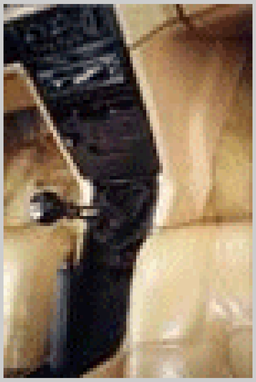


Step 8 : Install the clutch pedal, hydraulic lines, master and slave cylinders. This was all fairly easy. Volvo left a simple bolt-in blank in the firewall for the master-cylinder to bolt into, although it's kind of a pain to get to from the engine bay side, it's kind of down behind the strut-tower. (A big thanks to my fiance Michelle for having hands small enough to attach the hydraulic line to this for me, I just couldn't do it…) As for the pedal: I took only the clutch pedal itself from the junkyard, you may find it easier to grab both the clutch and brake pedal assemblies. I only had to move a computer box (ABS I think?) aside for a moment to get the pedal into place. That still left me with the big ol' auto brake pedal, which I chose to simply cut down to size. This leaves the brake maybe 1/4 inch closer to the clutch than normal, but no biggie. (check out the pic below)

Step 9 : Install the shifter lever. Okay, I lied, this should be step 6.5. This is actually fairly impossible to do after you've put the driveshaft in.

Step 10 : Wire up the overdrive! This was cause for a little bit of apprehension, but it was completely unfounded. The wiring for the AW71 overdrive and the M46 overdrive is exactly the same! The exceptions being that you need to swap relays, and that you should really hook up the sensor on the M46 that tells the relay that you're in 4th gear. (You could leave it out, and drive around with an 8 speed, but I don't think the OD would last too long…) I wasn't able to snake this wire into place in the relay socket with the relay seated normally, so I had to make little jumper wires and lay the relay on it's side next to the socket. (yellow wires) and then I was able to attach the wire for the 4th gear switch (blue wire). You may be able to get the wire into the stock location if you have the center console apart and the relay-board out, but I wasn't about to go through that.

Step 11 : Bleed the hydraulic clutch, install the interior trim, replace the battery you wrecked by leaving the hood light and trunk light on for a week, and it's done!

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Volvo Auto Transmission Conversion: ZF to AW

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[Procedure thanks to Dick Riess] This narrative discusses the procedure to remove the old ZF22 automatic transmission from your Volvo 740/760 and replace it with an AW-70 series unit.

Parts Required:

- Transmission
- Transmission crossmember
- Drive line (shafts)
- Gear selector, complete with wiring and connections
- Relay for 4th gear
- Oil cooler lines (both)
- New Exhaust pipe gasket
- Gear selector grommets

Things to check and (or) replace. It will never be easier than now. See relevent FAQ files for auto trans, driveline, and engine seals for further information.

- Tail shaft bearing
- Tail shaft-housing gasket
- Tail shaft seal
- Torque converter seal
- Transmission pan gasket
- Transmission filter-screen
- Shaft seals, one each side
- Mount for transmission in crossmember
- Rear main seal
- Rear main gasket
- Universal joints
- Carrier bearing and its mount
- Gear selector grommets

Instructions:

Mount and elevate car safely so that the transmission may be removed and the new unit installed. You will also need room to remove and replace the drive shafts.

1. Drain oil from transmission
2. Disconnect oil cooler lines from radiator - use a counter hold wrench at the radiator to prevent damage. Also disconnect lines at transmission. You will bathe in oil. Remove line holder at bellhousing (l -10mm bolt). Remove lines from engine bellhousing.
3. Loosen nut holding filler tube - dipstick holder from oil pan. Once pan is drained, put plug backs in and block holes vacated by lines and filler tube.
4. Disconnect shift levers from transmission. Two E clips.
5. Disconnect driveline at back of transmission and front of differential.
6. Remove center support bracket. Total of 6 bolts. You will need the plate for mounting the new drive shafts.
7. Remove exhaust pipe support near the back of the transmission. Not on all cars.
8. Remove nuts from exhaust pipe to manifold (3).
9. Remove bolts holding exhaust pipe to bellhousing.
10. Free exhaust pipe from exhaust manifold.
11. Remove aluminum engine support bracket under the engine. This binds engine to bellhousing.
12. Remove 4 bolts holding torque converter to flexplate. You will need to counterhold the flexplate.
13. Loosen and remove starter bolts. The assumption is that you have already disconnected the negative battery cable.
14. Remove distributor cap and rotor. You don't want to crush it against the firewall.
15. Remove transmission crossmember. Two bolts on each side and one nut holding transmission to the crossmember. Remove the bolt from the transmission - need to tap with a hammer once the crossmember is removed.
16. Mount transmission jack under the transmission, safely securing it.
17. Remove all bellhousing bolts.
18. Carefully pull transmission back until clear of bellhousing and lower. You will probably take another transmission oil bath, especially if the torque converter decides to come out. Best to cross wire in the torque converter to prevent it from slipping out.. Wire from ear to ear of bellhousing portion on transmission. Remove transmission from under the car.
19. Remove flex plate - loosen bolts in a cross pattern.
20. Mark or know the position of the flexplate on the crankshaft, as it prevents timing problems later.
21. Remove and install new rear main seal. FAQ provides instructions for this as well as other items skipped in these instructions.
22. Reassemble flexplate and torque to 50 lbs. using a cross-tightening pattern.

23. At this point you reassemble with the new transmission and associated parts.

In the Car:

1. l. Remove the center console. This includes:
    - Ashtray
    - Fuse hiding panel
    - Clip holding center console panel nears the fuse panel.
    - 2 screws in parking brake recess.
    - L shaped plastic clip near parking brake, black in color
    - Lift panel, disconnect seat heater plugs (2) and light. Remove panel
2. Good time to check that all small lights are working and to clean panel and area. Vacuum out. Loosen and flip up from right to leave the metal bar by the fuse panel. This swings out of the way and allows pulling of the fuse and relay tray for access to wiring underneath. You will need to pull this tray up and forward. There are two ears, white, one on each side that you need to push to the side as you lift and pull the fuse and relay panel out.
3. Remove 4 10-mm bolts holding transmission gear selector to the car. You can remove the selector now.
4. Under and along side the fuses relay panel, and usually on the left side you will find two unused plugs. Wiring should be: one yellow wires with sometimes a black mate. Other connector will have one brown and one blue wire. This should match color of wires from connector on new shifter. You may need to change connectors as Volvo did change connector types sometime between 1987 and 1990.
5. Check used shifter for working gear selector light and new grommets on the bottom end of shafts.
6. Install gear shifter.
7. Hook up plugs from car to plugs from the shifter. Wire colors should match.
8. Check that all lights function.

Under the car:

1. Reassemble by installing transmission to engine. This basically is retracing your disassembly steps. . Do assemble loosely so you can adjust for fit.
2. The new driveline needs to be mounted to old center support plate. Do it loosely.
3. Remember to hook up wire from shifter to the transmission overdrive solenoid (4th gear).
4. Check all nuts and bolts and tighten all.

Add transmission fluid. Suggest run car for a few hundred miles and flush transmission as noted in FAQ. Enjoy a much better shifting car. Check for leaks, always.

This file and pictures are courtesy of Cameron Price and Brickboard contributors, to whom thanks are given.

Symptoms Showing You Need a New Water Pump:

- Noisy water pump
- Leaking or loss of antifreeze
- Green residue around water pump seals
- Wobble or movement in fan pulley

Options:

- Take it to a garage - cost $190 - $250
- Replace the water pump yourself - cost <$100

Volvo has used virtually the same water pump on all four cylinder engines, from the B18B until the B230F. Volvo rates this job at 1.6 hours of labour and the cost of a new factory water pump is about $125 (Canadian). Add to this amount if any of the hoses show any signs of cracks. If you haven't had the timing belt changed in 80,000kms, then this might be an opportune time to replace the belt. Count on your garage to add the customary "shop supplies". If on the other hand you would like to save the high cost of labour ($55 per hour plus 15% tax in Canada) and experience the satisfaction of doing the job yourself, read on. This job can be easily performed in an afternoon providing you have all of the parts on hand. See the FAQ Cooling file for more tips on water pump replacement.

1. The water pump is attached to the front face of the engine block, by six (6) nuts and bolts, with an orifice on the top to the cylinder head, another on the right rear where a

metal pipe is joined to the pump with a bolt, and the bottom radiator hose connection, also on the right hand side.

2. Remove the fan, centrifugal clutch and loosen the fan shroud. If the bolts attaching the clutch are rounded, be prepared for a long ordeal (or take it to a reputable garage). Use a high quality 10mm open ended wrench for the fan bolts. Slack off the power steering pump (loosen top front bolt before loosening the adjusting screw), remove the fan pulley and the top part of the timing gear cover.

Water pump on engine front end

3. Remove the bottom plastic splash pan, if attached, then drain the antifreeze/coolant by undoing the radiator hose connection at the water pump. Place a pan under the hose to catch the coolant.

4. Remove the 4 bolts, 1 nut and bolt (for the rear metal pipe) and the bolt near the timing gear belt. I suggest you place a rag under this bolt, otherwise the bolt and washer could drop into the bottom timing gear cover. At this time inspect the timing belt and if it appears worn or it hasn't been changed in 80,000km, you should consider changing it now. Mine was changed 40,000km ago, so I decided to leave it for now.

5. Make certain that you have new rubber seals for the top connection and for the metal pipe. You will also need a new gasket for the surface mount onto the engine block. I suggest you buy new studs and nuts for the fan/clutch. I didn't do this and had difficulty removing the old studs without damaging them.

Water pump, gasket/seals, and studs

Rear of Pump

Surface of engine block

6. The most important thing to remember when installing a water pump, is to clean the block and head (not visible because of angle) surfaces as carefully as possible, before installing the new pump, to remove all traces of the old gasket or grease. This is where a small Dremel grinder with a brass brush for surface cleaning comes in handy. However, you can easily adapt any other tool to the task, including a putty scraper, a dull razor blade, copper wool, or very fine sandpaper to remove any trace of the old water pump gasket. Do NOT use steel wool or aggressive sandpaper. It is also important not to neglect the underside of the head mating surface, where the mushroom seal at the top of the water pump joins to the head. Often there are traces of old coolant deposits or gaskets left behind, and as a result the new seal starts to leak much more easily, especially in cooler weather. If the head mating surface has any imperfections due to old coolant deposits or gasket material, it is much more likely to leak. Needless to say, you need to clean carefully, since any gouges or cuts you make in the surfaces will increase the likelihood of a leak.

Clean the metal hose flange with sandpaper or a metal brush.

7. Before installing the pump. grease the seal and the hole where the heater pipe o-ring seal enters the pump body as well as the top mushroom seal that seats under the head. This is important to seat them properly. The best grease to use is silicone or a clear synthetic grease, although RTV or petroleum grease will work as well. One tip is to grease the paper gasket, which helps hold it against the block without shifting. By the way, no gasket sealing material is required: these merely help to hold it in place. Do NOT use

shellac or any other gasket sealers.

8. Install the new water pump after installing the new rubber seals and gasket. First make sure that the O-ring on the heater bypass pipe seats properly in the back of the pump. Then install the nut and bolt that hold the joint of heater pipe and water pump together. Tighten them up; this is better done before installing the pump so that the gasket in the heater pipe hole doesn't get shifted. Install the pump from its bottom, bringing it upward to compress the seal at the cylinder head. If the pump is a brand of reasonable quality, you will have to lift up on the pump once you hang it on the existing studs, in order to be able to put the new bolts in. Otherwise the bolt holes will not match properly and you will be forced to apply more upward pressure on the unit to make it seat against the head. First stuff a rag in the timing belt opening so you don't drop a bolt or nut into the timing belt. Using a 12-18" pry bar or screw driver, lever against the bottom-most portion of the pump and the crankshaft pulley or power steering pump and lift the pump upward. You need to get compression on that flanged o-ring. You don't have to use terribly much force, but it should be very snug. Start the remaining bolts in their holes while levering upwards, using a small amount of thread sealer on several as they do protrude into the water jacket. Now tighten the two nuts, still while holding pressure. Install all of the nuts and bolts, tightening them uniformly to achieve a proper seal with the block.

Installing new pump

Attach the radiator hose.

9. Install the pulley over the studs, attach the steering pump belt and then tighten the steering pump. Put the fan shroud in place (don't connect it yet) and then attach the centrifugal clutch and fan. Use new bolts and be careful not to overtighten them.

10. Bolt the fan shroud or electric fan in place, attach the splash pan, then fill the overflow tank with new antifreeze.

11. Start the engine, allowing it to reach operating temperature, checking for leaks and top up the expansion tank if necessary.

Installed pump and belt

Cost Breakdown:

- Remanufactured Water Pump (UAP/ NAPA P1381)...$59.90
- New studs & nuts for mounting fan... $10.00
- Miscellaneous supplies, cleaners, etc...$5.00
- 4 litres Prestone Antifreeze...$8.88
- Total cost + 15% PST/GST ====================> $96.35

Volvo Maintenance FAQ for 7xx/9xx/90 Cars

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B234F (16 valve DOHC) Timing Belt Replacement

(contributed by Dave Stevens)

Introduction and Cautions

The B234F 4-cyl, 16-valve, DOHC engine was available with certain 740/940/960 models. Although a smooth and powerful engine, you must not trifle with the Volvo gods when it comes to maintenance. Volvo recommends a maximum change interval of 50,000 mi (80,000 km) for both the cam timing belt and the balance belt. For severe operation or an extended time period, this interval should be shortened. The B234F uses an interference design which means the valves will collide with the pistons if the timing belt should ever break when running. This is absolutely one situation where you don't want to wait for something to happen before dealing with it –the resulting engine damage would be very costly to repair. As a further caution, no one acquiring one of these cars without service records should assume the belts were replaced at the proper service intervals –do an initial belt replacement to protect your investment. **If you have a B234 16-valve interference engine, you MUST maintain the entire timing end of the engine rigorously. This means new timing and balance belts and a new oil pump bolt every 50k miles, and replacement timing belt covers, new tensioner, and shaft seals on a regular schedule.**

For those experienced with the basic B230 red block engines, replacing the B234F timing belts is about twice as difficult. On the plus side, you don't have to remove the crank pulley to get the timing cover off. The biggest hassle is correctly setting the belt tensions. The Volvo procedure requires an expensive little tensioning gauge (p/n 998 8500). It's available directly from SPF/Kent-Moore to Volvo mechanics with a dealer number. Otherwise, it's only available through your Volvo parts department and, at around U$500, the average DIY'er won't likely be buying one of these for occasional use. In fact, many independent import shops don't have this tool. If you can borrow one of these tools then great, you'll be able to do a better job. If your engine has the newer auto-tensioner (see below) then it isn't overly critical to have the belt tensioning gauge. In any case, if you don't have the tensioning tool then you should be able to make do with one of the methods described below.

If you don't have the magical Volvo tensioning tool and this is one of your first ever attempts at timing belt replacement then you may find it more worthwhile to have a qualified shop do the job. A shop can do the job in a few hours, but you can count on closer to a whole day the first time you do it yourself.

As always, the following assumes a certain level of skill. Specifications provided may only be applicable to certain engines. Errors, inaccuracies and omissions may unwittingly be present. Use solely at your own risk.

Belts

There are two belts to be replaced: the cam timing belt and the balance shaft belt. The cam timing belt is obviously the most critical as you simply can't run without it. In a pinch you can run with the balance shaft belt removed if the revs are kept down to avoid harmonic vibrations (there have even been tales from people permanently running like this, but it really isn't worth the risk). Do note that if the balance shaft belt should break when running, the loose belt will likely get caught up in the cam timing belt causing it to break too. So if either belt breaks, the end result is likely the same: expensive engine repairs to replace damaged valves at the very least.

When it comes to replacement belts, Volvo is probably your most reliable source for quality and fit. Roulunds (Denmark) is a known OEM belt supplier to Volvo. Other aftermarket brands are Beck/Arnley, Clevite, Dayco, Dynagear, Gates and Melling. When it comes to timing belts, price is probably your best guide to quality. An inferior belt that is noisy or fails prematurely isn't worth a $20 or even a $50 saving. If you don't know better, use the suggested list price as a guide to quality, but do shop around for the best buys. Apart from Volvo dealers, sources for these belts are your local parts houses (like specialty import or NAPA and GAPA suppliers) or on-line suppliers like carparts.com and vlvworld.com.

Balance Shaft Belt

The balance shaft belt is a 110-toothed double-sided belt. The Volvo replacement belt is p/n 354745. Aftermarket equivalents are Roulunds 110HP140, Beck/Arnley 026-0281, Dayco 95174, Dynagear TB174, Gates T174 and Melling B0174(verify part numbers when ordering).

Cam Timing Belt

Note that there are two different cam timing belt lengths for the B234F depending on whether the engine has the early manual tensioner or the later automatic tensioner.

The timing belt used with the auto-tensioner is longer than the belt used with the manual tensioner. You need to be sure your parts house is aware of this when ordering. Some people incorrectly assume that belts listed for “B234F -manual” and “B234F -auto” refer to the transmission.

Belt Tensioners

Timing Belt Tensioner

A revised timing belt tensioner was introduced in the early ’90 production. The original style was a locked in-place, spring manual tensioner. The revised style is a floating, hydraulic piston automatic tensioner. You can identify which you have by looking at the bolt in the center of the upper timing cover face. If the bolt is in a deep recess then you have the manual tensioner, otherwise you have the automatic tensioner. Additionally there is a rubber knockout in the timing cover above the crank pulley. This knockout is round for the manual tensioner and elongated for the auto-tensioner. The newer auto-tensioner cannot be retrofitted to the older engines.

Manual Tensioner (up to early ’90 production)

This is a coil spring tensioner, much like that used in the SOHC engines. The spring is used to set the initial tension before locking the tensioner idler pulley in place. One disadvantage is that a new belt needs to be re-tensioned after a break-in period. Another disadvantage is that the spring does a relatively crude job of setting the initial tension. Unfortunately, the earlier B234 block with the manual tensioner isn't upgradable to the automatic tensioner - bolt holes are simply in the wrong place.

The cam timing belt (manual tensioner) is a 164-tooth belt. The Volvo replacement belt is p/n 271720. Aftermarket equivalents are Roulunds 164HP230, Beck/Arnley 026-0285, Dayco 95173, Dynagear TB173, Gates T173 and Melling B0173 (verify part numbers when ordering).

Automatic Tensioner (early ’90 production on)

This hydraulic tensioner is a floating idler that puts a constant pressure on the belt. The advantage is you don’t have to re-tension a new belt after break-in. The disadvantage is that the hydraulic section can leak allowing the belt to get too slack and eventually break. This is a good reason to accurately check the cam timing belt tension to make sure the tensioner is functioning properly as this is critical for the B234F. The auto tensioners do not last forever and the hydraulic fluid may leak without being noticed.

The cam timing belt (auto-tensioner) is a 167-tooth belt. The Volvo replacement belt is p/n 271714. Aftermarket equivalents are Roulunds 167HP230, Beck/Arnley 026-0293, Dayco 95032 and Gates T198 (verify part numbers when ordering).

There is a Volvo Customer Interest Bulletin (TSB Group 21 #706, June 1990) that fully describes the updated timing belt replacement and adjustment procedures, including diagrams. The AllData CD-ROM contains this TSB or you can try your local friendly Volvo shop.

Balance Shaft Belt Tensioner

The tensioner is simply a toothed idler pulley with a concentric hub for adjustment. A revised balance belt tensioner pulley was introduced some time after 1989. The original style had black plastic teeth on a steel hub and was secured with a large Allen head bolt. The plastic teeth have developed a reputation for disintegrating in climates subject to freezing temperatures (end of pulley, end of belts, end of valves). The newer style is an all-metal pulley secured by a hex head bolt. You can easily verify which you have by simply looking at the pulley bolt head.

If you have the old style pulley and drive in sub-freezing temperatures then you should **consider upgrading** to the newer style. The updated adjuster pulley design is Volvo p/

n 3547543 which also requires a longer bolt (p/n 965221). You may notice that the lower front timing cover has a plastic stud that bumps into the new pulley. Simply grind the plastic down so the cover fully seats.

To adjust the early style, loosen the center bolt slightly with an 8 mm Allen key. Place a socket (16 mm or 5/8”) over the bolt head to act as a pivot sleeve. Place the short leg of the Allen key through the socket to hold the center bolt. Use another large Allen key with the short leg in the hole next to the socket, which you then rotate to adjust the off-center pulley hub. Tighten the center bolt when you’ve achieved the desired belt tension.

To adjust the newer style, loosen the center bolt slightly and simply use a 24 mm wrench to turn the square faced portion of the off-center pulley hub while holding the center bolt with a box end or socket wrench. Tighten the center bolt when you’ve achieved the desired belt tension. See the Balance Shaft Belt Tensioning section below for a diagram of a homemade wrench that can be used to adjust this and is safer to use than a wrench when tension is adjusted with the engine running.

A few notes that apply to both types of balance shaft belt tensioners:

a.Turn the center pulley clockwise to tension the belt. If you go the other way, the belt will be sandwiched against the edge of the rear timing cover.

b.Note the off-center idler pulley to the right of the lower balance shaft pulley. This idler/keeper pulley should be set with the blue dot at the 3 o’clock position then turn it clockwise so that the pulley lightly rides on the belt where it enters the balance shaft pulley and lock it in place. Turning it the other way to support the belt on the long span is incorrect.

c.Note the small, dished, metal plate inserted in the rear cover edge approximately halfway between the two balance shaft pulleys and above the belt. This appears to be a wear plate to protect the cover and to help dampen excessive belt vibration. Make a mental note of where it belongs otherwise you won’t have a clue if it drops out.

PROCEDURE

A. To gain access to the timing belts:

1.Loosen the four 10 mm nuts holding the fan to the water pump (try not to round the nuts). Loosen the alternator top locking bolt and back the tensioning adjuster all the way out so you can push in the alt to remove the belt. Now remove the four fan nuts.

Unbolt the fan shroud from the radiator (top two screws). Disconnect the flex aluminum pre-heat hose at both ends to permit removal with the shroud (or just snip the tie under the shroud so you don't have to remove the hose). Lift out the shroud and fan (together).

2.Remove the main air intake tube (the flexible black plastic tube between the AMM and the intake manifold). There are two 1" rubber hoses attached to the intake tube. Disconnect the rear one and leave it on the engine. The front one that goes to the idle air control valve (IAC) should be taken off the engine with the intake tube. This will give you clear access to the accessory mounting bolts. You may find it even easier if you also remove the alternator and swing it out of the way for an unobstructed view of what you're doing (disconnect the battery to prevent accidentally shorting the rear alt terminals).

3.Loosen the upper P/S mounting bolt (the long bolt through the cast bracket) and the lower P/S locking nut then back the tensioning adjuster all the way out so you can push in the P/S unit to loosen the drive belts. You will probably need more slack to get the drive belts off; there are two ways. The official way appears to be from under the car, removing the splash pan then removing the lower A/C compressor mounting bolts to allow the compressor to swing inward. The other way is from above, freeing the P/S pump from the main mounting bracket so it can be pushed in closer to the block. If the belts are very tight you might need to do both. To free the P/S pump simply remove the loosened top mounting bolt (long bolt). When you've loosened the belts as much as you can, turn the crank clockwise and "walk" the two drive belts off the pulleys using a large socket wrench on the crankshaft center bolt.

4.Remove the three timing cover sections. See the above diagrams for locations. Good light, a clean engine and possibly a mirror will help you find all the bolts and screws. Try not to drop the screw that's buried on the top right side of the middle cover section –it can easily go down behind the accessory main mounting bracket (gee, why do I know this). Carefully note the two lowest cover bolts that also secure wire harness clamps. The right (intake side) bolt also secures a metal bracket. If you're working from above it is very easy to miss all this during reassembly. The covers should easily come free once you remove all the bolts and screws. For the middle cover section, you'll need to push the P/S pump back out a bit to get the cover out from behind the crank pulley. Try not to force anything as the mounting tabs and edges of the covers get brittle.

5. While you're here, inspect for any signs of oil leaking from the front engine seals for the camshafts, crankshaft and balance shafts or any accumulation at the bottom of the timing covers. Any sign of oil could mean one or more of the front engine seals need replacing or it could simply mean the PCV system needs cleaning. You don't want oil dripping onto brand new timing belts.

B. Removal and Inspection

1.Start by locating and highlighting all the rear timing cover alignment marks (raised ridges). See the diagrams for locations. Note that the mark for the crank pulley is below while all other marks are above their pulleys. White correction fluid makes a good temporary marker. Locate and highlight the corresponding notches in the edge of the rearmost belt guide plates for each pulley. Also, note if you can still see the thin line alignment markings across the cam timing belt. If they're no longer visible then, for future reference, you might want to mark your own to correspond with the rear timing cover marks.

2.Rotate the crank clockwise so cyl #1 is at TDC. You can use the marks underneath the crank pulley for this (you may want to use a mirror). You can also temporarily replace the middle section of the front timing cover to use the 0 deg. timing mark and the corresponding timing mark scribed across the crank pulley. Once set, make an easier to see mark on the rear timing cover above the crank pulley aligned with the scribed timing mark.

Now check that all the marks you've highlighted line up. If you happen to find one of the pulley marks won't align with its cover mark when the crank is at TDC then this indicates either that the belt has jumped a tooth at some point (be glad you've caught it now) or the last installer failed to properly align the belt (it's not that hard to do). In either case, you've likely noticed poor performance. If this has happened then be sure to check all the pulleys for bearing wear as a sloppy bearing can allow a belt to jump as can an improperly tensioned belt.

3.Lay the new belts up against the old with the two sets of marks exactly aligned. Follow the new belt around the old belt to make sure all the other markings match otherwise you may have gotten the wrong belt.

4.Remove and inspect the timing belt tensioner

Before removing the tensioners, familiarize yourself with the current belt tensions. Measure belt deflection at the mid-point of the longest span. First, use one finger to see how much force it takes to get a ¼" deflection. Then, use thumb and forefinger to see how much force it takes to make a 90 deg. twist (or as far as you can go). This will help you later. If you have a gauge then use it now to check the current belt tensions. For the hydraulic auto-tensioner, if the timing belt tension is below spec then the auto-tensioner likely needs replacing. Double check the hydraulic tensioner by stretching the belt then turning the crank once or twice and re-checking the tension.

a)For the manual tensioner, start by loosening the tensioner pulley bolt. You need to compress the tensioner spring enough to get a retaining pin (nail) through the holes to hold it closed. Do this either by straining the belt to force the tensioner to retract (difficult) or directly compressing it using something like a c-clamp (simplest). Once the pin is in place, remove the tensioner for cleaning and inspection.

b)For the hydraulic auto-tensioner, remove the upper tensioner mounting bolt then loosen the lower mounting bolt. The tensioner will pivot free of the belt so you can remove the lower bolt. Remove the tensioner for cleaning and inspection. The hydraulic portion of the tensioner needs to be checked for signs of leakage. There is a bench test that can be performed, but apparently it's no longer recommended (when rushed, the test may damage a good tensioner). The approved method is using the magic Volvo tensioning gauge to check tensioner operation by way of the belt. If you don't have the gauge then you should perform the original test -when done slowly and carefully, there should be no problem. Mount the tensioner in a vise (or other large clamp) and depress the plunger by gradually turning the vise handle about 1/16 turn every 5-10 seconds until the locking pin can be inserted in the hole. During this, the plunger should offer some resistance, but should not be seized. Afterward let it sit for a while with the locking pin in place. There should be no evidence of leakage. Release the tensioner carefully.

Once the tensioner has been removed, check the tensioner pulley. Start by cleaning the outside of the pulley bearing using something like WD-40.The pulley should spin freely, without bearing noise and without any slop. These are wear items and need periodic replacement. Now remove the timing belt. Clean, spin and check all remaining idler pulleys for bearing wear. Replace any worn ones.

5.Remove and inspect the cast oil pump gear pulley (lower right -intake side).

To remove the bolt you will need to restrain the pulley. One simple way is to insert the short arm of an "L" shaped tool (like a long legged 3/8" Allen wrench) into one of the lower pulley holes in such a way that the long arm of the wrench rests on top of the crank pulley. Then use a socket wrench to remove the bolt such that the Allen wrench gets jammed between the socket and the crank pulley (be careful not to let it damage the crank pulley).

The **oil pump pulley bolts have a reputation for shearing off** usually resulting in a broken belt and consequent top end damage. Whether this is due to an over-tensioned belt or to an under-rated or over-torqued bolt is open to debate. In any case, **they should be replaced with new bolts at each timing belt change.** [Karl-Dieter Haugk] The replacement bolt is Volvo p/n 948472, an extra strong metric 10.9 class

M10 x 1.5 mm (standard thread) x 30 mm long bolt including a flat washer (Volvo p/n 960148). This appears to be an upgrade from the original class 8.8 25.4 mm long bolt which should reduce or eliminate the incidence of failure. **Use the new, higher grade bolt as this is a critical engine part.**

Remove the oil pump pulley itself and carefully inspect for any signs of damage. These pulleys have been known to self-destruct, again, probably where the belts have been over-tensioned. In particular, look for signs of stress fractures on the back inside of the casting where the sidewall meets the face. **Replace the oil pump pulley at the first sign of a problem**.

Re-install the oil pump pulley with the new bolt and washer. Use a little Loc-tite and torque to 15 ft-lbs (20 Nm) then angle tighten a further 60 deg. A one step torque to 40 ft-lbs (55 Nm) should also be adequate, just don't over-torque. You can restrain the pulley using the Allen key method described above.

6.Loosen the balance belt tensioner pulley (lower left -exhaust side). Turn the hub to loosen the belt and remove it. Clean, spin and check all idlers for bearing wear.

C. Belt Installation

If you didn't do it before, layout the new belts against the old belts with the markings aligned to verify that you have the correct belts. If the new belts aren't marked you may want to mark them now to match the old belt. You don't actually need the belt markings, it just makes the job a little easier and a little safer. Note that if the belt marks don't match the original then either the belt needs to be flipped or you may have the wrong belt(or at least one not specifically made for the B234F).

See the diagrams for belt paths and mark locations. Markings and adjustments must be accurate to within a tooth. Site each mark straight on when checking alignment (use a mirror for the lower crank mark if needed).

1.Re-install the timing belt tensioner. For the manual tensioner, keep the tensioner compressed with the locking pin in place and loosely tighten the tensioner pulley bolt. For the auto-tensioner, install it normally extended, tilted to the left with just the lower mounting bolt in place and loosely tightened.

2.Install the balance belt. Have the tensioner pulley turned in as far as possible and the idler/keeper pulley turned counter-clockwise away from the balance shaft pulley (blue dot at about 2 o'clock). Line up the marks on the new belt with the marks on the pulleys, which should still line up with the marks on the rear timing cover. Orient the belt then place it over the right balance shaft pulley with the corresponding mark aligned, then go under the crank pulley, then over the left balance shaft pulley as you slide the end loop over the tensioner pulley. Turn the tensioner pulley hub clockwise to snug up the belt and lightly tighten the center bolt. Check that all associated marks line up. Turn the idler/keeper pulley clockwise so that it is just lightly pressing on the belt and tighten to spec.

3.Install the cam timing belt, lining up all the marks. It may take a few tries to slip this on in the right order. Start with the belt around the oil pump pulley then wrap the belt over the crank so that the double mark on the belt lines up with the TDC mark on the pulley. Partially unwrap the belt off the crank pulley, loop it up and slip it over the cam shaft pulleys keeping the belt between the idler pulleys. Manually tension the belt inward on the left side and check that all associated marks line up.

4.Position the timing belt tensioner.

a)For the manual tensioner, retract the tensioner pulley slightly so that you can remove the locking pin. Gradually release the tensioner pulley onto the belt being careful not to lose belt position. Rock the crankshaft back and forth a bit to ensure the belts are seated. Lightly tighten the idler pulley bolt to spec.

b)For the auto-tensioner, install the lower mounting bolt (loosely), pry the tensioner into position and install the top mounting bolt. Torque the tensioner mounting bolts to spec.

5.Rotate the crank clockwise through two revolutions back to TDC (re-align the crank pulley mark with the rear cover mark you made earlier). Do a final check of the pulley marks against the rear cover marks. NB. The belt marks will no longer align once the belt has been turned, leastwise not for many thousands of revolutions.

6.Make an initial tension adjustment for the timing belt (manual tensioner only) and the balance shaft belt. Be sure to finish by turning the crankshaft through two revolutions and re-checking belt tension. Procedures for belt tensioning and checking are detailed below.

7.Tighten bolts to specifications:

- Balance belt idler/keeper pulley (3rd from left) 9 ft-lbs(12 Nm)
- Balance belt tensioner pulley 30 ft-lbs(40 Nm)
- Timing belt manual tensioner pulley 37 ft-lbs(50 Nm).
- Timing belt auto-tensioner lower mounting bolt 37 ft-lbs(50 Nm)

- Timing belt auto-tensioner upper mounting bolt 18 ft-lbs(25 Nm)
- Timing belt idler pulleys 18 ft-lbs(25 Nm)
- Balance shaft pulleys 37 ft-lbs(50 Nm)
- Crankshaft pulley 44 ft-lbs(60 Nm)plus 60 deg
- Oil pump drive pulley 15 ft-lbs(20 Nm)plus 60 deg

8.Run the engine to normal operating temperature. This will be difficult to do unless you re-install air intake hoses and alternator. You don't need to install the fan, just the alternator pulley on the water pump (use spacers on the threads if needed). During warm-up, if the belts start to wander on the idlers or if there is excessive belt vibration or noise then stop what you're doing. If the problem can't be corrected then re-install the original belts –the new belt may be defective. Note that a certain amount of belt flutter and even a slight whine should be present on a properly tensioned belt.

9.Do a final belt tension check. In particular, this is the time to dynamically tension the balance belt.

10.Replace the timing covers and main drive belts. The main drive belts should be set fairly taught. The alternator belt more loosely, but not to the point of being able to slip when turned by hand. Replace fan, shroud and alternator drive belt, etc. Say a little prayer and you're done.

D) Re-Tensioning

With the later style auto-tensioner, re-tensioning of the cam timing belt should not be required. However, re-tensioning of the balance belt should be performed after a few thousand miles (the service guide indicates 5,000 mi / 8,000 km). This only requires removal of the lower timing cover. The lower bolt is much easier to get at from under the car.

With the early style manual tensioner, both belts should be re-tensioned after a few thousand miles (the service guide indicates 5,000 mi / 8,000 km). This actually only requires removal of the upper and lower timing covers if you remove the round rubber knockout to access the tensioner bolt. However, if the drive belts are blocking the access hole then everything will probably need to come off again.

Belt Tension Checking Methods

Belt tension can be checked using one of the following methods: (crude/better/best):

Method A: For both the timing and balance belts, press down quite firmly using one finger at the mid-point of the longest belt span between pulleys. A properly tensioned belt will have a deflection of about ¼”. The deflection for the balance belt should be greater than for the timing belt. This is a fairly crude method and should only be used for initial settings and rough checking.

Method B: For both the timing and balance belt, using your thumb and forefinger, twist the mid-point of the longest belt span as far as you can. You should just be able to twist a properly tensioned timing belt by about 90 degrees. It should not be as difficult to twist the balance belt to 90 degrees (and with effort, no more than about 135 degrees). For the timing belt, this method is about as good as you’re going to get without a gauge. For the balance belt, you can do better by performing a dynamic belt tensioning as noted below.

Method C: Use a general-purpose belt tensioning gauge. Tension is normally measured in Newtons (or lbs-force) at the approximate mid-point of a reasonably long belt span. One Newton is one kg-force. Unfortunately, the only published tension specifications are for the Volvo special tool (see below). No units are mentioned and observed comparisons seem to indicate it’s not linearly related to Newtons.

Based on observation, it would appear that the timing belt should be somewhere around 14 N (30 lbs-force) with the manual tensioner and closer to 18 N (40 lbs-force) with the auto-tensioner. The balance belt should be somewhere around 23 N (50 lbs-force). Please do not use these numbers for adjustment, they’re mentioned here only to promote further investigation.

As for non-Volvo belt tensioning gauges, the “Krikit I” made by HMC International in Colorado is a nifty little tool. You should be able to get it for under U$20, either direct from HMC (www.hmc-international.com) or from your local parts house as Dayco p/n 93865 (an in-stock item at Lordco Canada). It would be quite useful for doing the timing belt if you managed to have the tension specification. It would not be appropriate for doing the balance belt as the range doesn’t quite go low enough and the tool isn’t designed to sit on the toothed side of a belt.

Method D: Using the sacred Volvo belt tensioning gauge (p/n 998 8500), the timing belt tension should be 5.3-5.7 (Volvo units) for the manual tensioner and 3.0-4.6 for the auto-tensioner. The balance belt tension should be 4.7-5.1 units. When installing a new belt, set the tension to the high end of these ranges to allow for subsequent belt wear-in during the first few thousand miles. When re-tensioning a used belt on a fully warmed engine, aim for a mid-range setting. This is an expensive tool for casual use - approx U$500 from Volvo, slightly less from the SPD Kent-Moore distributor, but only for those with a Volvo dealer number. For the timing belt, the tool is positioned on the short span leading from the bottom of the left cam pulley. For the balance belt, the tool is positioned at the mid-point of the long upper span.

Belt Tension Adjustment Methods

Cam Timing Belt

For timing belts with the hydraulic auto-tensioner there is no adjustment. Check the tension as above. If the proper tension cannot be achieved then the tensioner will need replacement. This is no place to cut corners; if the tensioner isn't replaced when needed then expensive engine repairs may be the result.

For timing belts with the manual tensioner, loosen the tensioner pulley bolt slightly. Adjust the tension by pulling out on the pulley or by prying the idler section of the tensioner using a large screwdriver. Re-tighten the bolt. Turn the crank two revolutions to TDC to seat the belt and check the tension as above. Repeat as necessary.

Balance Shaft Belt

For the balance belt tensioner pulley, turn the concentric pulley hub clockwise to increase tension and snug the center bolt slightly to hold it. See the Balance Shaft Belt Tensioner section above for more details on how to do this for the two types of tensioners.

Make an initial setting for the balance belt tension (as below). Start and fully warm the engine.

A. Static Method (With Engine Off)

Back off the tensioner pulley bolt until the pulley can just be turned with the adjusting wrench. Alter the tension using the adjusting wrench, re-tighten the bolt and check the tension. If the tension seems correct then turn the crank two revolutions to seat the belt and re-check the tension. This is the approved method when using the special Volvo tensioning tool.

B. Dynamic Method (With Engine Running)

This method is only appropriate for longer belts with chisel-shaped teeth such as the balance belt. This is best done dynamically (adjusted with the engine running), but can be done statically (engine off, adjust, restart and test) with a fair bit of trial and error. Take great care when working around moving engine parts.

To make a dynamic adjustment you only need to re-install enough to run the engine, i.e. the air intake hose and the alternator. For safety’s sake, don’t install the fan, just the alternator pulley on the water pump (use spacers on the threads if needed). Back off the tensioner pulley bolt until the pulley can just be turned with the adjusting wrench. Adjust the initial tension manually, as best you can, if anything a little on the loose side. Now start the engine and adjust the balance belt tension to the point where the belt makes a definite whirring sound (the belt will be fluttering). That’s the sound of the belt teeth starting to climb up the pulley teeth. For a new belt, that should be close to the proper setting -the whirring will go away as the belt wears-in. Stop the engine and manually check belt tension. If it seems wrong (too taught) then you’ve gone past the magic point. When re-tensioning a used belt, back off the tension until the whirring almost away. For the balance belt, this method is about as accurate as you can get without a gauge.

For a dynamic adjustment, it is important to use a wrench that will not catch in the belt or pulley during adjustment. A wrench with a thick head or one that has to be used at an angle is not appropriate. A good solution is to fashion a wrench out of an L shaped piece of flatbar with a channel cut in one end (the short leg) for the adjuster nut(see diagram). Hold this wrench parallel to the pulley face and underhanded (so as to release from your hand if accidentally caught).

Balance Shaft Belt Makes Noise After Adjustment. [Inquiry] I replaced the belts about 400 miles ago and there's still a noticable whine from the balance belt. If I loosen the belt, the whine quiets down, but the belt seems loose. [Response: Mike] The balance belt is too tight. Adjust while running at warm idle at the bottom tensioner. Adjust in very small increments until belt starts to flop. Then tighten slightly until flopping decreases. I had the same problem. Remember this belt does not drive a heavy load so lots of tension is not necessary. Too tight a balance belt will damage shaft bearings or produce bearing noise. [Tips from Greg Mustang] The balancer belt should be looser than what you and I are used to on belt drives. Almost floppy. Too tight or too loose and it will be noisy. I just adjusted mine CAREFULLY with a thin spanner with the engine running to get the minimum noise. I was careful to keep my eyes and hands out of the line of fire. Make sure you lightly grip the spanner in such a way that if it should catch on the rotating pulley, it will rotate away from your hand and not pull your hand into the fray. It really should be adjusted with a tensioner. Or you could make minor adjustments with the engine off and check for noise with the engine running. Just be safe!

Back to: Top Seals-Belts-Vent FAQ Home

Volvo B230 Headgasket Replacement

Note: See other procedural tips at Engine: Mechanical

Article by Boe Kalinoski, Import Specialist, courtesy of ImportCar Magazine

Volvo engines have always been noted for their durability and long-term, trouble-free operation. But just like any internal combustion engine, they could develop head gasket problems that stem from owner neglect or the engine design. This article will detail the diagnostic process and procedures for replacing the head gasket in the most common Volvo engine.

The B230F engine is one of the basic four-cylinder engines that was produced until 1995 in the 240/740/940 body styles. When the head gasket developed a leak in that particular engine, it was caused primarily by the vehicle's age or a troubled cooling system. The cylinder head is aluminum and, while it saves weight, it expands 1.5 times faster than the cast-iron block.

Distortion and warping are common problems with aluminum cylinder heads because of a combination of the very high thermal conductivity of aluminum, the fact that the head is thinner and smaller than the block, and the physical law that heat rises. This expansion rate will induce motion and scrubbing between the head and block, and eventually cause a leak.

Scrubbing is a common problem in a bi-metal engine, where two different metals are used for the cylinder head and engine block. The scrubbing action causes abrasion and shearing to the head gasket, which results in failure. Following the correct head bolt tightening sequence and applying the proper torque will help to minimize this effect.

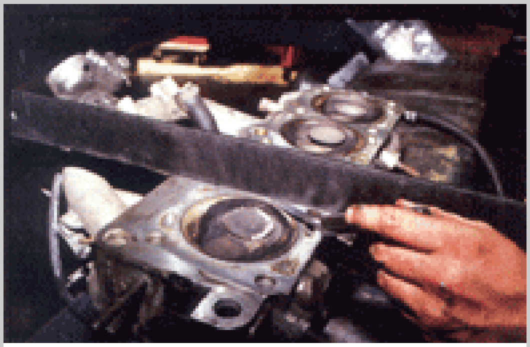


Fig 1. Check with a feeler gauge for warping between the surface and the straightedge.

Volvo uses a graphite head gasket because graphite has natural lubrication that can handle the differences in temperature between the aluminum head and the cast-iron block.

Graphite is a very soft material that provides good sealing when cold and it can withstand very high temperatures. The head gasket must seal combustion pressures up to 1,000 psi, as well as withstand temperatures in excess of 2,000° F. Required to withstand this severe environment, the slightest fault in a gasket will eventually lead to failure.

BASIC SEALING PRECAUTIONS

For the head gasket to seal properly, the cylinder head and the engine block must be inspected for flatness. Place a straightedge lengthwise on the block and then the head. Check with a feeler gauge for warping between the surface and the straightedge. The total maximum amount of combined clearance between the head and block should not exceed .004 inch (see Fig. 1). Don’t forget to check it crosswise (also should not exceed .004 inch).

A proper surface finish is also very important for the head gasket to provide a quality seal. If the surface is too smooth, it might not provide a good grip to hold the gasket in place. And, although a rougher surface provides more grip, it also will cause abrasion and deterioration as the combination (head and block) expands and contracts from the extreme changes in temperatures. Not only does the head gasket seal high-compression cylinder pressures, it also seals coolant passages and oil feed galleries that lubricate upper valve areas.

A mandatory procedure at our shop is to send out the cylinder head to a machine shop for resurfacing. Afterall, when the head is resurfaced too much, it could lead to trouble. Major factors to avoid are making the compression extremely high and valve interference. Never go over 0.015 inch, as the timing belt could be affected in a way that the marks won’t properly line up and will cause the camshaft timing to retard. Some aftermarket manufacturers sell thicker head gaskets to raise the head to the original specification.

The first step is to clean the head of all grease, oil and carbon before inspection. Cracks can be found around the exhaust seats where they are pressed in the head.

Most of the time, you can leave the valves in the head, but pull off the camshaft. If there is any suspicion of overheating, it is a good idea to perform a valve job and install new seals at that time. When the cylinder head is dropped off from the machine shop, blow out all the oil passages and bolt holes with compressed air to remove any tiny fillings that could lodge in the oil pump pressure regulator valve, causing catastrophic failure.

The engine block can be belt-sanded, or you can use a Jidder bug with 60-grit paper and (very carefully) try to move the sander all over, not stopping at one area. Never use abrasive pads to buzz off the old gaskets, as they can leave low spots on the sealing surface that the head gasket may not be able to fill. Never use any type of sealant on the head gasket to keep it dry. Some sealers will break down the gasket, causing leakage and possible comebacks from unhappy customers over a period of time.

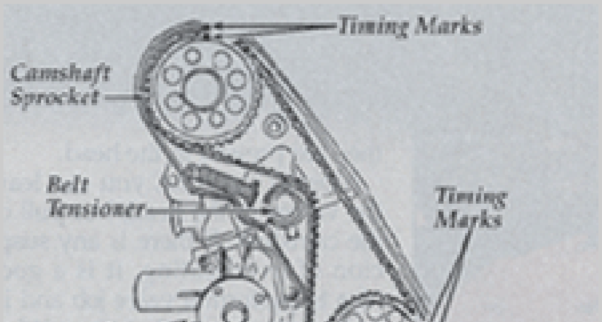
The head bolts are often overlooked, so I recommend replacing the head bolts when the cylinder head is removed for any reason. The B230 engine has torque-to-yield bolts (TTY) and the B5254 engine also uses them. TTY bolts are essentially stretch bolts that produce more clamping force on the cylinder head for proper sealing of the head gasket.

TESTING PROCEDURES

1. Perform a leak-down test. It provides a lot of information about the condition of the engine. Check for bubbles in the expansion tank.
2. While the engine is running, hold an exhaust analyzer close to the coolant expansion tank to obtain a reading.
3. Pressurize the cooling system and crank over the engine. Look for coolant leakage in the cylinders.
4. Check the spark plugs for a green tinge on the electrode.
5. Add dye to the oil to detect small leaks between the head and the block under the manifolds.
6. Properly diagnose the source of the gasket failure, since it must be corrected before or during the replacement procedure. Otherwise, the replacement gasket will fail from the same problem.
7. Check the cooling system, water pump, radiator, hoses and cooling fan operation. Thermostat stuck? On the Volvo 850, don't forget to check the cooling fan and the relay, as they tend to work erratically at times. The 240 Series uses a clutch fan with the electric fan for the A/C. Do not overlook that area.

The B230 engine, which is an eight-valve, belt-driven engine with an OHC design cylinder head, is a snap to remove. When executed correctly, this repair generates good profits and no comeback problems after the replacement procedures are completed.

REMOVAL PROCEDURES
When removing the B230 cylinder head:



1. Drain the cooling system at the radiator and the block, disconnect the negative

battery cable and remove the intake manifold and exhaust manifold (discard the old manifold lock nuts).
2. Remove all drive belts and the water pump pulley. Remove the fan, preheater hose, and fan shroud and timing belt cover.
3. Using the center bolt on the crankshaft, rotate the crankshaft so the mark on camshaft pulley aligns with the TDC mark on the timing belt cover, and the crankshaft pulley mark aligns with TDC mark on timing belt cover (see Fig. 2).
4. Loosen the belt tensioner nut one turn. Pull off the timing belt to compress the belt tensioner spring. Tighten the belt tensioner nut. Then install a 3mm drill bit in the hole of the belt tensioner bolt to lock the tensioner spring into place.
5. This might be a good time to replace that worn-out belt. If not, mark the belt with the camshaft sprocket, using typing correction fluid to ease installation.
6. Remove the spark plug wires and distributor cap. Remove the cylinder bolts in the proper sequence and remove the cylinder head (see Fig. 3). Volvo recommends replacing the head bolts if they are stretched or used more than five times. As mentioned earlier, when in doubt, replace them!

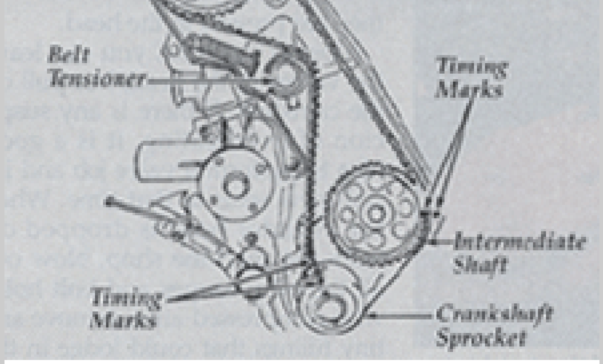


Fig 2. Rotate the crankshaft so the camshaft pulley mark and the crankshaft pulley mark align with the TDC mark on the timing belt cover.

INSTALLATION PROCEDURES

1. Ensure that the camshaft is positioned so that the valves are closed on the No. 1 cylinder and the No. 1 piston is at TDC. Install the new head gasket with top marked upward (and don't use sealant!). Ensure that the O-ring for the water pump sits correctly in the groove (this is a good time to replace the water pump). Install the cylinder head.
2. Apply a light coat of oil on the new head bolts before installation. Install and tighten bolts in sequence to the specification using the three stages (also see Fig. 3). Start at 14 ft.-lbs., then go to 43 ft.-lbs., then go an additional 90 degrees.

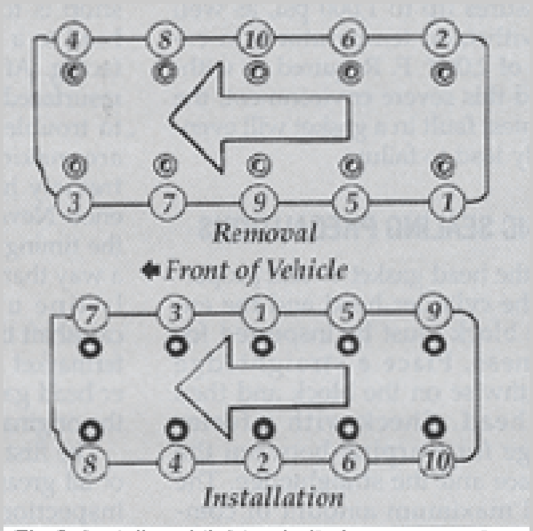


Fig 3. Install and tighten bolts in sequence to the specification

Some shops overlook the oxygen sensor after the cylinder head gasket is replaced. Antifreeze has a silicone base and could destroy the sensor in no time. Check the sensor's output after the engine has been started, and make sure that all other systems are functioning properly.

The B6304 engine is more complicated with its two-piece head design that uses double camshafts and an aluminum engine block. That engine is an interference engine. The only time we had to remove the cylinder head in that particular type of engine was when the timing belt failed and caused catastrophic failure.

Volvo Side Marker Lamp Installation

FAQ Home

Volvo Maintenance FAQ for 7xx/9xx/90 Cars
Version 7.5

New Hella Side Marker Lamp from IPD

Early Hella Side Marker Lamps

Side Marker Lamps Description.
[Written by Dave Barton, to whom thanks are given]

German-made Hella side marker lights look great on the front fenders of Volvo 240's, 740/760's, and 940/960's. Some drilling is required to fit these to a North American 240 made before 1986, but all '86 and newer 240's, all 700/900 Volvos, and all 850's already have the necessary hole behind the front fender "VOLVO" badge. As you may already know, Euro versions of these models did come with similar lights used as turn signal repeaters, thus the reason for the hole in the fender to begin with.

Where to Find Euro Side Marker Lamps. [Editor] New Hella side marker lamps and wiring kits are available from IPD (see the photo for their modern version of this lamp). Lamps without wiring kits similar to the amber version in the photo are available from aftermarket dealers serving Porsche and Audi owners, including Pelican Parts and Vertex. Search their catalogs for European side marker lamps used on mid-1980s Porsche 911 cars. Used lamps and wiring connectors may be had from recycling yards with mid-80s Audi 4000 or Porsche 911/912 cars. To remove these from existing cars, just use your fingers to push the light forward (towards the front bumper) it will then come free on the back side and then it's loose.

Marker Lamp Installation in Fender. [Written by Dave Barton]

Models With Existing Hole In Fender.This hole is found behind the "VOLVO" badge, which is placed on the fender with adhesive only. The badge should be carefully pried off. A hair dryer will help to warm up and soften the adhesive. Then some dental floss will help to loosed the grip of the old adhesive. I have found that when installing these lights in the fenders with existing holes, as depicted in the photo of the red 740 Turbo, it made for an easier fit to slightly enlarge (elongate horizontally) the holes with a small 1/2 inch half-round metal file. This should be done slowly while periodically test fitting the side marker. Very little metal actually needs to come off, possibly 1/16 of a inch or so. This takes only about 5 or 10 minutes, so this should not be of much concern. For those of you concerned with keeping your fender hole intact (due to rust, fear of committing sacrilege against the Volvo gods or whatever), the back sides of these lights are plastic and may also be modified to fit the existing hole by carefully trimming some of the plastic material on the back with a razor or small file. The goal is to be able to install the light with a snug fit, but not too tight as you risk breaking something on the light by forcing it in.

740/940 Side Lamp Fender Hole

Older 240 Models Without Existing Hole in Fender. The most difficult part of this install is getting over the fact that you are cutting into your Volvo fender! The rest is easy. On my '84 245 I started with a simple 3/4 inch (7/8 inch would be better) hole saw. Drilling the sheet metal on a perfectly good Volvo fender with a standard hole saw is not a natural act and can be unnerving, but if you do it slowly and gently, you will easily cut through without any fuss. A small sheet metal nibber is a good tool to have to elongate the hole horizontally. If this tool is unavailable, a small metal file as mentioned above will work, but will take a little more time. Your goal is to make a rectangle about the size of the hole in the red 740 above. The hole will be about 3/4 to 7/8 inch high and about 1 3/8 inch wide. The hole should be a snug fit for the light, but not too tight or you risk breaking some of the plastic on the back of the light if you force it in. So careful, periodic test fitting as-you-go is necessary. The side marker light simply snaps into place once the hole is the proper size.

Fishing Wires from the Lamp to the Connections. [Modified from Dave Barton's Contribution]

Fishing Wires. Most Volvo's do not already have a wiring harness in the fender for turn signal repeaters. For you 240 and 740/760 & 900 owners, you will have to wire it yourself. You need to fish the two wires through the fender well and run them forward to the front turn signal and ground connectionsl. On the inside fender near the front, there are a number of round plastic plugs which provide access for rustproofing, etc. You can remove one of these, insert a coathanger or electrician's fishtape wire rearwards until it is visible at the hole for the signal. I have easily fed a fish wire from the front toward the rear - much easier than going from the light location forward. Just put a slight curve in the wire so that it rides over the inner fender liner and ends up near the opening for the light. Fasten the signal wires to the fish wire and pull them forward. Then cut a small 'X' in the plastic plug and pull the wires through it. Reinstall the plug and attach the wires. If you do not have the plastic plugs in the inner fender, you will have to first remove the wheel first, then the plastic inner fender liner, a very simple job with only a few screws. You might need to drill a small hole in the inner metal fender if you can't find a place to pass the wire through to the engine bay. If you drill a hole in the inner fender metal it's a good idea to rustproof the hole with new paint and to install a rubber grommet to prevent the wires from chaffing against the metal. *960/90 Note*: I used a ~6 ft. long wire and snaked from the front to the rear on both sides. On the drivers side, I went high. Right above the turn signals, where the fender metal bends over and down from the engine bay to the outside fender there is a gap that you can easily snake a long wire into and over the tire.

You can purchase the wiring harness from IPD or make your own assembly. The IPD extension wires are just the OEM Volvo pigtails with some extensions soldered on and the whole thing closed inside some flex or quick loom covering and electrical tape at the ends along with a couple of scotch connectors. To make your own, use extension wires that are correctly color coded for the front turn signals. If the pigtail wires that fit the plug for the turn indicator are not long enough to reach all the way to the front turn signals, you will need to solder some extensions on to them. Be sure to leave enough slack in the wires to allow you to easily remove the repeater from the fender with about 6" of wire. It is also helpful to use some 'quick loom' to cover and protect the wires that are inside the fender. Where the repeater lights go into the fender, there is a rubber plug in the inner panel behind the outer fender. You will need to remove this plug as the connector on the back of the repeater will extend into this hole.

Wiring Connections. Once you've fished your wires, connect ground to the turn signal's black ground wire or to the front ground connection point on the inner fender behind the headlight (several blank tab terminals available). Connect the hot side to the turn signal lead with a Scotch plastic snap-on connector. It does not matter which wire from the side marker goes to the 12v hot wire for your turn signal. On most Volvos I've seen, one side had a green wire and the other side a blue wire. I use an inexpensive 12 volt circuit tester to verify the wires I use. This eliminates guesswork. The type that uses a sharp point to probe a wire is best for this job.

Wiring Flashing Side Marker Lamps. [Written by Daniel Stern, to whom thanks are given]

Side Marker Wiring Options

Non-Flashing Setup. Many cars have amber front sidemarker lamps that DON'T flash with the turn signals. This is permitted by our (outmoded, inadequate) lighting and signalling specifications in North America, but these lamps are also permitted to flash. Having them flash is an advantage, because that way your turn indicators are more visible to drivers who are flanking your car, and cannot see your front or rear indicators.

Flashing Setup. The side marker bulb socket is isolated from ground, and one bulb lead goes to the parking lamp positive circuit. The other lead is tied into the turn signal positive lead. When the parking/running lights are on and the turn signal off, it grounds throught the turn signal filament and illuminates the marker lamp. When the turn signal flashes, it interrupts the ground and the marker will flash. When the parking lights are off, the process is reversed, with the ground being through the filaments of the running light circuit, and the marker will flash in sync with the turn signal instead of alternately.

Bulb-Out Relay Circuit Concerns. [Dave Barton] I have done four cars to date (one 240, two 740's, and one 760) and no problems with the vehicles' "bulb-out circuits" have surfaced. The key with this circuit is to maintain even current draw between the left and right sides of the car. Installing these light as outlined here should not interfere with your "bulb-out" feature.

Brake Fluid Comparison

This information was compiled by Gary Hackney and was edited for Volvo cars by S. Ringlee. Many of the racing fluids with poor wet boiling points or fluid incompatibilities were removed since these fluids are not designed for everyday use. Only Glycol (Polyalkylene Glycol Ether) fluids are shown; **no silicone DOT 5 fluids are listed because they may not be used in Volvo cars** without major brake system modifications. The new DOT 5.1 glycol fluids may be used, since they are compatible with DOT 3 and 4.

From BMW: Brake Fluid Moisture Effects

The DOT specifications are based on the concept of wet and dry boiling points. The dry boiling point is applicable when fluid is fresh and the wet boiling point after the fluid has been exposed to moisture and has had the opportunity to adsorb water. The minimum values for the wet and dry boiling points are specified for each DOT level, and increase from 3 through 5. Note that these are minimum values, and there is no constraint on by how much a manufacturer may exceed them. To achieve a DOT rating, the fluid must meet both dry and wet boiling point specifications. In addition to DOT level, another important consideration in selecting a brake fluid is the presence of anti-corrosion additives, commonly found in street fluids but not in track fluids. Note that Volvo ABS-equipped cars must have brake fluids flushed every two years to remove moisture, renew additives, and prevent corrosion.

Corrosion Issues. [Adapted from Brake and Front End magazine, May 2004] The single most important reason brake fluid must be changed regularly is to replenish the anticorrosion additives. Corrosion inhibitors, pH stabilizers and antioxidants are added to brake fluid to improve the long-term corrosion protection of brake systems. Over time these corrosion inhibitors can become depleted leaving the internal parts of the brake system vulnerable to corrosion. There are many variables involved in determining how long it takes to deplete the corrosion inhibitors including brake fluid chemistry, chemical and thermal stability, brake system design, driving habits of the operator, frequency of maintenance, temperature, and road surfaces. Another unrelated extensive study found that the buffer capacity and inhibitor concentrations "drop to less than 10% of their initial levels after only 30 months of service". (Jackson, SAE paper 971007,Corrosion Prevention SP-1265, 1997) The rate of depletion is affected by many factors. One of the studies found the rate of depletion is fastest at the wheels. This is where the fluid is exposed to the highest degree of heat and the heat causes the corrosion inhibitors to breakdown. Vehicles with ABS show even faster degradation due to the aggressive circulation of the fluid caused by the cycling of the ABS system. This, combined with the fact that ABS systems use close tolerance valves and other precision parts, makes them more susceptible to the affects of corrosion or deposits.

Copper has a direct role in the corrosion of the brake system, as well as providing an indirect relationship to the age of the brake fluid. In a NIST report, Ricker et al hypothesize "the copper in the brake lines corrodes at a slow rate over several months or years resulting in copper ions in the brake fluid. These ions then act as oxidizers and plate out in the ABS valves when the corrosion inhibitors can no longer prevent corrosion of the ferrous components. According to this hypothesis, copper corrosion starts when the vehicle is new and proceeds at a rate that is limited by the oxidizer content of the brake fluid, mass transport of this oxidizer, and the effectiveness of the corrosion inhibitors in the brake fluid at retarding copper corrosion." Copper is the first or "Alpha Contaminate" and will corrode before other metals in brake system according to Ricker because "even though copper is in galvanic contact with more active metals, the low conductivity of the brake fluid allows copper corrosion to proceed." You might ask how does copper get in the brake fluid? The answer is from the brake lines. The inside surface of the brake lines is coated with a copper brazing alloy.

How do you accurately determine the copper content of the brake fluid? The answer comes in the form of test strips that provide a way to determine the "virtual age" of brake fluid . The patented FASCAR® technology used provides a measure of the copper in the brake fluid which indirectly provides a measure of the level of corrosion inhibitors in the system. The test is simple and straightforward. Simply dip the strip in the brake fluid of the reservoir for one second. In 30 to 120 seconds, the reaction zone will change colors depending on the condition of the brake fluid. Compare the color of the reaction zone and make the appropriate recommendation. Replace the brake fluid if copper content exceeds 200 ppm.

In the absence of the test strips, just flush according to the manufacturer's recommendations.

Shelf Life. [Tip from Castrol RE: LMA Brake Fluid] Shelf life is no longer than 2 years, provided the oil has been stored in a cool, dry area, with no extreme fluctuating temperatures and the seal has remained intact.

[From Hackney:] The "Estimated BP After 6-months" column is estimated based on a page I found that says brake fluid gains about 3.5% moisture per year, which is where the wet boiling point is measured. [Editor: See the chart to the right from BMW, which notes an approximate gain of 2.5% per year]. Assuming linear degradation this column is where you'd be. The last two columns may be confusing. They're the price per ounce, divided by the degrees F the fluid exceeds the dry or wet DOT spec; sort of a price for performance number where lower is better. Yeah, I'm an engineer. FWIW: My conclusion: ATE Type 200 and Super Blue are not only the cheapest of the performance brake fluids, they are also the cheapest per degree of boil protection, and have a very high 6-month BP estimate. In addition you can alternate with each change and the color difference will tell you when you're done. [Note that ATE Blue is not DOT-approved because of the color.] ATE and some of the higher-performance fluids are available from IPD and FCPGroton. Valvoline and Castrol are commonly found in mass merchandisers.

Conversions: $F = (C \times 1.8) + 32$
$C = (F - 32) \times .5555$

Fluid	Dry BP	Wet BP	Est. BP after 6 months	US $/oz	US $/oz per °F > DOT4	
					Dry	Wet
Castrol SRF	590	518	554	$2.076	$.0144	$.0100
NEO Super DOT	585	421	503	0.983	.0071	.0089
Motul Racing 600	585	421	503	0.712	.0051	.0065
Motul DOT 5.1	509	365	437	0.675	.0107	.0125
ATE Type 200/ATE Super Blue	536	392	464	0.295	.0033	.0036
Valvoline High Perf Synpower	503	343	423	0.16	.0023	.0073
ATE SL	500	329	415			
Castrol LMA	450	311	381	0.219	.0547	n/a
Gunk DOT 4 Brake Fluid	510	311	411	0.16	.0024	
DOT 5 Spec	500	346	423	n/a	n/a	n/a

DOT 4 Spec	446	311	379	n/a	n/a	n/a
DOT 3 Spec	401	284	343	n/a	n/a	n/a

Sources:

- http://www.ipdusa.com
- http://www.panteracars.com/motul.html
- http://www.neosyntheticoil.com/bkfluid.htm
- http://www.ogracing.com
- http://www.valvoline.com

Seat Belt Retractor Repair

[Text and illustrations courtesy of Art Benstein] The driver's seat belt retractor hangs, making it a pain to get the seat belt out. (Illustrations show a 240 series belt; 740 similar.)

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1. Slow Retraction or Stuck Belt. I have come to the conclusion that sluggish retraction is mostly due to the nylon webbing becoming stiff with age and dirt contamination. You'll know this as the driver's belt will be the slowest. Last time I used Dreft, a mild laundry soap, to clean the belts. Clamp the belt fully extended and use a SOFT brush in a bucket of soapy water. You don't even need to disassemble anything. There is a safety hazard that arises from abrading the belt material with harsh scrubbing, so be gentle.

Stuck Belt [Tip from Jeff Pierce] In my case, the belt refused to retract. It was turned 180 degree behind the trim. I took the trim off, flipped the belt back and that fixed the problem.

2. Stuck Retractor.

Retractor with mounting hardware

- Remove driver's seat - (4) 13mm [heater connection]
- Remove step plate
- Peel U-molding from door openings on pillar
- Remove snap-on trim from top of seat belt attachment
- Remove belt at top - 16mm - or is this 5/8 SAE
- Remove nut at bottom - 18mm - perhaps 11/16 SAE
- Peel back carpeting
- Remove seat belt retractor bracket (4) 13mm
- Disassemble retractor from bracket

Showing part number on small end.

- Remove small end of retractor - not spring end. - (2) phillips

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The inertial lock device

The radial ratchet you see here locks the belt when the vertical weight rocks off of its plumb. There was no problem with this function.

Centrifugal lock shown:

The two plates are held in place by spring wires. One of the wires was not in its slot, allowing the plate to easily lock the belt -- too easily.

Spring wire upper left and lower right not in slot.

- Reassembly is not quite reverse of disassembly. Hold the centrifugal clutch at the bottom while replacing it in the drum.
- Test by holding plumb and withdrawing belt at moderate speed.

Note: this excellent illustrated article on Do-It-Yourself Headliner Replacement from DIYNetwork.Com summarizes an episode of Weekend Mechanic. This has been edited to include a variety of Brickboard tips from Volvo owners and OEM instructions from Volvo Technical Manuals.

1. Headliner Repair: Introduction and Prep

The problem: Our project car, a 1990 Volvo 760 Turbo, has one of the more aggravating problems that can occur in a vehicle's interior: a sagging headliner. This sagging typically starts at the dome section of the car's ceiling and works outward as the fabric cover separates from the foam backing on the contoured board. Though some people try temporary or partial fixes using tacks or T-pins, that solution is never permanent, and sticking pins throughy your headliner could damage electrical wiring. Permanently fixing this problem, and doing it the right way, requires removing the headliner board from the vehicle so that new headliner fabric can be glued on. *The headliner should never be repaired inside the car*.

DIY Difficulty Rating for Repair: This job is fairly straightforward, and something that seasoned or novice do-it-yourselfers can undertake. We gave it a difficulty rating of **2** on a 5-point intermediate-level scale. Depending on the severity of the difficulties encountered, this project should be one that can be finished in a single weekend. Allow yourself about 12 hours to complete this project. Estimated DIY cost for the repair is around $100. The trickiest part of the procedure is removing the headliner board from the vehicle without breaking it.

If you choose to have this job contracted out, expect a price range between $300 and $450 for the entire job.

Materials:

IPD sells a complete headliner repair kit for about $175 including instructions and all the materials you will need. If you do this yourself, you MUST use 1/8" headliner EVERYWHERE, not just on the sunroof. Don't listen to what anyone else tells you... ask for 1/8" material. If the fabric store you visit doesn't have it have them order a new rol or go elsewhere. The reason for this is that the headliner must go under various edges around the car (including under that plastic edge at the sunroof opening) and the 1/4" material is too thick to fit. The 1/4" material is also much heavier and will pull off the headliner backing board over time faster than the 1/8". For adhesive, 3M makes a spray glue ("3M General Trim Adhesive - Clear Part No. 051135-08088") made specifically for this purpose.

In addition to standard auto-mechanic's tools, some of the specialty tools that will be needed for this project include **glue gun, torx screwdrivers, wooden spatula for prying trim panels, steamer or hot air gun, whisk broom, coarse sandpaper, duct tape,** and **heavy-duty scissors**. Safety equipment includes ear protection and eye-goggles or protective glasses. Removing and installing the headliner board itself is a two-person job.

Prep Work

- Begin by removing the front seats from the vehicle (**figure A**). This will make it much easier to get the headliner board out of, and back into, the car. Removing the rear seat in a sedan will make it easier to remove trim panels. Also recommended is removal of the center console. With these out, you can remove the headliner through the passenger door with only very slight bowing. In a wagon of course, you can remove the headliner out the back hatch.
- It is possible to remove the headliner through the front or back window openings by removing the glass. Because a rear window is more costly than a front windshield and is held in place by tough urethane adhesives (and your sandblasted front windshield may need to be replaced anyway), consider removing the front glass instead. This clearly does not apply to a wagon/estate in which you can open the rear hatch for headliner removal.
- With the seats removed (**figure B**), there is more room to work. In order to get

the headliner out, it will be necessary to remove the interior side-trim pieces, sun visors, and the dome light assembly.


Figure A


Figure B

In some cases, the headliner may not merely be sagging, but may actually come detached from underneath trim pieces (**figure C**). This can interfere with driver sight-line and cause a driving hazard.


Figure C

Since our vehicle has a sunroof that is also covered in fabric (**figure D**), the sunroof panel will need to be removed and re-covered as well. (The sunroof has a vent panel inside the sunroof headliner.)

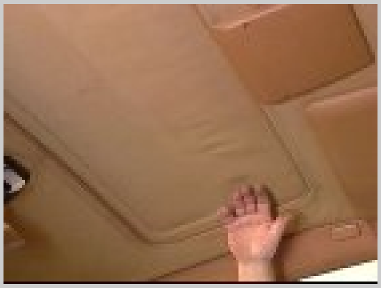
Figure D

While the sunroof is off, it's also a good time to inspect the working parts, cabling and drain holes to make sure that they are all in order.

Volvo Wheel Balancing

Eliminating Steering Wheel Shimmy In Volvos by Mark

I have owned a 1992 745t for three years and during more than half that time I have been annoyed by an intermittent steering wheel shimmy. At times, the wheel would shimmy at low speeds. Other times it would shimmy at highway speeds. Occasionally, after rotating the tires, it would go away completely for a month or two only to return. Inspection of the tires revealed no unusual wear, so a quick trip to a local tire store to have the tires/wheels balanced was expected to fix the problem. Wrong! Balancing of the tires helped mitigate the severity of the shimmy for a short period of time. However, it never eliminated it completely, and the shimmy steadily returned to its original intensity. Despite purchasing four brand new tires for my beloved Volvo, the steering wheel still shimmied almost immediately with even greater intensity. At this point I knew that a more systematic and intensive diagnostic protocol would be needed to identify and exorcise the "Shimmy Demon" from my Volvo. What follows is a summation of my experience dealing with this annoying but, for Volvos, altogether too common problem.

Problem Statement: Steering Wheel Vibration or Shimmy

Despite new tires that had been computer balanced, my Volvo with 133,000 miles on the odometer still exhibited an intermittent steering wheel shimmy at highway speeds. The shimmy would start at approximately 55 mph. While driving at this and higher speeds, the shimmy would appear and disappear. In other words, the steering wheel would be rock steady and smooth one second and shake noticeably the next. Road surface type and condition would have little effect on either the occurrence or amplitude of the shimmy. Frequency of shimmy was consistently proportional to vehicle speed.

Possible Causes

The factors listed below can cause, either by themselves or in association with other factors, steering wheel shimmy.

1. Bent or out-of-round rim.
2. Excessive inconsistencies in tire construction (Radial Force Variation, RFV- more about this later)
3. Improper tire balance
4. Worn suspension parts
5. Worn bearings in wheel hub
6. Improperly adjusted wheel hub
7. Component characteristics (includes improper adjustment of suspension components)
8. Brake component irregularities

Tracking Down the Culprit

Having just bought new tires and double-checking the balance, I pretty much eliminated tire balance as the cause of the shimmy (or so I thought). I turned my attention to the condition of the suspension. Since purchasing the car I have replaced the strut cartridges, lower ball joints, radius arm bushings and added Cherry Turbo upper and lower chassis braces. Both inner and outer tire rod ends checked out to be in excellent shape as well as the steering rack. No discernable play was detected in any of these steering components. In addition, I replaced the front rotors and brake pads shortly after purchasing the car. To further ensure brake components were not the cause of the shimmy, I borrowed a friend's dial indicator to check rotor run out. After removing some superficial rust between the rotor and hub, run out was reduced to .002 inch, which was well below the Volvo specified maximum of .004 inch. Checking these items and correcting rotor run out did not have any affect on steering wheel shimmy.

I next turned my attention to rim/wheel condition. To isolate a bent or out-of-round rim I rotated the wheels and tires front to back on the driver's side only and went for a test drive. This did not change how the car drove. Next, I rotated the tires on the passenger side in a similar fashion and went on another test drive. Still there was no change in how the car drove. Based on the results of this test, I concluded that all my wheels were bad or all were good. I opted for good.

I next checked the front hubs. After removing the tire/wheel and caliper I check for any play or looseness in the hub. None was present. Subsequent removal of dust cap and checking of spindle nut with torque wrench further indicated nothing was wrong.

At this point, everything I knew to check appeared to be as it should. The Volvo, in theory, should drive perfectly. Frustrated and running out of options, I called a friend of mine who owns a 1994 944t with the same wheels as mine and asked to borrow his two front wheels and tires. His car drove smoothly without any shimmy. After switching wheels, my car drove like new. No hint of steering shimmy throughout the 10-mile test drive. Upon putting my wheels back on my car the shimmy returned as expected. Using this process of elimination I finally concluded that improper tire balance was the cause of my shimmy problem.

[Editor] Note that Tire Rack has a useful diagnostic flow chart to help pinpoint vibration problems.

Correcting The Problem

While searching archived posts on related wheel shimmy problems on the Brickboard, I came across a post that described a new tire and wheel balancing machine manufactured by Hunter Engineering Co. The machine is the GSP9700 Wheel Vibration System and it represents an evolutionary leap in tire and wheel balancing technology. The GSP 9700's outward appearance suggests that it is no different from most tire balancing machines found by the thousands in shops around the county. A closer inspection reveals a difference, however. The difference is a cylinder that contacts the tire as it is spun by the machine. This cylinder is forced against the rotating tire with substantial pressure and is attached to a number of very precise sensors that measure a variety of tire and wheel parameters not detectable by less complex tire machines. Once a tire/wheel has been tested by the GSP9700, a technician can make any number of adjustments to Force Match the rim and tire, dynamically balance it and bring the tire/wheel as close as possible to what could be called total and perfect balance.

Tire Balance

Before delving into the complex workings of the GSP9700 a moment needs to be spent talking about tire and wheel balance. Later model vehicles have become more susceptible to shimmy problems for a number of reasons. These factors include the development and use of more precise steering systems (e.g. rack and pinion), the reduction in weight of steering and suspension components, lower profile tires, higher tire pressures, and increased expectations from car owners. With the advent of these more exact and sensitive vehicles, drivers are now able to feel road imperfections and vibrations to a greater degree. To achieve optimum ride quality greater attention to and accuracy in tire balancing is now required. This fact is even more critical when dealing with a vehicle that, for reasons of design, is more susceptible to wheel and tire vibration.

Tires can be static balanced, dynamically balanced or Forced Matched to help eliminate shimmy problems while driving. Static balance is accomplished by placing the rim/tire on a special balancing stand that has a cross hair and bubble level in the center. Wheel weights are added to the appropriate place along the outside edge of the rim to line the cross hair with the bubble. When this is accomplished, the tire is balanced. The major shortcoming of this method is the fact that the tire is not spinning and therefore the added balancing weights are unable to compensate for any rotational inconsistencies. Years ago when parallel steering systems and "mushy" bias ply tires were the norm, static balancing generally proved adequate.

Dynamic balancing involves placing the rim and tire assembly on a computer balancing machine that spins the tire. As the tire spins, sensors measure and locate the up and down imbalances as well as the side-to-side (wobble) imbalances. The machine then shows where and how much weight needs to be added to balance the tire in both directions. In dynamic balancing, correctional weights are placed on both the inside and outside of the rim to achieve balance whereas with static balancing weights are only placed on one side of the rim and tire. Often, when tires are mounted on expensive alloy rims, self adhesive balancing weights are applied to the inner rim surface, behind the spokes, to maintain pleasing aesthetics. Dynamic balancing is far superior to static balancing and is the most common method used in shops around the country. While the sophistication of these machines has grown and, in capable hands, can be used to balance a rim and tire to a high of accuracy, they cannot detect certain elements that would cause a shimmy in an otherwise "balanced" rim and tire.

When a new car or light truck leaves the assembly line the rims and tires it is riding on have, for the most part, been OE Matched or Force Matched. OE/Force Matching is a balancing procedure that separately identifies the low spot of a rim and matches it with the highest point of Radial Force Variation in the tire. The now matched rim and tire assembly is then placed on a dynamic balancing machine resulting in a more perfectly balanced unit that is less likely to be the source of vibrations on a moving vehicle.

Despite the high degree of precision involved in the manufacturing process, rims are not perfectly round when they come off the assembly line. Before an automotive rim leaves the manufacturing facility it is placed on a machine that measures radial run and locates the section of the rim where circumference is the least. This area is called the "low spot" of the rim. The valve stem hole or a round sticker along the outside edge of the rim often marks the low spot of the rim.

Over at the tire factory, a similar process is undertaken to identify any inconsistencies with the tire's internal structure. Just like the rim manufacturers, tire manufacturers take great pains to maintain a high degree of consistency with regard to the tire's internal structure. Despite manufacturer's efforts some internal inconsistencies exist within a tire. These internal inconsistencies exert an uneven force as the tire spins and are referred to a Radial Force Variation (RFV). Radial Force Variation is detected and measured at the factory using a large, expensive and very precise machine named the Akron Standard Model D-70. The Akron Standard rotates a tire against a spinning drum that is pressed against the tire. The precision sensors attached to the drum measure the forces pushing against it by the moving tire. The D-70 locates and measures the location of the greatest RFV or "high spot" of the tire. The manufacturer then marks the location of the greatest RFV with a round sticker or similar method on the sidewall of the tire. When the tires are mounted on the rims at the assembly plant, the low spot on the rim is then matched with the high spot on the tire by aligning the reference marks. The now OE/Force Matched tire will greatly increase the ride quality of the new vehicle.

I did not find any quantified information regarding the maximum allowable amount of RFV in a given tire. It is certain that different tire manufacturers have different figures for their tires. In addition, lighter, high performance tires must be manufactured to closer RFV tolerances to ensure acceptable performance. For example, a RFV of 10 lbs will be more noticeable in a 255/45 17 tire on a Chevrolet Corvette compared to the same amount of RFV in a 10.5" X 20" tire on a Kenworth T2000. However, a post on the Brickboard mentioned that one tire shop liked to see no more that 6 lbs. of RFV in tires that they mounted.

The GSP97000: Balancing Taken To The Next and Highest Level The GSP9700 takes dynamic balancing to a new level by testing aspects of the tire and wheel that up until now could only be identified by ultra high dollar equipment. This machine is able to measure all aspects of rim and wheel dynamics so corrective measures can be made. The GSP9700 can identify and/or measure the following wheel and tire related items:

- Run out of Rim, Tire and Rim and Tire as an assembly
- Force Variation of Tire
- Wheel Imbalance (side to side and up and down)

If the rims and tires on a vehicle have been Force Matched and the car still demonstrates a shimmy, it is now possible to eliminate the rims and tires as a source of the problem. Attention can then be focused on other possible causes. However, it has been my experience that the vast majority of wheel vibration/shimmy problems are caused by the something out of whack with either the tire or rim and can be identified by using the GSP9700.

The Cure

Using the locater feature on the GSP9700 website, I located a nearby tire shop that has this sophisticated machine. I paid $60.00 to have all four tires matched and balanced. The subsequent improvement in the ride quality of my Volvo was phenomenal. The car drove incredibly smooth and steady. Needless to say I was very, very pleased.

Having tires analyzed on the GSP9700 usually costs more than having tires balanced on a more traditional machine. However, after having been plagued by stubborn and frustrating steering wheel shimmy problems for some time, it will in all probability seem like a small amount of money to restore the smooth, solid ride your Brick had when it was new.

What All This Means to a Volvo Owner

Based upon what I have learned, I can say with a fair degree of confidence that 700/900 series Volvos are more susceptible to wheel vibration or shimmy than other cars. It is also my belief that front wheel drive Volvos are also prone to wheel shimmy felt through the steering wheel. Information that I have seen indicates other vehicles are also prone to wheel shimmy. Some 3-series BMWs, Mazda Miatas, and earlier model Ford Explorers are three examples. The good news is wheel shimmy is not too uncommon and can be identified and fixed with a little investigative diligence on the part of the car owner. The first step in correcting a wheel shimmy problem is having the tires balanced to a high degree of accuracy by a competent shop. For Volvos plagued with a chronic wheel shimmy problem, I strongly recommend finding a shop with a Hunter GSP9700 and have them run a full diagnostic and Force Match all four tires and rims. This procedure should substantially mollify or completely alleviate any wheel shimmy. Lastly, be sure to maintain proper air pressure, rotate tires on a 6,000 to 12,000 mile schedule, and keep front end components in peak condition.

I hope this helps and drive safely.

Vocabulary

- Radial Force Variation: The outward force a spinning tire exerts because of inconsistencies with the tire's internal construction.
- OE/Force Matching: Balancing procedure that separately identifies the low spot of a rim and matches it with the location of highest measure of Radial Force Variation (RFV) in the tire.

References and Further Reading

Hunter Engineering Co's GSP9700 website and machine locator: www.gsp9700.com/

Coats Tire Machine website: www.nytechsupply.com/coats/

Match Mounting of Yokohama tires in their tire service bulletins site: www.yokohamatire.com

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Volvo Roof Rack Construction

[FAQ Home](#)

Volvo Maintenance FAQ for 7xx/9xx/90 Cars Version 7.5

[Tips from L. Sage] Here is some information about putting together a very sturdy, yet reasonably priced set of gutter clamp roof racks. They are extremely sturdy and you can increase their structural integrity by using stronger crossbar materials.

- The cornerstone of this roof rack is the Quik N Easy gutter clamp brackets. These are available for $46.50 plus a nominal S&H charge(csot me $6.00). The website for the cheapest price is: http://www.mohawkcanoes.com Search their online store for the UKS-1 brackets. They are cast aluminum and are extremely rugged yet simple to use.
- Yyou can opt to buy the crossbars and clamps with the brackets as a complete set of racks with 5' crossbars for about $70.00 plus S&H. Still a good deal compared to Thule or Yakima rack systems. I found both to be extremely expensive.
- Once you get the brackets, you can use any of the following for crossbars all of which are available at Home Depot or Lowe's: -iron pipe -metal conduit -copper pipe -galvanized pipe or fence posts. I used 1.25" copper tubing.
- My parts list was as follows: 4-galvanized split ring pipe clamps@ $1.65 each 4-3/8"x1.5" bolts -0.10 each 1-10' section of 1" ID Copper pipe-$7.50 4-copper pipe end caps-0.75 each 2-1.5" eyebolts(optional depending on what you are securing)$1.00 2-lengths of foam pipe insulation-$1.20 each I cut the copper tubing with a tubing cutter to 2 lengths of 50". I then used JB Quick Weld to fasten the end caps to insure the ends were not sharp to catch an eye or clothing or whatever you plan to carry. I then placed and tightened the split ring galvanized pipe clamps approx. 4"in from the end of each section of pipe/ crossbar. I then bolted Quick N Easy brackets to the copper tubing/crossbars with the pipe clamps in place with the 3/8" bolts(hex heads). I painted the crossbars with a "stainless steel" finish paint. I don't like the look so they will be spray painted flat or satin finish black. I also drilled holes straight through the exact center of each crossbar to accomodate the 1.5" eyebolts for securing my

UKS-1 Brackets

bungees or EPDM hook straps.
- I have not decided yet how to fasten the bungees or straps to the outside ends. This can be as simple as horizontally drilled holes to accept the EPDM strap's hooks or I will use some chain or cable rigging hardware from Home Depot or Lowe's. Or.....I'll just hook the straps directly to the crossbars. Total cost: Approx. $85.00 with straps and eyebolts as well as foam pipe insulation to cover the crossbars as I use the racks to hold my surfboards on my 93 945. Bottom line: you can set these up to hold just about anything from 4x8 sheets of plywood to boats, to surfboards to fishing poles...whatever.

Mounting Volvo High Mileage Badges

FAQ Home

Volvo Maintenance FAQ for 7xx/9xx/90 Cars

Version 7.5

Courtesy of Brian Murphy.

Just a easy and cheap way to nicely mount high mileage badges so that they are easily removable.

Parts you'll need. Mine uses 5 washers but I have been able to make them with 4. You will need 2 screws, 2 nuts, and a high mileage badge.

The three washers in the bottom left corner are glued together

This is what the mounting bracket looks like without the badge.

Picture of the mounting bracket with the badge. Not glued together yet.

Picture of the mounting bracket glued to

the badge. I used J. B. kwik weld for this. I am sure any decent glue will work.

The mount bracket/ badge mounted to the grill. It is held in place by the nuts.

On the car. Looks

decent and holds tight.

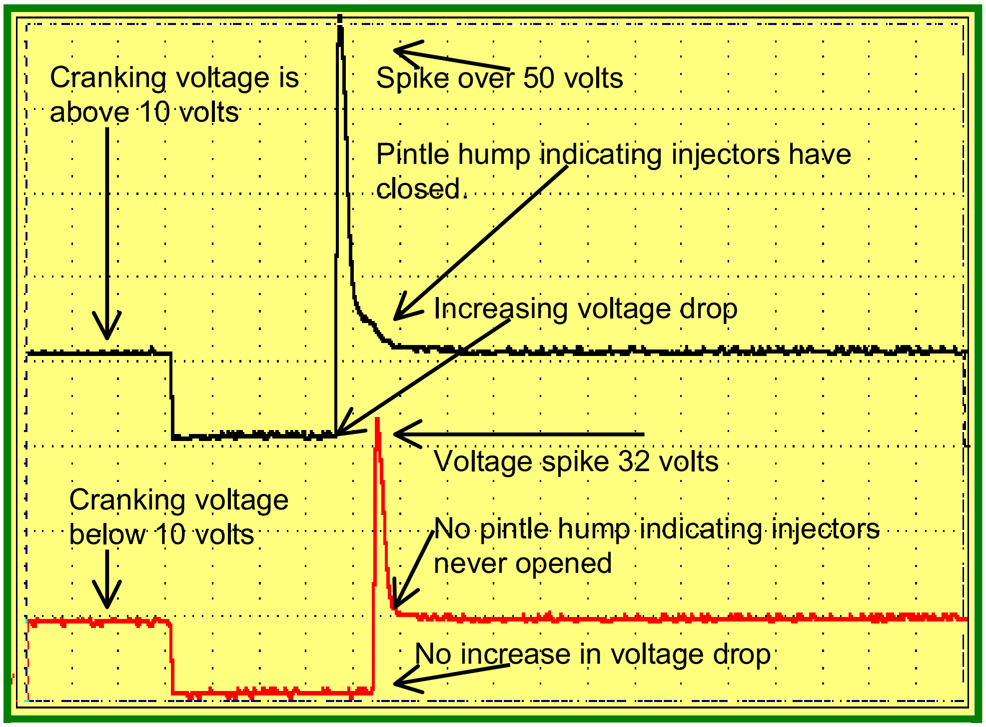
Another picture of the badge on the car.

[Volvo Maintenance FAQ for 7xx/9xx/90 Cars](#) [Top of Page](#)

2.3L LH-JETRONIC
On a 1989 Volvo 740 series (None-Turbo)

Crank no start Volvo has been a very intermittent problem. Finally got it to act up. After all the basics checked out good including battery, alternator, and starter, the weak injector pulse was found with a current clamp. The following Waveforms are single shot tests. Using 1:1 test lead for voltage and a current clamp for amperage.

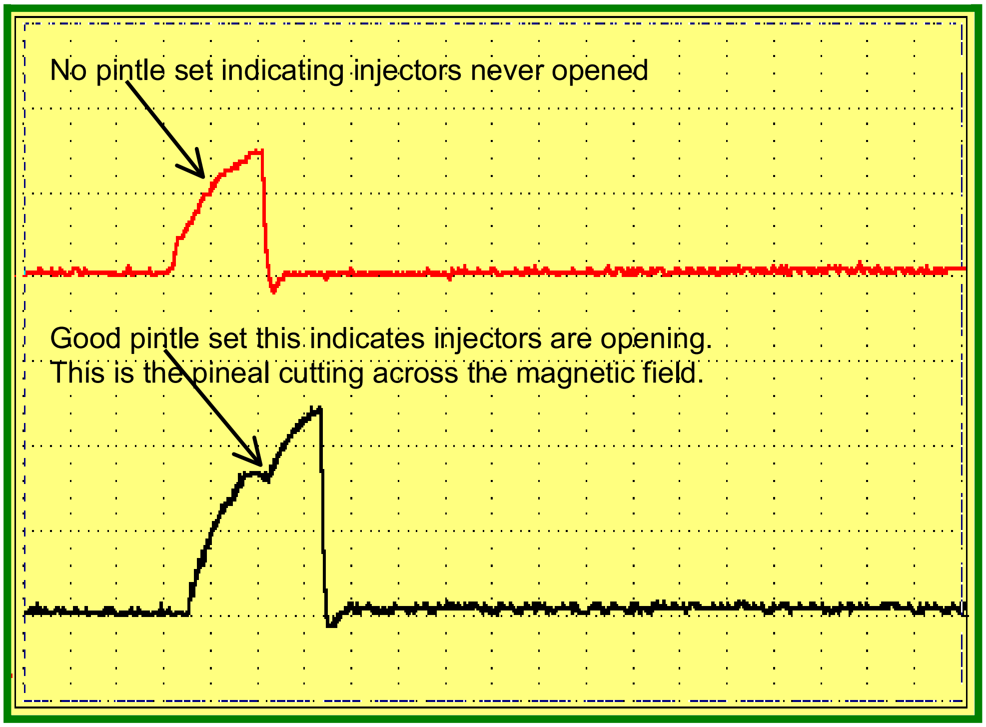
1mSec/Div 10Volta/Div 1msSec/Div 10Volts/Div



The black trace is showing a single shot test when engine was starting. Note the voltage spike is 50 volts due to the stronger magnetic field collapsing. The cranking voltage is above 10 volts and the voltage drop on the ground-side increases due to the current increase. This is a healthy circuit.

The red trace is showing the engine when it was not starting. Note the voltage spike is just above 30 volts due to the weaker magnetic field. The cranking voltage is under 10 volts and there is very little voltage drop increase on the ground side indicating less current build up. There is not enough current to open the injector caused by the voltage drop on the positive side of the circuit. Looking at the whole picture with one test is just one advantage using a scope has over a noid light. Keep in mind, the current required to flash a noid is considerably less.

Clamp Conversion = 100mv/1Amp

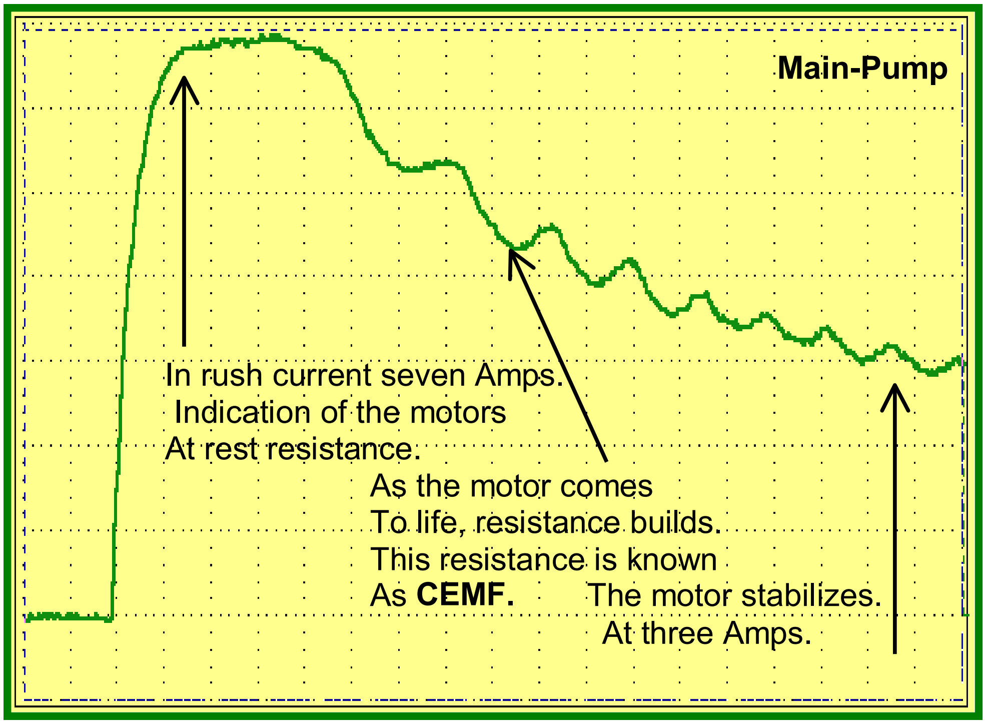


Using a current clamp. Red trace when engine would not start. The maximum amperage is 1.4 and no pintle set.

The black trace when engine would start is showing maximum amperage at 2.4 and good pintle set.

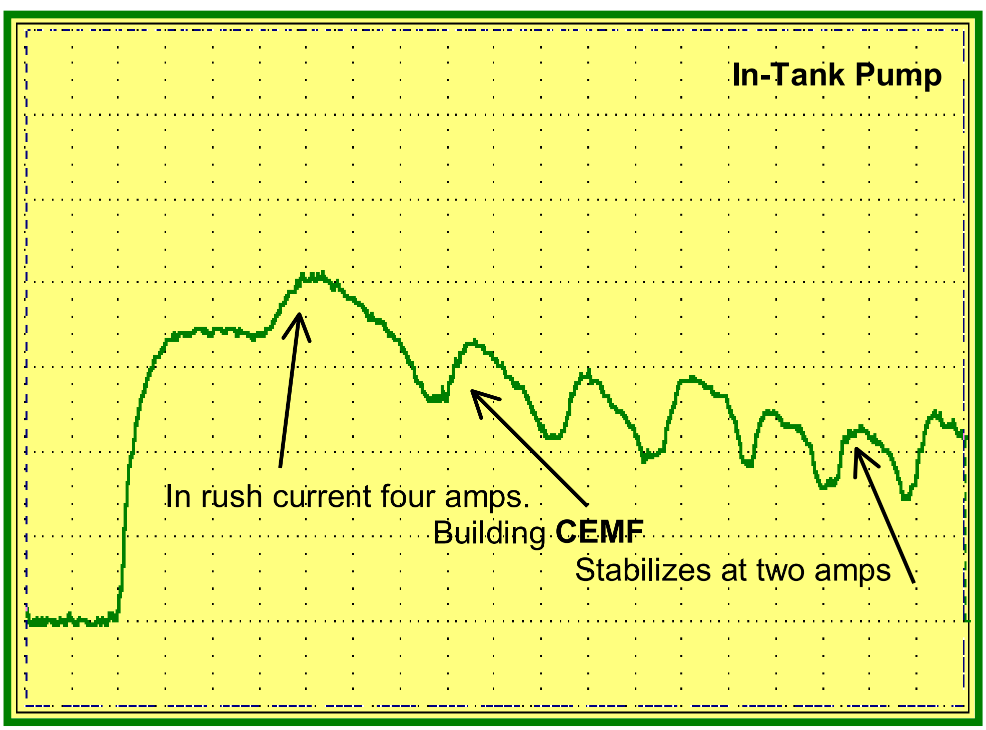
1989 Volvo 740 Series 2.3L (None Turbo)
Single Shot Testing (Fuel Pumps)

Testing both in-tank and main-pumps with engine not starting. This test can uncover a lot more than just bad fuel pumps. Looking at the fuel pumps current Waveforms while cranking a no start can uncover: Bad Crank shaft sensors, Fuel system relays, Ignition system ECU, Fuel System ECU, Wiring problems powers and grounds, Restricted fuel filters, and bad pumps. For example: If the pumps don't kick in at all when cranking the engine anything electrical or electronic that has to due with running the pumps would be suspect. Using wiring diagrams is an essential part of this process. Below are the fuel pumps being tested in this manner



Testing the pump with the clamp around the negative wire engine not starting. This is a measurement of the main pumps branch current. The pumps on this Volvo are in a parallel arrangement. Looking at the main pumps trace is proving the pump is in good condition. The rest of the system should be in good condition as well.

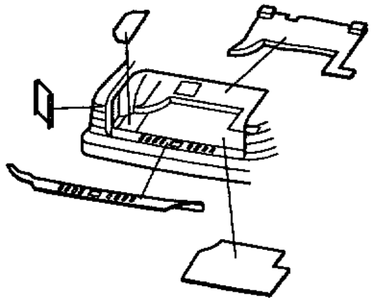
Clamp conversion = 100mv/1Amp



The in-tank pump stabilizes at two amps. This is a much smaller pump and is supplying the main pump. This pumps trace is showing a good pump and circuit.

UD. Change fuel pump (FP)

Special tools: 999 5448



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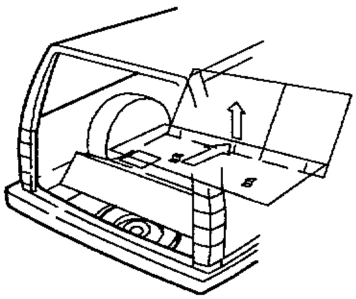

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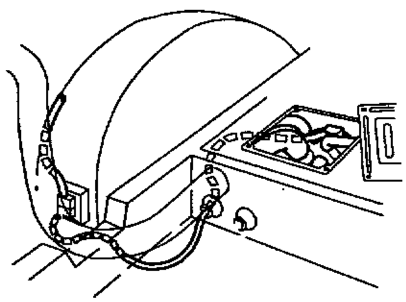
UD1

Remove:

4-door models:
- Spare wheel cover.
- Trunk floor carpeting.

5-door models:
- Left rear wheel-arch cover.
- Floor panel behind rear seat. (Fold down seatback to reach nuts and then draw panel forwards and upwards.)



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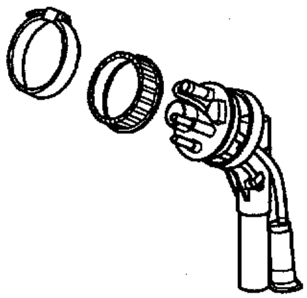
UD2

Remove:
- Tank unit cover. Clean around tank unit and hose connections.
- Hoses from tank unit. (Remove quick-release coupling by simultaneously pressure on hose and sliding sleeve upwards.)

> **Note:**
> Wear a mask to avoid inhaling fuel vapor.

UD3



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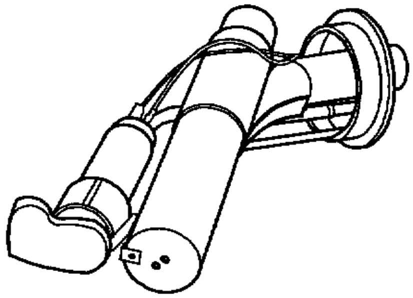
Remove:
- Hose clips around nut.
- Nut to tank unit with tool *999 5448*.
- Lift up tank unit as far as electrical leads allow.
- Seals.

If nut is not replaced within about half a day, it must be changed or it will not fit and leakage will result.

UD4



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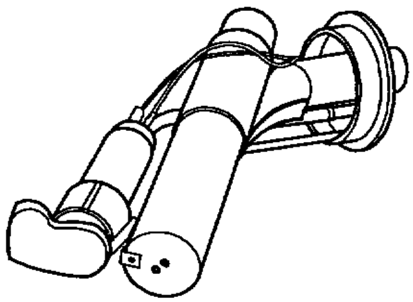
Slack off pump

First detach lower pump fastener then upper fastener.
- Disconnect electrical leads.
- Slack off hose clip at pump.
- Carefully remove pump from hose.
- Change pump.

UD5



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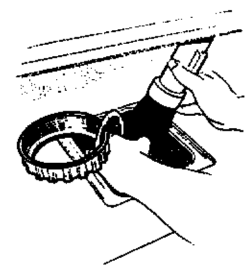
Fit:
- Pump electrical wiring.
- Pump to hose and tighten hose clip.
- Attach upper fastener first.
- Press in lower fastener.

UD6



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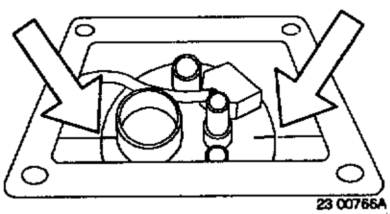
Fit tank unit
- Fit new seal to tank opening.
- Grease tank unit contact surface with a thin layer of petroleum jelly (glycerol).
- Lower tank unit into tank, taking care not to damage pump fixings against tank wash-plates. Check that seal is not drawn into tank.

UD7



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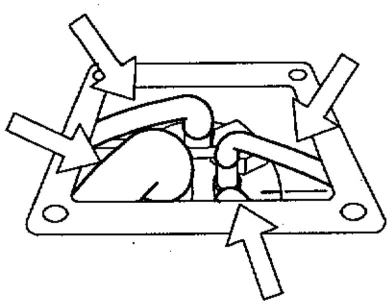
Locate tank unit
- Locate position marks against tank plastic joints (see Fig).
- Enter nut and tighten with tool *999 5448*, taking care not to damage nipples.
- Lock with hose clip.

UD8



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Fit:
- Hoses. Check that hoses cannot slip off pipes on tank unit.
- Tank unit cover.

UD6

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UD8

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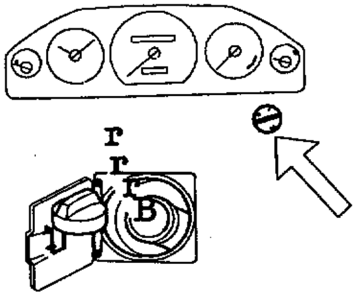

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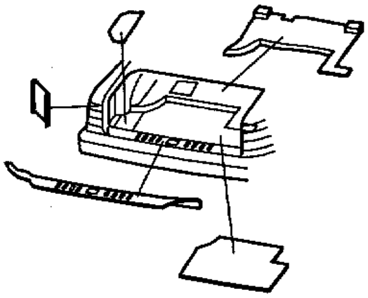
UD10

Carry out function check

Check pump and measurement functions.



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UD11

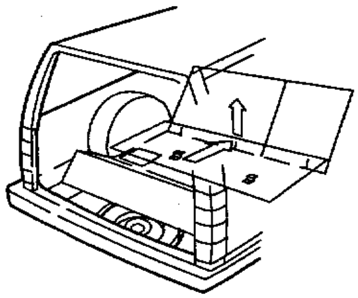
Fit:

4-door models:

- Spare wheel cover.
- Trunk floor carpeting.

5-door models:

- Left rear wheel-arch cover.
- Floor panel behind rear seat.



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M-46 Overdrive Exploded Parts Diagram

Parts numbers are cross-referenced to the table in M-46 Overdrive Parts List

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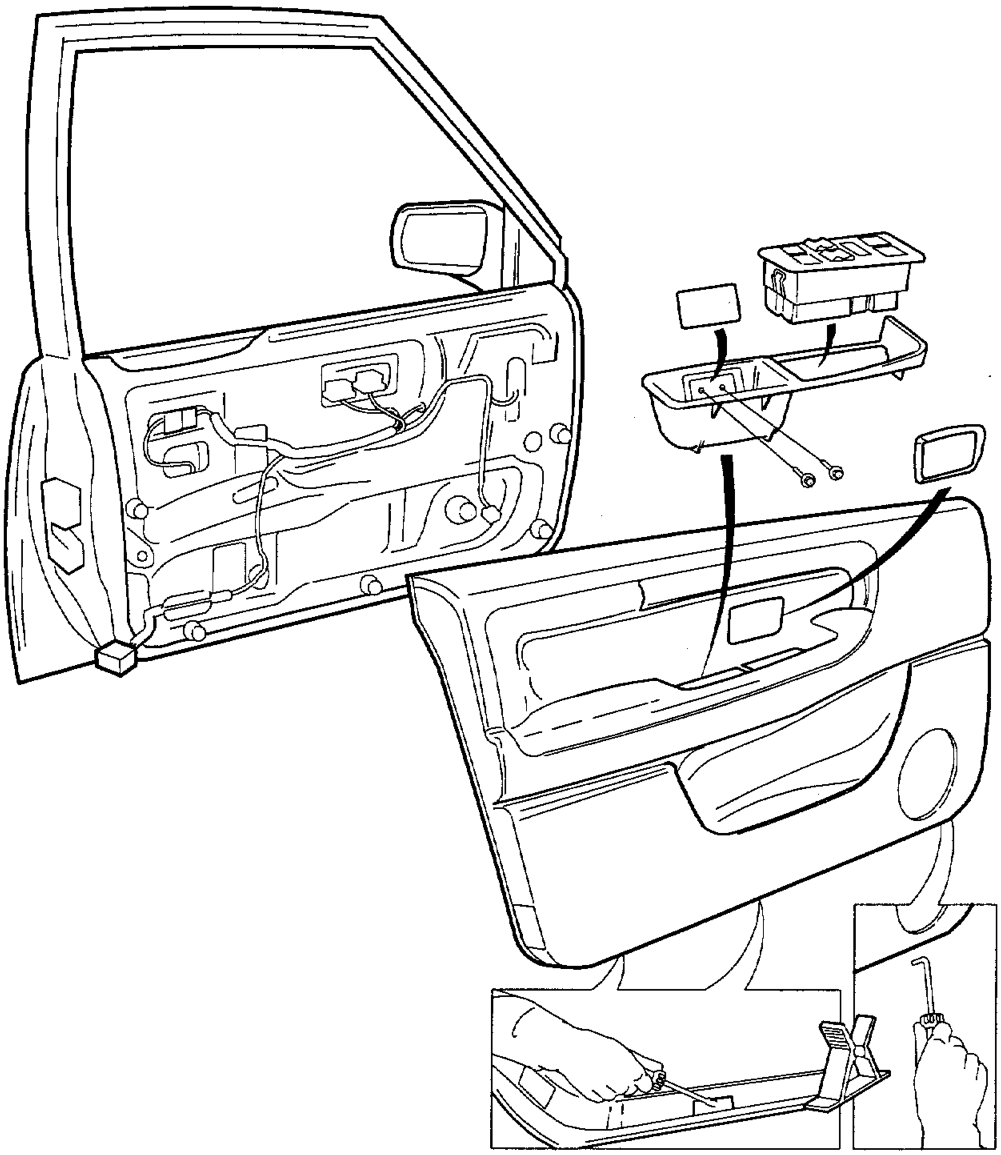
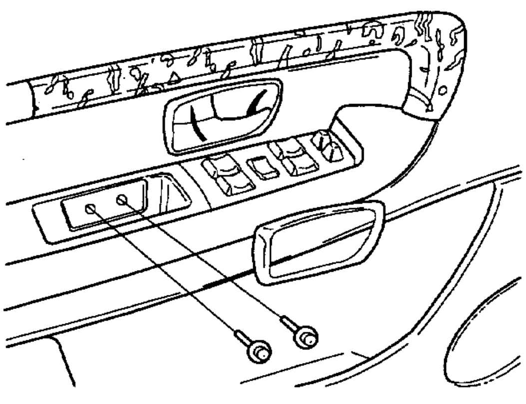
Removing door panel, front door, 960 1995-



8300239A

BA4

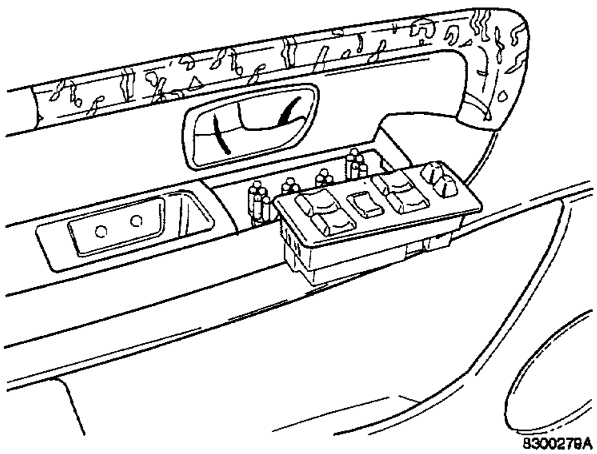


8300278A

Remove:

- rim around interior door opener (see fig.). Use a bone knife.

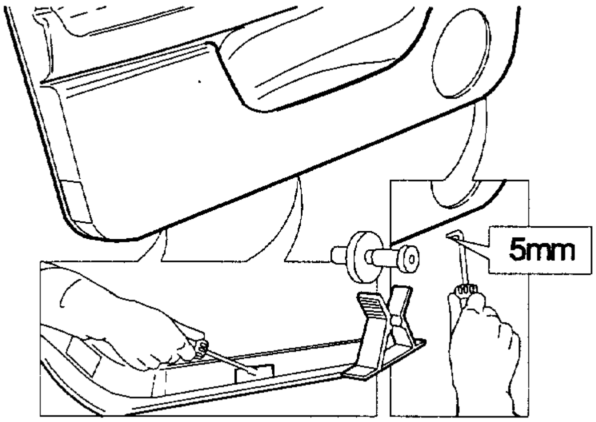
- cover in handle (see fig. above). Use a bone knife.
- screws under cover (2) (see fig.).



8300279A

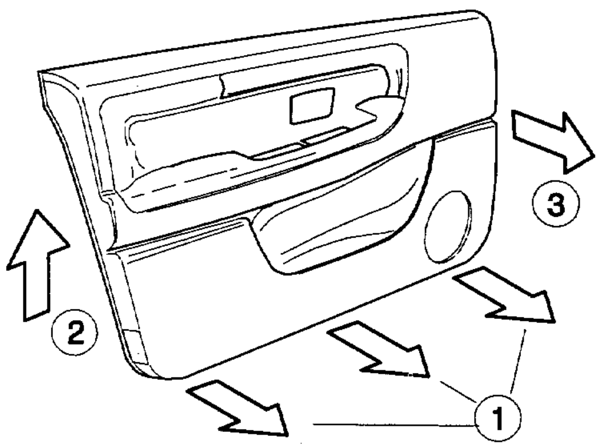
– control panel for window lifts and electrically operated mirrors (see upper fig.)

– door warning light.
Use a bone knife.



8300280A

– clips in lower edge (3).



8300376A

Pull bottom of panel outwards (1).

Press panel upwards at rear edge (2).

Loosen panel by pulling outwards at front edge (3).

Remove cables from door seal.

Loosen door seal at top and bend downwards.

> Note: The three clips at the bottom of the door seal must not be removed.

BA5

Install:

In reverse order.

Door locks, front doors 960, 1995-

Inside door opener, front doors, 960, 1995-, replacement

Lock is the same as on earlier models.

Operation differs in that a cable is used instead of a link rod.

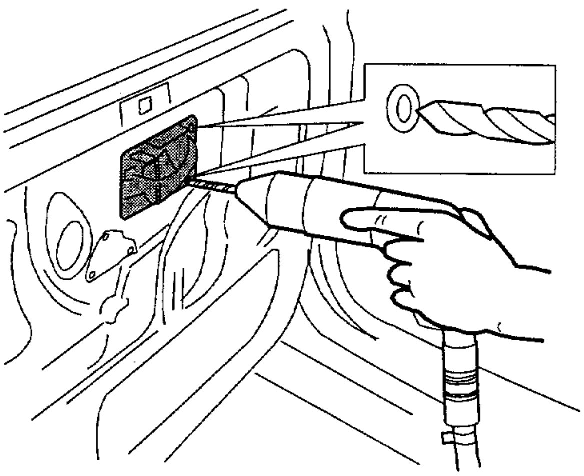
Replacement: door opener/cable

BC4

Remove panel (as per BA4).

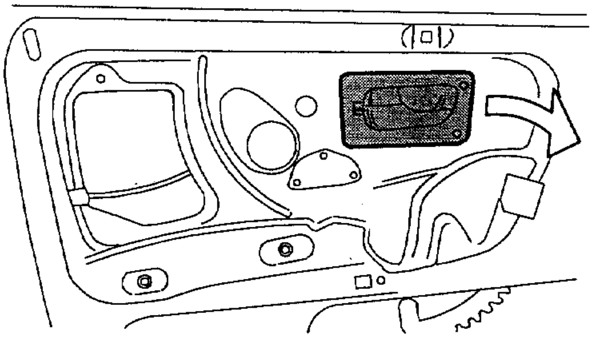
BC5

Remove inner door opener control.



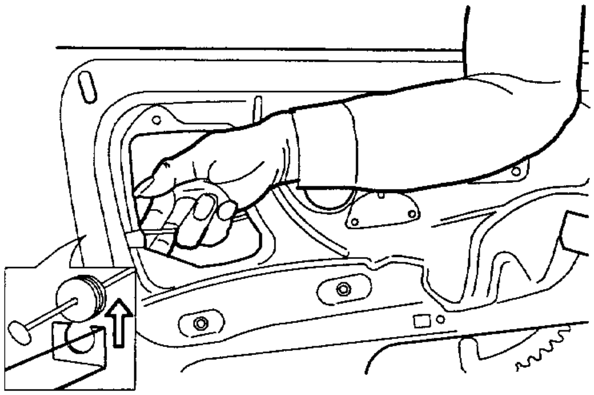
8300236A

Drill out rivets retaining door opener control front edge in door, using 6 mm bit.



8300237A

Tilt the door opener control outwards (see fig.).



8300238A

Bend cable out of bracket at lock by hand.

Remove cable attachment from lock bracket.
(Small inset in figure.)
Remove inner door opener and cable.

BC6

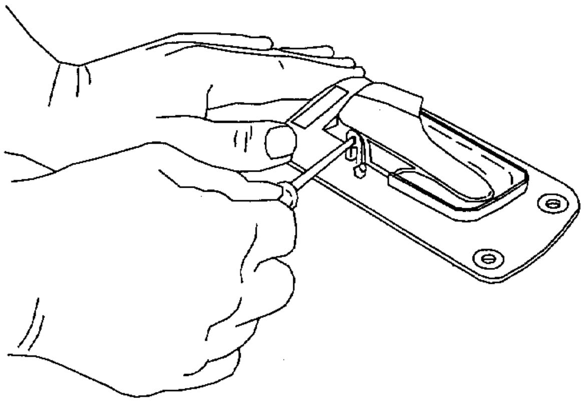
Install:

In reverse order.
Use new pop rivets.

Cable, replacement/component parts in inside door opener, replacement

BC7

Remove:

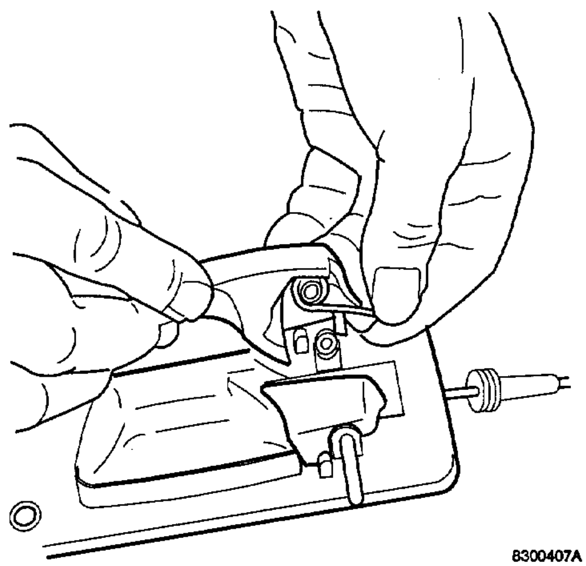


8300417A

– inner door opener with cable (as per BC4-BC5).

Loosen pin which retains both locking buttons with a mandrel.

Hold down with index finger so that spring does not shoot out both locking buttons.

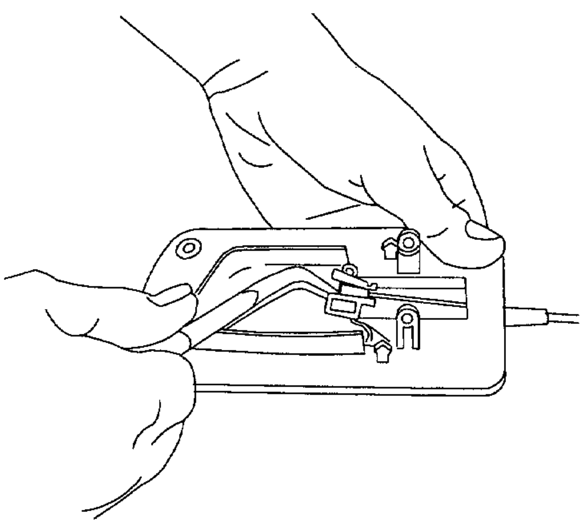


8300407A

– spring.

– button that guides door lock.

– button that blocks lock in locked position.



8300413A

Pry out pin to loosen cable from control plate.

Use screwdriver and pliers.

Remove counterhold.

Remove cable

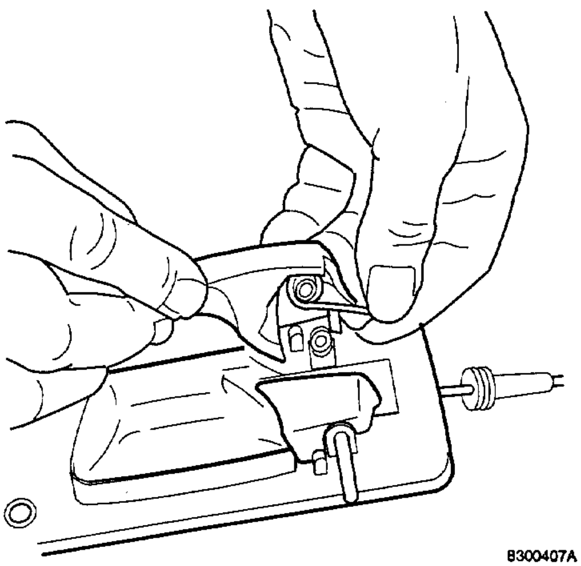
BC9

Install:

- new cable in control plate.
- counterhold.
- pin for lock
  (push in by hand).

Place counterhold in its slot

Press it to its rearmost position.


8300407A

- spring in locking button that blocks lock.
- locking button in position.
- locking pin.

Secure the uppermost locking button by pushing down pin halfway.

– spring in the locking button that guides door lock.

– locking button in position.

Knock pin in position.

– inner door opener and cable in door (as per BC5).

VOLVO AC refit kit instructions for the 700 series

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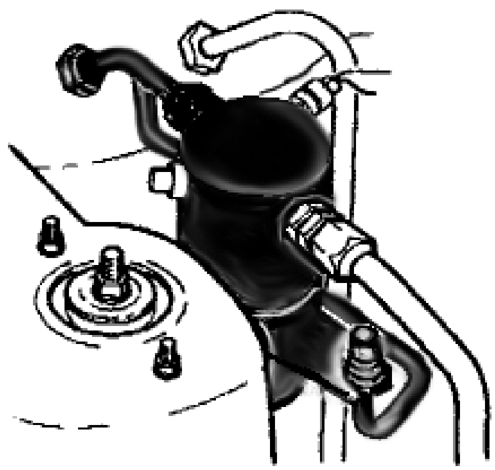
Volvo Maintenance FAQ for 7xx/9xx/90 Cars: **FAQ Home** Volvo Maintenance FAQ for 7xx/9xx/90 Cars: **Heating-Air Conditioning R134 Home**

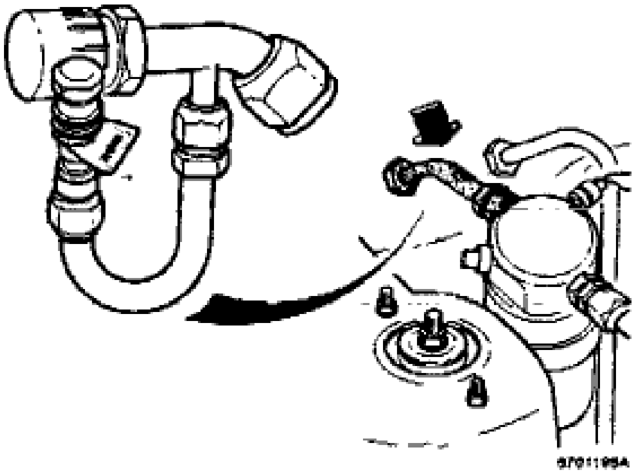
Overview: Page 2

Contents of basic and supplementary kits from R12 to R134a

Note that both the basic and supplementary kits can have different part numbers.
Some of the basic kits may have different supplementary kits.

Use these pages a guidelines for the conversion of the A/C system

	**Basic Kit 9145660-8** The illustration shows a car with the pipe runs and the factory filling valve installed. My car did not have this and need Sup kit#1. The basic kit has the new quick release valve that the R134a uses.
	This illustration shows a car not equipped with the factory filling valve. This can also occur if the A/C was installed as an accessory. In this case a Supplementary kit, PN 9134032-3 is also required which replaces the pipe shown in the upper part of the illustration. **Exception 1:** Requires in addition Supplementary kit (2) PN 9134344-2 for following models



740/760	-1987	Engine D24T

Exception 2: Requires in addition Supplementary kit(2) 9134345-9 for following models:

780	1988-	Engine B280F

Go to: Page 1 2 3 4 5 6 7 8 9 10

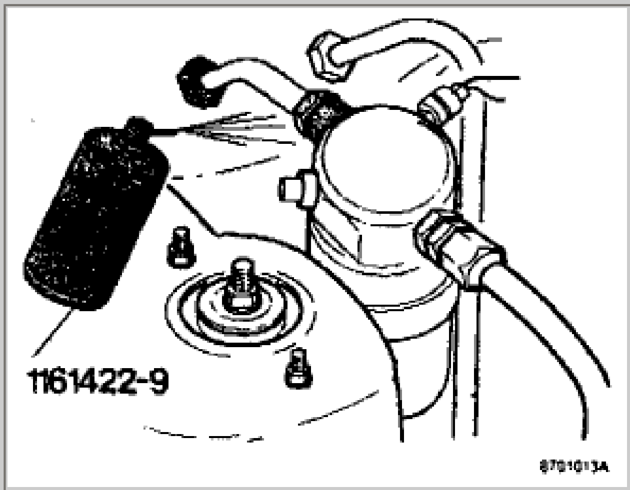
VOLVO AC refit kit instructions for the 700 series

Conversion of A/C system form R12 to R134a "Retrofit": Page 3

The method described below is for installing Basic kit PN 9145660-8. This is, in principle, the basic method for installing Basic PN 9145661-1 or supplementary kits according to the first two pages.

Empty refrigerant from System

This MUST be done by a licensed AC technician. The free release of freon R12 is a federal offense. Most places should do this for a small fee. This also helps remove the oil and the freon trapped in the oil that could cause problems later on because of the incompatibility between the two type of freon.

<table>
<tr>
<td>
</td>
<td>

A1

Remove:

- Battery negative cable
- Receiver

A2

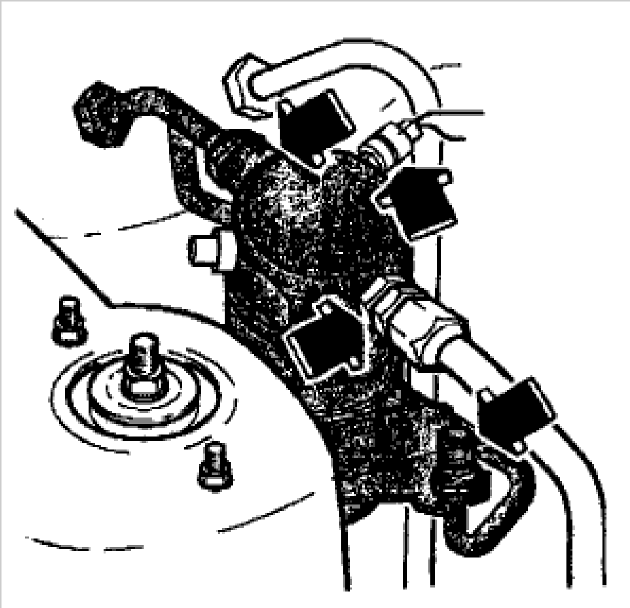
Use rust inhibitor PN 1161422-9 on all screw joints which are to be detached Allow the inhibitor several minutes to work before undoing screwed joints.

NEVER USE EXCESSIVE FORCE

Note: Under no circumstances use heat when removing

I didn't do this step and all went fine. I would say this is precautionary but not fully necessary

</td>
</tr>
</table>



A3

Detach:

- ETF/KRU valve bracket. Remove circlip and valve (where installed)
- pipe connections at the receiver inlet and outlet. *Be sure to use two wrenches when undoing connections so not to twist lightweight metal.*
- the pressostat connector. Remove pressostat: this will be reused. This is the low pressure cutoff switch. *If defective you can purchase one at the local parts store for about $12.*
- Existing O rings (note sizes) Replace with new rings from kit on new equipment.

A4

Remove screws holding the receiver clamp

A5

Lift out Receiver

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VOLVO AC refit kit instructions for the 700 series

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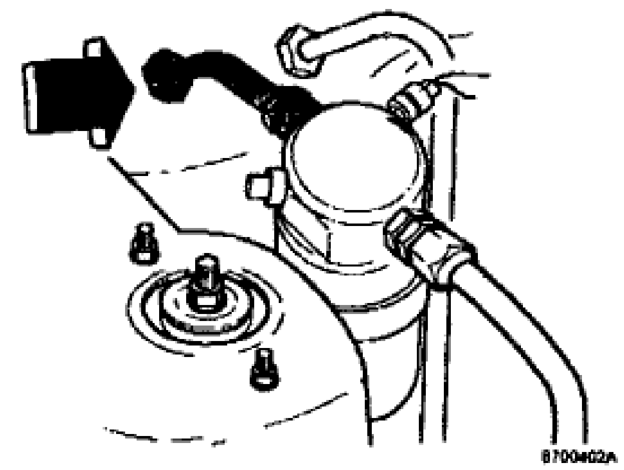
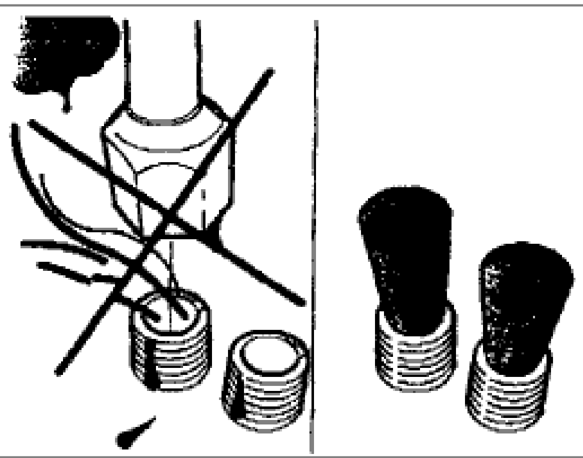
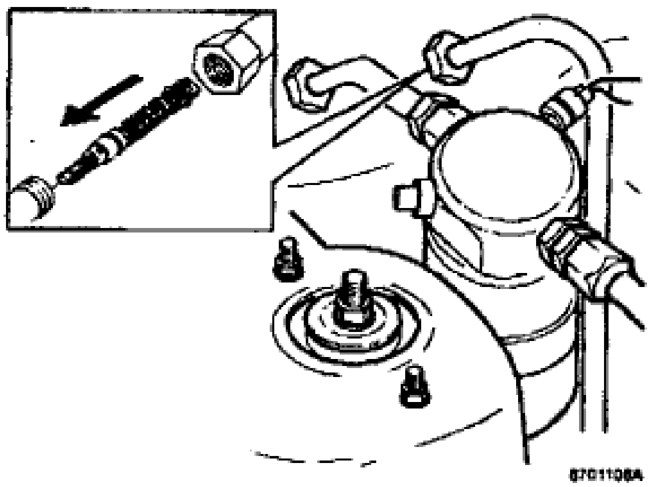
Volvo Maintenance FAQ for 7xx/9xx/90 Cars: **FAQ Home** Volvo Maintenance FAQ for 7xx/9xx/90 Cars: **Heating-Air Conditioning R134 Home**

Conversion of A/C system form R12 to R134a "Retrofit": Page 4

	**Remark:** On older cars or cars where the A/C system was installed as an accessory, there is no EFT/KRU valve In this case remove the pipe (see arrow) at the firewall. Then use Supplementary kit (1) PN 9134032-3 for installation. *Be sure to backup with a wrench both sides of the joint as no to twist the light metal.*
	**A6** Plug all open pipe ends to prevent moisture from entering the system. **A7** Wipe clean around all connections that have been opened.

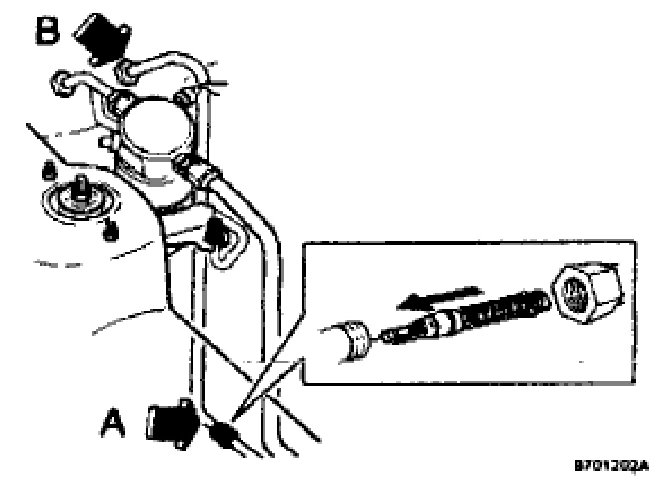


A8

Expansion pipe (orifice) location:

On model years 1991 and earlier (780 - 1990) the orifice is located in the receiver inlet at the firewall (see arrow).

Note: Make a point of noting how the orifice is sited in the pipe. Refer to this and the next illustration. Arrow B



A9

On model year 1992 and later (780 1991-) the orifice is sited in the High-Pressure pipe at the pipe joint on the side member, Arrow A

Note: In some cases the work will be made easier if the pipe for the evaporator inlet is removed at the firewall (the right side pipe as shown at Arrow B).The O ring must then be replaced PN 3537503-9

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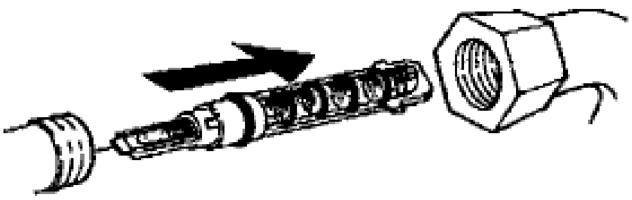
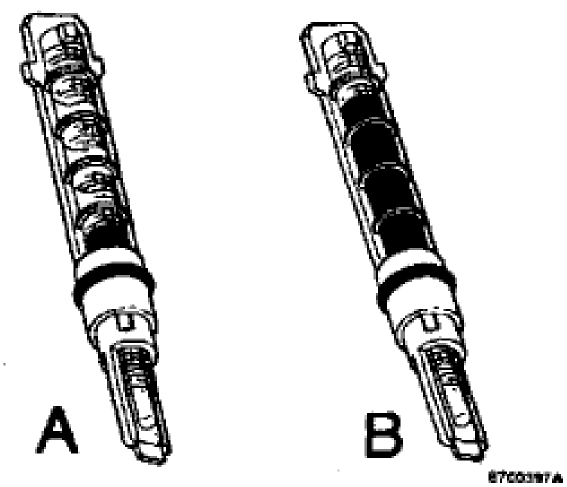
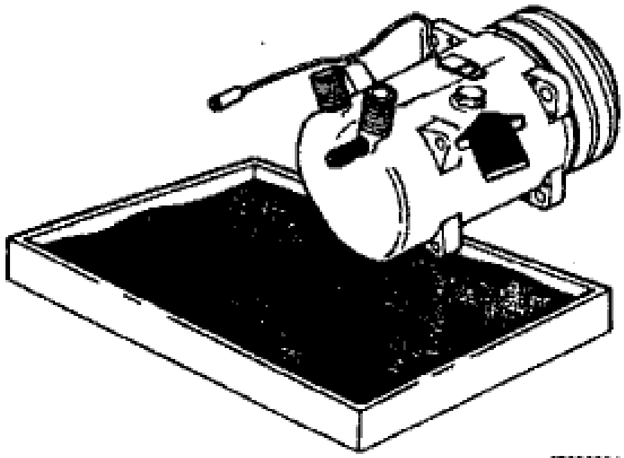
VOLVO AC refit kit instructions for the 700 series

Conversion of A/C system form R12 to R134a "Retrofit": Page 5

	**A10** **Remove expansion pipe (orifice)** Clean the joint thoroughly Remove the union nut Pull or "wiggle" the expansion pipe out (it is not threaded). Take care not to break off the expansion pipe. Make sure the whole unit is removed.
	**A11** **Inspect expansion pipes (opening's) filter section** If the filter is choked or there are a lot of metal particles in it (refer to illustration) then the compressor may be in poor condition and need replacing with a new unit. **A rule of thumb:** If more than 3 of the 5 filter sections are clogged (Fig. B) then the compressor oil should be examined. If the compressor oil is black and heavily contaminated, or if the compressor is dry, then replace the compressor with a new unit. Fig A shows an orifice that is normal. After inspection the old orifice should be scrapped. The conversion kit contains a new one.



If the compressor must be replaced:

The new compressor unit as a replacement part is filled with mineral oil. Empty the oil and replace with ester oil (200 ml 6.76 fl oz) form the conversion kit

Warning! Do not fill Receiver with oil if replacing the compressor.
Only fill the compressor using the filler plug not through the inlet or outlet connections.

Note! The O rings on the compressor inlet and outlet must always be replaced with new ones These Rings are not included in the kits and must be orded separatlly

For compressor replacement refer to the Service Manual Section 8 (82-88) Body Fittings, Interior, Climate Units 740, 760 1982-19...

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VOLVO AC refit kit instructions for the 700 series

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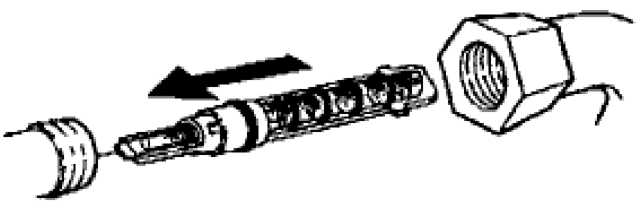
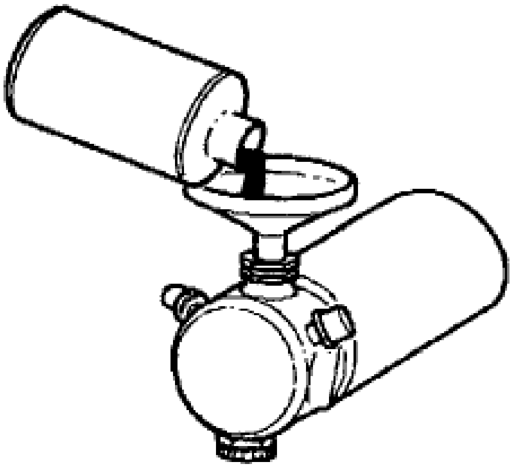
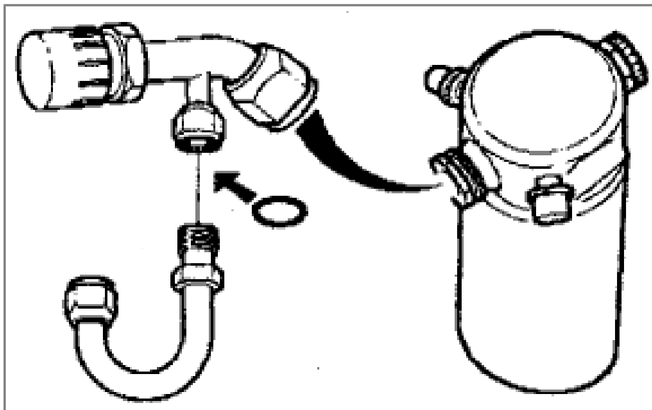
Conversion of A/C system form R12 to R134a "Retrofit": Page 6

	**A13** **Install expansion pip (orifice).** Install a new yellow lubricated O ring on the new expansion pipe. Compare size on the new O ring with the old one so they are the correct dimension. Install a lubricated O ring in the pipe joint at the firewall (or side member). Install expansion pipe (orifice). Tighten the joint to the evaporator (or the side member) to 12 Nm (9 ft. lbs).
	**A14** **Top up the oil level in the new receiver** Fill the receiver through the inlet side with ester oil supplied in the conversion kit (200ml). Note: If the compressor has been replaced and filled with ester oil in previous steps, no additional ester oil is needed in the receiver.



A15

Remarks: On older cars without pipes for ETF/KRU valve;

Install pipes from Supplementary kit (1) PN 9134032-3 Finger tighten against the receiver. Use lubricated O rings. Connect filling pipe (U pipe) using a new lubricated O-ring

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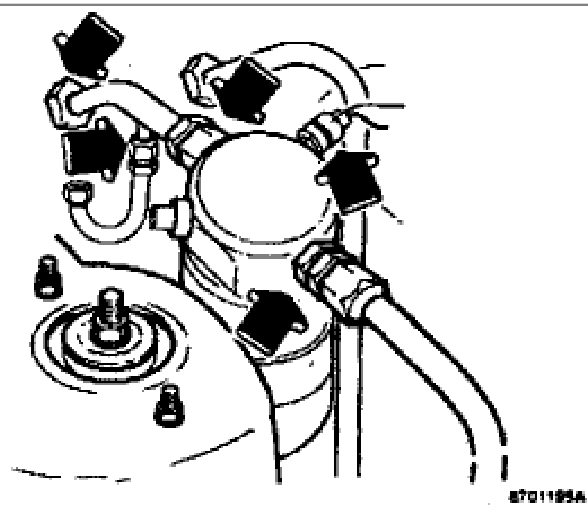
VOLVO AC refit kit instructions for the 700 series

Conversion of A/C system form R12 to R134a "Retrofit": Page 7



A15

Install the following:

- Receiver in the Car
- new lubricated O-rings at the joint between the evaporator and at the receiver outlet.
- pipe to evaporator and at the outlet. Tighten by hand

A16

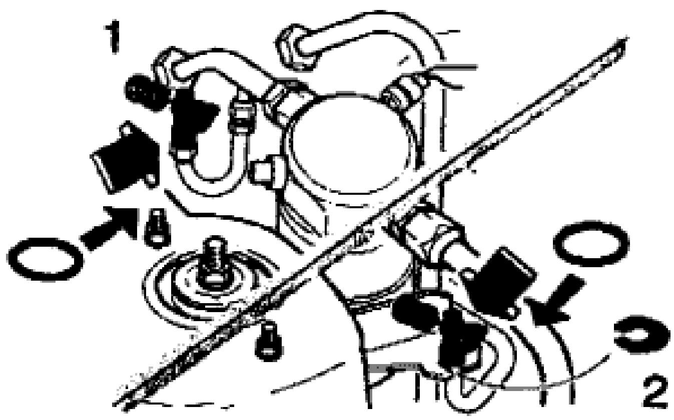
Tightening an torques:

- the pipe between the evaporator and receiver. 27 Nm (20ft lbs) at the evaproator and 45 Nm (33 ft lbs) at the Receiver
- the pipe at the receiver outlet with 45 Nm(33 ft lbs)
- fillter pipe (Upipe) with 16 Nm (12 ft lbs)
- screws on the receiver clamp

A17

Use a new O-ring for the old pressostat,(lubricate with ester oil) and install it on the receiver

Compar size of the new O-ring with the old one to ensure correst dimension. Tighten the pressostat with 3.5 Nm(31 in. lb)

	A18 **Connect the connector to the pressostat**
 	**A19** **Install the new SAE Filler valve for R134a** **Alternative 1:** Use a new yellow lubricated O-ring and install on the filler pipe (U pipe). Insatll SAE filler valve. Tighten with 15 NM (12 ft. lbs) **Alternative 2:** Use a new yellow lubricated O-ring. Install on the filler pipe (U pipe). Insatll SAE filler valve and circlip (included in basic kit). Tighten with 15 NM (12 ft. lbs)

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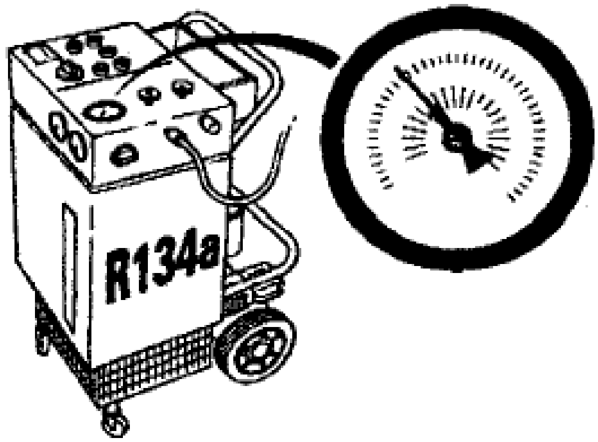
Conversion of A/C system from R12 to R134a "Retrofit": Page 8



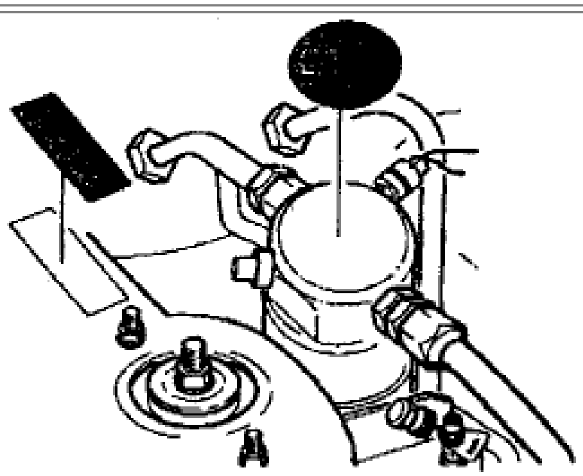
Inspect A/C System

A20

Vacuum pump the A/C system

Connect R134a recycling/filling unit. Start vacuum pumping and continue for at least **50** min.

Check that system keeps a vacuum. The vacuum must not sink during a 4 min period. *(This is with the vacuum turned off) The recycling/filling unit is not required for this step. I used a standard AC vacuum from a R12 system. and connected it to the other R12 charging port opposite the pressostat (See arrow in the bottom picture) and ran the vacuum for the 50 min.*



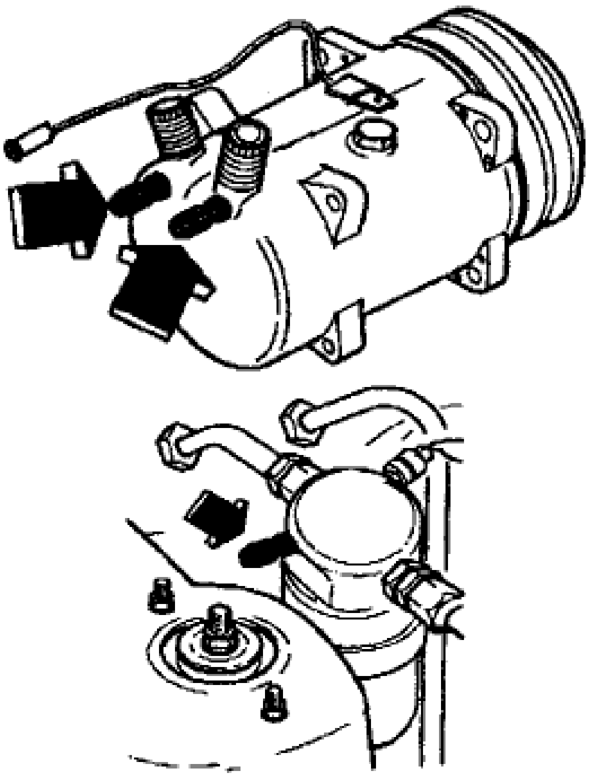
Finaizing work

A21

While evacuating, the following work can be carried out:

Complete the light blue rectangular R134a "RETROFIT" label before the protecteive paper and carbon is removed

Using ball-point pen, note:

	- technician intials - dealer number, if applicable (or repar shop name, city, state) - Date Carefully clean off the old r12 decal on the body work, remove the carbon paper and stick the new, light-blue R134a "RETROFIT" lable over it. Make sure the old label is completely covered. Using mineral spirits, clean top of accumulator, then stick the round R134a "RETROFIT" decal on the receiver.
	**A22** **Install the caps (included in kit) in the service valves which are no longer used.** Two on the compressor (in sertain cases there are none on th ecompressor) and one on the receiver (see illustration below) Use locking fluid PN 1161351-0 or equivalent on the caps.

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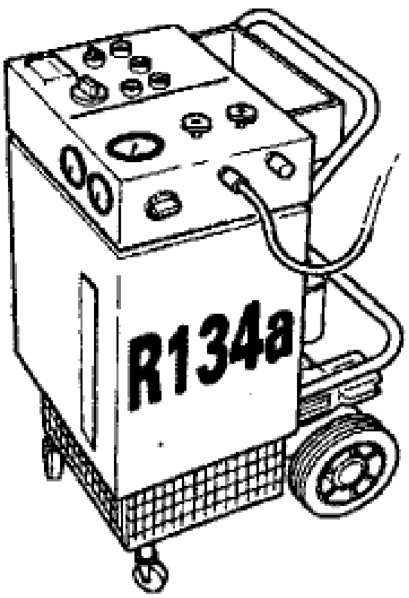
VOLVO AC refit kit instructions for the 700 series

Conversion of A/C system from R12 to R134a "Retrofit": Page 9



A23

Refilling system with refrigerant

On completion of vacuum pumping, fill system with max. 200 grams (0.44 lbs) refrigerant R134a

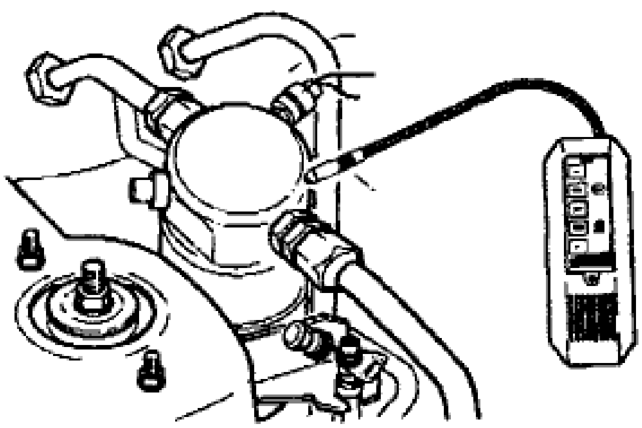
Leakage testing after filling. Use leakage detector.

Repair any leaks.

When no leakage is detected fill with remainder of refrigerant R134a to the amount stated below. (the link refers to a table of refrigerant capacities)

740	-1990	2.4 lb
760	-1987	2.4 lb
780	-1991	2.4 lb
740/940	91-92	2.1 lb
940SE/760/960	88-92	2.0 lb

I applied the small amount of freon from a filler hose that I purchased at a local parts store where I purchased the freon cans.

	One end screws onto the can and the other snaps onto the filler cap installed previously. Hold the can upright so gas, not liquid, is sucked into the system. I then opened the valve and let the vacuum suck the initial freon into the system and then the can provided enough pressure to trigger the pressostat switch to turn on the compressor. I started the car and turned the A/C system on to max cool and raised the idle and made the compressor suck the freon out of the can. I have a 88 740 which requires 2.4 lb or 38 oz. The cans are 12 oz. I put in 36 oz and saved the other can for a spare. Once freon is added check for proper cooling, and your done. The remainder is if you could pump the correct amount in the system.
	**Verify Functions** **A24** **Start:** • Engine • A/C System **Check that:** • Compressor starts and operates normally without unusual noise • In car air is cooled. **Stop engine** Check for leakage with leakage detector Repair and leaks indicated.

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VOLVO AC refit kit instructions for the 700 series

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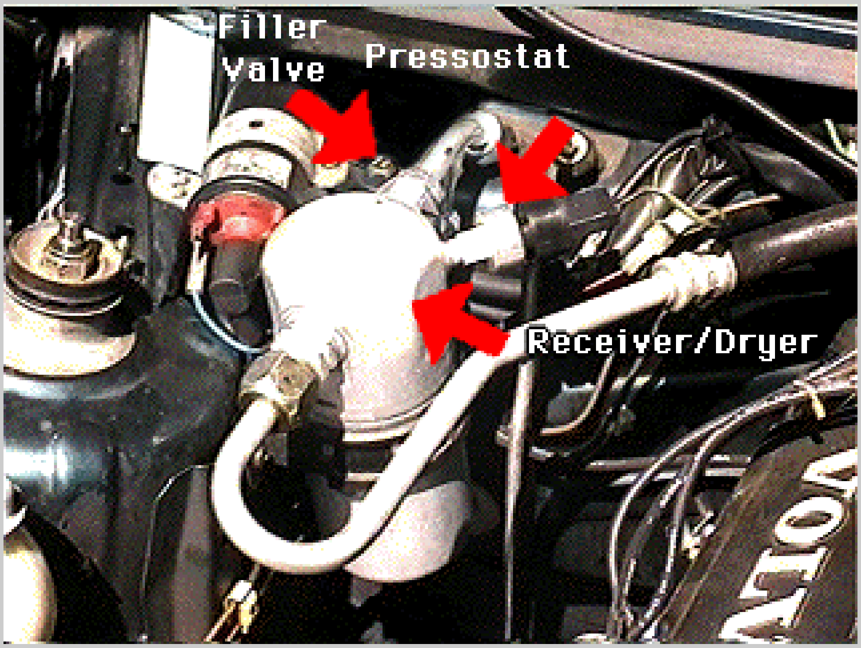
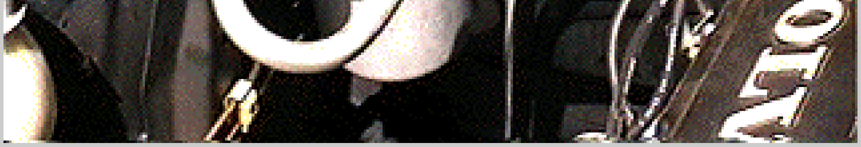
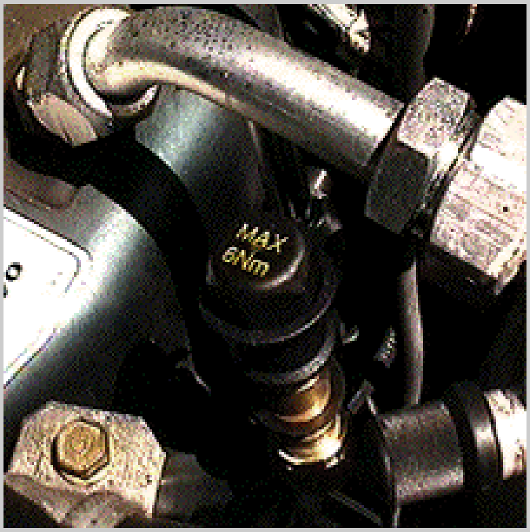
This is my 1988 745 Volvo which has had the AC RETROFIT

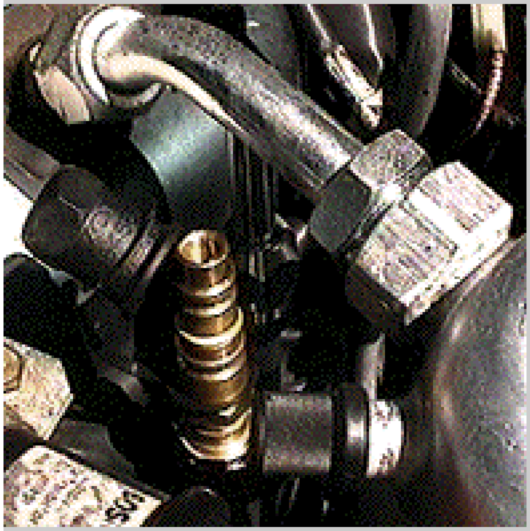
Here are some pictures of the retrofitted parts. Looks about the same.



Here is the filler cap and the filler cap opened. Notice that the filler is a quick release connection. You can alos see the U joint from supplementary kit (1)







Here is a picture of the notice stickers you put on the car.

Thanks to Dave Urban for adapting this material.

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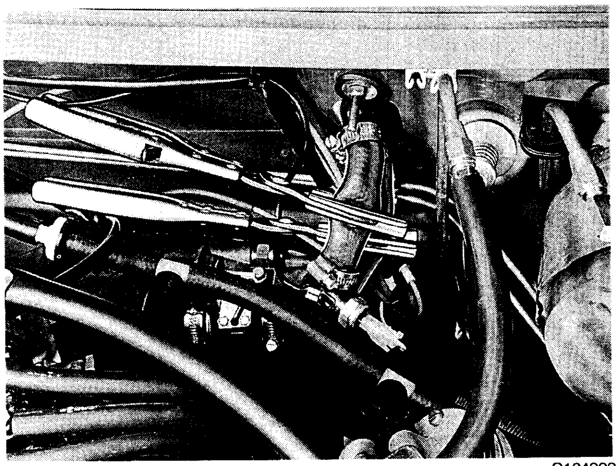
CU/ACC/MCC/ECC climate units for 740 (760-1987), 780/940. Heater, replacement

Vacuum motor in air distribution housing, replacement



S134292

I1

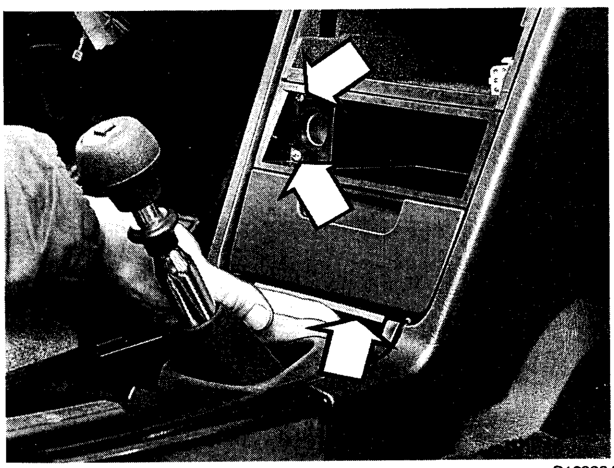
Disconnect battery ground lead

The following operation (I2) applies only to replacement of the heater:

I2

Clamp heater hoses in engine compartment as illustrated.

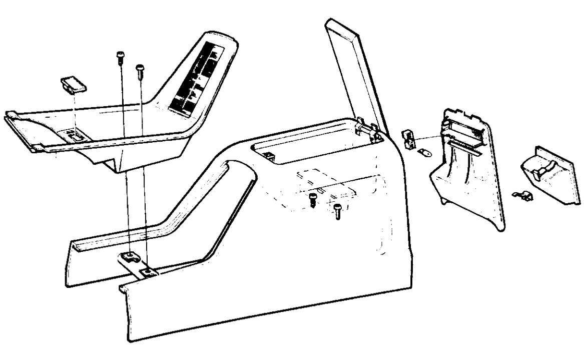
Disconnect hoses.



S132334

I3

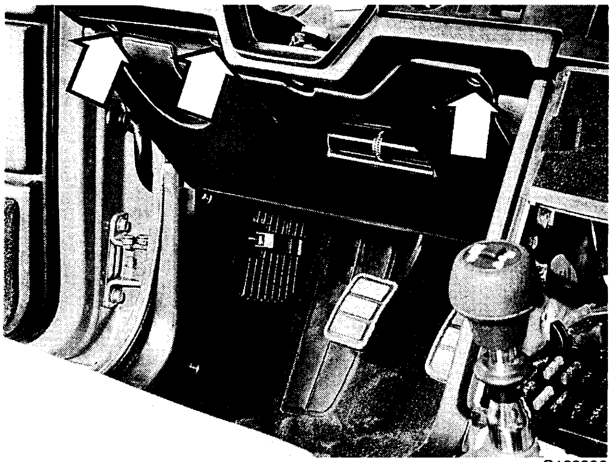
Remove:
- ashtray and holder (press catch under ashtray upward)
- cigarette lighter and storage compartment (2 screws under plastic cover).



S132335

I4

Remove:
- frame around gear lever and parking brake. Undo connector.
- rear ashtray, complete with panel and light
- screws under plastic cover in bottom of storage compartment
- parking brake cover.

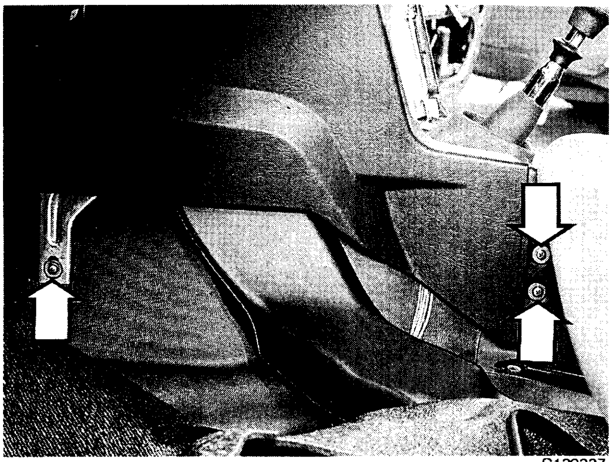


S132336

I5

Remove/disconnect on left-hand side:

- panel under dashboard (3 screws)
- air hose to steering column outlet.

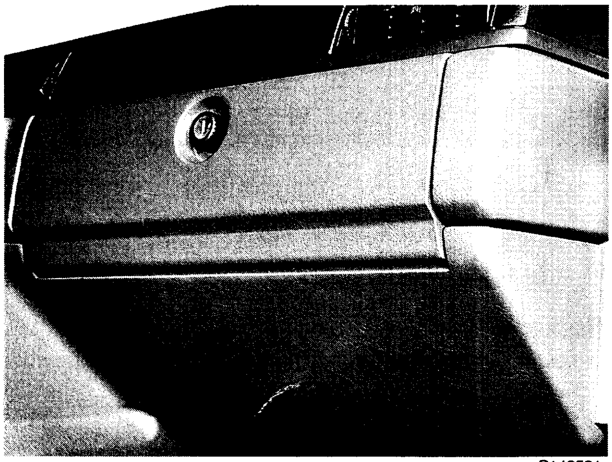


S132337

I6

Pull back carpet at center console and remove:

- screw at front of side panel
- screws at rear of side panel.

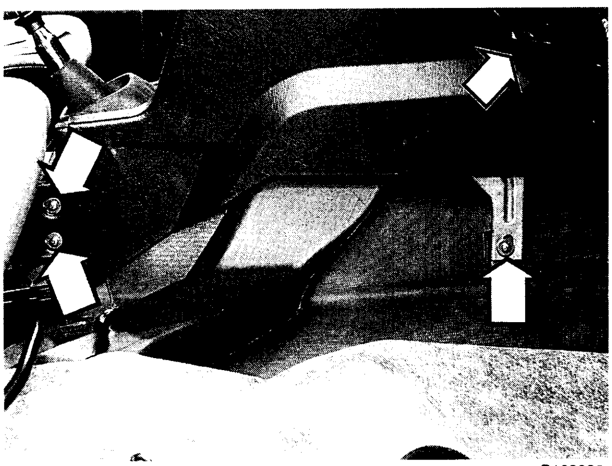


S143521

I7

Remove on right-hand side:

- panel under glove box
- glove box and light.

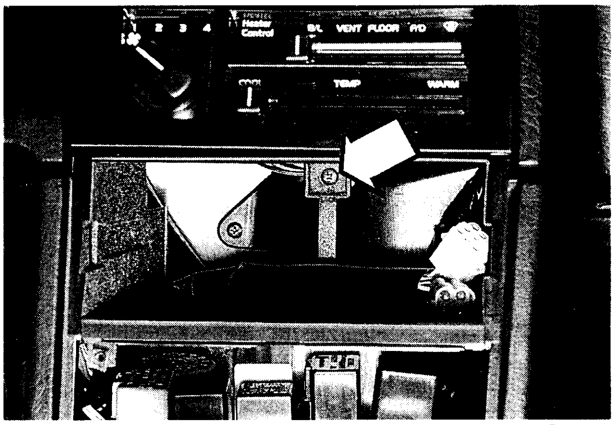


S132339

I8

Pull back carpet on right-hand side and remove:

- screw at front of side panel
- screws at rear of side panel.

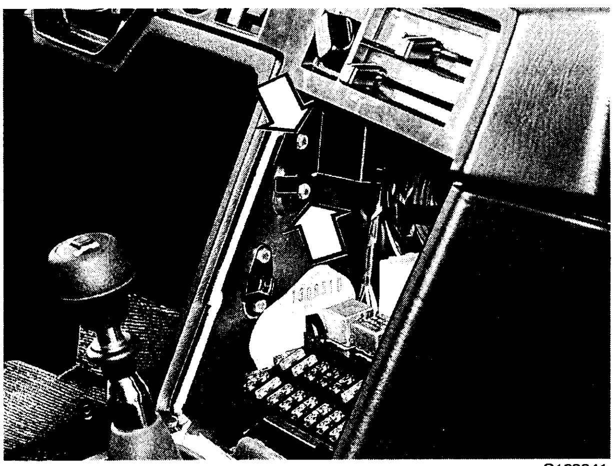


S132340

I9

Remove radio compartment.

Press rear wall forward and remove screw.

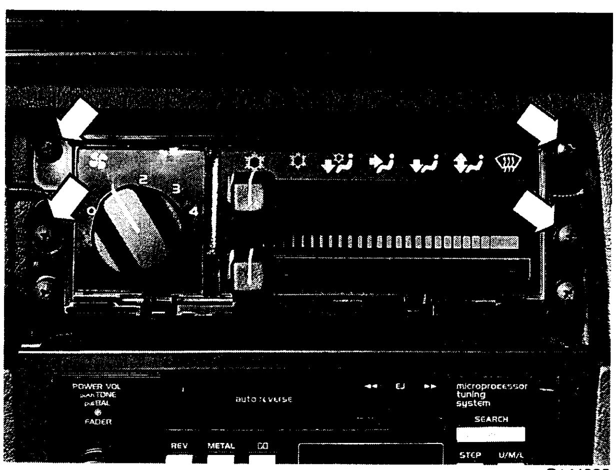


S132341

I10

Remove side panels.

Remove screws in radio compartment bracket (each side).



S144088

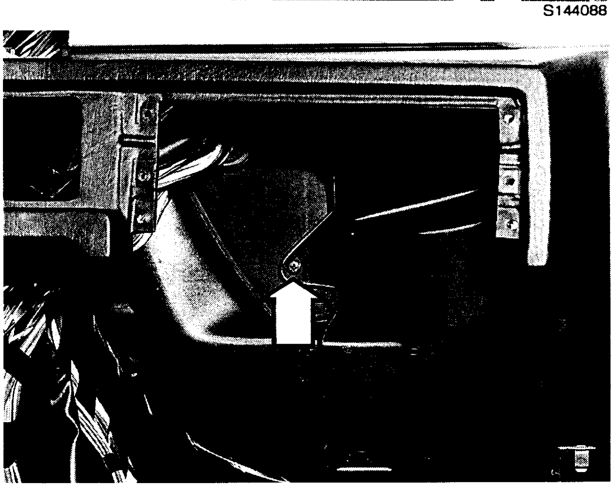
I11

Remove:

- control panel trim
- radio compartment bracket
- control panel.

I12

Remove electrical distribution unit and bracket.



S132343

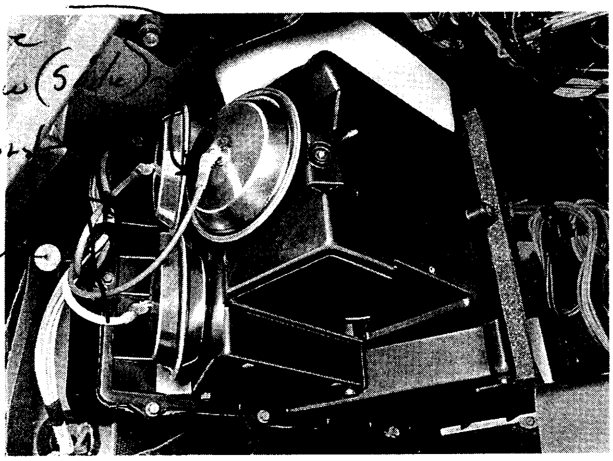
I13

Remove:

- center panel vent
- screw securing air mixing box
- all air ducts to panel vents and air mixing box
- screws securing air ducts to rear seat
- air distributor to rear seat ducts.

Vacuum motor in air distribution housing, replacement

Blue
Yellow
Natural
Red



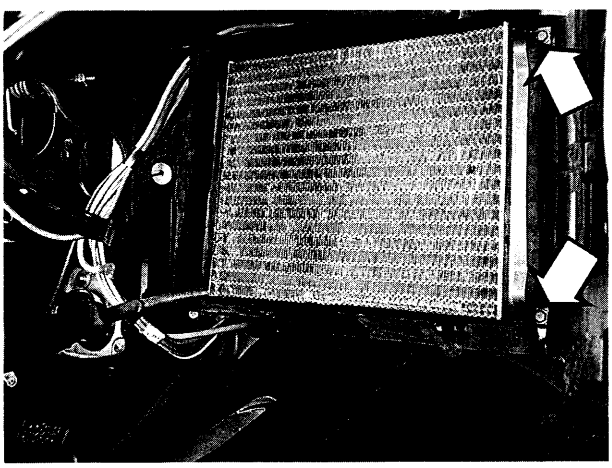
S134293

I14

Disconnect:
- vacuum hoses to vacuum motors
- aspirator hose (ACC version only).

I15

Remove air distribution housing.



S134294

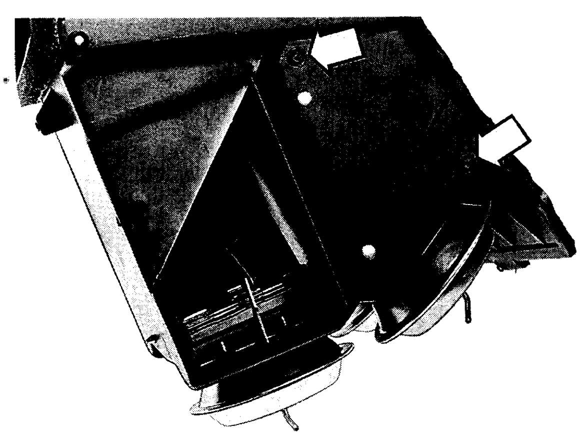
If replacing heater:

I16

Remove:
- heater mountings
- heater (four screws).

I17

Install new heater.



S134295

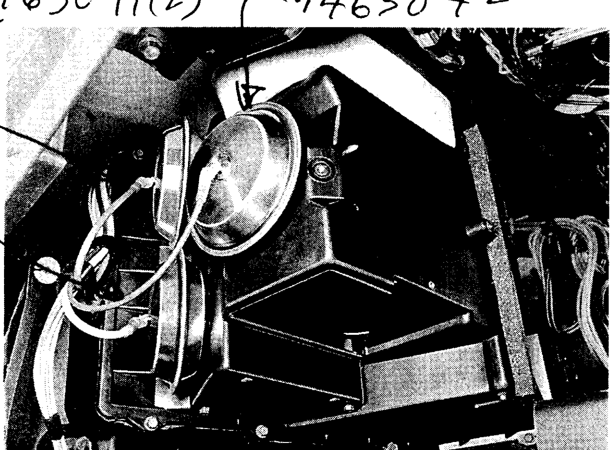
If replacing vacuum motor:

I18

Remove plate from air distribution housing (four screws).

Replace faulty vacuum motor.

9463041(2) 9463042



S134293

Installation

I19

Install:
- air distribution housing
- aspirator hose (cars with ACC only).

Check that foam rubber buffer is sealing joint between defroster duct and climate unit.

Reconnect vacuum hoses.

CU system:

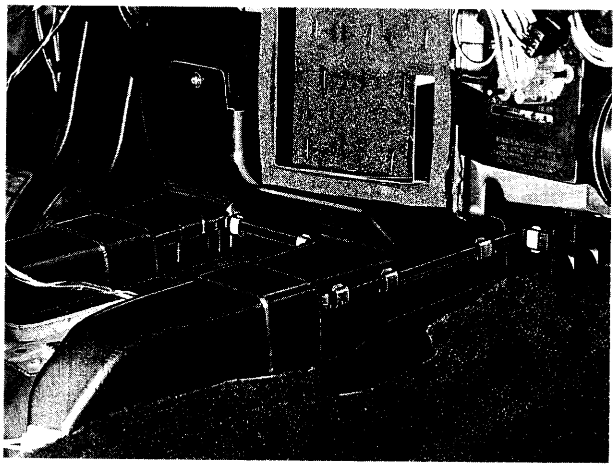
Red to **upper** panel vent shutter. **Light brown** to **lower** panel vent shutter.

Yellow and **blue** to floor/defroster shutter, **yellow** to innermost (see also vacuum diagram on page 54).

ACC systems:

Red to **upper** panel vent shutter. **Blue** to **defroster shutter.**

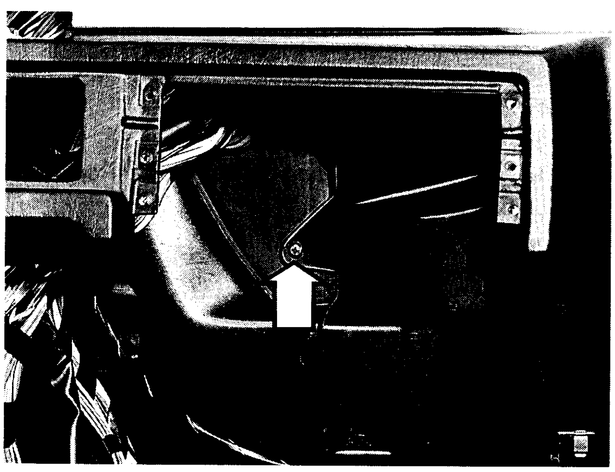
Light brown to lower panel vent shutter (see also vacuum diagram on page 58).



S134296

I20

Connect/install:
- air distributor to rear floor
- screws securing air ducts to rear floor.



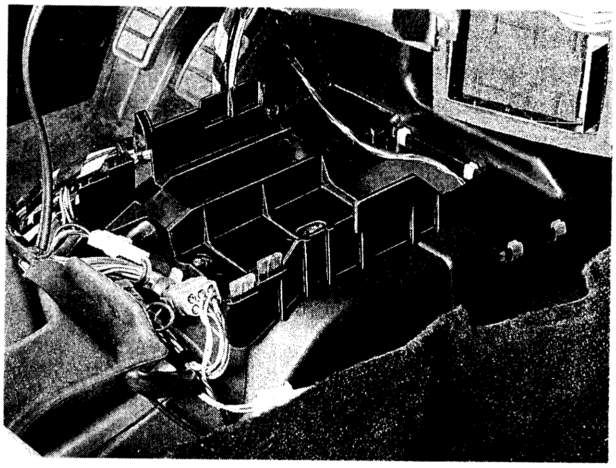
S132343

I21

Reconnect/install:
- air ducts to panel vents
- air mixing box
- center panel vent.

I22

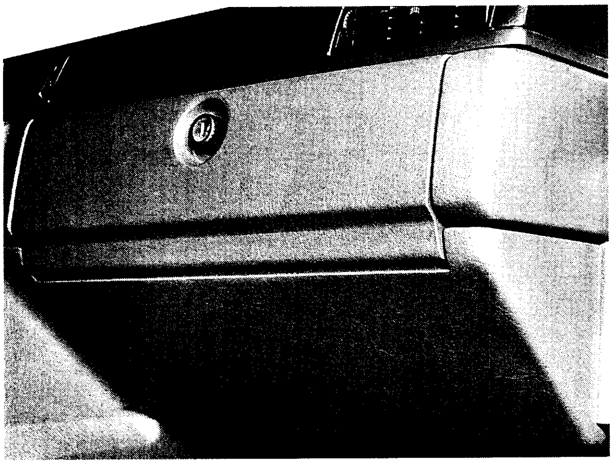
Reassemble ducts.



S134297

I23

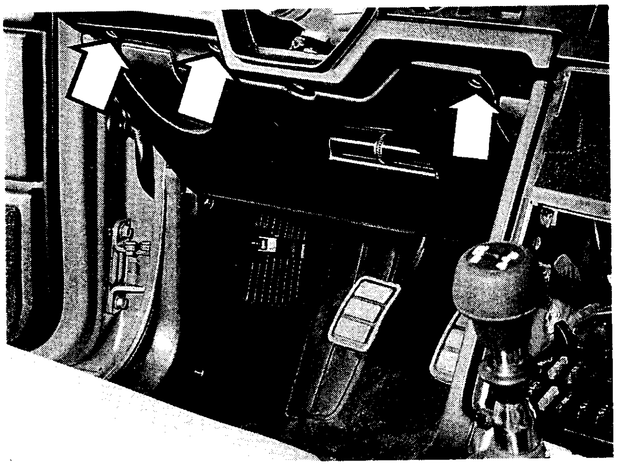
Install:
- electrical distribution unit bracket (see illustration)
- electrical distribution unit
- control panel
- radio compartment bracket
- center console side panels.



S143521

I24

Install:
- glove box (reconnect light)
- panel under glove box.

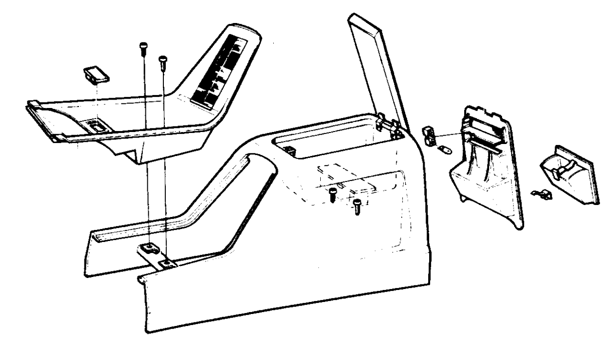


S132336

I25

Install panel under left side of dashboard.

Reconnect air hose.



S132335

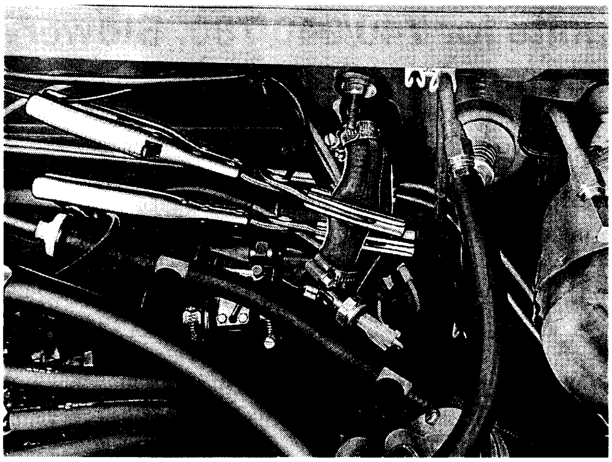
I26

Install:
- parking brake cover
- ashtray holder (reconnect light)
- ashtray
- frame around gear lever and parking brake. Reconnect connector.

S132334

I27

Install:
- radio compartment and cover
- storage compartment with cover and cigarette lighter
- ashtray and holder.



S134292

If heater has been replaced:

I28

Reconnect heater hoses.

I29

Remove hose clamps.

I30

Top up with coolant as required.

I31

Reconnect battery ground lead

Fig.1: Inlet and exhaust turbine shaft.

Volvo AW-7X Transmission Valve Body Service
[FAQ Home]

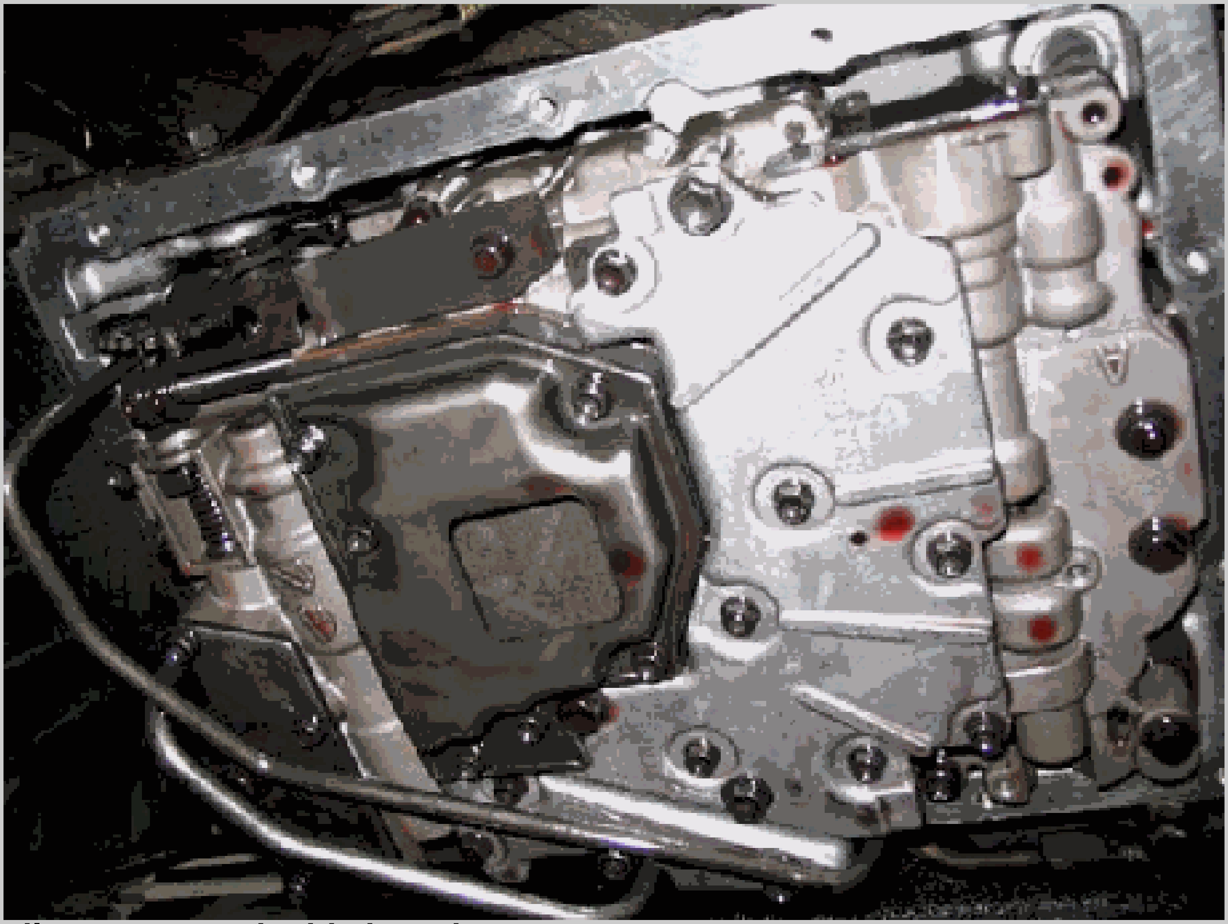
[Volvo Maintenance FAQ for 7xx/9xx/90 Cars] Version 7.2

Aisin-Warner AW-7X Valve Body Service in a Volvo 7XX-940 Car

All information written by Brad Wightman and used by his kind permission.

Disclaimer: I will not accept any responsibility for loss or damage if you follow these instructions. If you choose to follow these instructions, you do so at your own risk. These instructions are, to the best of my knowledge, complete and accurate. However, I will accept no responsibility for any errors or omissions. And so to work…

1. Drain the transmission fluid. No matter how long you leave it drain, there will still be some fluid left in the pan.
2. Raise the car and put it on jack stands as high as you can safely get it. The more room you have the easier the job will be.
3. There are 2 methods to getting the pan off. One is to undo the filler tube nut then remove the 14 10mm bolts for the pan and drop the pan. This will work if you are lucky. If you are unlucky (like me), you will have to remove the starter motor bolts (2 18mm bolts). These 2 bolts hold the filler tube in place via brackets welded to the tube. It's not very hard to get these bolts out. You can then take out the pan bolts and remove the pan and filler tube as one unit.
4. Once you have the pan off you can see the lower side of the valve body. See pic below.



5.
6.
7.
8.
9.
10.
11.

Oil pan removed. This is a view
12. **of the underside of the valve body.**
13. **Front is to the left.**
14.
15.
16.
17.
18.
19.

5. Remove the fluid strainer (6 10mm bolts). Be prepared to lose more fluid. My transmission had a spacer above the filter with 2 gaskets. The sequence goes (from bottom to top): filter, gasket, spacer, gasket. See pic at the top of page 8.
6. Using your manual as a guide loosen off the valve body securing bolts (10 mm) EXCEPT the bolt behind the gear selector valve. If you have an AW71L transmission, you will need to refer to the second picture on page 82 of the manual for bolt locations. NOTE: The bolts are all different lengths so don't mix them up. Use whatever method will help you to remember where the bolts go.
7. Loosen the bolt behind the gear selector valve enough to let your accumulator piston retainer plate to slide into position. It goes in the right hand side. I

secured the plate using the 3 rearmost pan bolts on that side.

Volvo AW-7X Transmission Valve Body Service
[FAQ Home]

Aisin-Warner AW-7X Valve Body Service in a Volvo 7XX-940 Car: Page 3

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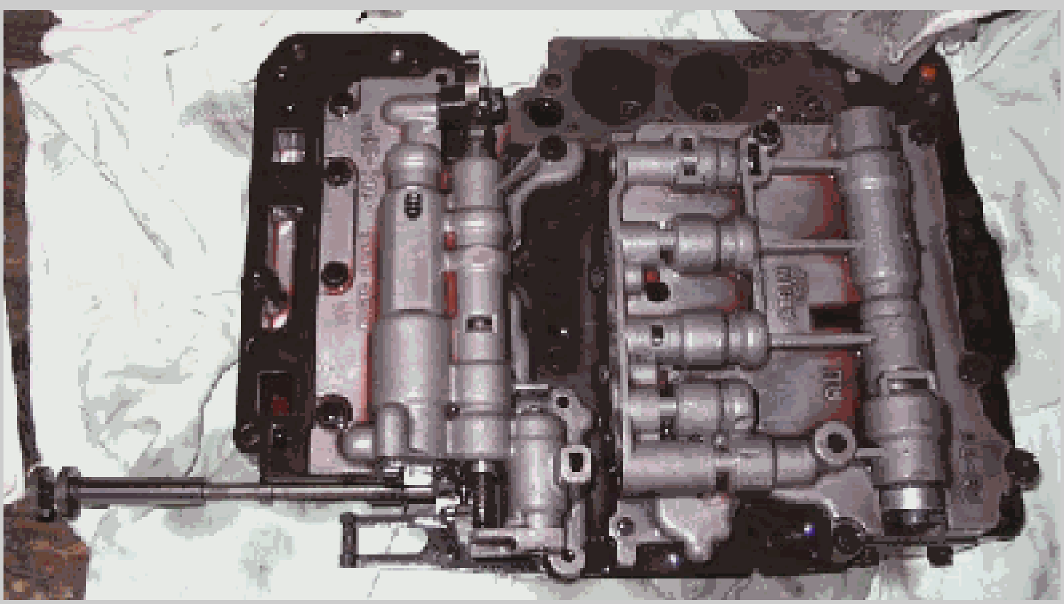
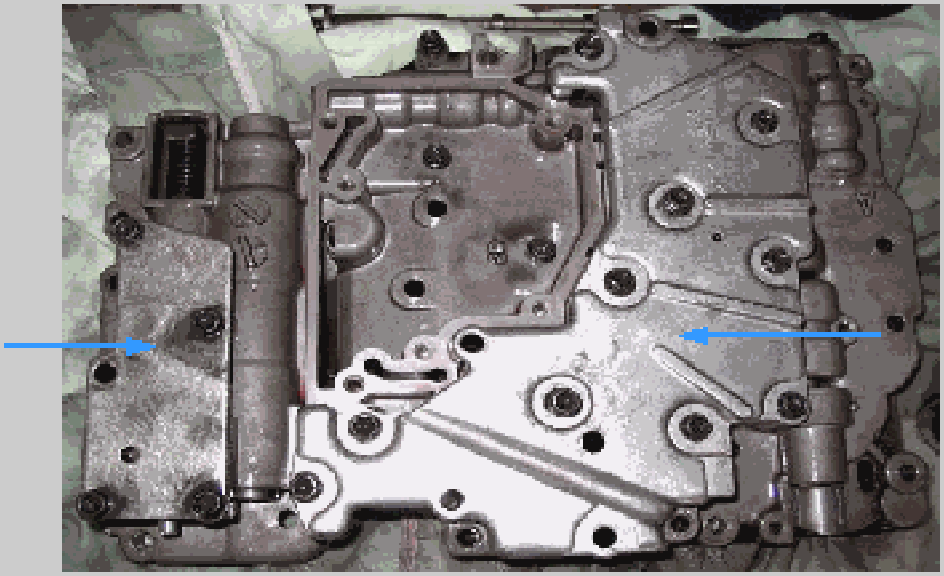
8. Once the retainer plate is in place, support the valve body and remove the remaining bolt. The valve body is surprisingly heavy so make sure you have a good hold on it. Lower it down carefully and remove the kick-down cable from the cam located near the right hand front corner. You can now take the valve body out and place it on your workbench. See pic below.



The front of the valve body is to the left. The long object poking out at the bottom left is the gear selector valve.

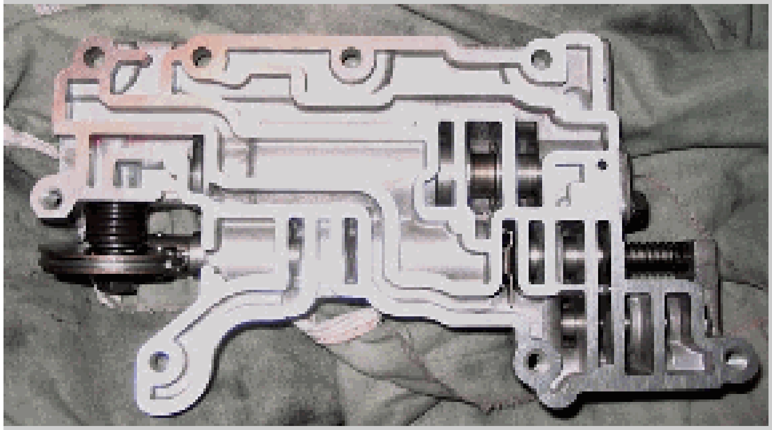
9. Remove the 5 10mm bolts from the upper front valve body and the upper rear valve body. Four of the five bolts in each part are the same and one is longer than the others. Again arrange them in a way that will ensure you remember where they go.

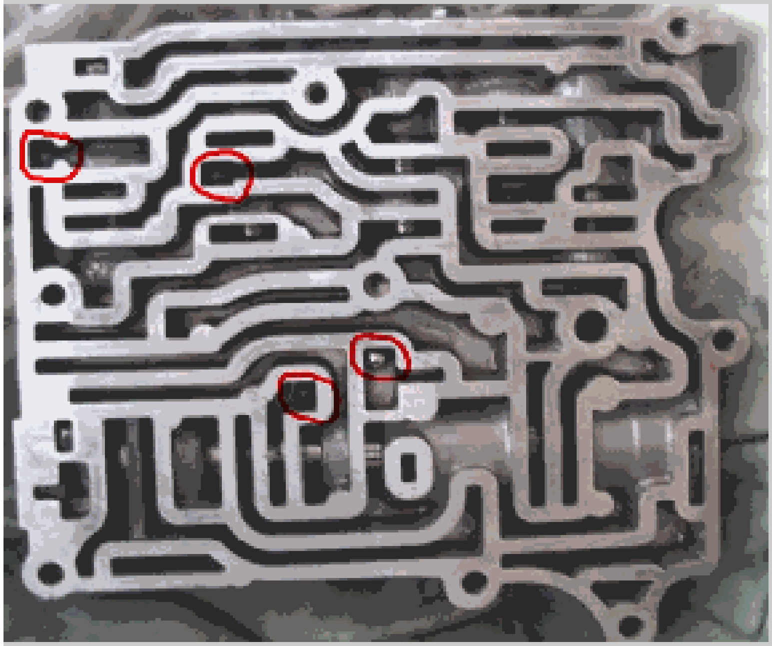
10. Grasp the lower valve body, holding the gaskets and separator plate and carefully turn the valve body over. See pic below.



Underside of valve body on bench. Front is to the left. The arrows point to the 2 covers. Remove 5 bolts to finally separate the upper and lower sections of the valve body. See step 11.

11. Pull the gear selector valve gently out of its bore and also undo the bolt holding the selector pawl and remove it and place it aside. Refer to your manual and remove the last 5 10mm bolts to separate the upper and lower sections of the valve body. Grasp the lower valve body and the gaskets and separator plate and CAREFULLY lift off the lower valve body and place it, right way up, on the bench. See pics below.





Upper front valve body	**Upper rear valve body. The red circles show the location of the check balls. The right-most ball is metal.**

Aisin-Warner AW-7X Valve Body Service in a Volvo 7XX-940 Car: Page 4

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Lower valve body. The red circle shows the location of the check ball responsible for the 1-2 shift. This ball should measure 5.5mm in diameter. When worn, it causes a hard shift from 1-2 gears.

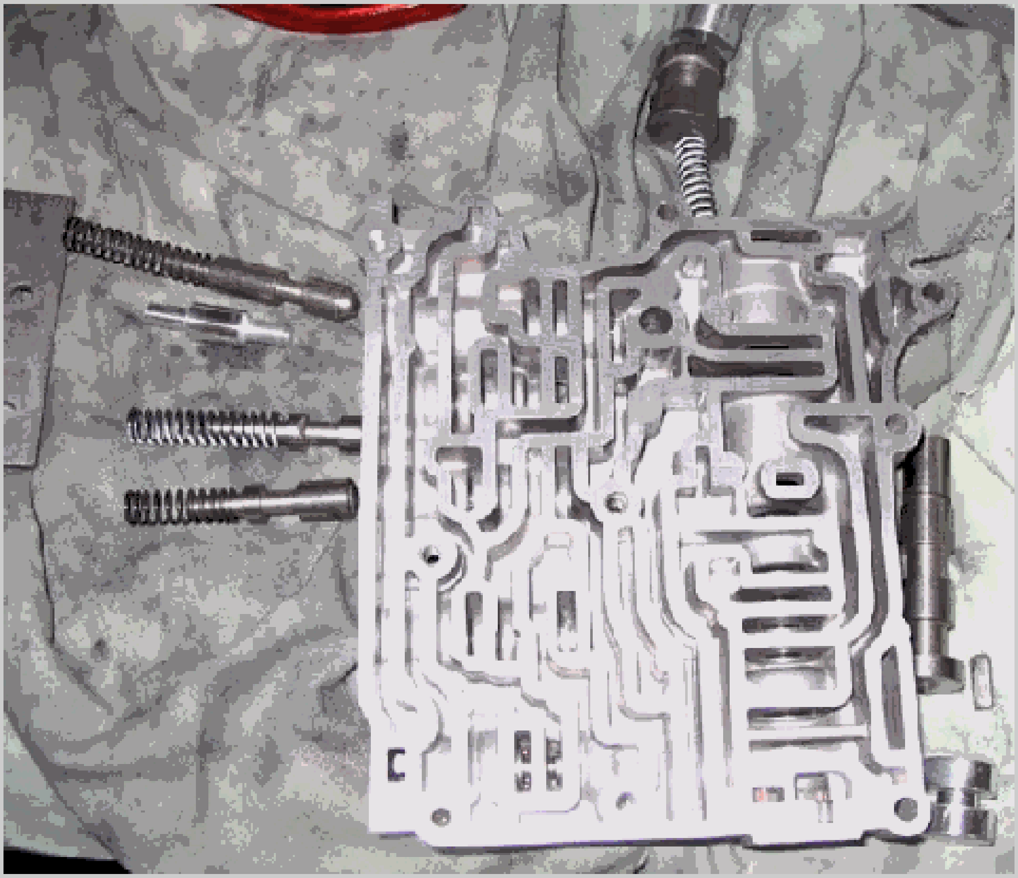
You now have the valve body completely separated. If you have come this far to just replace the check ball in the lower valve body for the 1-2 gear shift, the photo above shows the location of that check ball. You could then button everything back up and leave it at that. But since you have done this much work, it makes sense to do a more thorough job. As long as you are careful there is nothing inherently risky or dangerous about doing this.

12 I started with the upper front valve body. Remove the 4 check balls and check their diameters. All should be 5.5mm. Place them aside somewhere safe. There is a long cover plate on one side which retains 4 valves (detent regulator valve, Modulator valve - manual downshift 3-2, Control valve for rear clutch C2 and Governor modulator valve). Undo the 2 8mm bolts while holding the plate down firmly. Three of the four valves have springs which keep pressure on them so make sure you don't let the cover plate fly off or you will lose everything.

13 There are 2 other valves that run perpendicular to the valves detailed in step 12. These are the 2-3 shift valve and the manual downshift valve 3-2. The downshift valve is held in by a metal plug which itself is held by a short retaining rod. Fish out this rod and use a small flat blade screwdriver (with the end suitably covered) to prise out the plug from behind. Gently tip the valve body up to let the valve slide out.

14 The 2-3 shift valve is also held in place with a small retaining rod. This valve has a spring behind it so be careful when removing the retaining rod so the valve doesn't fly out. Dis-mantling of the upper rear valve body is complete. See pic below.

mantling of the upper rear valve body is complete. See pic below.



Aisin-Warner AW-7X Valve Body Service in a Volvo 7XX-940 Car: Page 5

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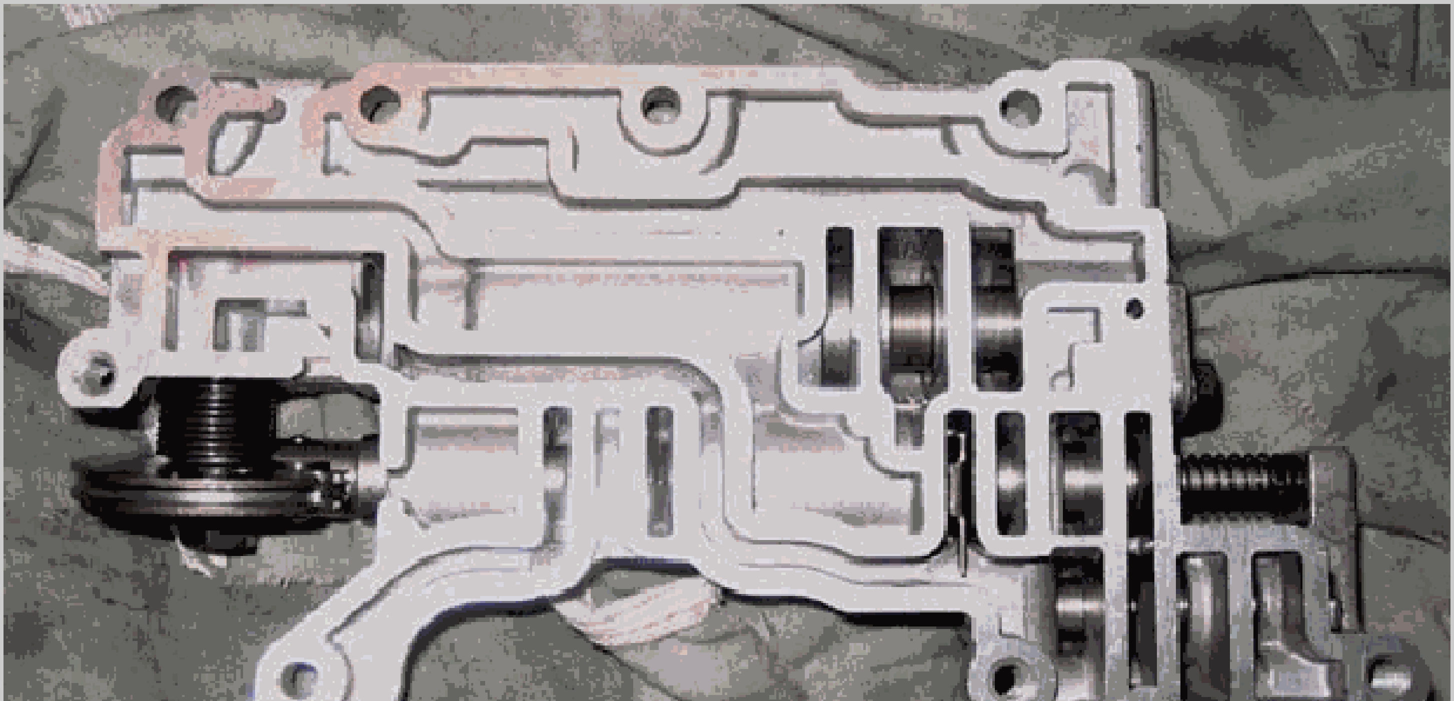
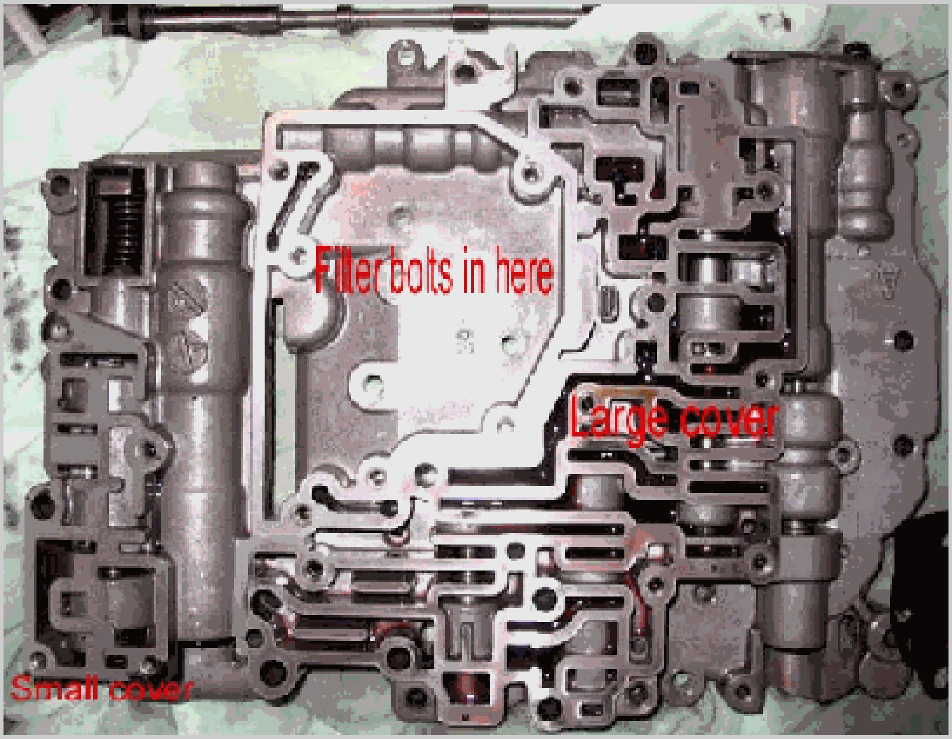
15. Put each valve in your favourite cleaning agent (I used turps). Also put the valve body in to soak as well. Rinse it out (I used just water) then blow it dry with compressed air being sure to blow out all the passages and bores and ensure that it is completely dry before reassembling.
16. Reassembly is simply a reversal of disassembling. Be careful not to confuse the orientation of the valves (ie. don't put it in backwards). Some valves contain orifices in them that are very small (sorry, don't remember which valves have them). The position of these holes in the bores of the valve body does not appear to be critical. Torque the retaining plate bolts to 3.5 - 4.5 ft lbs. (5 - 6 Nm). Place it aside somewhere clean and turn your attention to the upper front valve body.
17. Disassembling the upper front valve body follows a similar process to the upper rear valve body. See pic below. The Volvo manual gives some details about disassembling this section. A word of caution: On page 85 of the manual there is a warning about strong spring pressure behind the cover retaining the secondary regulator valve and they're not joking. There is A LOT of pressure behind that cover (the spring is quite beefy). This cover is located just above the spring on the right hand side in the picture. Make sure you have a very good grip on the cover and are VERY careful as you turn it to expose the valve otherwise you risk shooting the valve across your garage.



18. Follow the same procedure as before to clean the valves and the valve body itself and reassemble and place it aside safely.
19. The lower valve body is the most time consuming to work on. There are 3 sections to the lower valve body. See pic below.



This is the underside of the lower valve body (the side you see when you take the pan off). The bottom covers have been removed.

Aisin-Warner AW-7X Valve Body Service in a Volvo 7XX-940 Car: Page 6

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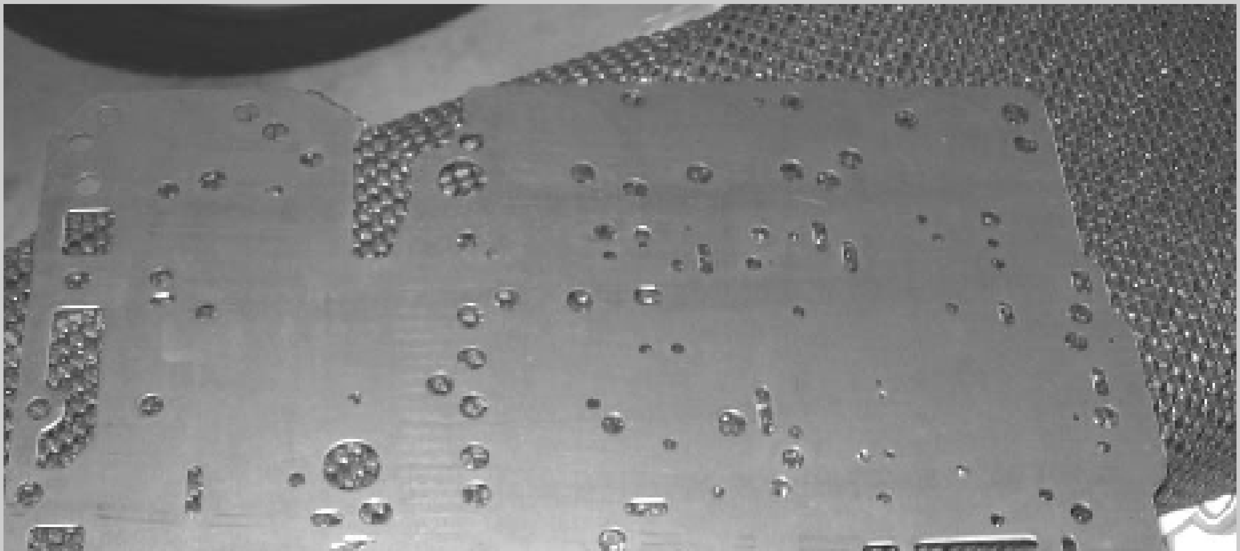
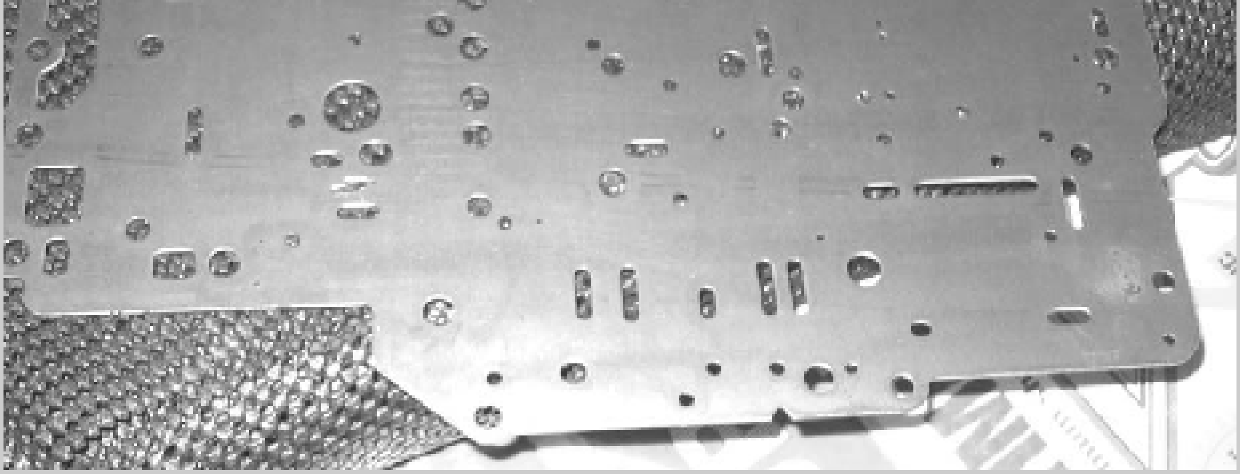
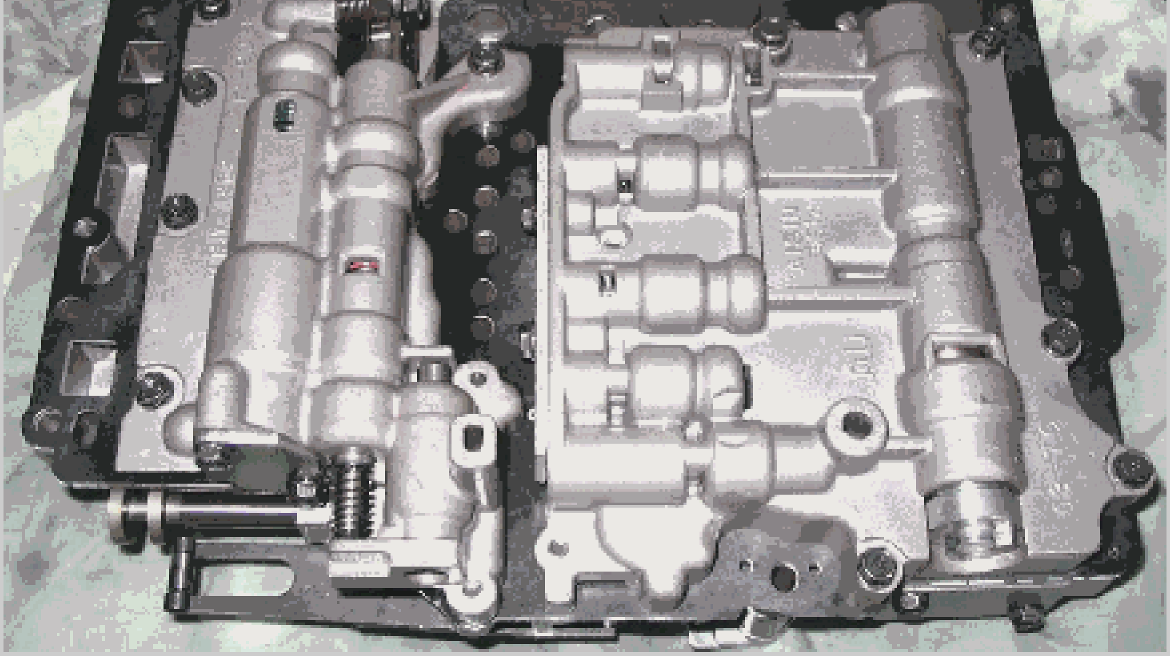
20. Disassemble the lower valve body in a similar way to the other two sections. If you have a transmission with lock up torque converter (AW70L, AW71L or AW72L) pay close attention to the signal valve and changeover valve. The changeover valve, in particular, has a couple of small orifices in it that can easily become blocked up. Blow them out with compressed air. Soak the valves and the valve body in your cleaning solution, blow dry with compressed air and you are ready to reassemble.
21. Using your diagrams, digital camera pics or whatever method you used to help you remember where things go, reassemble the lower valve body. Do the underside first. Replace the check balls into their correct locations. Use new gaskets when replacing the covers and torque the covers to 3.5 - 4.5 ft lbs. (5 - 6 Nm).
22. Turn the valve body over and replace the parts taken out. When this is done you are ready to reassemble the valve body.
23. Place the lower gasket on the lower valve body. Then place the separator plate on top of the gasket. See pic below.





Valve body separator plate. This goes between the lower and upper gaskets as noted in the text.

24. Place the upper gasket on top of the separator plate and put one bolt into the area of the upper front valve body to hold everything in position.
25. Position the upper rear valve body on the bench then grasp the lower valve body, including separator plate and gaskets, pick it up and turn it over and place it on top of the upper rear valve body. Put the bolts in and do them up finger tight.
26. Turn the unit back over and put the top bolts in and do them up finger tight. The reason you do them up only finger tight is to allow for some movement in the gaskets and separator plates to line up the holes when putting the upper front valve body in place.
27. Remove the bolt from the lower valve body that was put there to hold everything in place. Position the upper front valve body and pick up the lower valve body and turn it over onto the upper front valve body. Put in the bolts finger tight. Turn over the whole unit and put it the upper bolts. Torque all bolts alternately to 3.5 - 4.5 ft lbs. (5 - 6 Nm). See pic below.



Page 1 2 3 4 5 6 7 8 9 Next

Aisin-Warner AW-7X Valve Body Service in a Volvo 7XX-940 Car: Page 7

All information written by Brad Wightman and used by his kind permission.

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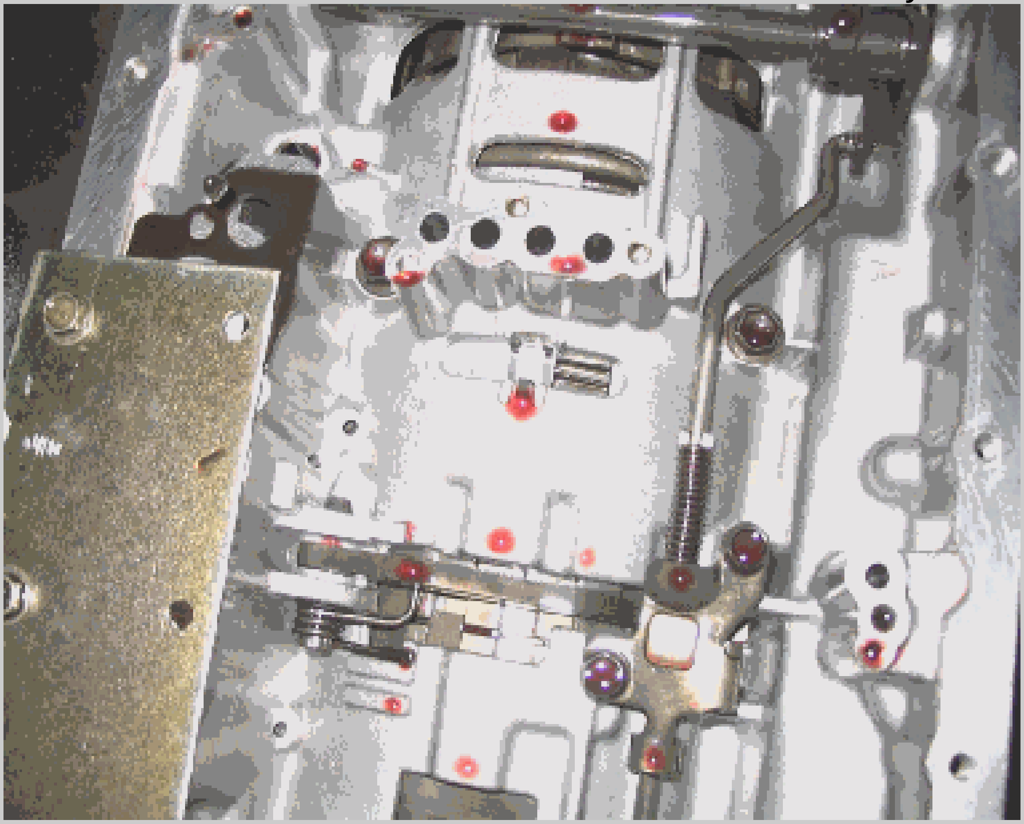
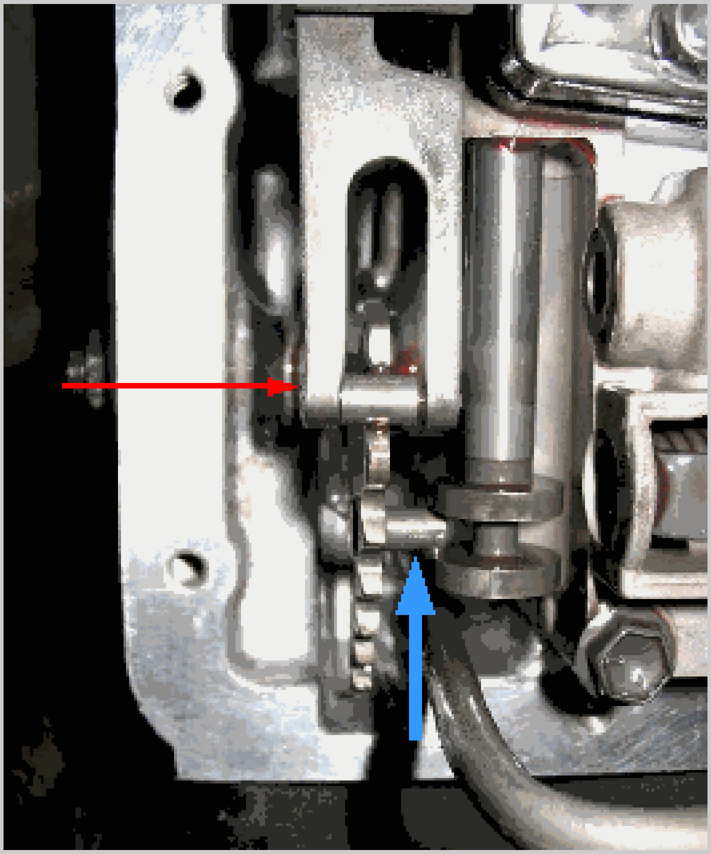
28. Now you are ready to put the valve body back into the transmission. Make sure you have all of your tools on hand and in easy to reach places. The pic below shows the inside of the transmission with the valve body removed.

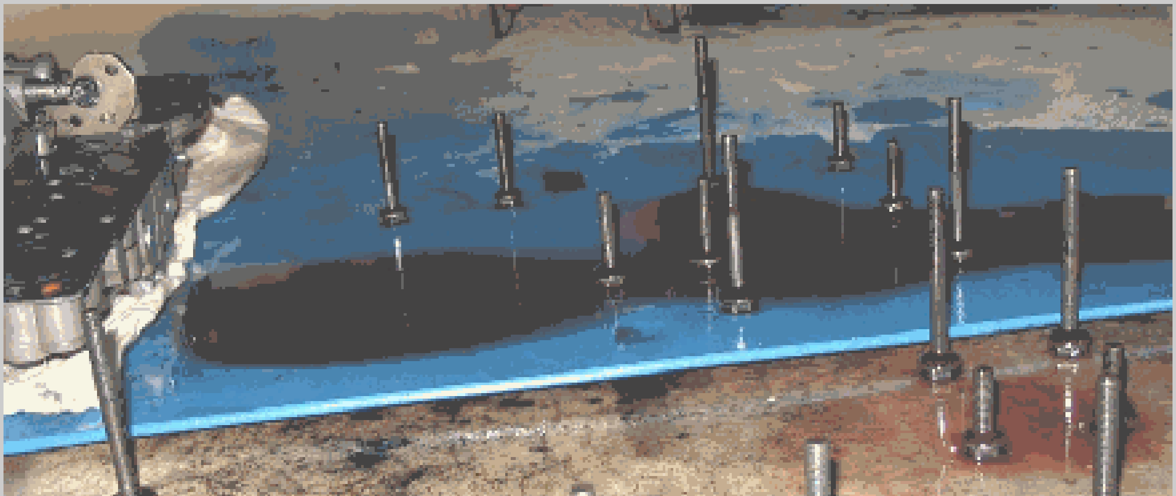


Front is to the top. Note the accumulator piston retainer plate in position on the left. This is held in place using 3 oil pan bolts.

29. The manual says to reattach the kick-down cable as a first step. This may be possible if you have an assistant but I found it was damn near impossible on my own. If you are doing this job on your own it's easier to reattach the cable with the valve body back in place in the transmission. It's just like doing a cable replacement.
30. Position the valve body correctly, ensuring that the selector cam at the front of the transmission is correctly engaged in the gear selector valve. See pic below. While holding it with one hand, begin to install the bolts. Remember, the bolts are different depending on their position so don't muck them up.



The pawl on the valve body (red arrow) should engage in the last detent of the gear selector cam when the gear selector lever is in park. Ensure that the pin is located in the gear selector valve (blue arrow).



These are the valve body retaining bolts. It's a little hard to tell but they are different sizes. The bolts in the foreground are at the back of the valve body. They have been placed on the floor in positions relating to their positions in the valve body. You can see part of the valve body to the left facing the correct way ready to go in. The kick-down cam is visible at the top.

Volvo AW-7X Transmission Valve Body Service
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Aisin-Warner AW-7X Valve Body Service in a Volvo 7XX-940 Car: Page 8

All information written by Brad Wightman and used by his kind permission.

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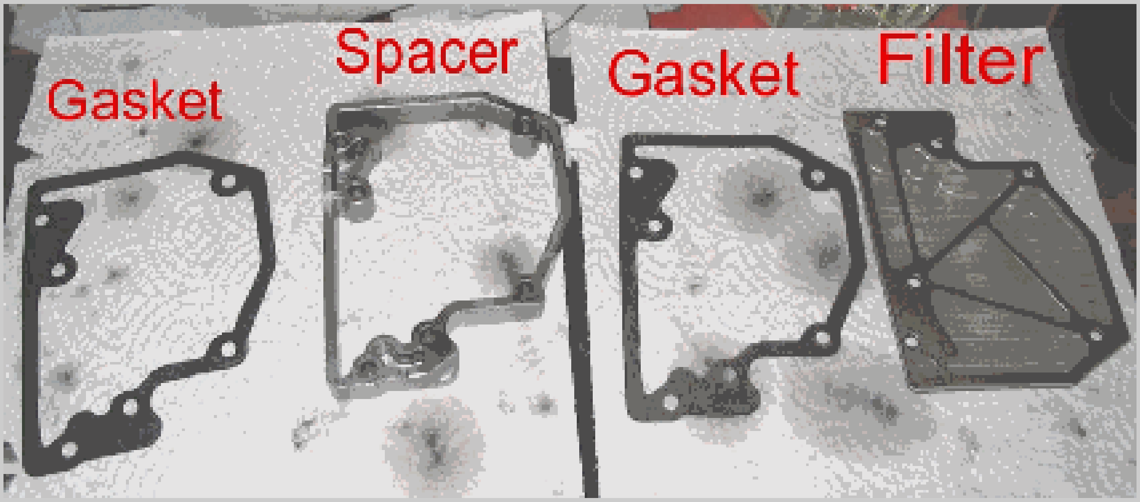
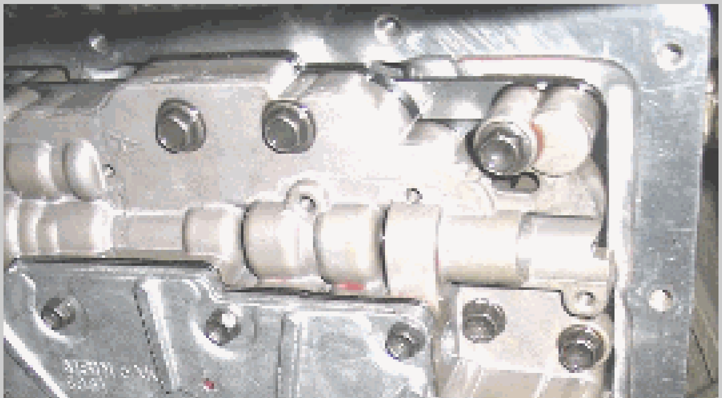
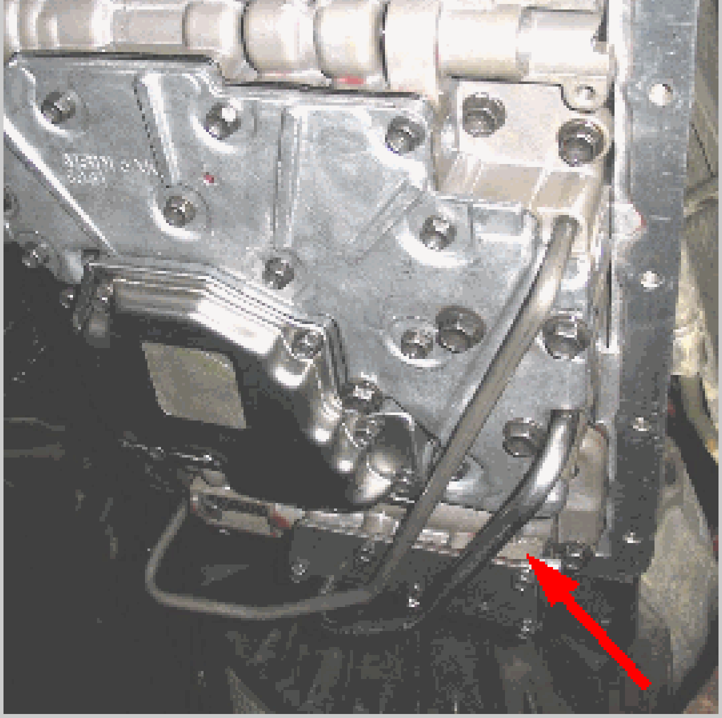
31. Remove the bolts holding the accumulator piston retainer plate in position and carefully remove it. Install and tighten all the valve body bolts alternately to the correct torque of 6 - 9 ft lbs. (8 - 12 Nm).
32. Install the oil filter. Torque bolts to 3.5 - 4.5 ft lbs. (5 - 6 Nm). See pic below.



This pic shows the sequence of assembly. Filter goes at the bottom obviously.

33. Reattach the oil pipes onto the valve body. See pic below.





Valve body installed in transmission. Front is to the bottom. The red arrow points to the short oil feed pipe. This pipe attaches to the front and the side of the valve body. This pipe will require some strength to put back in place. It is held in by friction only. Ensure that it is fully engaged in its holes at both ends.

34. Reattach the kick-down cable if you didn't do it earlier. Ensure that the cam pulley can return to its full rest position. Adjust the cable if necessary.
35. Clean out the oil pan and place its gasket in position. See pic below. Install the pan on the transmission and bolt in place. Torque for sump bolts is 3 - 3.5 ft lbs. (4 - 5 Nm).
36. Place the starter motor in position and install the bolts to secure it and the filler tube in position. Reattach the wires to the starter motor.

Pan & filler tube clean and ready to install. The filler tube stayed on because the nut had seized up. Starter motor bolts were removed to get the pan off. The arrows point to the brackets that are held in by the starter motor bolts.

Aisin-Warner AW-7X Valve Body Service in a Volvo 7XX-940 Car: Page 9

All information written by Brad Wightman and used by his kind permission.

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37. Fill the transmission with the correct grade of transmission fluid. The manual says put in 5 litres of fluid. I put in about 5.3 litres and the level was still low. You could safely put in 5.5 litres or more. Just be careful not to overfill the transmission.
38. Reattach the battery cables if you removed the starter motor.
39. While trying to keep your heart rate down, start the car and allow it to idle for a minute or so to let the fluid pump around the transmission.
40. Change your clothes (unless you like transmission fluid in your car) and take the car for a drive. Check to make sure the transmission engages the correct gears and everything works as it should.
41. If all is well, congratulate yourself on a job well done. You now have bragging rights.

Volvo Headliner Replacement-2

2. Removing Headliner Panel and Sunroof Headliner

Though this is the most difficult part of the project, this step is necessary to properly repair a sagging headliner.

Safety Alert: As a standard safety precaution, always disconnect the vehicle's negative battery cable before you begin work on any electrical or mechanical components.

Materials:

Standard mechanic's tools (wrenches, ratchets, extenders, screwdrivers, nut-drivers, etc.)
Headliner tool (or wooden spatula)
Scissors
Marker
Needle-nosed pliers

Removing the Headliner Panel

- Begin by removing the trim pieces in the front of the car using a torx driver (**figure A**). 

Tip: Loosen, but do not remove, the vertical trim pieces that can simply be pushed out of the way.

- Remove the rear-view mirror.

- Remove the sun-roof motor cover.
- Since the sun visors are mounted into the headliner, they will need to be removed also (**figure B**), as well as the sun visor clips (**figure C**).

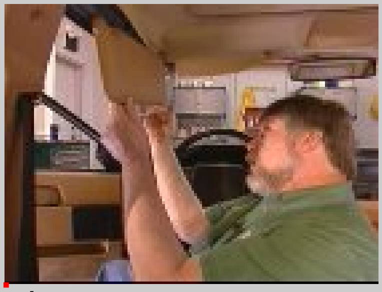

Figure B

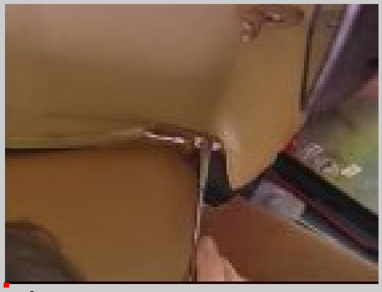

Figure C

- On the passenger-side sun-visor, there may be a wiring harness for the visor's vanity mirror. Most will have a disconnect plug, making it easy to detach the wiring harness when you remove the visor. Avoid cutting the wiring harness.

Figure D

  Tip: You can use a pair of scissors to cut a slit in the headliner board and fabric to make it easier to move the wiring harness out of the way (**figure D**). The cut can later be concealed under the plastic trim piece.

- In the back seat, remove the covers from the grab-bars so that the mounting screws can be removed in order to take down the grab bars. Remove the rear courtesy light and detach it from its wiring harness.

- Remove the side trim-panel (**figure E**) first, followed by the rear trim panel.

- Use a headliner tool (or wooden spatula) to loosen and remove trim panel pieces (**figure F**). These pieces are removed by popping out the retaining clips behind each panel.


Figure E

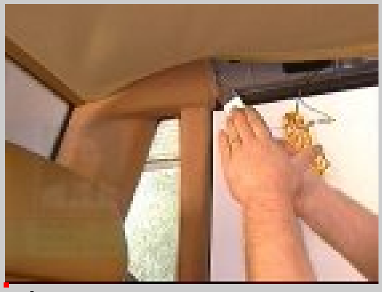
Figure F

- Remove the dome light (**figure G**), taking care not to avoid chipping the cut-out in the headliner board that accommodates the light assembly.

  Tip: This is a good time to check the wiring connections in the dome light, inspecting closely for any cracks or breaks.


Figure G

- Remove the flexible edging around the sunroof that anchors the headliner cloth to the opening in the roof (**figure H**).

  Note: Replace the sunroof edging if it is hard, cracked or broken.


Figure H

- With the sunroof liner and all of the other trim pieces removed, the process of dropping and removing the headliner can begin by pulling downward in the center of the headliner board (**figure I**). Flex the board gently from the center, allowing the board to bow and begin to come loose.


Figure I

- Take your time as you remove the headliner board. The corners of the board are the areas most likely to break.
- **Important**: The headliner board can be taken out in one piece by curving or bending it, but *only* if this is done slowly and carefully. Bending the board too abruptly will cause the board to crack (**figure J**),

particularly if it is old and brittle. The trick is to bend the board slightly, but not in ONE single place. If you bend it sharply in one spot, it'll break. Picture curling a piece of paper, as opposed to creasing it, and you should have a good mental image.

Figure J

- Since our board did, in fact, break apart upon removal (**figure K**), repair would be required. This situation is not uncommon since sun and heat damage typically causes headliner boards to become brittle and increasingly fragile over time. Many are simply made from a pressed-cardboard material. However, the damage to this board was repairable.

Figure K

Note: Breaks around the sunroof opening are among the most difficult to repair.

Removing the Sunroof Panel

With the main headliner board removed, the sunroof panel can now be removed as well.

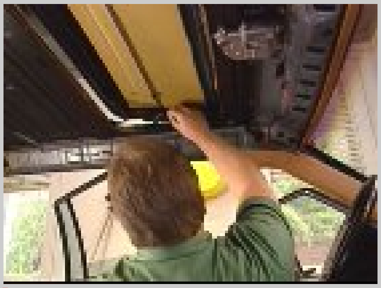

Figure L

- With the sunroof in the vent position, use needle-nose pliers to release the springs so that the sunroof headliner will lay flat.
- Slide the panel back so that the top can be removed.
- Mark the locations of the sunroof mounting screws carefully (**figure L**), then remove the screws.

Figure M

- With the screw removed, carefully lift off the top of the sunroof (**figure M**).
- Remove the sunroof air-dam.

Figure N

- With the top portion of the sunroof removed, the sunroof headliner simply pops out (**figure N**).
- Inspection of our sunroof headliner reveals that it is

in fairly good shape. The fabric on the sunroof headliner is actually attached to a metal framework (**figure O**). Repair for the sunroof headliner should be fairly simple when compared to the overall headliner repair.

Figure O

Volvo OEM Instructions. Below are the Volvo OEM manual procedural steps for removing the parts and panels noted above, from the exceptionally illustrated "Body Fittings-Exterior" (TP 8202201) available from Volvo Tech Publications:

- **Sedans/Saloons:**
  - Remove sun visors with bracket;
  - rear view mirror (slide cover to one side by prying, then remove attachments)
  - front grab handle above passenger door and cover above driver door
  - A-post pillar panels (insert spatula between panel and molding at top and pry; or remove screw in retaining panel for later cars)
  - Rear seat lamps and reading light
  - Rear seat grab handles
  - Headlining top side panels held by clips (use fingers to pry off)
  - Rear center clips for headliner and rear window top molding, which may be stuck to butyl tape on window
  - Sunroof: open sunroof and remove clamp and edge molding around sunroof opening
  - Secure drivers seatbelt to outside of door pillar.
  - Transmission: engage 4th gear (manual) or position 1 (auto)
  - Remove top windshield molding
  - Lower headlining and pass through the roof lighting unit while pulling out headliner from rear side panels.
  - Remove headliner diagonally through passenger side door OR remove windshield and pass it through the front: this is a two person job!
  - Vehicles with sunroof: remove traces of adhesive from edges of base plate.

- **Wagons/Estates:**
  - Sunroof equipped: open sunroof completely. Remove sunroof motor cover or manual crank and cover
  - Remove front grab handle and cover above driver door
  - reading lamps over rear seats

- roof light (note two u-shaped plastic retainers for this unit
- rear grab handles by prying off cover strip
- plugs in top of B- and C-post panels, then the screws retaining these panels. Pull out panel at top.
- Insert spatula at front roof panels, pry and pull straight out.
- Loosen A-post panels at top and remove
- sun visors, brackets, and rear view mirror by sliding casing to one side. Loosen mirror attachments.
- cargo space light and disconnect wiring from light. Remove clip behind light by turning 1/4 turn.
- clips retaining rear top panel and remove panel.
- rear roof panel by inserting spatula under the edge and prying.
- Sunroof equipped: remove joint cover retaining edge surround molding, then remove molding . Detach fabric material at sunroof (which may be glued into position: use a hot air gun on the metal to loosen).
- clips in roof above rear seat; and molding above windshield by pushing forward.
- Push headlining forward so it hooks onto attachment at roof light, then pass roof light through hole.
- Pull headlining back through hatch: this is a two person job!
- Vehicles with sunroof: remove traces of adhesive from edges of base plate.

In the description that follows, the work begins on uncovering and repairing the damaged headliner board, and re-covering it with new headliner fabric.

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3. Headliner Repair: Board Repair, Fabric Replacement, and Reinstallation

Below are instructions for uncovering and repairing the damaged headliner board, and re-covering it with new headliner fabric.

Materials:

Standard mechanic's tools (wrenches, ratchets, extenders, screwdrivers, nut-drivers, etc.)
Replacement headliner material
Soft-bristle brush
Glue gun and
Spray-on automotive-grade contact adhesive
Duct tape
Razor knife
Scissors
Respirator mask
Eye protection

Repairing a Damaged Headliner Board

Since our headliner board broke apart upon removal to fix a sagging headliner, repair to the board would be required. This situation is not uncommon since sun and heat damage typically causes headliner boards to become brittle and increasingly fragile over time. Many are simply made from a pressed-cardboard material. However, in our case the damage to this board was repairable.

- Begin by scrubbing all of the old foam and glue from the headliner board using a soft-bristle brush or coarse sandpaper. (**figures A and B**). This step is critical to repair of the old board since the new covering will need a clean surface to adhere to. Without a good attachment, a new covering will sag just as the old one did.

  Important: Avoid using a wire brush. It may tear the headliner board.

  Important: Never use a chemical glue-remover to clean old adhesive from a headliner board.

Figure A

Figure B

- The repair begins of the back (underneath) side of the headliner board. Lay the broken pieces out onto a flat surface to align them (**figure C**).

Figure C

- Use caution when aligning the pieces to avoid overlapping the edges. Creases left from overlapping will show through the new fabric.

- You can use ordinary duct-tape to join the cracks where the pieces join together (**figure D**). Double-tape all of the cracks to ensure a secure repair.

Figure D

  Important: Avoid using duct tape on the interior side of the board, as it will leave a crease in the headliner fabric.

- Trim away any the excess duct tape along the edges using a razor knife (**figure E**).

Figure E

- Repeat these steps to repair all of the damaged areas.

- Once all of the parts of the headliner board have been joined together securely, carefully flip the board back over. You're now ready to apply the new fabric cover.

- The fabric covering comes with a cloth side and a foam side. You'll need to have a piece of fabric slightly larger than the headliner board so that the edges of the fabric hang over the board on all sides. I cut the fabric 6" longer than the board.

- **Important**: Use only a spray adhesive specially formulated for use with auto trim. This type of glue is made to withstand extremes of heat and cold and continue to hold its bond. **Safety Alert**: Always work in a well ventilated area when working with spray paint, glues, solvents or other hazardous chemicals.

- The contact adhesive should be applied with a glue sprayer to the surface of the board (**figure F**) and to the foam side of the fabric covering. The bond forms when the two surfaces are brought together, and the glue achieves optimum tackiness for bonding about 30 seconds after spraying. Once the glue has been sprayed onto both surfaces, you can carefully lift and position the fabric, allowing it to drape over the edges of the board (**figure G**).
- Fold the fabric in 3 sections - no cutouts for sunroof - and glue one section at a time. Using the sprayer, apply an even coat of glue to the first third. Get your helper and start at the rear being sure to totally anchor the molded section allowing headroom for the backseat. Smooth the fabric down onto the board, beginning at the center and working your way outward.
- Repeat the process, spraying the foam surface of the cloth and the board surface, on the remaining thirds. Once that application of glue has set up and is tacky, drop the fabric into position (**figure H**) and press the fabric lightly to smooth it and glue it down (**figure I**). Avoid pressing down heavily onto the fabric as this may force the glue to the surface. After doing all 3 sections, trim to 1" around edge and flip over and spray glue to secure.
- An alternative method first adheres the center of the fabric to the board, a tip passed along by an auto upholsterer. Assuming you have the backer board out of the car and nicely cleaned up, run one pass of adhesive along the backer board midline.....one end to the other..... and then one pass on the new headliner material along its midline. Glue headliner to backer board. Then fold

one half ofthe headliner material back from edge to glued midline, spray adhesive on half the backer board and the folded back part of the headliner. You may want to place clean paper around the headliner edge between the two layers before spraying adhesive so it doesnt get on the other half of the headliner which is facing up. Then, roll the headliner back onto the backer board starting at the midline. Slow and steady, light pressure with your hands, and it should lay down flat and smooth. Then repeat for the other half.

Figure F

Figure G

- 

Figure H

Figure I

Figure J

- With the headliner fabric in place and properly contoured, you can flip the headliner board over (**figure J**) to trim the excess fabric from the edges.
- Start by cutting around the outside, leaving an inch or so of overlap. For the sunroof opening - cutout leaving 6" fabric to secure to the roof opening in the sunroof frame. (**figure K**).

- Use your scissors to punch holes in the fabric in the appropriate locations for the visors and mirror.
- Fold the overlap along the edges and glue it down along the front and back (**figure L**).


Figure K

- This **sunroof panel**, is consists of two pieces that will be covered separately. Begin by peeling off the old fabric covering the panels (**figure M**). This may be more difficult to remove than the fabric that was covering the headliner but the glue is easier to remove and cleanup is quicker.


Figure L

  Important: A commercial grade automotive contact cement will be required to bond the fabric to the metal frame.

- The headliner material is attached to the sunroof panel by gluing only the edges of the sunroof panel, and not the backside of the panel.


Figure M

- Once the glue has been applied, stretch the fabric tightly over the panel to make the fabric thinner. This will make the sunroof headliner slide more easily and fit better. Fold the material over the edges and press the fabric down (**figure N**). This side of the panel will not be visible once the panel is installed, so it won't matter if the glue bleeds through the fabric in these locations when pressed down.


Figure N

- Once the glue has set, cut an opening for the vent and trim away the excess (**figure O**). Fold over any remaining overlap and glue it down tight.


Figure O

- Repeat the steps for the other portion of the sunroof panel. Remember that glue only needs to be applied so that the edges are secured on the underneath side of the panel -- unlike the gluing process used earlier for the headliner board.

- With the sunroof removed, it's a good time to check some of the operating components such as the drains and motor. On this vehicle, the drains connect to four separate water hoses (**figure P**) that drain the water away and out of the car. Check the drains to ensure that they are not clogged, and check the hoses and clamps to make sure they are in good order. Also check the drain troughs to ensure that they are not blocked with debris.

- Check to see if your sunroof mechanism needs lubrication. Since our vehicle has a power sunroof, we took this opportunity to check the electric motor and wiring (**figure Q**). If your power sunroof motor is dragging or causing problems, this would be a good time to replace it.

Figure P

Figure Q

After repairing the board and recovering the material, the headliner and sunroof panel are reinstalled in the vehicle. [Chris] I put the board back in the car through the front passenger side of my sedan, the same way I took it out. I moved the seat as far back as possible, and lowered the back as far down as possible. It does go in without taking the seats out. Try real hard to get the new headliner board back on the roof without breaking it.

All vehicles:

- Install in reverse order. A slight deformation of the headlining paper material (not the cloth) at the sun visor attachments is OK as it is not visible once the headlining is installed.
- Vehicles with sunroof:
  - tape the leads in the recess in the top of the headlining;
  - position rear drain hoses in headlining recesses
  - keep drain hose screw clamps from exerting pressure on headlining
  - apply double-sided tape to base plate around sunroof opening
- Slide in headlining beneath the rear side panels and loosely support front edge on the sun visor attachments or mirror. Sedans/saloons: slide in headlining through passenger side door; wagons/estates: slide in through rear hatch. In

both cases this is a two person job.

- Vehicles with sunroof: remove backing paper from tape installed to hold fabric;
- Center: install headlining at rear with clips (pre-92 have two clips; 92+ have three)
- Vehicles with sunroof: stretch material around sunroof opening; fold in edge and install edge protector molding with joint at center of rear edge with joint cover
- Reinstall trim panels and attachments.
