The Volvo Performance Handbook & The Gothenburg Bible

Volvo Preventive Maintainance - Volvo Performance Upgrade - Volvo Repair - Volvo Technical Data

Maintaining or modifying your Volvo? Perhaps our books can help.......

PV 544, 120, 1800 S/E/ES, 140, 160, 240, 260, 740, 760, 780, 940, 960
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"The Gothenburg Bible" and "Volvo Performance Handbook" contain technical data, tips, and proven solutions for Volvo sedans, wagons and coupes. Clear explanations of mechanical and electronic systems, combined with the insight provided by years of troubleshooting, repairing, modifying and competitively driving Volvos makes these books a unique and valuable addition to a home library, garage, or service department.

About Our Books:

- Gothenburg Bible
- Volvo Performance Handbook
- Reader's Comments
- About the Author

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The Gothenburg Bible

General Information

Title: The Gothenburg Bible
Author: Paul Grimshaw
First Released: First Edition Released August 1995
Current Edition: Second Edition Released June 1996
Format: "Lay Flat" GBC Spiral Bound, Wipe-Clean Front & Back Cover, 9 x 11 1/4 inches
Length: 109 pages, Eight Chapters
Additional Features:

- E-Mail Support to Registered Users for One Year

Manufacturer's Suggested Retail Price: $29.95 (US Dollars)
Retailers: iPd, Volvo Club of America (members only), or Direct From Author

"The Gothenburg Bible", named after the Swedish city from which Volvos originated, provides the novice, intermediate and advanced do-it-yourselfer with information on automotive mechanical principles and longevity. The theme of the book focuses on preventative maintenance of major components and covers PV 444 & 544, 120 Amazon, 1800, 140, 160, 240, 260, 740, 760, 780 Bertone, 850, 940, 960, S/V/C 70, S/V 90 and S80 models.

The book is richly illustrated with scores of figures and tables, dimensional/perspective illustrations, graphs, charts & formulae.

"The Gothenburg Bible" is an ideal companion to owner's manuals, workshop manuals ("Chilton", "Haynes", "Robert Bentley" etc), and Volvo service literature. It has been enjoyed by every-day owners, serious Volvo afficiandos and professional mechanics throughout the world!!!

Order a copy today and treat your Swedish Beauty to the secrets of eternal youth!

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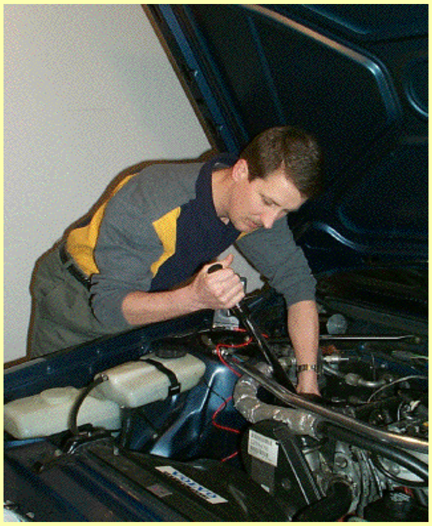

About The Author...

Paul Grimshaw has been fixing, competitively driving and writing about Volvo cars for the past ten years. An avid "shade-tree mechanic", Paul believes that meticulous research, quality parts and applied basic mechanical principles are important building blocks of automotive maintenance and reliable performance. In 1993 he founded Alliance Volvo, a non-profit club serving Canada's national capital region which quickly grew into the largest club of its kind in Canada.

His monthly column entitled "Keeping Your Volvo Like New" in the featured critically acclaimed club newsletter provided both novice and experienced owners with a wealth of information on practical, long-term maintenance. This theme was continued as the founding Technical Editor of Virtual Volvos, an Internet-based news magazine dedicated to Volvo cars.

Paul's first book, produced in 1995 and entitled "The Gothenburg Bible", focused on preventive maintenance. The book was an instant hit -- reaching out to those enthusiasts wishing to efficiently maintain their cars.

Since that time he has completed his second work, "The Volvo Performance Handbook". This book examines Volvo performance issues in a no-nonsense manner, providing upgrade philosophies, tips, and part numbers to the growing enthusiast base.

Paul Grimshaw regularly supports various clubs and media groups by providing special articles, technical workshops and through consultative work. A frequent contributor to the media, Paul has been published in the "Wheels" section of the Southam daily "The Ottawa Citizen". Watch for his column, entitled "Oversteer", in Volvo Club of America's "Rolling" magazine.

"The Gothenburg Bible" and "The Volvo Performance Handbook" may be ordered directly from the author or from participating retailers.

The Volvo Performance Handbook

General Information

Title: The Volvo Performance Handbook
Author: Paul Grimshaw
Version - 2nd Edition (February 1999)
Format: "Lay Flat" Spiral Bound, Plastic Laminated Front & Back Cover, 9 x 11 1/4 inches
Length: 130 pages, Seven Chapters
Additional Features:

- Appendices on Volvo Handling
- Tire & Wheel Charts
- Camshaft Specifications & Part Numbers
- Worldwide List of Performance Suppliers & Volvo Enthusiast Clubs
- Engine Specifications
- Glossary Covering Performance Terminology

Manufacturer's Suggested Retail Price: $35.95 (US Dollars)
Retailers: iPd, Volvo Club of America or Direct From Author

"The Volvo Performance Handbook" details how to plan and modify the chassis, suspensions, engines, and braking systems of Volvo 200, 700, 800, 900 and S/V/C70 & 90 series cars. The book highlights proven and economical performance solutions and is the first its kind to de-bunk the myth that Volvos are square, slow and sensible.

The Volvo Performance Handbook's 130 pages are organized into seven chapters containing 99 figures and tables covering the following a broad range of subjects from planning to testing your project Volvo. Special appendices on handling and terminology will enable readers to define and discuss performance needs with professional tuners, steering clear of the pitfalls often associated with performance upgrades.

New to the Second Edition is a comprehensive listing of the specifications and part numbers of Volvo camshafts for all gasoline Volvo engines built since 1944!

This is an incredibly detailed book, drawing upon a wealth of experience and years of research. A one-of-a-kind, "The Volvo Performance Handbook" promises to be a valuable reference to those seeking the best performance from later-model Volvo sedans, wagons and coupes.

Order your copy by clicking here.

The Volvo Performance Handbook

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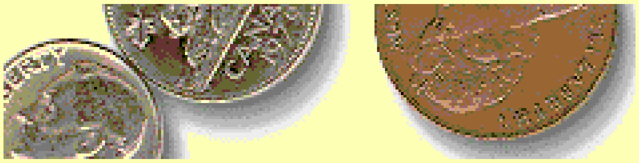

Book Prices

Q: I enjoy automotive manuals but consider their price to be rather high.

A: A $25-40 (US) price point for *any* technical book is extremely competitive considering the research, special equipment and time which are required to support their production.

Specialty automotive magazine subscriptions cost between $20 and $50 -- and half of what you get for this price is advertising copy. Some magazines such as Road&Track, EuropeanCar, and Auto und Sport provide very good technical information in their articles, but Volvo-specific data is rare!

The primary publisher of technical books in the U.S. is the Society of Automotive Engineers (SAE). SAE publishes and sells most of its technical works in paper-back, ring bound format at prices ranging from $50.00 to $75.00. Few, if any of these books are written to support a particular make of car, and coverage of Volvo models is almost non-existent.

Volvo Technical Series, distributed by Volvo Cars of North America, for a specific model/year cost about $500.00 to $800.00. These books provide definitive advice on repair (I highly recommend these books if you are planning do-it-yourself repairs) but do not address preventive maintenance or performance modification.

Price isn't everything; it's value that counts most. To that end, it is important to consider the advantage of owning books which fill a need. If one of our books' many tips prevent accelerated wear or breakage, an ill-advised expense, or 1/2 hour of shop labor, then they will have proven their worth.

Readers' comments indicate strong support for our books and suggest a loyal and dedicated audience.

Q: Our Volvo Owner's Club is interested in carrying "The Gothenburg Bible" and "Volvo Performance Handbook". Do you offer bulk discounts?

A: Discount prices are applicable *only to accredited clubs and retailers*. Special prices may be obtained when submitting a single order of 10 or more books. EMail for details.

Q: Do the prices quoted on your homepage include postage?

A: Yes. The prices quoted for private purchasers include postage via first class surface mail to anywhere in the world. Those interested in receiving their book via Air Mail are encouraged to EMail for details as delivery prices will vary according to location.

Bulk purchases by clubs and retailers will be shipped via UPS GroundTrac®. The cost of this service ranges from 60 to 80 cents per book for deliveries within North America. Shipping to Europe and Australia, however, varies considerably as not all countries permit direct UPS operations. In such cases, extra charges will be incurred as UPS will have to transfer the shipment to a national or local courier for final delivery. Again, this is an issue that can best be cleared up by EMailing in advance.

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Should you be inadvertently charged duty at your end, take your shipment to a local US Customs office and refer to the desk clerk to TSUS 4901.99.0070. This article in US Customs Policy acknolwedges that our books are duty free and will help you secure a refund and correct any oversight on the part of the US Customs Service.

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We value your service and take all reasonable means to get our books to you on time and in good condition.

The Volvo Performance Handbook

&

The Gothenburg Bible

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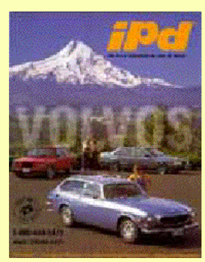
iPd has been a well-respected source for aftermarket Volvo parts and accessories since 1962. iPd sells "The Gothenburg Bible" under Stock Number 9L0200 and "The Volvo Performance Handbook" under Stock Number 9L0240. VISA, MasterCard, Discover and American Express Accepted. Worldwide shipping available.

Check out their specialty catalogs for reasonably priced replacement parts!



The Volvo Club of America, Afton, NY, USA

Phone/Fax 1-607-639-2279

The Volvo Club of America is a popular owner's club serving North America. Club members may order "The Gothenburg Bible" or "The Volvo Performance Handbook" under their discount books program. VCOA accepts VISA, MasterCard, and American Express.

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The Gothenburg Bible®
Long Term, Cost-Efficient Maintainance for All Volvo Automobiles

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The Volvo Performance Handbook®
Sports Car Performance from Sedans, Wagons & Coupes You Can Live With

Item	Quantity	Price
The Gothenburg Bible	________	@ $25.00 (US) or $30.00 (Cdn) each (price includes delivery via first class surface mail)
The Volvo Performance Handbook	________	@ $35.00 (US) or $40.00 (Cdn) each (price includes delivery via first class surface mail)

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E-Mail Address ________________ Year/Model(s) of Volvos Currently Owned ____________

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The Volvo Performance Handbook

Figures & Tables

Figures:

Tables:

In the News

Listed below are comments made by Volvo specialists on our books & the dedicated e-mail support that is offered to registred owners of either "The Volvo Performance Handbook" or "The Gothenburg Bible".

"The Volvo Performance Handbook"

"Volvo enthusiast Paul Grimshaw clearly did his homework on this one. It's ring bound and was prepared on a PC, so don't expect coffee-table-book quality. But that's not the point. Each chapter is well researched and offers a clear explanation of the theory involved with each area of modification before specific recommendations are covered. That's the only flaw, as sometimes the theory covers six pages and the actual how-to tips and part numbers take a page or so. But the information is still well researched, relatively easy to read and appears quite accurate. A must for anyone souping up a Volvo."

Matt Stone, EuropeanCar Magazine, August 1998

I had been toying with the thought of doing some head modification for some time in the interest of adding a little "zip" to a car that I've become rather fond of, but being something of a novice with regard to performance upgrades on any vehicle -- let alone the Volvo 240 -- left me a bit in the dark. Needless to say your book (The Volvo Performance Handbook) was both enlightening and

invigorating and I really do appreciate your publishing it.
Jerome B.,
Renton, Washington

The Volvo Performance Handbook provides information on effective engine modifications that can increase power and handling poise without affecting reliability or drivability.

Over the past two years, Jerome & I have used e-mail to take his project car from a concept to very well-prepared car! Meeting in person at Volvo events, our "virtual friendship" has taken on new meaning.

"The Gothenburg Bible"

"Paul has the rare gift of writing and sharing information in a way that is interesting and helpful to the novice as well as the expert."
Scott Hart
iPd Newsletter
Vol. 9 No. 1

You are apparently a Volvo Master Tech, as I am. You are right on with your tips, keep up the good work.
Rex F.

"Excellent. Good show!"
Johan G.
Goteborg, Sweden

"Keep up the good work. I look forward to putting your knowledge to work on my Volvos."
Mike O.
Remington, Indiana

My books deliver engineering theory and practical information to the Volvo enthusiast. Armed with this knowledge, owners can immediately decide what is best for their Volvo.

"Thanks for a great info resource."
Bryan R.
Forest Grove, Oregon

"Thanks for providing this manual! It's a very good resource on some things that regular manuals don't address."
Doug G.
Walden, Colorado

Unlike repair manuals, The Gothenburg Bible provides strategies designed to prevent mechanical failure, salt corrosion & more. I believe that this unique approach to Volvo care is far more effective than repairing what could have been prevented in the first place!

"Have been very happy with the purchase."
Bill V.
Plano, Texas

"Wonderful book. Wish I had it eight years ago."
John G.
Glenshaw, Pennsylvania

"You have done and extraordinary and comprehensive job!"
Joshua J.,
Montclair, New Jersey

Owner Support

Let me say that your article is the best kind of automotive writing. Technical, but surprisingly accessible to those with limited technical knowledge (like myself). It successfully takes the bewildering complexity out of the subject without losing the meaning.

Mark M.

Thanks very much for your 2 excellent books. On modifying the 240 airbox (May Performance Tip) -- this worked beautifully on my GT -- cured a bad pinging problem that must have been due to a failed thermostat locking the flapper into drawing only hot air.

Robert H.

This website is intended to compliment the strategies and tips contained in my books. I'm sure that my airbox tip will compliment the high performance camshaft that you selected (after consulting "The Volvo Performance Handbook"). Combined, these mods should increase power output by 15 to 20%-- making your Volvo quicker, more responsive and, ultimately, safer.

I thought I would take a minute and give you some feedback on some advice that you gave a year or so back.

Our 89 740 Turbo has had a few short-term problems with the air mass unit or connection thereto. The last time it was a problem was in August 1998. We have been patiently waiting for a return and a few weeks back it happened. I followed your advice. After reconnecting the unit, the fault had cleared completely. It seems fairly safe to say that this was the problem and likely not the air mass unit itself as had been suggested to me two years ago.

On a slightly related topic, last month the car failed AirCare for the second year in a row. Last year, the shop was unable to diagnose any problem and when the car was re-tested, it passed. This year it was discovered that the O2 sensor was cooked; replacing it solved the problem. Perhaps it was intermittent last year and we were just lucky the second time.

Cam F .

Diagnosing problems over the 'net can be difficult. Fortunately, few well-cared for Volvos suffer from major problems -- many tales of horror can be a simple case of misdiagnosis by a mechanic. Armed with the proper advice, Volvo onwers can play an active role in servicing their cars.

It's not rocket science, just economical!

I recently purchased your Volvo Performance Handbook and I love it! It is extremely insightful, and Website really adds to it as well.

Mark J.

The single most important lesson I have learned from reading technical material is that knowledge can be limited by the pages of a book. E-mail and web technology allow me to reach beyond the pages of my books to better support to you & your Volvo!

Paul, I'd like to thank you for the detailed response to my posting. I can see that it took you some

time to prepare and it is an excellent tool to assist me in finding the culprit that keeps my car from starting.

Mike W.

I work more with people than publishers, and more with drivers than readers! My support to registered owners extends beyond the short, pithy answers commonly provided by automotive writers.

Thanks for sharing such thorough research on my diesel-turbo-intercooler questions. I very appreciate your spending so much time with the Volvo technical data. The information on diesel component differences and boost pressure differences is most helpful.

Jim M.

I learned alot by researching the answer to your question. Compression ignition engines are lamentably overlooked by mainstream authors. I'll keep my eye focused on diesels in future tech articles!

Just wanted to thank you for taking the time to respond to our inquiry. My husband and I were very impressed and appreciated it very much. He drives a Saab so we had been debating about which would pull the camper best and at your advice, feel the Volvo will handle it best.

I also appreciate your books from a woman's standpoint, a non-tech minded one.

Cheryl and Lyle D.

Volvos are very versatile and, with the proper preparations, make ideal vehicles for the summer camping trip or winter back-country ski adventure. Versatility is also an important aspect of my books, which are designed to satisfy a diverse readership: from the die-hard techie, to the interested owner.

I must say that an opinion is one of the most valuable sources of information available today. The problem I find is everybody wants to share their opinions, but very few want to give a well-constructed or thought-out one. Being as new as I am to the field of automotive repair, I have to weigh the value of all the various opinions from different viewpoints, whereas someone with greater expertise can (but shouldn't) discount certain ones. I've found that yours are the most valuable of all, only because of their technical content, but also due to the thought and principles behind the opinion.

I read all of your postings whether they are relevant to my model or not; often the ideologies presented apply on a more philosophical level and span a broad area of thought.

Just wanted to thank you back for your help thus far. I'll be anxiously awaiting your return!

Chris B.

from an INTERNET Newsgroup

When it comes to newsgroups, my opinion has landed me into more hot water than my tech advice!

The time devoted to registered book owners grows wih my readership, making my forays into newsgroups difficult to sustain. I do, however, promise to answer *every* tech question posed to me via e-mail by registered owners of my books.

An entertaining and educational post; learned more about Volvos in your one reply than I have in ownership over the past 20 years. That's partially my fault and partially credit to you for a great reply!

Rich N.

Thanks a million for your explanation and advice. You were exactly right; the injectors I got were for the non-turbo.

Mike P.

You responded to my plea for help about my 740 flooding when cold. Though you would be pleased to know that you called it correctly. It was the water temperature sensor.

Bill H.

In your article (More Than Just Some Loose Change), you point out that many 'component' failures are actually due to poor connections. Exactly. After 5 years repairing HP Laserprinters, it became obvious that most 'component failures' were really the result of 'vibration corrosion' on the connectors. I saved many customers from high repair bills by simply reseating and 'tweaking' small electrical connections. No component failure; simply failure to get those little electrons from one place to another - across a corroded connection.

Alan R.

Thanks for the feedback. The advice provided by my article can be put to use by many owners to save themselves from very expensive, and unnecessary, repairs.

A friend of mine was raving about what a great book this is. Do you have any recommendations for a similar publication for Generation 2 Mazda RX-7s?

Dave B.

Sorry, mate. "The Volvo Performance Handbook" and "The Gothenburg Bible" are for Volvos only.

Now if only someone would give me an RX-7 Turbo as a research project... Hmmm ;-)

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The Volvo Performance Handbook & The Gothenburg Bible

Volvo Preventive Maintainance - Volvo Performance Upgrade - Volvo Repair - Volvo Technical Data

Maintaining or modifying your Volvo? Perhaps our books can help.......

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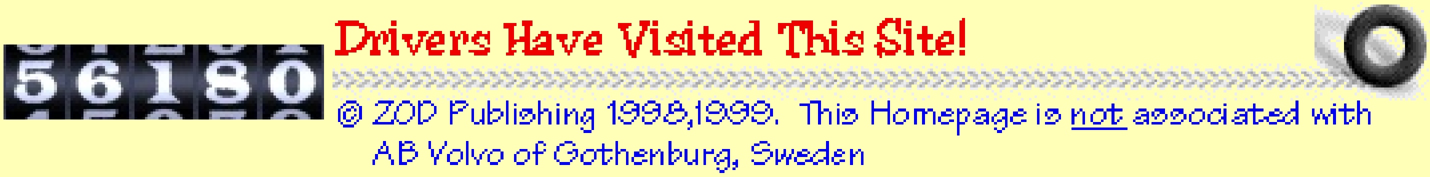

The Volvo Performance Handbook
&
The Gothenburg Bible

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The Volvo Performance Handbook & The Gothenburg Bible

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- Number of years you have owned your car;
- Odometer reading in miles or kilometers (specify);
- The Country, State or Province in which you Reside;
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Performance Tips

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The Volvo Performance Handbook

Induction & Exhaust:

Air Box Modification (All B21F, B23E/F, B230F Engines)

Cylinder Head Modification (All Engines)

Improving Throttle Body Performance (All Engines)

Anti-Reversion Techniques (B18 thru B230 Engines)

Fuel & Spark:

Fuel Injector Sizing (B21F Engines)

Spark Plugs & High Tension Wires (All Engines)

Electronic Control Unit Modification (800-series & Newer Models)

Octane Solutions for Older Volvos (B4, B14, B16, B18 & B20 Engines)

Chassis & Suspension:

Chassis Reinforcement (200-series Models)

Tire & Wheel Combinations (200-series & Later Models)

Hub Spacers (200-, 700-, most 940-series Models)

Choosing Alloy Wheels (All Models)

Alloy Wheel Cleaning & Mounting (All Models)

Wheel & Tire Combinations: Practical Performance vs Poseur Pleasure (late model Volvos)

Miscellaneous:

Lighting Upgrades (All Models)

Brake Rotor Cooling (140/160, 200, 800, 900, S/V-70, S80 Models with Vented Front Rotors)

Reducing Engine Inertia (or Increasing Power & Response) (All Engines)

Web Master's Note:

The tips listed above are a few examples of economical upgrades that improve the performance of your Volvo. More dramatic and effective upgrades can found in "The Volvo Performance Handbook" !

Registered owners of "The Volvo Performance Handbook" can seek answers to their performance questions by e-mail. This service is ONLY available to registered owners. E-mail from other parties will not be anwered.

If you have not yet ordered your copy of "The Volvo Performance Handbook", refer to the following web page:

Yes! I'd Like my Own Copy

Maintenance Tips

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The Gothenburg Bible

Powertrain:

Diagnosing Turbocharger Problems (all turbocharged models)

Saving Gearbox Synchronizers (H6, M4, M30/31 and M40/41 Transmissions)

Universal Joint Maintenance (all RWD Models)

Curing Manual Transmission "Crunches" (M45, 46 & 47 Transmissions)

Constant Velocity Joint Maintenance (700-, 900-, 800-, S/V/C70, 80 & 90 Models)

Chassis, Body & Brakes:

Rustproofing your Sedan or Wagon (All Models)

Winterizing Your Volvo (All Models)

Preventing Door Handle Breakage (200- and 700-series Models)

Preventing Brake Pad Squeal (200-, some 700/900-series Models)

Bleeding Brakes (All Volvo Models)

Antilock Brake Fault Light (all equipped models)

Brake Hose Inspection & Replacement (all models)

Suspension & Steering:

Tire Care (All Volvo Models)

Choosing Your Next Set of Tires

Steering Gear Maintenance (all models)

Electrical System:

Battery Ground Cable Replacement (most 700 Models)

Exorcising Electrical Gremlins (all models)

Keeping Rear Light Cluster Clean & Dry (All Models)

Web Master's Note:

The tips listed above are a few examples of economical upgrades that will increase the service life of your Volvo and keep repair bills to a minimum. More dramatic and effective upgrades can found in "The Gothenburg Bible" !

Registered owners of "The Gothenburg Bible" can seek answers to their maintenance questions by e-mail. This service is ONLY available to registered owners. E-mail from other parties will not be anwered.

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Automotive parts can be frustrating. First you need to identify a need, find a source, agree on a price, arrange delivery and, if mechanically inclined, install the part yourself. The aim of this page is to differentiate between "the good", "the bad" and "the ugly" parts and suppliers so you may order and install parts with confidence.

iPd's Safety Sway Bars for All Volvos

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Replacing Rear Bushings

by Paul Grimshaw

How many times has the interior comfort of a Volvo sedan or wagon been undermined by the cacophony of sounds and sensations that accompanies a drive over less-than-perfect roads? I don't know the answer, but I suspect that it occurs somewhere in America every day.

An owner's first response is often to replace the car's shock absorbers. This certainly improves comfort and control, but the suspension continues to feel its age. After months of aural discontent and imprecise handling, the car is assessed to be a victim of too many miles and too many bumps. A "for sale" sign appears in the window.

This article will focus on the role that bushings play in maintaining a good quality ride in 200-, 700-, and 900-series cars.

What Are Bushings?

Bushings are flexible cylindrical cushions fitted between moveable components to attenuate vibration and assist in alignment. Typically used between suspension components, bushings are constructed of synthetic rubber, polyurethane, special plastics or aluminum.

Bushings work by transferring the kinetic energy of moving parts into heat. Repeated heat cycles and oxidation eventually causes the bushings to shrink, harden and lose their elasticity. When this occurs, the bushings can no longer adequately attenuate vibration or assist in the alignment of components. The result is increased transmission of noise, vibration and harshness throughout the chassis.

Bushing Materials & Characteristics

Although bushings are available in a wide variety of materials, Volvo has chosen synthetic rubber to isolate suspension components in 200-, 700- and 900-series cars. Synthetic rubber has several advantages and disadvantages:

Advantage #1: It's generally resistant to mild abrasion. This helps them to endure friction from road grit and rust;

Advantage #2: It's inexpensive to formulate and mold, reducing components' manufacturing and replacement costs;

Advantage #3: Rubber has excellent noise and vibration damping qualities. These qualities help reduce unwanted noise from entering the passenger compartment;

Disadvantage #1: Rubber will deteriorate if exposed to moderate-to-high temperature, ultraviolet radiation, oxygen or hydrocarbon fuels or lubricants; and

Disadvantage #2: The damping characteristics of synthetic rubber will change with temperature. On very cold days, rubber bushings will harden considerably. On very hot days, the rubber will soften to the point where deformation will occur.

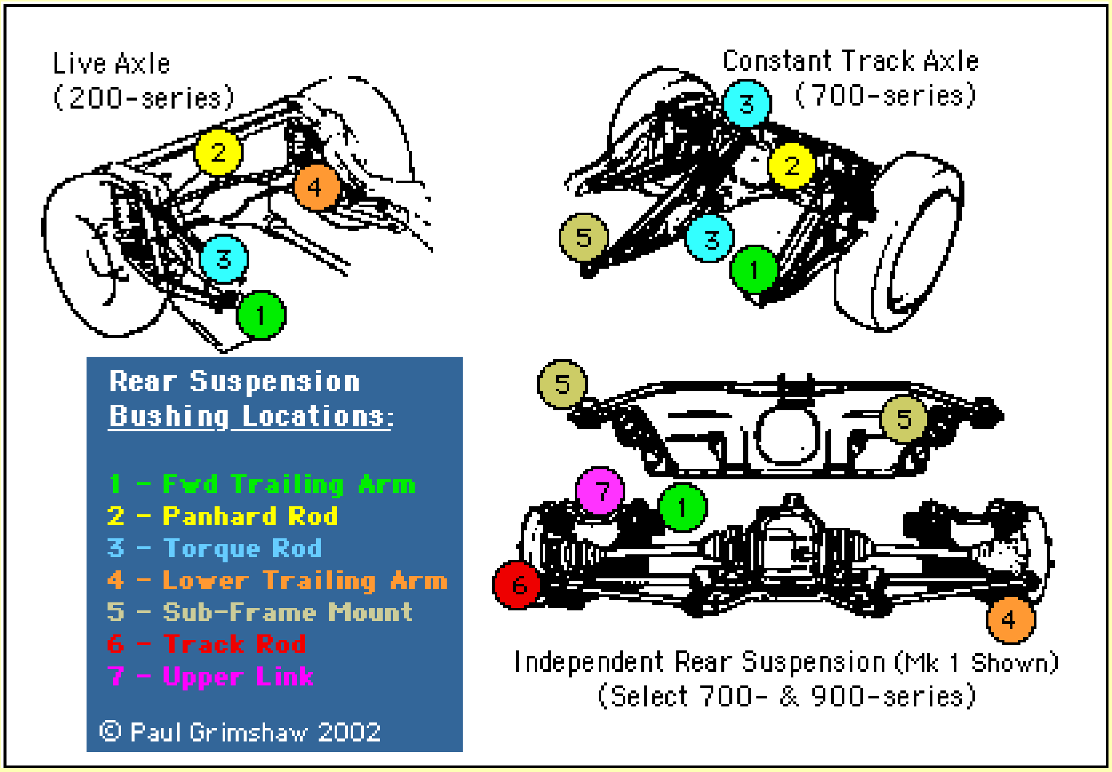
Polyurethane bushings can be used in applications that are exposed to tension, but not shear. Its slightly higher cost is offset by excellent temperature stability and good resistance to heat and chemicals. Polyurethane has very good damping characteristics, being slightly stiffer than a corresponding rubber bushing.

Delrin, a Teflon-impregnated acetal plastic developed by duPont in the 1950s, is sometimes used to manufacture competition car bushings. Although Delrin possesses high strength and exceptional resistance to non-acidic chemicals, its relative hardness makes it unsuitable for application in passenger car suspension bushings.

Aluminum is very durable, but transmits too much noise and vibration to be suitable for use in passenger cars.

Location and Service Life of Volvo Suspension Bushings

The location of bushings in 200-, 700- and 900-series cars is shown in the diagram below.



The life span of the bushings shown is greatly affected by suspension design.

The lower trailing arm suspension bushings in 200-series cars bear considerable loads from the movement of the heavy live axle assembly. The torque rod bushings in these cars are prone to rapid wear as driveline torque twists the bushings during brisk acceleration.

Lower trailing arm bushings require replacement after five to seven years of normal driving. Stock torque rod bushings should be replaced every three to five years, but polyurethane versions can last twice as long provided that they are lubricated before installation.

The sub-frame in the 700-series cars does a much better job of controlling unwanted movement of the axle assembly. As a result, 700-series torque rod bushings normally require replacement every five years, whereas bushings elsewhere in the sub-frame should be replaced after about seven years of normal driving.

The bushings used in Independent Rear Suspensions (IRS) generally last much longer than those used in live and constant track axles. Increased life span is attributable to the lower unsprung weight of IRS suspensions. When it does occur, wear is usually found in the track rod and lower training arm bushings. These bushings should be replaced after five years of normal driving.

The Seven Habits of Highly Effective Suspensions

Some of the tips listed below can be found in Volvo technical publications. Others, however, are based on practical experience.

Tip #1 - Many bushings for Volvo 200-, 700- and 900-series cars are wrapped and sleeved with steel to isolate the rubber from any shearing forces imparted by moving suspension components. These bushings are installed with the aid of press tools and hydraulic rams.

Mechanics occasionally to install 200-series lower trailing arm bushings backwards or upside down. Lower trailing arm bushings are tapered and slightly oval. They must be aligned properly and installed with care, not brute force.

Tip #2 - The bores of steel sleeved bushings should be liberally coated with anti-seize compound prior to installation. This will help prevent through bolts from rusting to the sleeves and shearing the bushing material during suspension movement.

Tip #3 - Threaded suspension fasteners should not be tightened until weight is placed back on the suspension and the car is at normal ride height. The use of a torque wrench to properly tighten nuts and bolts is essential to ensuring normal suspension function. Do not, under any circumstances, use an impact wrench to tighten suspension bolts.

The torque specifications for suspension components can be found in the appropriate Volvo technical publication for your car. Publications are available at reasonable cost by calling 1-800-25-VOLVO.

Tip #4 - Beware of the used car business practice of spraying oil on worn bushings. This may temporarily mask noise, but can accelerate the disintegration of the bushing material. Lubricants, free of solvents or penetrating compounds, may be safely used to reduce the noise created by "dry" polyurethane suspension bushings.

Tip #5 - Do not use Delrin in place of rubber or polyurethane bushings in Volvo passenger cars. Delrin's reputation as "synthetic stone", a nickname applied to the material by duPont's Assistant Research Director Frank C. McGrew in the 1950s, is well-earned!

Tip #6 - Tip #5 may be equally applied to aluminum bushings.

Tip #7 - Check alignment after replacing the rear bushings in 700- or 900-series Volvos equipped with an Independent Rear Suspension.

Conclusion

Periodic bushing replacement is an important element of rear suspension maintenance. Careful installation of the proper bushings will take years off your car's ride and make you wonder why you ever considered selling your "older" Volvo.

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Body & Chassis FAQ

Q: I was wondering if you have any advice for winterizing Volvos? I'm planning to move to Edmonton, Alberta.

A: Edmonton? I thought Ottawa was cold! Between December and February, Edmonton is like the dark side of the moon! Winter night-time temps of -40 to -45 are common, so you'll need to have the following equipment fitted:

a. A battery blanket (an insulated, electrically-heated wrapper which keeps the battery warm overnight). It will prevent the battery from freezing and will aid in cold weather starts. Cost: around $15.00;

b. A block heater (if not already fitted). I recommend the original Volvo block heater. Cost: around $40.00

c. A heavy duty battery. Get the *largest* one which will fit. Generally around 700 to 800 cca (cold cranking amps) should do. Of course, make sure that the battery cables are clean, tight and well crimped. Cost: around $80.00;

d. A grille cover. This will prevent the rad from freezing while the car is underway (Remember that the wind chill at highway speed could be as cold as -70F). Just abount any brand will do fine if trimmed to fit. Cost: $20.00

e. The proper fluids. Most usually forget this one, although using 5W30 synthetic motor oil and 80W90 synthetic gear lube for the rear axle will help fuel economy and reduce driveline strain. Although I'm a big fan of most synthetic oils/lubes, Mobil 1 has my vote because of its cold weather performance (it pours at -63F and flows at -40F). Try AMSOil gear lube for the final drive unit..... it has served me well.

f. A set of *very high-quality* jumper cables (8 ga wire). Cost: $50.00. If you have a well-tuned car and the above equipment you may not ever need a boost, but you'll be well received by "damsels-in-distress"!

Since your car is a U.S. model, I presume that it is fuel injected. If so, it should fare quite well. K-Jetronic equipped cars start better in the cold since the higher fuel pressures improve atomization (remember, at -40F, the fuel does not vaporize, it remains in small droplets). LH-Jetronic cars are quite acceptable. Carburated cars tend to stop working at temps lower than -35F, unless their block heaters and battery blankets are *always* "plugged-in".

Living in Ottawa, the world's second coldest capital city (just behind Ulan Bator, Mongolia), gives one a good appreciation for cold weather operations. Equiping the car is the first step. Equiping yourself is the second. I recommend that every car carry the following:

a. a candle and matches

b. a sleeping bag;

c. a spare pair of gloves, winter boots and a hat; and

d. a few candy bars.

I'm glad to have had the opportunity to answer your questions concerning body work and cold weather preps. As they say in Canada: "Good luck, eh!"

Q: What do you recommend for repairing corroded metal?

A: To truly repair rust damage, one must cut the bad metal out completely and replace it with new steel. Depending on the year/model of your Volvo, the following areas may some sign of rust:

a. front fenders;

b. spare wheel containers (those half moon cubby-holes beneath the cargo hold);

c. rear hatch;

d. edges of the rear wheel arch & rocker panels;

e. along the rear valance, just behind the rear bumper; and

f. the small stowage bin under the cargo hold floor.

Sub para "a" is the easiest to repair.... just bolt on a new replacement fender and paint. Very little skill required.

Sub paras "b, c & d" may be repaired fairly easily with replacement panels. A good body shop can get them through Volvo and weld them into place, using the belt-line trim to conceal any bead. It is likely, however, that some minor work will be required around the wheel wells themselves, possibly in the area of the seat-belt anchor bolts.

Sub para "e" is somewhat more difficult and often requires a repair panel and custom metal work.

Sub para "f" is much more difficult and requires some truly artful (expensive) metal work.

Body work is, in my opinion, as much of an art as it is a science. Using metal replacement panels are a must since they preserve the structural integrity of a unit body chassis. Body filler should only be used to smooth over *metal* imperfections prior to painting. The quality of the job is generally directly related to how much you pay.... and a good job costs a lot of money. (That's why the Gothenburg Bible recommends very complete rustproofing, using quality materials.)

Q: Is there an easy way of removing the undercoating from Volvo cars? I've be chipping it off but it's going really slow.

A: Yes, there is an easier way. Take your Volvo to a Truck repair facility. Many have HP Steam systems used to degrease million mile rigs before re-builds. A few brushes of the wand and the rustproofing will melt right off. A low enough temperature setting does not melt the rubber though since no trucker wishes to replace *all* hoses and electricals come re-build time.

Q: You recommend weekly washings. Does this still apply in the winter when the temperature is below freezing? How about below zero? Please note that at these temperatures, handwashing is not really an option. What are your feelings on "touchless" commercial washing. This is an automated high-pressure process where nothing contacts the car but the water.

A.: Regular washing of your Volvo is still recommended and can (depending on windchill) be successfully carried out until -14C/5F. At these temperatures, however, it is imperative to make sure that door locks and hinges are kept well lubricated and that door seals are chamoised dry before the car has a chance to freeze up.

In temperatures below zero F, even salt water freezes. This effectively prevents the salt-laden sluch from acting as an electrolyte. In other words, the rusting process slows considerably! This helps explain why east-coast cars tend to rust out faster than say, Chicago cars. The borderline freezing coastal conditions provide just enough heat to keep salt water in a liquid form where it can act as a very effective electrolyte.

Although many "car washes" appear to clean a car, they tend to leave behind a thin film of road dirt. Exceptions to this are the brush-based systems which tend to scratch a car's finish. The bottom line is that careful hand washing remains the best way to safely clean delicate automotive finishes.

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Engine FAQ

Prologue - Those unfamiliar with Volvo's engine designation methodology may wish to read a special article on the subject

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Engine General

Q: I'm trying to find the carburator specifications and rebuild information for a 1989 740. This car has a VIN of YV1744836Kxxxxxxx. As I write this, I have an engine code of 48 indicating a B21F-8. I got this car from a returning service member who said he couldn't get it worked on to find the local Volvo dealer is totally unwilling to even talk about working on it, although they can sell me a kit.

A: If you're writing from Canada or the U.S., it would appear that the car is a grey-market vehicle (probably from Eastern Europe, Middle East or Asia). That is to say that the car was imported by someone other than a certified importer (serviceman) and does not meet Transport Canada or U.S. Department of Transportation specifications.

The reason why the dealer won't touch it is because none of his technical manuals will contain anything on a carburetted '89 740. Depending on the locale, it may be illegal to adjust a vehicle that does not have things like a catalytic converter.

The Gothenburg Bible provides maintenance strategies for Volvo cars. It is not a repair manual. There are many repair manuals out there -- even for your car. The trick is finding the correct one. I would tray writing Haynes Publishing Group, as they'll likely have a manual covering the market from which your car originated.

Q: I have a 1993 850 5 speed manual with 159,000 miles. My car is affected by a recurring problem every winter. When coming to a stop sign and bringing the car to a stop, the engine speed drops, the engine hesitates, and stalls. This sequence is very predictable on winter mornings below 30F and occurs even if the engine is fully warmed up. Any ideas? Tune up done per Volvo intervals, cleaning air box, flame trap replaced - all done.

A: It's often difficult to diagnose intermittent engine problems, but your e-mail provides some clues that narrow down the cause of your 850's habit to stall during the first stop of a cold winter day.

I suspect that the problem could be attributable to combination of faults (all of them minor):

a. throttle position sensor (TPS) out of adjustment. This prevents the ECU from switching to the idle map and maintaining idle stabilization with the Idle Air Control (IAC) valve. The TPS needs to be adjusted to a high degree of accuracy and could account for the idle problem disappearing as the engine is warmed up (minor expansion of metal and plastic parts during warm-up are common). Your car's electronic control unit (ECU) will register a fault code of 332 or 333 if the throttle position sensor is not properly adjusted and 243 or 411 if the signal provided by the TPS is not responding within normal parameters;

b. IAC valve inoperative or dirty. The IAC valve works by allowing air to bypass the throttle plate when the throttle is completely closed. The volume of air allowed to bypass the throttle plate is influenced by a signal from the ECU. The ECU determines the quantity of air required to maintain idle based on input from the Engine Coolant Temperature Sensor (ECT), Mass Air Flow (MAF) meter, and air temperature sensor. A dirty IAC valve, very common on all modern Volvos, can operate intermittently. Your car's electronic control unit (ECU) will register a fault code of 223 if the IAC is not responding within normal parameters; and/or

c. engine coolant temperature (ECTs) sensor operating intermittently. This sensor varies its resistance in response to the temperature of the engine coolant. ECTs sometimes provide intermittent of fluctuating response as they age. This would explain why the engine misses during its first warm-up cycle. Its often difficult to diagnose a faulty ECT. The ECU may provide a fault code of 123. Then again, it may not, with the only other symptom being reduced fuel economy as the engine continues to operate in an overly rich condition.

The only way to confirm ECT operation is by measuring the resistance across the sensor at given temperatures. 32F should equal 7300 ohms. 68F should equal 2800 ohms. 104F should equal 1200 ohms. At normal engine temperature, the reading should lie between 150 and 300 ohms.

There are other problems that could contribute to poor idle quality. Old air and fuel filters and restrict air and fuel flow to the point where minor inconsistencies in TPS, IAC and ECT readings stall the engine. Ditto for fouled spark plugs and dirty throttle plates.

The best solution is to check each of the sub-systems, correcting any faults that may be found. I normally find that it is best to keep going after the first fault is found, as engines typically succumb to a myriad of minor problems. When everything is corrected, you'll probably find that engine response, power, fuel economy and idle quality improve simultaneously.

Q: What is considered to be 'standard' for a compression test on a 1990 B230FT?

My test came up with 130psi, 130psi, 127psi, 125psi on cylinders 1 through 4 respectively. While everything I have seen indicates that the compression should not vary by a certain percentage from the upper to lower range, no real number is given.

A: Volvo's specification for your engine (B230FT) is 0.9 MPa or 130 psig, with variation between cylinders not to exceed 20%. This specification is based on a warm engine.

In my opinion, the cylinder variation deemed acceptable by Volvo is too broad. I feel that +/- 10% is an adequate limit. Anything beyond that could indicate a problem in one or more cylinders.

Your engine's cylinders appear to be within specification. This would suggest that the rings, bores and valve seats are in good condition. To be really sure, you may wish to have a leak-down test performed. This involves filling each cylinder with compressed air of a known pressure and noting the leakage that occurs. 5% leakage is excellent, 10% is good and 15% or more indicates wear of some kind. The leakdown test will pin-point exactly where.

Q: My 740 turbo's engine is about to blow because of a blown piston ring. so when it does, I have two options - Buy a new engine or one from a used 240.

A: How do you know that you have a piston ring problem? What are the symptoms? Have you dismantled the engine to find the cause of the problem? Do you have the results of leakdown test or physical inspection?

The reason that I ask is that I know hoe expensive it is to replace an engine. It's likely to be even more expensive if you have to replace the engine, wiring harness, ignition and fuel injection computers, fuel pump and exhaust system with one from a 240.

It's important that you determine the problem affecting your B230FT, assess the cost of repair, and reconcile your performance objectives with a realistic budget.

The cost of repair could be mitigated by using a good quality used cylinder head, a re-bore/re-hone and a new set of rings and/or pistons (if that's the problem).

Q: I own a 1978 Volvo Bertone equipped with the original engine. Recently I experienced difficulty with approx 80% oss of power and very rough idle. I left my car at the garage and was told that the timing belt broke and bent the valves on one side of the engine. How can this happen? I was still able to start the car and drive it. The idle speed was high while the power was almost none existent but the car started on the first flip which it hadn't been doing previously. Is this mechanic for real? I'm going down to see the damage today but I really need to know if this is a possible engine failure.

A: Your car's motor, a B27F, is called an "interference engine". This means that the pistons and valves *will* collide if something interferes with the synchronization of the pistons and the valves.

The B27F (and B28F and B280F) use a single timings chain that is kept taut by a tensioner. The chain can stretch over time. They can, in certain circumstances, even break. When this happens, valves and pistons come into contact. Casualties can also include:

a. damaged block;
b. damaged cylinder head;
c. broken camshaft(s); and/or
d. bent connecting rod(s).

That's the theory (and practice) of timing failures. I cannot comment on how, or why your car continues to run, albeit with "80% loss of power". It is entirely possible that the chain stretched enough to jump one or more teeth on one of the cam pulleys, affecting a cylinder bank (i.e. 3 of your engine's 6 cylinders). Diagnosis beyond that is
impossible without inspecting the engine.

Q: I have a 82 240 that I will be replacing the timing belt on. I need to know how to ensure that the the belt lines up correctly. I fear that the previous owner did not take this into consideration. The car has some stange symptoms: the injector are firing , the plugs are firing, yet, when I remove the injector contact on cylinder 2 & 3 there is no change in the engine same with the plugs on those cylinders. Any ideas?

A: Align the proving marks of the cam gear, countershaft gear and crank gear with those embossed on the face of the engine block. With the idler pulley retracted, carefully slip the timing belt onto the aforementioned gears. OEM timing belts have thin yellow lines drawn across them which may be aligned to the proving marks on the gears.

Return the idler pully to the tensioned position and tighten the nut. Turn the engine prior to re-assembly to ensure that the belt has not slipped a cog.

Your original problem does not appear to be timing belt-related. 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). Your Volvo's engine uses "port fuel injection" with some cross-over occuring 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.

That being said, use a volt meter to measure the voltage being supplied to the injectors. Lacking a volt meter, one may ensure 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.

To obtain a better appreciation on combustion conditions within each cylinder, one may pull the plugs for observation. Dark grey/brown indicates normal "burn". Light grey/white indicates lean "burn". Black and oily usually means a rich "burn" or oil control problem.

Q: I have heard that a broken timing belt on a B21/23/230 engine will cause the pistons and valves to come into contact with each other. Is this true?

A: The B21/23/230 engine family is a "non-interference" engine; that is to say that the pistons and valves cannot come into contact with each other. The pistons in these engines rise to within 12mm of the top of the block. Depending on the camshaft, the valves are extended between 9.5 (M cam) and 12mm (H cam, Volvo's highest lift stock cam for this engine type) from the valve seat. This still leaves a few millimeters of space between the two components should the belt fail.

The B234 (16-valve engine) is the only "red block" (ie. cast iron) engine which will crash if the timing belt fails. For this reason, owners are reminded to service the belt regularly.

Q: The timing belt replacement interval for the original B6304 was reduced to 35,000km (I think) when piled up heads started accumulating at the dealers but the manual for my 98 V90 says something over 100,000km. My service manual came with an update to reduce the interval but no second update to suggest that I can re-extend the interval on later models. Do you know if the late year B6304's still require a short change interval for the timing belts?

A: The early model B6304 did experience some trouble with premature belt failure. As the valve trains in the B6304 are of the interference-type, Volvo issued a technical service bulletin in 1992 to advise dealers to change the belt at 32,000 km. This interval was subsequently extended to 48,000 km in 1993.

With new belt materials and revised tension and idler pulley angles (introduced on 850/960 engine serial numbers 131035 & later) , the timing belt interval for 1994 & up B6304s was increased to 80,000 km. This was further increased to 112,000 km in the 1995 model year.

As of the effective date of this FAQ, Volvo recommended that the belt on its newest B6304 be changed every 100,000 km. This was not a reduction per se; it probably reflected a service schedule more easily remembered.

The timing belt saga of the 960/S90 parallels that of the 850/S70. Not surprising as the engines shared similar belt configurations. To directly answer your question, though, it appears that the change interval depends on your engine's serial number and model year. For additional details on the current belt replacement schedule, contact your dealer.

Regardless of how Volvo's change interval , I would recommend having any B5234, B5254, B6254 or B6304 belt visually inspected at least every 16,000 km. Simply removing the front timing belt cover to inspect for pealing rubber, cracks, missing teeth, frayed edges or evidence of oil contamination (from a leaking seal) would provide that extra piece of mind to the owner of a car with an interference engine.

Q: I've read a lot about special types of air filters, which filter is the best for my car?

A: Air filters are designed to strike a balance between filtration and flow, two qualities which are almost mutually exclusive. Paper filters offer excellent intial filtration, with flow decreasing as loading of the paper element occurs. Oiled foam filters are generally designed with improved flow characteristics in mind -- sometimes at the expense of filtering capability.

Of greatest concern are those companies which tout excellent flow, but do not say to exactly what size of particles their filters protect (I recall seeing specs for Volvo's paper element filter in the 5-6 micron range). This makes me suspect their "total" performance capabilities. If in doubt, ask to see the specification sheet for the filter which you are considering!

Forced-induction engines such as the B5234FT require the best possible air and oil filtration to protect main, cam and turbo bearings. The turbo's (intake) compressor is also suceptable to erosion should dirt be allowed to enter with the air stream. Imagine the minute, but significant, damage possible when small grains of dirt strike aluminum alloy compressor blades rotating at 120,000 rpm!

Q: I have an oil temperature gauge in my 240. I have noticed fluctuations in oil pressure as I drive. What is considered normal?

A: OEM (VDO) oil pressure gauges fitted to 200-series cars come in two varieties; 3-bar and 5-bar, equating to 0-43.8 psi and 0-73 psig respectively. Regardless of the gauge fitted to your car, however, oil pressure will vary according to:

(1) Engine Speed;
(2) Oil termperature;

(3) Oil Viscosity; and
(4) Engine Conditions.

The Volvo specification for oil pressure in later 200-series cars is:

15 psig @ 900 rpm
35 psig @ 2000 rpm
42 psig @ 3000 rpm
up to a maximum of 115 psi at 6000 rpm.

The readings are taken with a warm engine, fresh 10W30 oil and a new filter. At cooler temperatures oil pressure will be mcuh greater. Conversely, during periods of extreme heat, oil pressure will be lower as the viscosity of the oil is reduced.

Available pressure will gradually fall as the engine's oil pump wears. This will eventually undermine the film strength of the oil along the crankshaft journals and create wear on the main bearings.

Q: I have heard all kinds of claims about "Platinum" spark plugs. Could you please explain?

A: Conventional plugs use relatively large conductors to transmit a spark. The surfaces of the conductors tend to be sharp and angular when the plug is new since this promotes good spark. Over time, the conductors on a plug will become rounded and the gap between electrodes will increase. Such a plug will require greater voltage input for arc-over. If sufficient voltage can be generated to overcome the larger gap, a less intense spark of longer duration will be created. On the otherhand, insufficient voltage could cause the plug to misfire, failing to ignite the air/fuel mixture.

Platinum spark plugs are designed somewhat differently. The anode consists of a small "dot" of platinum, a highly conductive and inoxydable precious metal. Requiring far less arc-over voltage than a standard plug, a similarly-gapped platinum plug will promote the production of lower-voltage, longer duration sparks.... ideal for igniting the relatively lean mixtures prevalent in today's cars. As a result, platinum plugs have better firing charactistics and will usually improve the performance characteristics of newer cars, and older ones which may have borderline ignition maladies. Platinum plugs also last longer becuse their conductive surfaces are too small to be rounded off over time, and each successive spark vapourizes carbon from the extremely small conductive surfaces.

Q: My 1968 1800S with SU carbs starts fine with a manual choke. It warns up as usual and when it is warm I've pushed the choke in all the way. Now it is idling fine. As soon as I start to drive the engine looses power. It seems like when I want to accelerate rather than getting more gas it seems like I'm getting less. If I pull the choke out all the way again the engine will race and I can drive but the car is shaking and still loosing power . I guess the choke is compensating a bit but not making it clear what is wrong. What do you think I should look at first. Fuel pump, carbs, other tune up related???

A: Your 1800's problem is *probably* fuel related, making your concern over the carbs well-justified. SUs carbs rely on vacuum (what the British call constant depression or "CD") to move a piston-driven needle which in turn regulates fuel delivery. The vacuum is maintained by a small rubber diaphragm located under the prominent bell-shaped cover which forms the body of the carb.

If vacuum alone was used to adjust fuel flow, the carb would tend to run lean on acceleration and rich on deceleration. To compensate for these two extremes of operation, CD carbs are often fitted with an oil-filled damper and a spring. Both of these items moderate the movement of the piston-driven needle and allow enrichment on acceleration and lean mixtures on over-run.

I suspect that one (or maybe even both) of your 1800s carbs is in need of some refurbishment. The areas most in need of attention are (in order of priority):

1. Confirm that the dampers are filled with the oil specified in your owner's manual.
2. Check that the carb needles are not bent or stuck;
3. Remove the bell cover. Ensure that the diaphragm is not torn or crimped. Inspect the spring for damage.

Other Things to Check After Verifying Carb Operation.......

There is also an outside chance that your 1800s mechanical fuel pump is not operating to specification. Fuel flow specifications and troubleshooting procedures may be found in your Clymer, Haynes, Chilton or Volvo technical manuals. Extreme caution should be used during the procedures specified as a small quantity of gasoline can spill during fuel pump removal!

To check the spark system, remove each spark plug and check for fouling. Use an ohm meter to measure the resistance in each wire. It sould be no more than 500 ohms per foot. Remove distributor cap and rotor and inspect for pitting. Replace the condensor. Check battery density with a hygrometer. Watch for any signs of oil leakage from your 1800's ignition coil, troubleshooting this item is difficult since many coil problems are intermittent in nature. If all else is correct and the car still hesitates, consider replacing the coil.

I hope this helps point you in the right direction.

Q: I understand that I can get access to engine "trouble codes" from my 1990 Volvo 240. What are the codes and how do I access them?

For 1990, you are likely to have the Bosch LH-Jetronic 2.4 system with the diagnostic terminal being located near the driver's
side firewall. You can access the engine control computer codes using the attached test lead. Insert the test lead into hole 2, and press the button for at least one second, but no more than three seconds.

Engine control computer codes are then displayed in a "morse-type" code on the LED at the diagnostic connector port.

The codes are:

1 - 1 - 1 No faults
1 - 1 - 2 Control module fault
1 - 1 - 3 Mixture too lean
1 - 2 - 1 Mass airflow sensor fault
1 - 2 - 2 Air temp sensor fault
1 - 2 - 3 Coolant temp sensor fault
1 - 3 - 1 RPM sensor fault
1 - 3 - 3 Throttle posn sensor fault
1 - 4 - 3 Knock sensor fault
1 - 5 - 4 EGR valve fault
2 - 1 - 1 CO potenetiometer fault
2 - 1 - 2 Oxy sensor fault
2 - 1 - 3 Throttle posn sensor fault
2 - 1 - 4 RPM sensor fault
2 - 2 - 1 Mixture too lean or rich
2 - 2 - 3 Idle control motor fault
2 - 3 - 1 Mixture too rich
2 - 3 - 2 Mixture problem at idle
2 - 4 - 1 EGR valve fault
3 - 1 - 1 Speedo sensor fault
3 - 2 - 1 Cold start valve fault

Q: I am concerned that the fuel injection system on my US-spcification 1979 Volvo 244 may have been changed over to a different system at some point in time. Can you tell me a little about Bosch fuel injection systems as fitted to Volvo cars of my vintage?

A: Bosch fuel injection was first introduced to North American models in 1970 on 1800E and ES models. This was, of course, the L-Jetronic system. The 240 has always been offered in fuel injected form in North America since its intro in 1974. The fuel injected 240 model was fitted with the B21F, featuring the K-Jetronic fuel injection system. Your 1979 240 came equipped with this system, a lambda sensor and a three way catalyst. (Called K-Lambda for ease of explanation)

This is not unusual for a U.S. spec car, but it is for a Canadian spec Volvo, which did not see fuel injection fully implimented until 1982, and then only in GL and GLT models. Assuming that you are not the original owner, I would have reservations about assessing your car as anything but a U.S. spec car as there is nothing in itself which is unusual from what was seen on these (North American) shores; that is unless there is something truly unusual which you have not mentioned.....

Q: On the subject of Volvo's and particularly the Bosch fuel injection: I read some place that there

is a resistor in the fuel injector that sets the fuel/air mixture. The factory resistor sets the mix for optimum emissions, which is neither optimum mileage, or optimum power. I think this applied to the Bosch L-jetonic fuel injector which is different than what is in the 850's today. Does the 850's FI have such a resistor? Can I replace it or make a switch which sets it between optimum power and optimum mileage with a third setting for optimum emissions if I ever move out of New Mexico?

A: The resistor of which you speak is contained in the Mass Airflow Sensor (MAF) and can only reliably be adjusted using an exhaust gas analyzer. Slight enrichment will increase engine output somewhat, but it will also physically melt your car's catalytic converter -- a piece which is required to function in *all* 52 states (and most provinces up here in the "high north"). In addition, rich mixtures will increase carbon build-up in the combustion chambers, fouling spark plugs and potentially increasing effective compression to the point of ping.

Adjusting fuel trim to minimize fuel consumption will result in an overly lean setting, elevating combustion chamber temperatures and causing ping. This will result in less engine powerr as the ECU will respond by drastically retarding timing.

In short, there's no advantage to be made in fiddling with the MAF without having access to an exhaust gas analyser.

Q: My 1992 240SE was purchased last month. I have two problems with this current car: The fuel consumption is very high about 7km per litre. Turning on the re-circulation button does not prevent external air especially the exhaust from entering the car.

A: The fuel consumption figures you cite for your Volvo seem a bit high, but are dependent on local driving conditions and patterns (heat/humidity & city/highway). Nevertheless, I would start to check the car's systems to determine whether the excessive consumption is caused by a problem with:

a. fuel system;
b. spark system; or
c. vacuum (or a combination of the three).

Review the car's service log, checking areas which have not received attention as specified by Volvo. Also, depending on where your car has been serviced, an incorrect adjustment may have been made. At any rate checking service logs will usually pinpoint when the problem first occured and may provide clues as to the potential problem(s).

Hint: I would check the vacuum hoses leading to/from a small accumulator behind the dash since it sounds as if the car's recirculation vent flap is not closing fully, allowing exhaust fumes into the car.

Q: I've been keeping pretty close tabs on my fuel economy lately but have problems relating my mileage in metric or imperial measure.

A: Here's a quick table listing typical consumption rates:

Litres/100km	MPG (Imperial)	MPG (US)
10	28.25	23.52
11	25.69	21.39
12	23.54	19.60
13	21.73	18.10
14	20.18	16.80
15	18.84	15.68
16	17.66	14.70
17	16.62	13.84
18	15.70	13.07
19	14.87	12.38
20	14.13	11.76

Q: According to the chart, my 740T with the BF230T engine would require an Octane level of 94 to 97. I believe my manual indicates 91. Does this mean that I should switch from regular grade to mid-grade gasoline?

A: You may wish to verify whether your manual states your car's octane requirement in RON, MON, or AKI. An AKI rating of 91 equates to a RON rating of 97, a common upper limit of a B230F's octane requirement.

I suppose the comment which gives some indication of which rating system you are using is whether your should switch from regular grade (normally 87 AKI) to mid grade (89 AKI). In my opinion, you should use at least 89AKI, but preferably use 91 AKI, or high grade. This will allow your later model Volvo's engine to produce maximum power and deliver better fuel economy.

Q: I am interested in replacing my car's thermostat but am confused by the wide variety of temperature ranges. Which one do you recommend.

A: Like other manufacturers, Volvo tends to fit slighly warmer thermostats to their cars as they leave the factory for several reasons:

(1) Better fuel economy (as you pointed out); and
(2) Reduced emissions.

Upon replacement owners are faced with a choice. Shall we replace the original 197F/92C fitted to our 140-700-series cars or opt for a cooler 189F/87C, or in the case of V6s, go even cooler still to 180F/82C. Good question!

Fitting a slightly cooler thermostat will give the cooling system a little more margin to work with when operated in high ambient temperatures. Nevertheless, cylinder head temperatures will be reduced during all operations. Sounds good, right? Well, in a way.

Going too cold on a thermostat setting can create unnecessary wear as the engine oil never reaches the temperature necessary to boil-off accumulated water deposits (from condensation). Furthermore, reducing cylinder head temperature too much can cause deck warping as the differences between the combustion chambers (block and head) and the surrounding metal are of a greater difference. These problems, however, will only occur in a car which has either:

(1) no thermostat; or
(2) A defective or radically-low thermostat

The thermostats offered by Volvo, while cooler, are unlikely to cause any of the aforementioned problems. They will allow your engine to run *slightly* cooler, without the risk of running too cold. True, fuel economy may drop by a small amount (I would be surprised to see more than a few tenths of a mpg drop) and there may be a slight rise in CO, but there should also be a corresponding drop in NOx.

You will note that there are three thermostat ranges offered for V-6s. This may be to offset any cooling difficulties which these engines may have had in the past.

Also of interest is that *no* alternatives are offered for 850/960. They come with one thermostat range (each) only.

****I DO NOT RECOMMEND, HOWEVER, THAT OWNERS SWITCH TO A COOLER THERMOSTAT TO MASK A COOLING PROBLEM****

This does not make sense because eventually, the thermostat will be unable to overcome the lack of cooling provided by a plugged rad and/or crud-filled water passages. Should a cooling fault be present, a flush or, if unsuccessful, a new radiator is the way to go...... this may be the time to upgrade to a HD unit!

BTW. Change coolant annually and mix coolant with distilled water (or if you can get it, de-ionized water). Deposits will be less and the system will be much happier. Change thermostats every 4 years. It beats getting stuck at the side of the road with an otherwise well-functioning car.

Q: Since is actually sunny here this weekend, I thought I'd poke around a little in the $700 mechanic's special 245Ti I recently obtained ('84). The head is coming off, ("blown head") and when I disconnected the turbo air hose going from the turbo into the intercooler, I noticed the inside of the air hose is covered with a film of oil.

I sort of remember reading posts about oil in the turbo line, and as I recall, it's not good to see this. I assume there is a seal going out. Is this a death sentence for this turbo? I got the impression that this is not a DYI area, and I should maybe look at getting the Turbo rebuilt. Is it a matter of degree, or if you see oil it is toast?

A: The presence of oil in the intake hose of turbo motors is caused by lubricant getting past the compressor seal of the turbo's rotating assembly. Minor seal leakage is normally caused when high engine vacuum creates low pressure within the intake tract. While this condition is unfavorable (it raises HC count), it is common in even well-operating turbo units.

Large amounts of oil, on the otherhand, indicates complete seal failure -- a condition which should be remedied. The hardest part, of course, is to remove the turbo from the engine without breaking studs...... this is something which even plagues professional mechanics. As you are having the head pulled, however, this may not be as much of a problem since it will be much easier to tap and remove any broken studs.

Let me know if you have the model number of the turbo (printed on the turbo body). I can tell you if Garrett sells a new/re-con center housing rotating assembly (CHRA). The CHRAs are balanced, fully assembled, relatively easy to replace (if you can remove the turbo unit and have access to a torque wrench capable of inch-pound settings), and quite reasonably priced.

Q: I have now decided to go with another Volvo. I can get an 86 240DL one owner records, 127000m excellent shape for $3200, a 1988 with 131000m in excellent shape for $3500, or an 86 240DL wagan with 85000m white with not a scratch for about $4000.

A: Although I'm sure that you're comfortable with the normal stuff such as reviewing service records, testing compression, watching out for synchro wear, perhaps some in-depth info on what engineering changes those model years hold may be of greater use.

North American spec 1986 200-series Volvos were fitted with the Bosch LH 2.2 fuel injection system. This was an earlier version of the air mass system and, although not as troublesome as the very early LH 2.0 models, has fallen out of vogue with many repair shops because of its lack of self-diagnostic capability. 1988 & newer 200-series cars came with the LH 2.4 -- an improved system, featuring a more rugged Mass Airflow Sensor (MAF), additional computer memory, and a self-diagnostic/trouble code module which interfaces with the fuel and spark systems.

200-series cars fitted with the LH 2.4 (the 1988 MY was a transitional year, so it's best to check what you're getting) may be recognized by looking for a multi-pin bus just aft of the driver's side front shock tower. It looks like a relay, but some fiddling should free up the cover to reveal a six pin bus, a banana plug, a red LED, and a small push button. If the car is so fitted (and assuming that it meets with your approval on the mechanical bits), the 1988 is the one to buy.

In addition to the electronic goodies, the 1988 & newer cars were fitted with the B230F engine (vice the older B23F). This engine features lower friction internals, improved engine balancing and (some say) a stronger block. I cannot confirm the latter, as all "red-block" (aka cast iron 2.1 & 2.3 litre engines) OHC engines are practically indestructable.

Given that your car is a U.S. spec version, it will be fitted with an Exhaust Gas Recirculation (EGR) system. This is a nasty little piece of emission control rarely seen in Canada. The unit requires cleaning (again, I have the books for this) and, if neglected, replacement.

Bringing the car into Canada (should you wish to do so) will present few problems. Unlike BMW & Benz, all Volvos meet US and Canadian crash/bumper standards simultaneously. A series of stickers (bilingual or metric) for the fuel filler and spedo respectively are required beyond the normal safety/smog check.

The Volvo 240 was, in my humble opinion, a very good car. A few mods will bump the power from 114 bhp to 140bhp+). The only shortfall associated with the newer models was a slightly weaker transmission. Older cars used the M46, a four speed unit with a Laycock electric overdirve (sound familiar?). These were excellent transmissions and lived on in 900-series turbos out to MY 1995. Newer, normally aspirated, cars were fitted with the M47, a true five speed which was based upon the M46. Unfortunately, however, the M47 was fitted with weaker, low friction synchros. This makes them more prone to eventual breakage, the incidence of which is usually influenced by driving behaviour.

You'll be happy to hear that apart from the engine/transmission variations, the 200-series cars from 1982 to 1993 are practically identical. This makes obtaining parts very easy indeed.

Q: I have found it interesting how the dealerships have started chanting the less maintenance mantra. I've abandoned them for both a local trusted mechanic and some of that basic own/self maintennce. However, as a nontechnocrat mechanic (code for: he still needs to remind himself that theres no points to set on his 850) I can only change the oil so many times and hell the manual transmission oil is synthetic. I feel that I am at the mercy of the black box that analyses the numerous input / outputs that the system now operates by. Do you have any maintenance tips which I may have overlooked?

We all seem to be at the mercy of electronic boxes these days! While it is true that the electronic control unit (ECU) appears to be taking over, its role is really that of a pacifier for complex cars/poorly-trained mechanics/EPA regulators. That being said, many of the basic maintainance functions still apply.

Regardless of the ECU, lubricant changes and limited decarbonizing remains important maintainance tasks.

Flushing the auto-trans/gearbox on an annual basis removes the metal particulate generated by the gears "bedding-in" and helps guard critical bearing surfaces against embedding. True, the fluid is synthetic, but flushes are intended to remove particles in suspension, not compensate for the finite lubrication capabilities of the fluid.

Another basic bit of maintainance (not covered by the ECU, I might add) is very regular inspection of the 850's constant velocity joints. Inspect the boots for tears or leaks and (if you're comfortable with the procedure) clean and repack the joints every three years.

Although rarely specified as "regular" maintanance, I remove and clean the carbon from the throttle body/Idle air control valve every three years. This maintains good airflow through the induction system and helps prevent any stumbling associated with sticking throttle plates/rotary IAC valves (Volvos appear to be prone to this as they age).

Of course, air filters, and fuel filters get changed *very* regularly to help keep internal engine components free of contaminants.

Q: As a 850 owner I feel like there is such a limited amount of stuff written about the 850. can't even find a Chiltons or other gee I'd like to fix my car pubs. This is with the thought that most (I think) 850 owners wouldn't even think of crawling under the car and get their hands dirty.

A: Actually, there's quite a bit of technical stuff written for the 850. I recommend that you call 1-800-25-VOLVO (1-800-258-6586) and request a copy of their free "Aftermarket Product Information Catalog". It essentially lists all applicable Volvo service publications for your 850..... not the Chilton or Haynes variety, but the Volvo Technical Guides which are truly superior!

I believe that you are correct in perceiving that most Volvo owners don't want to get their hands dirty. I have found that Volvo owners fit into three categories:

(1) Those who will pay (sometimes dearly) for anything their mechanic suggests;
(2) Those who gripe about spending any money on car maintainance; and
(3) Those who do most of the work themselves, leaving the really difficult stuff (rebuilds, A/C work) for the garage to handle.

Owners at sub para 2 are the majority..... that's why one must be careful when buying a used Volvo. Owners at sub para 1 appear to make up about 30-40 percent of the market, whith half of those eventually switching brands due to gouging. Owners at sub-para 3 are indeed the minority.... probably less than 10 percent. The do-it-yourselfers tend to keep their Volvos much longer and are often the most brand-loyal.

I am currently finalizing research on a new book which looks at performance modification of Volvos and the 850s will receive a fair bit of attention. I'm not sure how my material will be received since I am an advocate of strengthening the systems (enlarged lube oil coolers, better filtration) *before* cranking up the power. That being said, adding another 20bhp to an 850 R or T-5R is futile unless one really *needs* the extra power and is able to reliably apply it to the road.

Cooling/Heating System

Q: I am considering fitting a block heater to my Volvo's engine but have noticed that there is more than one variety. Could you shed some light on the best/worst types to use?

A: There are a number of heater systems on the market, each varying in cost and complexity. Here are my opinions on the options:

(1) Gasoline-driven block and interior warmer, $1000.00. These items are made by Volvo for arctic conditions. It is kind of a mini thermal reactor which not only keeps the engine toasty warm, but will warm the interior to the point where the windows will defrost. Exotic, complicated, too expensive for the normal users this side of the Arctic Circle.

(2) Coolant heaters/circlulators. These items are electrical, and heat the coolant while flowing it around the entire cooling/heating system. When the car is started cabin heat is immediately available, albiet in small quantities. However, one must cut into some heater hoses to hook the thing up. I don't have anything against these devices, but I prefer a much simpler (and inherently cheaper and more reliable) device:

(3) The electrical block heater. These consist of small electrical elements whic heat the engine coolant and allowing convestion to circulate warmth to the engine. They commonly use a frost plug hole for mounting and if fitted with care, will not leak for at least 10 years. The cost is inexpensive ($40-50) and are available through your Volvo dealer. The Volvo ones are very well designed and come with a nifty plug holder etc.

Any of these designs will, if properly installed and leak-free, reduce engine wear if used during periods when the mecury dips below 25F.

Turbo & Exhaust Systems

Q: I am curious as to when Volvo started using the turbo engine in their vehicles? Particularly, what year and which models.

A: Volvo started using turbochargers in the 1980 244 GLT model. This car was equipped with a B21ET -- a mechanically-fuel injected 2.1 litre overhead cam engine producing 155 bhp in European trim. Eventually the idea of turbocharging caught on in Gothenburg and we have seen 2.3 and even experimental 3.0 litre force-fed designs.

Although Volvo first used a turbo in a production car in 1982, a company called ipd (small letters intentional) made a limited-edition car for enthusiasts in 1978. This special car also used a 2.1 litre ohc engine with a Schweitzer turbocharger providing between 9 and 11 lbs of boost.

Q: When I questioned the salesman and service guys about any special consideration I need to give the Turbo the answer was simply just drive it like any other car. Volvo recommend changing oil every 5000 miles, based on your info it sounds like a more frequent change would not be inappropriate for Houston, any comments? Would you have any comments about desert driving conditions? I will be in New Mexico, Arizona, Utah, and Colorado for 5 weeks this summer.

A: Turbo motors require very special care and attention on the part of drivers and mechanics -- your owner's manual explains that much (although not much more, I'm afraid). Although it's something I go into at great length in "The Gothenburg Bible", turbo care could easily fill a book in itself.

The high average temperatures common to the Houston area, particularly in the summer, will place an incredible thermal strain on your engine. As you may have observed in my article, intake air temperature is proportional to boost pressure and ambient air temperature. Most of the heat generated by an active turbocharger is absorbed by coolant and engine oil. With this in mind, I would recommend that coolant be replaced annually, vice the every two years that Volvo suggests.

Coolant should only be mixed with distilled water, not the tap variety which can eventually lead to clogged cooling passages via mineral precipitation. Although coolant mixtures which resist premature boil-over are necessary, you may find that it is preferable to stick with the most lean coolant/water ratio recommended by Volvo (probably around 40% coolant, 60% water -- but check your owner's manual!). Why? Water more readily absorbs and releases engine heat (water is able to absorb 4.2 kJ/(kg.K) vice ethelyene glycol's capacity of 2.4kJ/(kg.K))

Just as coolant must be optimized for hot weather/turbo operations, so too must engine oil which itself absorbs over 1/3 of engine heat. Heat accelerates the oxidation of anti-wear additive packages. This tends to hasten the onset of shear and eventually undermines the oil's lubricating properties.

With all of this in mind, you may wish to consider using synthetic engine oil. Why? They tend to resist shear, have far higher film strengths and resist coking much better than their conventional counterparts. My only caution is that you wait until 10,000 miles before switching to a synthetic motor oil since their improved lubrication has been known to interrupt the initial wear necessary to "bed-in" new engine parts.

Although Volvo *permits* the use of synthetic engine oil (again, check your manual) which meets a minimum API quality threshold, go for a name brand oil which meets or exceeds API "SH" and is approved for use in turbocharged vehicles. I use Mobil 1 15W40 in the summer and have found it to be an excellent performer. Nevertheless, change your oil twice as often as recommended (every 2500 miles).

Don't sweat the cost..... it will save money in the long run.

Not to be forgotten is the effect which Houston heat has on your 850 Turbo's automatic transmission. Change this fluid annually or face the prospects of early transmission work.

Three words on desert driving.... filtration, filtration, filtration. Desert dust will kill an engine in very little time. Make sure that the air filter is replaced as recommended or every 8 months, whichever comes first. When the air filter is replaced, remove and clean the airbox and trunking with water and mild dish soap (make sure you remove any electrical equipment such as the MAF). This will remove the finest dust particles which manage to creap into the intake system.

On that note, it is especially important to make sure that the clamps connecting various parts of intake system are tight. Having a new air filter doesn't do much good if dirt is allowed to enter the engine from a loose fitting. If it were me, I would use a good quality, heat resistant duct tape over each seam in the plastic intake system.

Q: I have a 1995 940 turbo wagon. It can from the factory without a boost gauge. The volvo rep's tell me that the gauge is not needed because of the low boost pressure (7-8 psi?). What are your comments about this?

A: Unless I miss my guess, your intercooled 940 Turbo receives a maximum of around 10.5 psig boost. Your comments re: boost gauge are well founded -- shame on Volvo for not having fitted such an instrument to a turbo car (my manual transmission 240 came without a tach?!).

Any mechanic who does not believe that a gauge is necessary should start talking to his/her friends. Warning lights are known in the business as "idiot lights" since they only warn of complete failure of a component -- not the minor/spurious malfunctions which are very common.

Should your car's turbo provide over-boost, a light will warn you of this.... that is if it is not burned out. Gauges are
preferable since they would tell the aware driver of the degree of malfunction, possibly allowing the car to be carefully
driven to a repair facility.

Using the boost gauge to minimize fuel consumption is a good idea. It may also help prevent feeding boost to the engine until it has reached full operating temperature... this will increase the life of the piston rings and main bearings.

Q: I own a 1985 Volvo 740 Turbo with 110K mi. I am currently in the process of installing a rebuild turbo kit. In doing some background research for this project I found an old article in Car and Driver (1986?) on a 760 Turbo Wagon that had been modified by Volvo. As part of the modifications they swapped the wastegate on the original oil cooled turbo with one from a factory intercooler for the B21FT motor. I would like to know if this is really true, and if so, what is the part(s) and numbers that I need to perform the swap?

A: Although I am not aware of the article to which you refer, I would advise against any alterations to your car's factory wastegate settings -- they simply add too much thermal stress to an already taxed component. Intercooled cars lower the intake temperature, thereby allowing the safe utilization of increased boost in the post 3250 rpm range. This requires a modification to the vacuum boost control unit and a boost "bump" from 6.5 psi to 10.5 psi.

My advice would be to visit a wrecker and remove an intercooler in good condition. With this component installed, you may then carry on with the addition of the factory control units/settings which will make increased boost more practical (and safe).

Q: Unfortunately my turbo is leaking oil into the fuel/air mixture and I am told I will need a new turbo at over $2,000. I have an '84 240GL. If you get a chance can you tell me if it is possible to disconnect the turbo? I don't care about the loss of power. Or, if it is possible to otherwise change it to non-turbo? Thanks.

A: You cannot simple disconnect the turbo without turning your Volvo into the slowest car on the road. The turbo motor's low compression ratio (around 7 or 8:1) would make the car practically undrivable, with engine output of around 60bhp likely. Modifying the car to non-turbo specs would cost significantly more than it would to replace the turbo unit. My advice is to (1) replace the turbo or (2) buy a replacement engine/transmission/wiring harness/ECU from a wrecker for retro-fit. Any way you slice it, it's going to cost a few dollars.

Q: As a new Volvo 850 GLT owner, I am trying to learn as much as possible about taking care of the Turbo engine. I wonder what is your opinion on the 850 GLT. It has no intercooler but it operates with lower pressure. Is it good or bad?

A: I am glad to see so many new Volvo owners seeking information which will help preserve the lives of their car's engines.

In reference to your question, I believe the 850 GLT to be a very well designed car; one which should provide many years of faithful service. That being said, however, I do question Volvo's choice of an inline five cylinder engine because of the design's inherent vibration -- much of which cannot be cancelled out by the usual balancing techniques (rotating masses/balance shafts).

To their credit, Volvo has designed the engine with incredibly large main bearing surfaces. This should help mitigate most (but not all) engine balance problems. Because of the free moments of inertia of the 1st and 2nd order, the engines will never be truly smooth -- at least not in the same way that a flat 6, inline 6 or V-12 can be.

On the issue of turbocharging and intercooling, I suspect that Volvo's low-pressure turbo was a marketing effort aimed at reducing the base price of entry-level turbo models. Any good engineer will tell you that intercooling has a number of benefits (better power, reduced thermal load on the engine) and only one liability (cost).

I am sure that Volvo's engineering department determined that the intercooler could not be reliably removed from the intake system without a reduction in manifold pressure (boost). This led to a reduction in boost and significant cost savings --
some of which was passed on to purchasers.

But why a low-pressure turbo in the first place? Well, that's marketing in the image conscious 1990s. Vee

6 engines are all the rage now (heavens knows why -- they're poorly balanced and complicated to plumb with only minimal benefit of reduced hoodline and smaller packaging). Part of Volvo's strategy is to market an engine which has a lot of torque (like most 3 litre V-6s on the market) without altering the 2.3/2.5 litre displacement of its family of engines (this would require new pistons and/or con rods to be produced and warehoused -- expensive!!). By switching to a low pressure turbo, a small turbo area ratio can be selected to provide great low-end spool-up. This leads to lots of low-end torque -- just like a large displacement V-6.

Volvo's marketing folks have recommended that all "turbo" badges be removed from its low-pressure turbo models and that sales staff accentuate the torque of the engine. This will lend the impression of a V-6 without causing the consumer concern associated with turbochargers (many folks think they're too racy or complicated). So that's the marketing strategy priority!

In a perfect world, intercooling a turbo reduces turbine temps and reduces the thermal load on an engine. This is very, very good. But intercoolers cost money -- and the resulting sticker price discourages sales. In dropping the intercooler, Volvo has wisely dropped the boost. Although this reduces the engine's power somewhat, it prevents unacceptable thermal loading on the engine. This fix is, in my opinion, neither good or bad. It's simply a cost/benefit arguement in which price wins over performance.

Q: What should I be looking for before purchasing a 240 Turbo?

A: Before you buy you should have a well-respected Volvo specialist check out the following:

(1) leakdown test to check for head cracks
(2) removal of valve cover to look for varnishing/condition of cam etc (should give a fair indication of oil change interval).
(3) A compression test
(4) A full road test, starting the car from *dead cold* and noting any exhaust smoke
(5) A check of the condition of the fitted air filter (has it been replaced this century?), fuel filter (ditto) etc.
(6) A check of the rear axle fluid (is it full of suspended metal particulate
(7) A check of the cooling system noting the build-up of sediment in the overflow tank
(8) A reading of the H_2O content in the brake fluid. If the fluid has never been changed (quite common) then you will likely face some stiff brake repairs over the medium term.

As you are aware, some Volvo drivers can drive 'em like they hate them. Others treat their cars like appliances, calling
the service guy whenever the thing gives up for good. Lesser cars can sometime tolerate this abuse, turbos cannot. This sound like doom and gloom, but I know of owners who have paid $5000 per year to right the wrongs of previous abusive owners. A lotta bucks, and well deserving of that second sober look. No love, no emotion, a real audit.

Q: I actually compared the Garrett TB03 & the Mitsubishi Turbo units on the workbench and they

are dimensionally nearly exactly the same. The compressor blades were quite different though. The Garrett had the tricky convoluted spiral, whereas the Misub had the old style straight blades. Do you have any comment or knowledge on the Garrett vs Mitsub change?

A: The difference which you noted in the impeller design between the Garrett TB 03 and Mitsubishi turbo chargers is very important and helps explain the different ways in which these turbos work.

The Garrett's convoluted spiral blade design is known as a backward-curved compressor impeller. In this design, the blade elements are not arranged in a strictly radial pattern, but are curved backward from the direction of rotation. This blade style is designed so that the air entering the impeller is at the same angle as the pitch of the blades. This reduces the shock losses at the inlet and allow the impeller to operate very efficiently at high rotational speeds. Despite their efficiency, however, these type of impellers do not exhibit as high a pressure ratio as radial-patterned impellers. Furthermore, centrifugal force at high speed tends to bend the spiral blades at their roots. So in essence, a turbocharger equipped with a backward-curved impeller helps an engine produce power in the upper-end of its rpm band (where its high efficiency in best appreciated), but is subject to severe stress which may affect its lifespan.

The straight, or radial impeller as used in the Mitsubishi, provides a higher pressure ratio at low rpm than the Garrett. As turbine speed increases, however, the straight blades give rise to inlet shock since the slower intake air strikes the intake's high-speed turbine blades at a sharp angle. This reduces compressor efficiency at high rpm. A Radial impeller used in housing of the same area ratio as a backward-curved impeller tends to result in improved low-end engine torque, but with less overall potential for power.

Interestingly, we see these two types of impeller designs being used in different ways in industry. Jet engines tend to use backward-curved impellers due to their high operating speeds. Large volume industrial blowers (such as those used in ventilation) use straight radial impellers.

It is likely that Volvo switched from the backward-curved and straight radial to improve the low-end response of its turbo motors. An added benefit, however, is that the (straight) radial impeller is cheaper to cast -- making the Mitsubishi turbocharger more cost effective. Given the strengths and weaknesses of each design, I would prefer the Mitsubishi turbo for street use and the Garrett for track use. Given that most Volvos live on public roadways, I would say that the decision to use the Mitsubishi turbo was wise.

Q: Where should the boost needle be with regard to the "boost" area on the gauge? Having just bought an 85 240T and put in a new watercooled turbo, I can find no references to what values are represented by the colored ranges on the car's own boost gauge. Can you help?

A: At full boost, your Volvo's boost gauge should read at the uppermost range of the orange band. If red is just touched before the boost drops (as the waste-gate is opened) this is normal.

At no time should the boost stay in the red part of the swept area. This would indicate a dangerous over-boost condition (a turbo fault) which could literally start to melt pistons and burn valves in short order.

If you are in any doubt about the accuracy of your Volvo's boost gauge or the waste-gate system, visit a competant repair facility for verification. Since turbocharged engines extend the volumetric efficiency of spark engines, your maintainance program should reflect the utmost of care.

Q: I own a 1986 Volvo 740 turbo, and previously owned a 1988 760 turbo, and the 740 makes a slight whine when the turbo is boosting. It also doesn't seem to have quite the power that the 760 had. The 740 has about 200,000km and the 760 had about 120,000km Is the slight whine and less power normal, or is it something that I should be concerned about?

A: Most high frequency whines generated by turbochargers are harmless, being caused by resonance of air rushing through the unit at high speed. The extent of the whine is similar to cassette tape whine during silent portions of the program.

Squaks, grinds or screaches are not normal and should be checked out without delay.

Notwithstanding these suggestions, it is always best to carefully monitor oil and fuel consumption -- the trends noted may give a better indication of potential turbo problems.

In addressing your observations of power loss, it is difficult to say whether the turbo is at fault. There's just too many variables to consider (gearing, fuel injection variants, boost/spark curves) between models. Nevertheless, the 200,000 kilometers on your 740's turbo probably means that the end is near anyway. I cite a recent study I conducted on the INTERNET on turbo longevity. In a nutshell, 120,000 miles (200,000 km) is about average for turbo life with lows of 50,000 miles (80,000 km) and highs of over 200,000 miles.

My advice is to have the unit checked, paying particular attention to the wastegate setting (do not deviate from the factory setting) and oil seals. If these items check out OK, then I would continue to drive the car and prepare for the inevitability of replacement (hold your breath, it'll cost you around $2000.00).

Q: How long does a turbocharger last?

A: The aim of this survey was to provide a baseline sketch of Volvo turbo ownership from the servicing cost, durability, and owner satisfaction standpoint.

Volvo owners were asked a number of questions concerning their experience with turbocharged cars. Only those currently owning cars with 25,000 miles or more were surveyed. The mileage figure was adopted after responses had been taken to correct for what were essentially new cars, still under warranty, and unlikely to exhibit any of the normal wear and tear associated with "a slightly weathered brick". 35 responses qualified and were seperated according to Volvo type (200, 700, 900 series). Although three responses from 850 owners were received, none were above the mileage threshold, nor had experienced any problems worthy of note.

Anomalies were not accounted for in the figures, but are mentioned in the narrative for individual consideration by the reader.

240 TURBOS

Model/Useage Information:

Nine responses were gathered. The average model year of those surveyed was 1983 with 167,398 miles on the odometer. The cars were mostly equipped with manual transmissions (60%) and were driven moderate distances each day. 20% of the cars surveyed were used for towing, 40% negotiated hilly terrain during daily life, and 33% were routinely operated in low ambient temperatures (less than -20F). Although the cars were driven in the moderate to hard range, 67% of owners reported idling their cars down over 1 minute prior to shut-down.

Servicing Information:

On the service side of the house, all 240 Turbo owners reported doing their own servicing, with one using independent garages for "the major stuff only". Oil changes ranged from a frequent 2000 miles to one owner who reported regular changes at the 10,000 mile mark or every 6 months. The median for oil changes was, however, 3000 miles with everyone replacing the filter with a new Volvo (40%), Mann (30%) or Purolator, Bosch or Fram unit.

Many 240 Turbo drivers used Mobil 1 (40%) or Castrol GTX (40%) engine oil. Air filters were reported changed after an average of 27,000 miles (no unusually high replacement values) and fuel filter changes averaged 37,142 miles, although admittedly one driver replied with a question mark either indicating an unknown level or he/she was unaware this unit needed changing at all. The average grade of fuel used was AKI 91 with only 20% of respondants using fuel additives such as Techron cleaner. Of note, no one used oil additives.

Servicing Costs & Problem Areas:

Although two of the respondants did not have any idea of what their annual servicing costs were, those who replied paid an average of $639.43 annually -- remember they were exclusively self-servicers. All 240 turbo owners reported having replaced their unit at least once. The average turbo life was 113,555 miles, but the worst of the lot had to be replaced after just 61,000 miles (only to be rebuilt further down the road at 120,000 miles). The best turbo out there (surveyed) lasted 160,000 miles. 10% of cars had required cylinder head replacement (expensive!!), but none required a rebuild, or suffered from any electrical gremlins. A few problem transmissions were identified, most just rough shifting autoboxes.

Owner Satisfaction

On average, owners rated their 240s an "8" for power (low-4/high-9.5) and "5" for fuel economy (low-1/high-9). All in all, owners rated their satisfaction with servicing costs as 7.13/10 and 90% said that they would buy another Volvo turbo.

700 TURBOS

Model/Useage Information:

Twenty-three responses were gathered. The average model year of those surveyed was 1987-88 with 123,988 miles on the odometer. The cars were mostly equipped with automatic transmissions (60%) and were driven moderate distances each day. 13% of the cars surveyed were used for towing, 26% negotiated hilly terrain during daily life, 21% were operated in high ambient temperatures (+100F) and 8% were routinely operated in low ambient temperatures (less than -20F). Although the cars were driven in the moderate range, 34% of owners reported idling their cars down over 1 minute prior to shut-down.

Servicing Information:

When it comes to keeping in tune, 40% of 700 turbo owners reported doing their own servicing, with 35% using independent garages, and the remainder using the dealer. Oil changes ranged from a frequent 2000 miles, but the average change was carried out after 3304 miles. Filters were replaced by almost 2/3s of 700 owners, although one admitted to be in favour of using "whatever was on sale".

An overwhelming number of 700 Turbo drivers used Castrol engine oil (60%), followed by a few Mobil, Valvoline and "unknown" users. Air filters were reported changed after an average of 29,000 miles (no unusually high replacement values) and fuel filter changes averaged 41500 miles. Like 200 turbo owners, a few of the newer car owners used a "?" to respond to fuel/air filter changes. The average grade of fuel used was AKI 89 with a slightly higher 26% of respondants using fuel additives such as Techron cleaner. Two 700 turbo owners regularly used oil additives (no brand was specified, though).

Servicing Costs & Problem Areas:

Although four of the respondants did not have any idea of what their annual servicing costs were, those who replied paid an average of $896.12 annually (low-$200/high-$2700). Unlike the 200 owners, however, 60% of 700 owners had someone else do the servicing.

Of the 23 owners surveyed, 5 had replaced their turbos (once only though) at an average of 136,400 miles. The winner of the turbo longevity award goes to an individual who's turbo is still going after 220,000 miles (owner maintained, little cool-down idling, but frequent oil changes with a Mann filter). Three owners, however, had to replace their cars' cylinder heads and two cars required a re-bore (at 133,000 and 241,000 miles respectively). One car had severe gremlins with almost half a dozen air mass meters, a main computer and transmission problems accounting for the chronic driveability problems.

The best turbo out there (surveyed) has lasted 247,000 miles and is still going strong. (2500 mile oil changes, moderate driving in hot conditions, $1000 annual servicing costs)

Owner Satisfaction

On average, owners rated their 700s an "8" for power (low-7/high-10) and "6" for fuel economy (low-2/high-10, indicating vastly different driving styles). All in all, owners rated their satisfaction as 8.8/10 and 96% said that they would buy another Volvo turbo.

900 TURBOS

Only three 900-series owners' responses fit within the accepted parameters. The average mileage was 35,666 miles. No problems were reported. Those not covered by the free servicing arrangement paid dealers and independents an average of $730 per year in servicing. Oil was changed at the 5000 mile mark, except for the owner who took his/her 900 to an independent who changed the oil every 3000 miles (a wise move!). Little else could be ascertained from the figures.

************Comparison*************

700 series cars' turbos lasted an average of 25000 miles longer than those fitted to 200 series cars. This may be due to water-cooled units and/or intercoolers, but little definitive data was obtained to corroborate this. This extra longevity cost 700 owners an average of almost $250 more per year though.

I may catch flak for this, but although most Volvos surveyed were relatively trouble free, a few were cash cows. Drive it like you hate it may have been a catchy 1960s jingle, but the turbo owner who boots it, on average, may pay for it too. The data to support this comment is thin though, meaning that if treated with an equal level of respect, some cars may not have lasted as long as the norm. I'll let you draw your own conclusions.

Volvo Servicing as a Whole

There was a general, but certainly not absolute, correlation between servicing and longevity. Neverhteless, so many abberrations existed, I wonder if folks used the same base number to calculate their annual expenses (I was looking for total annual expenses: tires, oil, pine tree air-freshners, the whole shabang!).

Admirable, however, is how I would comment upon most respondants' servicing habits. The value of frequent oil changes is generally well recognized here, with most owners changing the dino juice every 3000 miles. It would have been interesting to ask what the coolant/thermostat change interval had been (20/20 hindsight), especially since some head failures were noted.

The one exception in praise must be on the air/fuel filter issue. Fuel and air filters appear to be overlooked (many simply replied "?", muttered "interval" or replied "when ever my mechanic recommends it") by even the owner who insists chainging the oil every 2500 miles. Turbos are close tolerence devices, carefully filtering oil only to let in dirt carried by the air or fuel does not make too much sense!

Conclusion. Force-fed Volvos are generally durable beasts, but tend to require turbo replacement at the 120,000 mile mark. On the whole, turbo owners seem to drive their cars in the moderate-to-hard category, suggesting that finding a lightly used Volvo turbo is rarer than one may think! If you can handle paying between $200 and $2700 per year for maintenance (average of about $800 though), like very good power (8/10) and can handle average mileage (5.5/10), then a turbo is good for you. After all, 9 out of 10 Volvo turbo owners would do it again!

Other Articles in this site related to turbochargers:

Troubleshooting 200-, 700-, and 900-series Turbos

Turbochargers: An Owner's Guide to Preventing Catastrophe

Turbo Owner's Survey

Power to Weight Ratios - Tuning a Volvo into a Porsche

Q: I have a 1983 Volvo 240 that was recently shipped to Turkey. Since that time, however, there has been a persistent noise from the exhaust pipe. Could you provide any advice on what the problem may be.

A: I'll assume that the car continues to deliver normal power and fuel economy. That leaves the noise as the primary irritant. Most exhaust system noise can be traced to two sources: (1) rattles, in which the heat shield loosens and knocks against the exhaust pipes at irregular intervals and (2) exhaust system leaks in which gases upstream of the muffler escape with a loud staccato noise particularly when acclerating from moderate engine speeds.

The rattles are easy to fix. One may either remove the heat shield or opt for a new exhaust down-pipe. When the latter option is chosen, a new lower exhaust manifold gasket is wisely replaced. The cost for a Volvo down-pipe should run about $250 + $20 gasket.

Exhaust system leaks are much more difficult to find. In cooler weather, the leaks may be apparent from ground-level (ie. exhaust "smoke" coming from a section of pipe). In warmer climates, however, the source of the leak is much more discrete.

As a rule of thumb, the weakest parts of the pipe are at flanges (ie those areas of pipe which bolt together) where a variety of metal-faced gaskets are used to effect a more positive seal. Over time these gaskets can wear out and cause exhaust gas leakage.

If you have run your car on leaded fuel or on fuel of poor quality, there is a possibility that the catalytic converter has overheated. If this has occured, then the ceramic substrate of the converter may be either melted or cracked. This can cause a rattle or even power loss.

Removing and visually inspecting the catalytic converter can reveal a lot, but some mechanics in your locale may not be familiar with catalytic converters. If your mechanic is unfamiliar with converters, he should be looking for a regularly shaped, honeycomb structure through which light will diffusely pass. If areas of the catalyst are blocked or melted, the unit is dead and must be replaced.

If you have continued to use good quality unleaded fuel, the next area to check for leaks is at the exhaust resonator -- a device under the passenger footwell that looks like a small muffler. If this part is OK, then check (in order) the cross-over pipe that goes around the rear axle and the joints to/from the rear muffler.

If earch of these areas checks out, then concentrate on the exhaust manifold and down-pipe.

While uncommon, exhaust manifold cracks can be found visually or by "magnafluxing" -- a procedure that uses dyed magnetic particles to find cracks in ferrous parts such as a cast iron exhaust manifold. Exhaust manifold cracks cannot be repaired -- regardless of what your mechanic will tell you. Replace the unit through Volvo.

Down-pipe cracks need not be magnafluxed as any cracks will be clearly visible upon close inspection. Some down-pipe cracks can be repaired by a skilled welder. Large cracks, however, cannot.

That's the gammut of exhaust system leaks & repair strategies. I hope it helps.

Q: Could you provide some advice on exhaust systems? Based on price, one company promises a very low price.

A: Although you usually get what you pay for, some companies offer great prices. Befor commiting your money, however, collect the following data on each exhaust system:

(1) Which pipes are part of the package?

(2) What are the diameter of the pipes? Larger is better (up to 2 1/2 to 3 inches), but usually more costly to produce.

(3) Does the price include brackets/hardware?

(4) Are the pipes stainless, aluminized steel, or mild steel? (stainless best, aluminized acceptable, mild steel less-desirable)

(5) How are the pipes bent? (Using mandrel (better), or standard bending techniques (less ideal))

(6) What's the warranty?

The answers to those questions should allow you to make a wiser decision.

Lubricants

Q: I have recently started to change my car's engine oil (using a synthetic brand) and had some strange observations. Instead of the old oil being black, it has a thick, whipped consistency. I have heard that some synthetics are not suitable for use in passenger cars. What gives?

A: Oil which has the consistency of whipped foam or hand cream is normally associated with cars which operate at too low a temperature. This type of temperature may be seen in cars with a defective, missing, or incorrectly calibrated thermostat. As for this being a characteristic of synthetic oil, I have never heard of it.

Assuming that your thermostat is working correctly and there being no coolant leaks, I would check to see if the synthetic oil used was compatible with conventional oils (not all are!). As you are probably aware, synthetic oils are refined either from ethelyne gas or crude oil stocks to form ester or olefin compounds... each of which has its own specific strengths and weaknesses, and levels of compatibilities with the additive packages common to conventional oils (zinc compounds such as ZDDP come to mind as being generally incompatible with polyalphaolefin compounds). For this reason, some synthetic oils require an engine flush before use.

I have seen some discussion on the net about oils leaks which follow synthetic oil use in older cars. No, it's not the enhanced detergent content of the oil working here, but the fundamental molecular structure of the oil. Ester-oil compounds can cause seal shrinkage, whereas polyalphaolefins can cause some seal swelling, ergo a blend (if successfully engineered) will not adversely affect seals. You will note that the same type of seal compatibility issues surround synthetic (silicone) brake fluid. At any rate, switching back to a base-stock motor oil tends to correctthe seal problem in engines.

From your original posting on the net, it appears that you have not overfilled the engine (if more than 6 quarts/litres is used, then the crank impact could cause additional foaming). Perhaps the grade used is not ideally structured with anti-foaming in mind. If so then switching to another synthetic (Mobil 1?) may help.

If you can live with the cost of syntheetic oils, then the advantages are impressive. Sure, some compatibility issues arise, but most synthetics are very carefully blended for mainstream use. For that reason (and all discounting the problems first listed), I suggest switching to a more common brand -- one which specifies compatibility.

Q. Do you recommend a synthetic oil (like Castrol Syntec) over conventional oils? How many miles need to be on the vehicle before switching to synthetic? My volvo has less than 3 thousand miles on it. I have heard that synthetic is so slick, that the engine parts will not "break in" if synthetic is used too early on.

A. Wherever possible, I err on the side of warranty compliance. Volvo does not recommend *against* using synthetic oils, but stipulates that they must meet the same quality standards as their recommended conventional lubes. Since most name-brand synthetics meet or exceed conventional oil performance standards, they are generally considered safe for your Volvo. Clarification on how synthetics affect your warranty are best discussed with Volvo Technical Staff in Rockleigh, NJ.

I too have heard industry folks recommending against using synthetic oils until the engine parts have had a chance to "bed-in". Apparently, engines which have not bedded-in can become oil consumers. I agree with this philosophy and would not recommend using a synthetic motor oil unless:

1. The manufacturer specifies; and/or
2. The engine has accumulated at least 8000km/5000 miles or more.

Of course, the big advantages to synthetic oils are their extreme temperature characteristics. Ultra-wide viscosity oils (5W50) tend to be less temperature stable (lower boiling points/higher pour points) than selecting the right oil for the right ambient temperature conditions (5W30 - winter, 10W30 - spring/fall, 15W50 or 20W50 - summer). If you doubt this, write to the oil companies for their various oils' specs. You'll see what I mean.

I use Mobil 1 and select viscosities according to the season. This provides maximum protection during the broad temperature extremes of my locale (-40C/-40F to 35C/95F).

Q: I'm told that to do an oil change for yourself, you need some sort of special band wrench. Where can I get one, and how much do they cost?

A: There are four types of oil filter wrenches commonly available for do-it-yourselfers.

The first is a strap wrench. The advantage of the strap wrench is that it offers near-universal fit for oil filters and often comes with a long handle suitable for applying a zillion lb-ft of torque to the filter body. Disadvantges include the amount of space required to gain a purchase on the filter with the flexible strap. Cost is around $15.00.

The second type is the metal band filter wrench. This wrench must be selected according to the size of the filter being fitted/removed. Generally speaking, though, these type of wrenches come in two or three sizes. The advantage of the band wrench is that it may be used in a fairly confined space, particularly if fitted with an articulated handle. The disadvantage of the metal band wrench is that it tends to slip if the filter body is the least bit greasy. Cost is around $6.00

The third is the serrated jaw, clamp type wrench. These are normally a "one-size fits all" wrench which offers all of the advantages of the metal band wrench. Cost is around $10.00.

The fourth type is the end-cap filter wrench. These actually consist of a very wide, shallow socket which grips the serrations along the top of your oil filter. The problem is, not all OEM filters come with such serrations. To their advantage, however, these wrenches easily interface with 3/8 inch drive ratchets, making them easy to use in confined spaces. Cost is around $7.00

Of course, not all cars require filter wrenches. Some European models (Mercedes Benz comes to mind) continue to use a cartridge type filter, where the replaceable filter element slides into a machined housing and is secured with a bolted cover. The advantage of such a filtering system is that it is far more environmentally friendly (reduced metal use, practically no oil remains in the filter element so less pollutants end up in some landfill). But I digress.......

Having used each of the wrenches listed, my recommendation is to go for a the serrated jaw, clamp type wrench. When pushed, this wrench will firmly grab hold of just about any filter and will not slip if the filter is a bit greasy.

Q: What about synthetic oil in turbo cars? I believe that synthetics are inherently more stable at higher temperatures and less likely to COKE UP in the bearings. What about some auxilliary oil pump (electric) that continues to circulate oil b efore start-up and after shut down. These are available aftermarket, but no OEM uses them. How much time is REALLY needed to let the turbo spin down before turning off the key? 10 minutes is not practical.

A: Synthetic oils do generally provide superior protection for turbos. One reason is their tolerence to shear; others invovle flow characteristics, film strength, vapour point and (as you mention) the absence of coking at elevated temps.

On the issue of auxilliary oil pumps, a few of these devices have been marketed, but the most commonly available items are the turbo-timer (marketed by HKS, allows car to idle for 5-10 minutes before an automatic shutdown occurs) and the pressure resevoir (marketed by Accsump, this device maintains oil pressure for a few mintues after shut-down -- viscosity dependent, of course).

The time required for a turbo to spin down depends on the unit's temp, condition of the bearings, lubrication flow, and turbine speed. That is to say, it's highly variable but somewhere between 3 and 10 minutes. I would suggest that you use five minutes as a rough guide.

Waiting for a turbo to spin down is not practical. Neither is paying $1500.00 every three to four years. If I owned a turbo, I would purchase an Accusump turbo oiler. I believe that the retail price is in the $300.00 range. Also in my goodie bag would be a larger engine oil cooler. The one fitted in most Volvo turbos is fine for mild driving, but is too small for high-speed/load stuff. The stock Volvo unit would be a good choice for a normally aspirated car though.

Q: I have a 1976 244 with over 100,000 miles. My engine requires an additional quart of oil about every time I fill up with gas. I'm not sure if the consuption is normal or not.

A: One quart per 250 miles is, by Volvo's definition, excessive and unusual oil consumption. Volvo's guide for brand new engines breaking in is 1.6 quarts per 1000 miles. Their guide for an engine which has already broken-in is 0.7 quarts per 100 miles max consumption.

Just to be sure that your problem fits the definition, please confirm and quantify you car's oil usage as closely as possible over a 1000 mile period.

High oil consumption can be caused by a number of factors. Incorrect maintenance such as over-filling the sump or using an oil of poor or dubious quality can lead to high oil consumption. I assume that the oil you use is from a name-brand manufacturer and meets API's SG or SH quality rating. I also assume that the oil you use is matched to the season in terms of weight. (as per the Gothenburg Bible) If you are already following good maintenance procedures and oil useage persists, read on......

The next factor affecting oil consumption is the way in which you operate your Volvo. Hard driving (high speed, high revs, high load) will result in higher oil consumption as will mountain driving when engine braking causes very low crankcase pressures, literally sucking the oil up past the rings and into the cylinders. If you do not operate your Volvo in this manner or under these conditions, read on.....

Finally, there are mechanical factors to consider. Worn crankshaft and cam seals, leaking gaskets etc can lead to high oil consumption. You noted that no oil has been observed leaking from the engine. Is there an oil smell which eminates from the engine compartment when the car is warm? Are there globs of grease on the block (near head/block mating surface, near valve cover)? If you are unsure, have the engine steam cleaned first as this may actually save money by making a potential leak much easier to pinpoint.

If you have ruled out leaking, there are more traditional oil consumption factors to consider. Worn pistons and rings, scored cylinder walls or damaged valve guides can lead to high oil consumption. The root cause of this type of oil consumption is normally quite easy to trace.

#1. Remove the spark plugs. Are they covered in soot/carbon. If so, you are probably burning oil. The color should be light to medium brown, perhaps a light grey.

#2. Have a compression test done. If the compression is low, pour a teaspoon of oil into the cylinder. If the compression rises, the rings are shot and/or the bores are scratched. Corrective action consists of a rebuild. Cost can range from $1500-3000, depending on the severity of the wear/damage.

#3. If the compression does not rise appreciably, the valve guides are the likely culprit. Corrective action consists of a cylinder head overhaul. Cost can range from $600-1500 with the higher number yeilding a completely rebuild, Genuine Volvo replacement, cylinder head.

Looking at your odometer reading (200,000+ miles) and fuel economy figures, I would guess that its (1) the bores/rings, or (2) the valve guides.... *but this is purely a guess only* and is contingent on all else being in perfect working order..... it often isn't. So have a compression test done on all cylinders. The readings of each cylinder should be within 10 percent of each other. Exact PSI specs should be held by your dealer/specialist.

If the head/rings/bores are worn, the problem will only get worse. What could be simple worn rings could progress to worn pistons (Mahle pistons as fitted to your car cost about $400 per set). So unless you are going to either get another engine or junk the car, you may have to bite the bullet on repairs or face a higher bill down the road.

Notwithstanding that the problem will only get worse (and likely more costly) with time, there are environmental issues to consider. With the oil consumption figures given, it is likely that your 1976 244 is putting out as much Hydrocarbon (HC) pollution as 100 or more cars and quite possibly as much Carbon Monoxide (CO). Just adding oil isn't going to help the environment and, depending on your state laws, could result in some sanctions being applied against your car. This can range from an EPA check and warning to impoundment. Even if nothing like this happens, there is no way to get away clean, so to speak.

I would recommend that you have the car completely checked out by a competent garage which is equipped to undertake all of the possible repair scenarios listed. "Joe's Garage" may have cheaper labor rates, but chances are they will lack the tools and specifications necessary to effect the *proper* repairs. If you have to go the rebuild route, sometimes it's better to go the specialist or dealer route. Genuine Volvo remanufactured engines are not a bad deal and can be damn attractive if you plan to keep your car a while. The same goes for Genuine Volvo remanufactured cylinder heads.

P.S. Should the problem be traced to worn pistons and guides, have the cooling system checked too. You could have a damaged head gasket or cracked cylinder head which has leaked coolant into the bores, undermined the lubrication system, and provided the root cause for your car's problems. There's no use having a rebuild done if the original casue of the problem continues to lurk in the background.

P.P.S. If you do have any of the mechanical systems rebuilt, carefully follow break-in procedures listed in your owner's manual. This will help extend the life of the components you have recently refurbished.

Q: Do you have any experience with engine oil additives (PTFE)?

A: I don't believe in mixing any additives with quality engine oil. Neither do the following companies:

AB Volvo
NASA
GM
Briggs & Stratton
Mercedes Benz

Other than the product manufacturer's themselves, I cannot recall any *engine* manufacturer or fleet which advocates
their use. I do note that several folks at work brag about buying the bargain basement oil (79 cents/quart) but do not balk at the $30.00 price of many of these additives. Strange logic.....

Environment

Q: Is there an environmentally-friendly way to dispose of old anti-freeze or motor oil?

A: There sure is! Many of the garages which accept used motor oil will also take coolant. In fact, many municipalites accept coolant which is placed in the Blue Box (recycling box) for responsible disposal. If you have a chainsaw, try using the oil oil to top-up your chain-lube resevoir.... these devices are not close-tolerance and will tolerate less-than-perfect lubes.

Q: My Volvo just failed its annual Maryland State Smog Check. I would like to remedy the situation and offer the following data for your review:

The following is the information that you requested:
Car's mileage: 134,000 mi.
Year: 1985
Model: 740 Turbo
Modifications: None
Driving Habits: Moderate daily driving; some highway,some suburban; no
hard driving
Maintenance Schedule: Oil every 3k mi., all factory recommended maintenance
performed on schedule(plugs, timing belt, valve adjust, air filters, fuel
filters, etc.) No other problems than the emissions

Other miscellaneous info:
-I am the original owner.
-Turbo is original an appears to be functioning properly
-I have never had previous emissions problems, and therfore have never had to
replace any components(nor would I know which to replace)
-Failed the emission test last week; but passed with no problems for the last
10 years(Maryland performs testing every two years, so something has changed
in the last two years.)

The idle emissions test results are as follows:
Hydrocarbons Carbon Monoxide
HC CO
State standard 220 PPM 1.20 PCT
Readings 255PPM 6.55 PCT
Result FAIL FAIL

The car passed the requirement for Carbon Dioxide.

I also have the detailed graphs from the dynamometer test showing the above readings over a simulated drive. The car failed miserably. I can fax these graphs to you if you give me your fax number. I think they will be of some help.

Thanks for any help you can provide.

A: First of all, let me commend you on the level of attention placed on record keeping and car maintenance. From the data you supplied, you appear to be doing all of the right things (3000 mile oil & filter changes, moderate use, regular adjustments) and your record keeping (suppored by your ability to produce the past several years of emission tests performed by the State of Maryland) is further proof of your comittment.

It is my pleasure to help out and I submit the following analysis of your 1985 740 Turbo's emission woes:

Maryland Inspection Standards. In the interest of fairness, I reviewed the standards which the State of Maryland imposes for emission control. Their maxima for HC, CO and NOx are very pragmatic and represent levels *ten times -more- relaxed* than manufacturers must meet for EPA certification under U.S. FTP 75, 49 States, 1995. In my opinion, this does not make Maryland rules lax as they appear to tolerate mild infractions in the hope that the grossly polluting cars can be identified and if necessary, removed from the road.

Even though your Volvo passed earlier testing, it appears that Maryland's new procedures take a much more scientific approach to emission measurement. The older tests, consisting of HC, CO and CO2 readings at *idle* were not able to identify many mechanical problems which occured at elevated engine speeds commonly used in traffic. If your car *had* been subjected to the older test this year, it likely would have passed with flying colors (note the 0 mph readings of the 1996 Dynamic Test, you will find that HC, CO and NOx all fall well within the old maxima). With this in mind, it is possible that your Volvo has had an underlying mechanical or tuning problem for some time -- the testing procedures just haven't been in place to identify it!!!

No worrys, mate! The data that they supplied in 1996 gives some pretty good clues to what the problem(s) could be, most of which can be verified from one's driveway.

Your Car's Results. In finding your Volvo's emissions at 4.64 grams per mile HC (against a maximum of 2.0), 192 grams per mile CO (against a maximum of 30.0) and .7 grams per mile NOx (against a possible maximum of 3.0), the State of Maryland has given you until 05/29/96 to effect the reapirs necessary to bring your car into compliance. This gives you plenty of time to investigate the suggestions which I will provide.

Interpreting the Test Scores. The emission traces you provided represent a treasure-trove of of information:

Clue #1 - HC and CO levels exclusively rise on acceleration (see readings taken between 15 and 20 seconds, 100 and 110 seconds and 160 to 170 seconds respectively);

Clue #2 - HC and CO levels do not rise on over-run (throttle-off deceleration) (see reading taken at 90 to 100 seconds and 225 to 240 seconds respectively);

Clue #3 - The NOx remains well below the maximum limit (throughout the test); and

Clue #4 - HC, CO and NOx levels do not drop-off over time, but remain constant or rise (note approximate levels at 80, 150 and 200 seconds respectively).

From this data three obvious, but "educated", guesses can be made:

(1) Your car is *not* running lean enough to ping. If it were, than NOx levels would be sky-high. No pinging is very good news. The heat and pressure created by even border-line ping can cause massive damage..... even though you can't always hear it!

(2) Your car is not running lean enough to misfire at over-run, but not lean enough to ping. Otherwise, elevated HC and CO levels would be detected during deceleration.

(2) Your car is definitely running rich. This does not necessarily mean that a "twist of the screwdriver" will fix it, but it does narrow the odds for finding the *real* problem.

Troubleshooting Maintenance. Although I am almost positive that you have already attended to these items, it is worth double checking that the fitted air cleaner is relatively fresh (not clogged or visibly black with dirt, preferably new), the PCV is clean and has been properly has been serviced (ensuring that the new style plastic flame trap is used instead of the old pattern metallic ones), and the plugs have been inspected (refer to the color chart in a Haynes or Bentley manual) and are in good condition, gapped to *turbo* specification.

Using an ohm meter, ensure that the spark plug wires have a resistance of not less than 500 ohms per foot. Any suspect set of wires should be replaced.

Examine the distributor cap. Remove the greenish deposits from the internal electrodes with very fine emery cloth. Ensure that the center (spring-loaded) electrode is not worn away. If in doubt as to the condition of the cap, replace it!

With those items checked and corrected, proceed onward, even if you had to replace/clean on of the above...

Checking for Worn Parts. Because your car does not grossly emit on over-run, the valve guides are unlikely to be damaged or leaking. If they were, blow-by and oil would pass through them once the throttle plate was closed and send HC and CO sky-high.

Conduct a compression test on the engine using the proper equipemtn and procedures specified in your Haynes, Chilton, Bentley or Volvo Shop Manual. Are the rings worn? If the compression rises after adding a little oil to the spark plug holes, this could be your problem. Worn rings will lower the effective compression ratio, requiring more throttle input for power. They will also allow blow-by gases to seep into the combustion spaces and exit the tailpipe. Worn rings would certainly send the State's testing equipment into HC spasms.

CO problems could be indicative of a poor burn caused from blow-by, or it could mean incorrect timing. Check out the timing.

Onwards to the Dreaded Turbo. With the engine shut off (and keys out of the ignition), and in accordance with your shop manual, remove the hose leading from the turbo to the intercooler. Check for a thin coating of oil or soot which could indicate a blown intake-side turbo seal. Wipe away any oil/dirt. Reassemble. Drive the car for a day or two and re-inspect. If there is more crud, suspect the seal.

Note: Although prudence demands that you check, I don't believe it to be an intake-side seal since oil would seap into the intake system even more on over-run, causing high HC and CO during closed throttle portions of Maryland's test.

It is almost impossible for a home mechanic to check out the exhaust-side turbo seal and oil return pipe without breaking a bolt. I recommend that you have these items checked at your Volvo specialist. Given the mileage on your turbo, it is quite possible that either the seal is shot or that the oil return pipe is partly clogged with carbon.

Having recently overseen an extensive survey among Volvo owners, I can attest to the fact that Volvo turbos last an average of about 120,000 miles. Given your car's mileage, the odds are that the turbo is well-worn.

Things for the Garage to Check. Your Volvo specialist should check the function of your lambda (aka O2) sensor. These items require periodic replacement (the two-wire systems have a particularly short life!). When a lambda sensor fails, the main computer usually switches to a richer fuel injection setting to prevent destructive ping. The result is, predicably, higher HC and possibly CO emissions.

If the lambda sensor is fine, have the garage set the CO level. This involves calibrating the Mass Airflow Sensor to yeild the lowest possible CO reading. This can have an effect on the lambda or excess air factor, a measurement of the ratio between the mass of the air and fuel entering an engine's combustion chambers. A misadjsuted MAF could explain the elevated HC and CO levels noted by state authorities.

If you have found one or more of the aforementioned items to be defective, have the catalytic converter removed and checked. Continuous rich running can elevate temperatures within your Volvo's catalytic converter to the point where the substrate will melt. In other cases, hydrocarbons (ie. oil seeping thorugh the exhaust-side turbo seal) can coat the converter. In either case, the unit will be ruined, emissions will rise dramatically. Replacement of the "cat" with a new unit is the only solution (it is *illegal* to fit used emission control parts to a car!).

Conclusion

So there you have it. Good news (I hope) and bad news (I hope not). My advice is to have everything checked out by a garage specializing in Volvo repair. If you have been going to such a facility, ask them if they have bothered to periodically check the CO levels (like they're supposed to during every tune-up).

I am very glad to read about those owners who are interested in helping their cars adhere to the proper emission levels. Vehicle emission testing supports both the enthusiast and environmentalist since it imposes a regimen to ensure the best possible performance while helping protect the environment.

Q: Does anyone know where a problem might lie with high nitrous oxides when all other emission values are very low??

A: High NOx readings are usually associated with elevated combustion temperatures and pressures. These conditions most frequently occur in an engine that is running lean (NOx values in an otherwise functional engine peak at 16:1 A/F ratio) or is pinging.

Fuel Trim. It would be worthwhile to have your car's MAF adjusted, as this will indirectly adjust fuel trim (the MAF only reads air mass, against which the ECU interprets and meters fuel flow).

Spark Control. Have the timing adjusted to specification and inspect the spark plugs for signs of overheating. Its a good idea to check the cooling system too as any cylinder head cooling problems could lead to pre-ignition.

Fuel Quality. Pinging may be an indication that the octane of gas you are using is too low. While most Volvos can tolerate AKI 87 fuel, a car's appetite for octane generally increases with age due to carbon build-up (increasing the effective compression ratio) and blow-by (which destabilizes the A/F ratio.

Boost. If your car is turbocharged, an over boost condition will raise combustion temperature and pressure -- resulting in higher NOx counts. Depending on the test cycle that your car is placed through, this could result in an emissions failure. If you have had the car's boost increased, this may be the time to bring it back to specification.

Catalytic Converter. Fuel trim, spark and fuel quality aside, there could also be a problem in your car's catalytic converter. Your car (like most on the road) is fitted with a three-way converter (TWC) that chemically oxidizes CO and HC and reduces NOx. TWCs require very tight fuel trim to operate correctly as the oxidation and reduction tasks can only be efficiently realized at 14.7:1 A/F ratio. If your car has operated in a lean condition for some time, it may have overheated the catalyst -- thereby damaging it. Although TWC failure would also raise CO and HC emission levels in a well worn engine, a well maintained engine may still be able to pass local/state/provincial emission testing due to their more relaxed standards (most state/provincial emission test thresholds allow far more pollutants than is required in the USA-FED FTP 75 test cycle). Judging by your "ca" address, however, I'll guess that you live in lower-mainland British Columbia where "Air Care" testing is required on an annual basis.

I hope these suggestions help. Its not an exhaustive list of causes, however, as many things can lead to emission failures. As a minimum, however, anyone having their car tested for emission control should have the engine tuned, filters replaced, and oil changed in advance as this will give you (and the environment) an edge in meeting compliance thresholds.

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Electrical Systems FAQ

Q: I have an '85 740 GLE and it's in need of some repairs to keep it on the road and I want (and need) to do the repairs myself. My 740 is now drydocked because of the crumbling hire harness syndrome that killed my main fuel pump. Replacement Volvo wiring harnesses are pretty expensive and I was thinking about making one myself. Is this a good idea? Also, what other tips can you provide concerning a 740's Volvo's electrical system?

A: There are a few tips to give with regard to re-wiring an engine bay of a 200- or 700-series car. First, it has been my experience that one must start with a brand new harness. A new harness is necessary because of the virtual impossibility of accurately and reliably locating and correcting faults of a fairly complex harness (a 1989 & Up B230F MFI connector has 30 pin-outs, and over a dozen termination points along its length). Nor is it practical to remove a harness without incurring the risk of damaging it in the process.

As for building a new harness, you may find that the correctly colored cables, gauges and connectors are very hard to come by. If you substitute colors, recognize that a garage will be unable to use factory manuals to accurately fault trace between the component and the MFI computer. Splicing will introduce current losses at the solder points and embrittle the wire being joined. If you re-use connectors, the possibility of further faults is almost certain as re-crimping will weaken the joints. If the gauge of wires is incorrect, fire will result. Given that one incorrectly routed wire can fry a $1500 MFI computer, I'm not sure if DIY harness construction is wise. I say this after having done a few replacements, the latest which was two weeks ago.

The following is required before one can safely replace a main wiring harness:

a. disconnect and remove battery;

b. remove engine splash tray;

c. remove intake manifold (requires removal of fuel injectors and disconnection of lines at the fuel rail). This may seem like a bit of a bother, but it will reduce the time required to replace the harness by 50%;

d. remove MAF (very carefully) and air inlet;

e. replace both battery cables with new parts. It may seem like a minor point, but you'd be surprised as how often garages will replace very expensive electrical components without first ensuring that the ground strap and positive battery cable -- two notorious points of failure -- are replaced;

f. check out all sensors (MAF, ECT, KS, H2OS) with a VOM -- replacing components where necessary;

g. lay the new harness over the old one, removing and re-attaching each connector in sequence starting with the MFI computer and ending with the alternator.

After removal of the old harness, inspect for signs of chafing. Install chafe guards on the new harness (this is something that a garage wouldn't necessarily do). Clean the fuze box, inspect each fuse for signs of corrosion and replace as required.

Verify that the voltage regulator is operating correctly. Check brush length.

When all components are put back together, operate the engine for a few days and check for the presence of trouble codes. It is not uncommon for an old, faulty harness to cause irreparable harm to the MFI computer.

I'm often criticized for painting a somewhat pessimistic picture. That said, I would rather highlight the facts up front than suggest that there are reliable low-cost alternatives to correcting a serious electrical problem. If you require an engine harness, buy a new one. Consider a Do-It-Yourself solution as the only way to save if you have the time, tools and experience.

Q: I am interested in modifying the air mass sensor on my 1992 744T by removing the screens or some of the wires from the screens. Wanted to use a backup sensor to do this, but have only found the older version in the local salvage yard (part no. ending in 007). Can I use this sensor in place of the 016 part? What does the adjustment screw do?

A: The fragment of the part number provided refers to Bosch 0 280 212 007. This part number is listed by Volvo as the standard fit for a B204E, a 2 litre, 16 valve engine that is based on the B230F family. The B204E was marketed in Europe. Whether or not this makes sense is difficult to determine, as your reluctance to provide your mailing address when registering your book prevents me from guessing the market for which the part was manufactured. (Note: The information that customers provide when registering their book(s) is kept confidential. It is not sold or distributed and is intended to help me provide tailored support.)

Bosch part number 0 280 212 007 is trimmed differently than the Mass Airflow Sensor (MAF) fitted to the B230FT. The correct fit to the B230FT is Bosch PN 0 280 212 016.

The adjustment screw on the side of the MAF is used to adjust the signal sent to the fuel injection electronic control unit. It should be covered by a tamper-proof plug, since it can only be effectively adjusted in conjunction with a 3-gas analyzer.

You may wish to exercise extreme care when removing or modifying MAF screens. Removal is best accomplished by removing the MAF and carefully removing the screen retainers with a thin bladed screw driver. Take care not to insert anything into the orifice of the MAF!

Removing part of the MAF screen is not recommended, as the remainder could collapse inward (especially under boost) and destroy internal components or proceed into the engine itself.

Q: I have a 1992 Volvo 240 station wagon that I am working on with 315k miles on it. I have a 221 code and a 231 code. I feel the 221 is a result of the 231, however, I am not sure what the Lambda adjustment is. Can you help?

A: I'm assuming that you've reset the trouble codes, only to have 221 and 231 (and maybe others) re-appear. I'm also assuming that your Volvo is not running correctly. That is to say that it hesitates, idles roughly, stalls or consumes too much fuel.

Fault codes 221 and 231 are used to warn of lean and rich fuel trim, as monitored by the throttle position and heated O2 sensors. These conditions could be caused by a whole host of problems including:

a. damaged multi-point fuel injection (or MFI) computer;
b. defective heated O2 sensor (HO2S);
c. defective mass air flow sensor (MAF);
d. wiring fault (either on its own or causing damage to the previous
three components);
e. a faulty fuel pressure regulator; and/or
f. defective charging system (including battery).

It is not possible to adjust the air:fuel ratio, or Lambda, on your car. The aforementioned sensors monitor engine conditions and determine the mass of fuel to be injected. The fault codes are triggered when the mass of fuel falls above or below a series of pre-established thresholds, as has apparently happened with your '92 245.

I've seen (and corrected) many problems involving fuel trim. Fault tracing for this kind of problem requires a factory manual, a few hand tools, and a volt ohm meter. In cases where the MFI computer appears to be the culprit, the only solution is to use a special Volvo tool called a break-out box to troubleshoot internal circuitry. It's either that or swap out the MFI computer with one that is known to be functional. This step requires, however, that all other faults be ruled out as a wiring or sensor fault could damage the replacement computer.

As previously mentioned, a factory manual is required for this type of work. Haynes, Chilton and Bentley manuals do not provide the degree of coverage needed to fault trace a problem of this magnitude. You can order factory manuals by calling 1-800-25-VOLVO.

Q: The 142 is only running on cyl 1 and 3. Do you know how the control unit, distributor contacts and injectors are wired and operate? We are not sure yet if he has a control unit failure or if one distributor contact operates 2 injectors and the other the remaining 2. The books I have do not go into enough detail.

He also has a problem with the 244 in that the main relay stays energized when the ignition is off. Someone may have done some rewiring, and the Bentley wiring diagram is not altogether correct or complete. Can't tell what should tell the computer that the engine is running, and presently the pick circuit ground side of the relay coil seems to have been tied directly to ground through a connection to a black wire in the computer harness.

A: When the ignition is switched on, the control unit of the Bosch D-Jetronic system receives voltage from the battery via the main relay. For 1 second of ignition activation (regardless of whether the starter motor is engaged), the main fuel pump is energized to raise fuel system pressure to 28.5-30.8 psi. Flooding is prevented by a pump relay, which can sense the speed of the starter motor or engine; the latter having to be over 200 rpm before the fuel pump is activated.

The 140E's ECU controls fuel injection via two-pairs of injectors. Injectors 1 & 3 and 2 &4 fire with each engine revolution. This not only supplies the engine with sufficient fuel, but also ensures valve wetting -- a valuable defence against the formation of excessive intake valve deposits. Timing for the injectors is, as you surmised, provided by the two sets of distributor contacts which are connected to the ECU at pins 14, 17 20, 9.

There is only one ground within the *ECU* itself, at pin number 11. Other grounds lead from the four injectors (4) the coolant temperature sensor (1), and fuel pump (1). If the *wire* numbering is still readable (***please don't confuse with the ECU pin numbering which runs from 1 to 24 inclusive***) these represent numbers 26, 27, 30, 31, 32, 35 and 11 respectively (142Es built prior to Aug 1971 have one additonal ground - the start valve connected to wire number 33). In addition to these grounds, current is supplied to injectors 1& 3 and 2 & 4 via *ECU* pin numbers 3 & 4 and 5 & 6 respectively.

Although your original e-mail requested pin layouts (specifically not trouble-shooting tips), I am sure that you have tried testing for voltage to between the inector contacts for injectors 2 & 4. Battery voltage is not necessarily seen here, mind you -- just enough to trigger the injector solenoid. For this reason, resist jumping battery voltage/current to field-test injectors, or they'll be damaged!

With the pin layouts, one should be able to test for continuity between the injector and ECU connectors.

There should, however, be no continuity between any positive injector connection and ground -- this would indicate a short circuit (normally the result of a problem with insulation).

Notwithstanding all of this interesting diagnostic chatter, it is quite possible that the distributor contacts are defective or that the cable connector for the trigger contacts has failed. This may be confirmed with a VOM test as described above.

Although not part of the injection system per se, check the manifold pressure sensor. A defective unit can cause some of the symptoms you mentioned.

Just for reference, here's the 142E ECU's *complete* pin assignment:

1 - to air temp sensor
2- to cold start relay
3- to injector 1
4- to injector 3
5- to injector 4
6- to injector 2
7- to pressure sensor
8- to pressure sensor
9- to throttle valve switch
10- to pressure sensor
11- GND
12- to ignition distributor
13- to air temp sensor
14- to throttle valve switch
15- to pressure sensor
16- to main relay term. 87
17- throttle valve switch
18- to starter motor term. 50
19- to pump relay 85
20- to throttle valve switch
21- to ignition distributor
22- to ignition distributor
23- to coolant temp sensor
24- to main relay term. 87

Q: The alternator mounting bushings on my 89 240 have gone bad so that the pulley is no longer in the same plane as the other pulleys so I will need to replace them.

Since I am going to be pulling the alternator to do this, I have a couple of questions:

1) The car has 165,000 miles on the alternator. Is there any maintenance for the alternator that would be

wise to do while I have it out? I was wondering about changing brushes, voltage regulator or possibly a total replacement. I don't want to do totally unnecessary work, but I try to be pretty aggressive on wear items to avoid breakdowns when on the road.

2) Are there similar mounting bushings for the a/c compressor and power steering pump that could be going out also? Is it fairly common for these rubber bushings to fail? The same thing happened on my in-laws '87.

A: It would be wise to inspect the voltage regulator/brush unit (VR) for wear while the alternator is removed from the engine bay. The small slot screws which retain the VR can be quite difficult to remove, especially if your car is driven in the "rust belt". The VR sells for around $70.00 and can be obtained at any Bosch supplier.

I apologise for not being able to give you a part number, but the VRs are selected to match particular alternators and, if my memory serves, later model 240s were fitted with one of three Bosch models (depending on tirm & accessories). One tip I can provide is to avoid cheaper, third world units as these can fail prematurely!

When re-assembling the VR 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.

On the issue of bushings. Yes & Yes! The rubber bushings tend to require replacement after about 7 years.

Q: My Amazon 121 was built in 1968, and was fitted with a generator. The strong point of a generator, so I have been told, is that your can still drive with a flat battery. One cannot do so (in the dark/rain/etc.) with an alternator fitted. Is this true, and if so, it might be worth mentioning?

In the nomenclature for spark plugs, the B20A and B20B engines are left out, what spark plugs are recommended here? And when running on LPG? (hotter plugs?).

A: In reference to your question, alternators are superior in just about every way to generators. The reason why they did not appear until the 1960s & 70s is that rectifier technology was not sufficently advanced to provide AC to DC conversion (at least not reliably). While it may be theoretically true that a car fitted with a generator can run without a battery, the voltage variations created by a generator (or alternator, for that matter) would eventually burn-out relays, bulbs and other electical/electronic components.

As for B20A/B engines, a Bosch W6DC should work fine. There are no appreciable differences in combustion temperatures to warrant special plugs for LPG-run engines.

Q: Should I disconnect the battery during those weeks when my car sits idle?

A: If you are planning to park your car for 2 weeks or more, my recommendation would be to remove your battery and hook it up to a trickle charger. As a battery's charge diminishes, lead sulphide forms on the plates. After repeated discharge cycles the build-up interferes with the flow of electrons and the battery is no longer able to hold a charge. Although there are ways to burn deposits off, it's better just to prevent them from forming in the first place..... hence the trickle charger which keeps a battery fully charged at all times.

Q: My "Check Engine" Light on my 1985 Volvo 244 comes on periodically. The ECU codes indicate a damaged MAF. Do I really need to replace the MAF if the car otherwise runs correctly?

A: Your 85 either has a B23F or B230F engine. The symptoms you describe sound hauntingly familiar. My 91's warning lights would flash with the gear upshift light in very high humidity/high load conditions. Accessing the OBD indicated a air mass meter problem... but it went away completely (and has stayed away for 3 years now) after I disconnected every underhood electrical connection, cleaned the contacts (yes, some do get scummy after a surprisingly short time!), lubing the contacts with dielectric silicone and re-attaching the connectors.

According to Robert Bosch GmBH, 90 percent of electical faults occur at connectors, not within the electrical components themselves. From my Navy days I recall particular attention being paid to electrical system wiring/switches, especially when moisture is prevalent. The technique of cleaning/applying dielectic silicone has been mentioned by AB Volvo in their Technical Bulletins and is fairly common use in the marine industry.... probably for the reasons already specified.

You must, however, use dielectic silicone.... the normal stuff dries into a rubber type compound, whereas the dielectic variety remains in a gel-like form to act as a flexible barrier against moisture. The down-side is the cost - about $15.00 for a tube similar in size to a tube of toothpaste. Also, I must admit that it took me about 6 hours of steady work to find/ clean/lube every contact, fuze, etc. It requires no special skill mind you, just time.

Also prone to error is the logic incorporated into the air mass meter. If a rapid change in air density is noted by the computer (via the MAF), the computer can assume a MAF error and temporarily trip into limp- home. Although rare, this lasts just a few seconds and causes what feels like a miss or hesitation... then it's gone, leaving the "Check Engine" light and a MAF error code to ruin your day. Most mechanics will tell you to replace the MAF ($400-600), Volvo says to clear the code, restart the engine and if all is well not to unnecessarily worry.

Q: I have heard that the life of the Mass Airflow Sensor (MAF) can be diminished by high temperatures. Is that true?

A: MAF failures attributed to the warm air induction inlet sticking open confirms your suspicions. Both Volvo and Porsche, desiring better airflow characteristics, decided against fitting cooling fins to the circuit board in their versions of the Bosch LH MAF. Chevy (in FI Corvettes) did fit the cooling fins, but had to contend with the 15% reduction in airflow -- something which the builders of small engines (Volvo's 2.3, 2.5 & 3.0 litre and Porsche's 2.5, 3.0 and 3.2 litre engines) could not accept.

I believe that Volvo and Porsche made the right decision. Not all cars, in fact very few, are desert driven.

The bulk of our market is rather mild (downright cold here right now) and therefore easy on electronics.

One should, however, periodically verify that the warm air induction inlet thermostat is in good working condition.

Q: Hey I need some info regarding the fact that when I let my engine warm up during extreme cold weather, the "Check Engine" light comes on. I took my '91 940GLE to a Volvo dealer. They told me it's a sensor problem dealing with the exhaust. Anyhow they reset the computer to turn the light off. The next day while warming my car up, the "Check Engine" light came on again. Any insight or help?

A: The check engine light can be triggered by a number of things including a false or absent sensor reading. The Mass Airflow Sensor (or MAF) measures intake air, feeding the necessary data to the main computer for fuel injection calibration. If there is a sudden increase or decrease in the MAF reading, the main computer can reject the data, igniting the "Check Engine" light on your dash. How could this happen?

Well, when your car starts up, a flapper valve in the air filter box draws air from a hose which is indirectly connected to the exhaust manifold. The pure, incoming air heats up
quickly as it passes by the exhaust manifold, thereby making for smooth idling and decreased emissions. Since you cite the problem occuring during the start-up phase on cold days only, my *guess* is that the warm air induction thermostat in the air box may be defective.

This may result in intermittent interruptions of the relatively warm air, allowing the colder ambient air to enter the air box in its place. Since there are very large differences between air (density wise, that is) of -20F and +70F (arbitrary numbers, but in the ball park!), the MAF would re-assess the different air masses and send this data to the main computer where it could be rejected..... triggering the "Check Engine" light.

Since your car has been given a clean bill of health by the dealer (seeking professional help was a wise move on your part!), it is unlikely to be a defective MAF or computer, but something more discrete. I believe that the air box fits into this category.

P.S. If there is a problem with an exhaust sensor (the Oxygen Sensor) and you live in North America, the manufacturer is bound by federal law to replace any defective emission control equipment for up to 5 years/unlimited mileage. It's covered under Transport Canada guidelines
(to the north) and the Clean Air Act (state-side). I only hope that your bought your car less than 5 years ago (a 91 should be just on the edge).

**Q: Chasing a electrical problem on my 1981 240DL with a 21F gas engine and a
BW-55 transmission. Battery warning light on dash is on when the car is stopped, engine off and key removed from the ignition. When ignition is off or in position I the light is on. In position II, start and with the engine running the light is off.**

Have run continuity checks on most of the wires running between the alternator and the starter and coil. Everything seems to check out OK.

Really baffled why the light is on when the engine is turned off.

A: Assuming that there are no wiring problems, it sounds as if it could be traced to one of two problems: a short in the alternator stator or burned-out diodes. In either case, testing these parts requires a fairly lengthy procedure which is explained in the Haynes 240 manual.

Have you recently removed the battery, jump started the car? If you hooked things up with the wrong polarity, then the diodes are likey burned-out.

Q: Right after I change my oil, I crank the engine with the coil wire disconnected. This makes the oil circulate in the engine before I start it. I crank the engine for about ten to twenty seconds then I connect the coil wire. The engine does not make any noise and the light does not come on. Will this procedure help prevent "dry start" engine wear?

A: DO NOT DO THIS... PLEASE.....Although this works in theory, disconnecting the coil wire may lead to arcing from the coil to the #1 terminal on the ignition coil. Should this occur, you run the risk of damaging your Volvo's main computer and tachometer. The reason for this is that the high tension arc from the coil will overload circuitry in either component.

It is for this reason that Volvo always recommends disconnecting terminal #1 from the coil when cranking the engine without the high tension coil to distributor cap lead.

The preferred method to preventing "dry start" is to replace the filter with a new unit which has been partially filled with motor oil (approx 1/4 quart poured down the "hole"). Taking into account this 1/4 quart, replace the drain plug and replace an appropriate amount of engine oil. Pre-lubing the filter will avoid running the engine dry for the 1-3 seconds it would normally take to fill the filter.

Upon completion, run engine, watch for leaks. Recheck oil and top up to "full".

I can appreciate owners trying to minimize the wear and tear on their beloved Volvos, so don't take this message as a sharp critique. It is intended to prevent a well- meaning act from turning into an unforseen trip to the garage. Do change your oil frequently, pre-lubing the filter if you are a fanatic about preventative maintenance. Don't get too fancy though.

Q: I have noticed that my headlights have a set of numbers embossed on the lens. What do these nubmers refer to, a stock number? Also, there is a small metal shroud which sits in front of each holgen bulb. Can I remove these to increase light output?

A: The markings noted were:

HCR

E2 20
149

These numbers indicate a European specification lamp. The "20" means that combined, your headlights put of 120,000 candella, a little over half of the legal limit (for European cars) of 225,000 candella (cd). Why only about half of the legal limit? To leave space (in candella) for driving lights etc which a European driver may wish to fit.

The bulbs fitted to this lamp are indeed H4 Halogens, as indicated by:

VOLVO
Bibie iodeH4

The metal work ahead of the bulbs are diffusers, designed to prevent "dazzle" or glare to oncoming drivers. I am sure that if you compare each lamp to 1986 or newer cars, you will find that the European lights have more pronounced cut-outs molded into the lens.

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Brake System FAQ

Q: Have you ever replaced, upgraded , or changed front pads in an 850? There's a spring clip on the outboard caliper which, once removed, is difficult for many to replace.

A: 850 brake calipers are of the "sliding" variety where brake force is exerted by two inboard pistons acting on a sliding mechanism which draws both inboard and outboard sides of the caliper together against the rotor. This type of system was first used by Volvo on the 850s as other models used fixed calipers with two sets of opposing pistons.

Sliding calipers are usually less capable of smoothly releasing clamping force than similar fixed caliper designs. For this reason, a spring is used to help the sliding portion of the caliper (in the 850's case, the outboard one) extend when brake pressure is released.

There are several tools (Snap-On makes nice universal tool for the job, and in a pinch, but some of the local specialists use small Channel-loc pliers) suitable for compressing spring clips -- it's really quite a struggle doing it by hand, you must have quite a grip!!!

On the preventive maintainance side, lightly lubricate the sliding caliper pins with moly grease to prevent uneven pad wear. Before installing pads, increase the bevel on the edges with a fine toothed file or Dremel grinding attachment to prevent pad chatter.

Finally, go to a clear stretch of road, gently accelerate to 50kmh/30 mph, then firmly apply the brakes until the car is just about stopped. Gently release the brakes, very gradually accelerate to 50 kmh/30 mph again and repeat the cycle at least five times. This procedure will gently warm the brake pads, safely burn-off the elastomers used to bond the brake lining matrix (copper, zinc, rock wool, etc), and prevent glazing of the brake pads. By bedding-in the brakes in this manner you'll increase the lining life by 20-30%!!

While on the issue of brake pads themselves, I am currently gathering data on friction co-efficients for OEM and performance brake pads to include in my next work, "The Volvo Performance Handbook". Initial indications indicate that the carbon-based pads provide slightly less stopping power when cold, better stopping when warmed, and, depending on the compound (I've sampled three different varieties), between -10 and +30% rotor wear. Their greatest disadvantage is, however, noise as many of the high-friction pads I've tried produce some low-frequency growl or high frequency squeal which may annoy most users.

Like most neat stuff, what is good for the track is not always good for the road. Additional technical details on friction coefficients and temperature ranges of OEM and aftermarket brake pads may be found in "The Volvo Performance Handbook".

Q: How do I prevent my brakes from squealing upon application?

A: Has anyone done a post-mortem on an incessantly squealing pad? I have. The dust groove gets blocked. With no where for the dust to go, it gets trapped (with brake gasses) and causes noise.

Buy a Dremel Moto Tool. Cut a V-groove into the pad where the U-groove had been cut. Smooth edges of groove so that there are no hard edges/nooks for hot brake dust to bind. Voila! No more brake squeal (for about 2 years anyway.).

I recommend cleaning pads with Dremel once per year.

Seriously folks, have your mechanic try this one. It really works. However, no need to widen the groove, just turn it into a vee so that the brake dust sloughs off.

Volvo brakes are great. Long life, good performance. Just require some care.

Q: I'll be coming up on 2 years ownership for my 850 Turbo, and wanted to ask you for a followup to your excellent explanation of extending brake life on page 14. The question is, if one keeps a close watch on the color and quantity of his brake fluid, is it still recommended to replace it after 2 years? Its just that bleeding for a novice, while not brain surgery, still looks like a fairly complex procedure. Friends of mine with other makes have manuals which don't even mention changing the brake fluid. If one of the problems is water in the system, how does it get in there to begin with?

A: Judging the age of brake fluid by its color was mentioned as a very rough indicator only. The majority of Volvos still have the original brake fluid which, as the book suggests, tends to be tainted with elastomer particles from the brake hoses & seals. Hence its dark color.

The fifth paragraph of Chapter Three goes on to explain that glycol's affinity for moisture can cause brake fade and internal corrosion. Although most folks believe that brake systems are "sealed", they are not. All master cylinders have some kind of breathing hole to equalize pressure with the atmosphere. All braking systems employ rubber hoses which allow some moisture transfer at the microscopic level. The result is, as Figure 3.2 shows, moisture absorbtion leading to a degradation of boiling point (and corrosion protection) over time.

But wait! Your car is an 850, and your manual/dealer says that the brake system is filled with non-moisture absorbing DOT-5 synthetic fluid. True, but all that means is that any accumulated water is held in its natural state, not in suspension. In DOT-5 systems, water can come to rest in an isolated portion of the brake system and cause very localized corrosion.

Volvo recommends that brake fluid be changed every two years. Although this is a conservative recommendation in relationship to other manufacturers, I don't believe it goes far enough. As a rule, I change my cars' brake fluid annually. This is easily accomplished with a few simple tools (I recommend the MightyVac pump, sold at most autoparts stores and available through iPd), 1.5 litres of fresh fluid of the proper grade, and a good shop manual for guidance.

Don't worry about the complexity too much, just read the instructions several times, collect the proper tools and take a deep breath ! If you still have reservations, take the car to a garage..... it shouldn't cost that much (more on cost later).

The reason why some manufacturers don't mention the requirement to change brake fluid is two fold:

a. either they issue directives to dealers to carry out such service free of charge as part of a normal maintainance schedule (rare indeed), or

b. they hope to gain future parts sales when the systems ultimately corrode.

I tend to believe the latter.

Because your car has a *very* expensive anti-lock pump, I recommend that you consider annual brake fluid changes. Even if each flush & change costs $50.00 (a more realistic figure is $30, or $10 if you do-it-yourself), annual changes compare favorably with the cost of replacing a $1400.00 ABS pump.

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Transmission FAQ

Q: I am the second owner of a 1995 850 and am interested in changing the car's transmission fluid before an upcoming trip. The person at the parts counter of my local (San Antonio, Texas) dealer said that my transmission was a "closed system" and you "don't change the filter". He then spoke with a mechanic who said that "you don't even want to change the fluid in older cars because of the increased lubrication will cause slippage."

This sounds completely illogical. The manual even shows the transmission pan/filter and how to change it. The car has about 80,000 miles on it. Is this true or should I attempt to get the parts directly from a factory store and change the filter and put in new magnets in the pan?

A: 1995 850s are fitted with Aisin Warner 50-42 transmissions. According to AB Volvo, the factory installed transmission fluid is normally good for life. Volvo does, however, suggest that cars that are frequently driven in hot or mountainous conditions benefit from an occasional fluid change.

The fact that no change interval is promulgated leads some mechanics to believe that the transmission would not benefit from fresh fluid. This is not the case. An automatic transmission is a precision component that is designed to work best with properly filtered and clean fluid.

All automatic transmissions use fluid to transmit power from the engine to the driven wheels. The synthetic composition of today's fluids impact a high degree of viscosity stability. Regardless, the heat and contaminants generated by a transmission's clutch packs will reduce the lubricant's ability to protect components from friction and oxidation. The result is premature wear and, in extreme cases, a complete transmission failure over time.

Volvo specifies the use of fluids that meet Dexron IIE or Ford MERCON standards. The factory also says that Dexron III compliant fluids are suitable. They even go so far as to indicate that the oil change volume is three litres (roughly three quarts) if the transmission is drained and have a variety of technical publications that illustrate the correct method for changing fluids and filters. By draining the transmission, however, 4.6 litres of old fluid will remain in the torque converter.

The best, and most complete method, of changing transmission fluid is to flush the system. The following is the correct procedure for such a job:

1. Park the car on level ground and turn off the ignition;
2. Remove the filter plate and, if necessary, replace the transmission filter;
3. Re-install the filter plate;
4. Disconnect the transmission lines at the oil cooler;
5. Secure an appropriately sized hose to the transmission return line. The other end of the hose should be immersed in a container holding approximately 10 litres of fresh transmission fluid of the correct specification (DEXRON II E or MERCON, alt DEXRON III);
6. Secure another length of hose to the output line from the transmission. The opposite end of this hose should lead to a large catch basin that is capable of holding 15-20 litres of fluid;
7. Keeping an eye on the container of fresh transmission fluid, have a friend start the car. The idling engine will simultaneously drive the transmission's internal pump, drawing fresh fluid into the transmission and torque converter, and forcing the old fluid into the catch basin;
8. Maintain an appropriate level of fresh transmission fluid in the container. That is to say that at no time should the return line be allowed to run dry or suck air;
9. Shut off the engine when the fluid from the output line runs clear (it will first appear to be darker than the fresh fluid, but will gradually lighten in color as the transmission is flushed);
10. With the ignition off, remove the drain and feed hoses. Re-attach the transmission lines to the oil cooler;
11. Re-start the car and check for leaks. Re-check the fluid level, making sure that it is in accordance with the owner's manual;
12. Dispose of your old fluid at a recycling depot or hazardous material site.

The fact that you've been driving in a very warm climate (San Antonio, Texas) for a number of years is sufficient justification to change the fluid. It's also a good idea to change the fluid if it is darkened by suspended particulate or has a burnt odor. If the job is done correctly, a transmission flush will not affect performance. On the contrary, it is one of the best ways to prolong the life of a very expensive drivetrain component.

Q: I live in Argentina and there is very little information about Volvos. I would be very grateful if you can tell me what the rear axle ratios are for 1980 200-series cars with four and six cylinder engines. I am planing to swap my diesel (D24) engine for a gaoline-powered six cylinder Ford engine, because in my country the spares for the diesel engine are very difficult to find and expensive to buy.

A: Volvo fitted its 1980 models with a variety of transmissions, each of which had specific rear axle ratios. Most cars with M46 (manual 4 speed + overdrive) transmissions featured a 3.31:1 final drive. Most automatic transmissions were paired with a 3.73:1 final drive. Both final drives were designated as Dana 1030 axles. All turbocharged B21FT engines (produced for various markets from 1981 on) were matched to either a 3.54:1 (manual transmission) or 3.73:1 (automatic transmission) final drive.

You can confirm the rear axle ratio in two ways. The first is to look for the metal tag attached to the rear axle tube (driver's side). The second way is to jack up the car and rotate the wheels for 20 or more revolutions, noting the number of corresponding turns made by the driveshaft. The ratio of wheel driveshaft turns to wheel revolutions
will be the final drive.

If you're upgrading the engine to one which has a higher output, a Dana 1031 is recommended. These may be found in 1989 or newer 200- and 700-series cars. The Dana 1031 has a heavy duty ring and pinion gear and will easily cope with the power generated by a small block V-8 or V-6 Ford engine.

Q: I have a 240 wagon with an automatic transmission. I am having serious overheating problems which are most likely due to a bad rad. Before going out and purchasing a new one (I don't want someone else's problem) I need to know if all volvo rads incorporate the transmission fluid cooler as part of the rad? Or is this just part of the Automatic volvos?

A: Your Volvo 240 is equipped with either a Borg-Warner 35 (3 speed) or a Aisin-Warner 70 (4 speed) automatic transmission.

Automatic transmissions act as a fluid couple to smoothly transfer engine power to the drive wheels. To allow progressive engagement, an impeller (contained within a device called a torque converter) acts upon transmission fluid to move an inducer which, in turn, provides power to the differential and drive wheels. This function is carried out by a donut-shaped object called a torque converter.

Because the automatic transmission fluid provides the medium for power transmission, it tends to get very hot. In an effort to control damaging heat build-up, an automatic transmission oil cooler is often used. This cooler is a heat exchanger which may be:

a. integral to the engine radiator; or
b. a separate matrix mounted ahead of the radiator.

The stock Volvo arrangement is to integrate the radiator and transmission oil cooler into a single unit (the Volvo part number for your year/model is 8601907-2) capable of maintaining transmission fluid temperatures between 70-130 degrees C. The benefit of this arrangement is simplicity. On the down-side, however, an engine cooling problem can overheat the automatic transmission. Too much heat decreases transmission life.

An optional Volvo arrangement is to augment the transmission oil cooler matrix with an auxilliary transmission oil cooler. This unit is connected in series with the stock rad/trans cooler unit to provide extra protection during high-load operation (primarily trailer towing and city driving). Such units are a common sight in Volvo cars and can reduce transmission fluid temperature by 20 degrees or more -- enough to double the life of the automatic transmission.

Aftermarket radiators, even the cheap units commonly installed by the less-informed Volvo owners, usually feature the necessary ports to connect to the transmission. That being said, the core density and thermal transfer capabilities of the materials used are often barely sufficient to keep the transmission happy.

Before you assume that your radiator is defective, ensure that the engine's ignition timing and thermostat are operating within normal parameters. Advanced timing or lean fuel delivery can place greater thermal loads on the engine's pistons, combustion chambers and cylinder head, taxing the cooling system beyond its capability. A failed thermostat can fail in the closed position. This prevents coolant from circulating from the rad to the engine. Not good. Your car's timing should be set at 10 degrees BTDC +/- 2 degrees at 750 rpm.

The thermostat should be fully opened at 87 C, although a cooler 82 C unit can be purchased if desired.

Another source of Volvo cooling-system failures is the water pump. All too often, owners fail to change their coolant every 2 years (I recommend annually), leading to excessive mineral fall-out, seal damage and eventual impeller failure. A defective water pump is unable to circulate coolant from the engine to the radiator and back again.

Because the engine and transmission cooling systems are inter-connected, there is a slight possibility that a failing transmission could place a greater thermal load on the radiator. If your car's transmission shifts smoothly and does not whine or clatter, its probably OK. If it does make a lot of racket, or the fluid is burnt (Try smelling it. Really!) or absent, perhaps servicing is long overdue.

It is entirely possible that the rad is no longer servicable. If so, replacing it with a *quality* unit will get your Volvo running again...... that is if engine/transmission damage has not already occured. If engine temperature has crept into the "red zone" at any time, chances are that some kind of damage has occured.

Expect a good quality brass radiator to cost $250.00 and a top-quality aluminium unit to run $700. What's the difference? The aluminium rad provides almost twice the cooling capacity and lasts about 8 years, compared with a brass radiator lasting about 3 years. If your car is in really great shape (ie. it is expected to keep rolling for the next decade), you will be better off buying the best rad you can afford.

The alternatives, namely a $1500 transmission or $2000 cylinder head, are not attractive.

Q: I have a 1988 Volvo 740 with 185,000 miles. As my car is warming up, I can feel a shudder run through the driveline whenever I release the clutch. What's the most likely problem?

A: U-joints are a possibility but the driveline shudder would continue even after the warm-up phase of your trip(s).

That being said, it may be a good idea to replace the joints anyway since they are normally well worn by the time a car accumulates 150,000 miles.

I suspect that your problem has something to do with the clutch assembly; and I'll explain why.

Operating temperature appears to be a factor. The fact that the shudder disappears when the driveline is disconnected rules out the differential (unless you have a limited slip unit). The fact that the driveline shudder disappears when the car has been driven a while rules out the driveshaft being out of balance. That leaves the center bearing, U-joints, tranny seals/bearing, and clutch components.....

The center bearing would cause a rumble, maybe a shudder but would generally be persistent. So would the U-joints. The transmission output bearing could be suspect, as could the differential input bearing.... but as you pointed out, the problem goes away and I assume that grinding/ narrow band noise is not evident. Neither is transmission or differential fluid leakage.

This brings us back to the clutch components. Could some oil have seeped onto the clutch? Have you noted a shudder on disengagement. Some light wind-up/shudder is normal due to the rubber flex-joint fitted to many 740s and some 240s, but anything excessive may be cause for concern.

Have you had the flame trap serviced regularly? I like to replace the flame trap at 50K miles since it prevents oil seepage past the rear (and front) main seals. Seepage from the rear main seal can contaminate the clutch.

Does the condition relate to operating temperture? The clutch's friction material is affected by heat (as is the sliding friction of most materials). Some light contamination can be burned off as the material reaches operating temperture. A little oil may not completely ruin the clutch, but it could make it a bit balky until it warms up.

Although I have laid the groundwork for examination of the clutch, I would have the following parts examined by your mechanic in the following order:

(1) U-joints, because they can be easily visually inspected with no undue labour charges;

(2) The center bearing, same reasoning as above;

(3) If it hasn't been done, have the flame trap serviced, it's a good bit of preventative maintenance at your car's mileage;

(4) Have the mechanic check for visible gearbox/diff leaks, again little labour charge for 2 minutes work;

(5) If the problem persists, have the clutch and associated bearing checked. This will require removal of the transmission (about 2 hours work).

Q: I own a 1975 B20F Equipped 244DL. I am planning on freshening up the motor next year with a valve job, gaskets, etc. The car is 4-spd equipped, with 120,000 miles. I would like to put a 5 speed in the car, and as I know that the B20 never came with one, was wondering if the later M47 could be mated to my B20.

A: I cannot definitely say whether a M47 replace an M40 on a B20F, but several factors suggest that there would be difficulties. First of all, an M47 is several inches longer than an M40. This is because an M47 is really just an M45 with a fifth gear and housing bolted on; not unlike the M46 which is an M45 with a Normanville de Laycock Type J Overdrive unit boted on to the rear casing. With an M47 being longer than an M40, one would require a different driveshaft.

A second problem one may encounter is with the splined engine output shaft. Volvo has different spline patterns, some even within the same model of engines. Therefore, it would be best to physically confirm that the replacement transmission clutch assembly can interface with your B20F.

The third problem one may encounter in a transmission swap concerns gear ratios. M45, 46 and 47 transmissions have different first and second gear ratios than those fitted on an M40. This could cause some driveability problems as the ratios may not necessarily be matched to your B20's torque curve.

Finally, you may wish to reconsider choosing an M47 for an "upgrade". From a longevity standpoint, the M46 is considered a much more durable box -- explaining why Volvo continued to use this transmission in

940 Turbos. It must have been hard from a marketing standpoint to put an electric overdrive-equipped tranny in a 1990s vintage car, but I suppose Volvo thought it would have less serious marketing reprocussions than a rash of early failures. A small, but significant point in avoiding an M47 also concerns the way in which the speedometer interfaces with the transmission. An M47 uses an induction pick-up, not the mechanical drive found on your M40. Not an insurmountable problem to overcome, but just another example of the complexities of swapping transmissions of different vintage!

With all of these factors taken into account, you may wish to seek-out the overdrive-equipped M41 transmission and the associated driveshaft. The M41 was fitted to B20s (it was the "5" speed mentioned in 1800, 140 and early 240 brochures). Short of using the shorter final gear as justification to fit a taller rear axle ratio, however, the M41 will not give you any better acceleration times, just better highway fuel economy due to decreased revs.

So I guess like most things, you may wish use a cost/benefit approach to solve your transmission dillema. Changing transmissions will involve more than fitting a new gearbox and may result in some performance irregularities. Unless your M40 has been abused, it may be more economical to have it inspected and corrected. This brings me to my final point.

With 120,000 miles on your B20F, I am left wondering why you feel you need a valve job to "freshen" up the engine. Have you had problems with valve seat recession? How about leaky valve stems? Problems with recession would demand harder valve seats to be fitted (it makes the engine more amenable to using unleaded gas, by the way), but valve stem leakage after 120,000 miles suggests that more frequent oil and filter changes are required.

If compression tests strongly suggest the B20's head no longer performs to specification, you will probably find it much more economical to purchase a factory rebuilt unit from your Volvo dealer. The pricing of the factory rebuilds are very competitive, come with a one year warranty, and meet more stringent quality control tolerences than a private or dealership rebuild could normally meet.

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The Gothenburg Bible

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The Gothenburg Bible

Forward

A brief explanation of what induced me to write a book on Volvo maintenance will give insight into how this project started....

My first new car (admittedly a Japanese import) was, as new cars are wont to be, an absolute jewel. With gleaming metallic paint, alloy wheels and loaded with every amenity possible, it was a striking little car.

In fact, I was struck with how my first routine servicing cost $80.00.

"Eighty dollars isn't that much!" You may add, but it was for what ended up to be an oil & filter change, a kick of the ol' tires and a 79¢ pine-tree air freshener. It was then that I realized that if the cost of routine service shocked me, I wouldn't survive a long term relationship in which the chaos of valve-jobs, rebuilds, and brake overhauls were sure to occur!

Having spent my early twenties at sea in ships many years my senior, I learned that the key to economically keeping a mechanical device in good working order for extended periods of time was through the adoption of preventive maintenance. For the uninitiated, preventive maintenance is a concept whereby forecast failures are avoided through careful attention to servicing. This concept is faithfully used by most automobile manufacturers when they establish their service intervals.

To understand automobile manufacturers' views of preventative maintenance is to enter the nebulous world of statistics. On this planet the strange beings (divided into three groups - marketing types, statisticians and engineers) work tirelessly to establish a servicing regime which results in an acceptable "mean time between failure" rate. This is where the fun begins....

The life of automobile systems depend on their frequency and severity of use, ambient operating conditions, and the attention paid along the way. Being unable to plan for every operating scenario, manufacturers base their recommendations on broad norms. These norms are predicated on each component lasting a specified duration, normally to the point where the average owner's perception of the marque's value is not shaken when failure occurs.

But perception is a funny thing in North America. Cars are considered "used" the minute they drive off of the dealer's lot and "old" after five years! This is reinforced by the statistics which show that the average owner keeps his/her car barely long enough to pay it off (about four years). This begs the question "Why do they sell them off so soon?".

The truth of the matter is that the average car starts to suffer initial mechanical failures after only three years of ownership, earlier if the manufacturer's service schedule is ignored. This is where the psychology starts. Car owners keeping their vehicle beyond five years are thought to be either destitute, unwise or idiosyncratic. Whatever the case, owners of "older" cars are led to believe that major repair costs are a fact of life, the unavoidable side-effect of getting out from under financing payments. This view panders to the interests of those who reap riches from whatever route the owner chooses.... Except one.

So hear I am, bracing for the shock of the first major repair. In my search for a way out I find that while an owner's manual provides guidance on operation, car guides -- ideas on replacement, and repair books -- refurbishment, there is precious little specifying how to preserve what I have - an attractive little car, still in its prime.

Ten years and over a quarter of a million kilometres later I became the proud owner of a larger car, a Volvo (actually two Volvos!) , said to be capable of carrying those possessions and loved ones gained along the way. Built to last considerably longer than most, Volvos feature engineering details which, if serviced with a view to long-term ownership, can provide a minimum of 15 years of economical driving enjoyment.

This book is divided into eight chapters, each explaining the basic operation of your Volvo's major systems and suggesting how preventative maintenance may be used to economically extend the life of major components. Whenever possible, technical terms are fully explained within the context of each section. If any questions arise, however, a glossary of terminology has been included.

This book is not intended to replace the valuable information provided to you by AB Volvo or your Service Manager, but to supplement the knowledge gained through careful reading of your owner's manual, technical publications and repair manuals.

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Improving Airbox Performance

By Paul Grimshaw

ENGINE BREATHING

Power-enhancing engine modifications serve to increase the breathing capacity of an engine. One of the most popular ways to increase engine breathing is through the use of a performance camshaft and/or a larger set of intake and exhaust valves. While such modifications have the potential to improve engine output, they also place a greater demand on the rest of the induction system to perform at a higher level.

POPULAR SOLUTIONS, LIMITED CONSEQUENCES

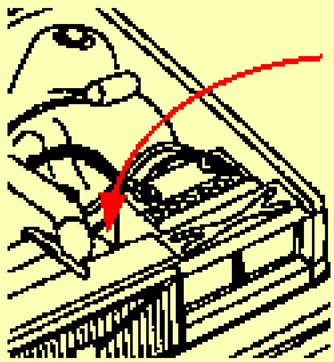
Cone filters are becoming a popular, but somewhat expensive ($70-100), method of improving flow through the induction system. Their primary weakness, however, is that most cone filters draw air from inside the engine bay where high temperatures reduce the density of the air being admitted into the cylinders. As a result, the advantage of increased induction flow is offset by the reduction in the *mass* of the air reaching the engine. This limits power.

DOES VOLVO KNOW BEST?

Factory air boxes are designed to meet strict tolerences. Their shape and interior volume are carefully crafted to improve engine breathing by resonating at specific points along the engine's powerband. For Volvo air boxes, resonation occurs in the 2000-3000 rpm range to improve low-end torque.

FINDING THE AIRBOX...

Most normally-aspirated 200, 700- and 900-series (B230) Volvos are fitted with fuel injected "red block" B21, 23 or 230 engines.



The factory airboxes fitted to these engines may be found on the driver's side (Eur, NA) of the engine compartment, tucked between the battery and the radiator.

Notwithstanding the impressive engineering of the stock airbox, a number of market considerations interfere in optimum airbox performance. First, the airbox must allow rapid engine warm-up for reduced cold-start emissions. Second, any resonations must be "whisper-quiet" so as not to disturb the marque's luxury image.

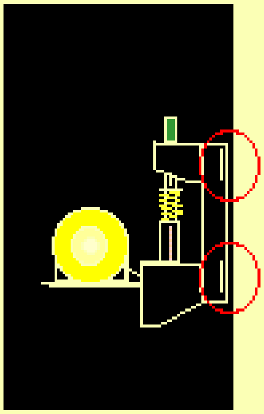
To meet each of these considerations, Volvo has incorporated two design features into its airbox design. First, a thermostatically-controlled warm air induction flap enables a constant air temperature of 70°F/21°C to be maintained throughout the system. Second, a gently tapering intake "snorkel" reduces intake noise as the system draws outside air.

While each of these modifications serve their designed purpose, they prevent optimum engine power from being attained.

THE CURE

The factory airbox fitted to most B21, 23 and 230 engines can be easily modified for maximum performance by removing both the warm air induction flap mechanism and the intake snorkel. Each of these components may be removed by releasing small plastic clips (flap) and friction collars (snorkel). This modification is best initiated by removing the factory airbox from the car, cleaning away tar and road grime, and using a small slot screwdriver to carefully remove each component.

The warm-air induction flap mechanism (highlighted) resides inside the factory airbox and serves to maintain a constant intake temperature of 70°F/21°C.



The flap mechanism may be removed by releasing three small plastic clips which secure it to the airbox (location of the two main clips are circled in red).

Re-install the modified airbox and securely re-connect the intake trunking. If in doubt, refer to your Chilton®, Haynes®, Bentley® or AB Volvo® Technical Repair Manuals.

The best part about this modification is that it can be conducted at no cost to the owner who is proficient with a screwdriver and wrench.

CONCLUSION

Although this factory airbox modification will improve the breathing of a stock engine, it is best suited to an engine which has received more fundamental performance modification. The "Volvo Performance Handbook" lists the specifications, part numbers and sources of a number of relatively inexpensive performance camshafts and valves -- each of which are capable of significantly increasing engine power and throttle response.

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Special Article -
More Than Just Some Loose Change....

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by Paul Grimshaw
Author, "The Gothenburg Bible"

50,000,000,000 is a big number. In seconds it works out to a little over fifteen hundred years. In dollars, however, 50 billion is what North American drivers shelled out in 1979 for car repairs. The most disturbing thing was that a National Highway Traffic Safety Association (NHTSA) study conducted that same year found that half of the money spent was wasted on unnecessary repairs.

Obviously, many car owners were raped by either unscrupulous repair facilities motivated by rich profit or by incompetent service staff confounded by technology. If you're having trouble finding out what has changed, you may be excused from reading the next section.

THE MORE THINGS CHANGE, THE MORE THEY REMAIN THE SAME...

In 1979 our continent was recovering from the economic shock induced by the Oil Embargo of 1974. Inflation was limiting whatever purchasing power our growing salaries provided. Automobile manufacturers continued to be challenged by the demands for improved fuel economy and cleaner air levied by the U.S. Environmental Protection Agency (EPA).

Looking back, it's very easy to find parallels with today's world. Job security is dwindling and disposable income is falling almost as quickly as the ethics of the day. For every hard-working and honest mechanic, there is (just as there was in 1979) an evil twin ready to boost his or her monthly paycheck with an inflated work order.

All ethics aside, however, the most proletarian car leaving the dealer's lot today is a technological marvel -- even when compared with yester-year's most exotic models. This quantum leap in technology has left the typical "grease monkey" behind. Mechanics lacking model-specific knowledge on computers, sensors and composite materials are simply unable to reliably fault trace today's most common problems.

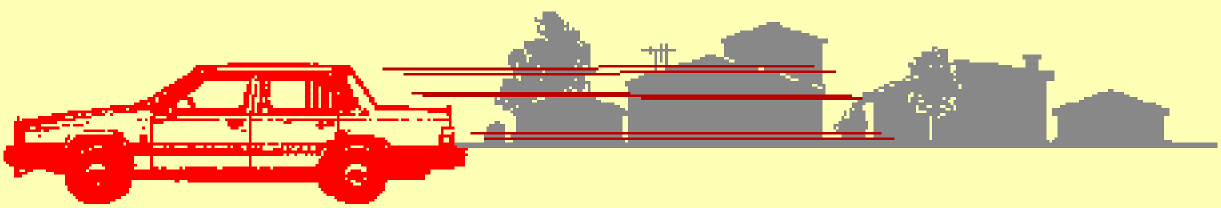
When ethics and technology clash, the result can be dramatic.

REPAIR PHILOSOPHY IN THE 1990s

The complexity of computers and on-board diagnostics (OBDs) have brought about some profound changes to the automotive service industry. Third-line maintenance, a process which begins with fault tracing and ends with refurbishment, repair and preventative action has given way to first-line maintenance. For the uninitiated, this means that fault tracing is normally carried out to identify which component requires replacement only. The differences are subtle until the bill is presented.

A BRIEF EXAMPLE FOR THE MODERN VOLVO OWNER:

Picture this: You are driving down the road on a fine summer day in your post-1988 240/740. Suddenly, with little more than an engine miss, your Volvo loses power. It doesn't quit outright but the power loss is so severe that your car is limited to 25 mph or 40 km/h. The orange "Check Engine" light is shining brilliantly, a reminder that your day of carefree motoring has just come to an end.



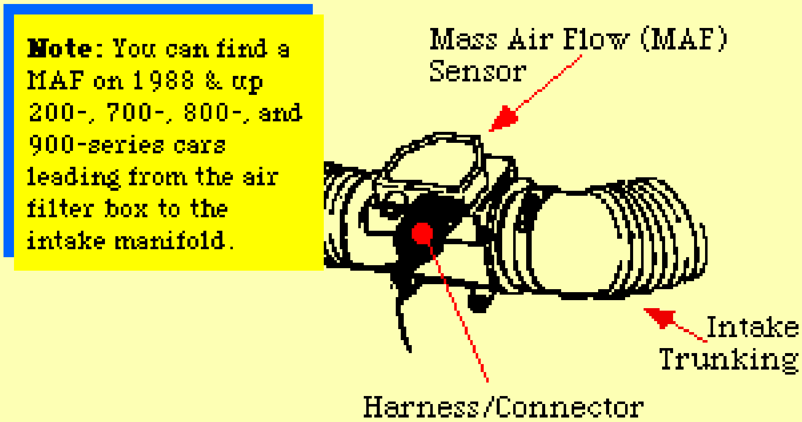
After making your way to your mechanic a quick examination is carried out using the diagnostic socket/L.E.D. fitted to your Volvo's electrical/fuel delivery system. A fault code is replayed for you. The mechanic tells you that your Mass Airflow Sensor (MAF) is shot and the power loss you experienced is "limp home", a computer fall-back mode which often prevents an electrical fault from completely immobilizing your car.

Your mechanic has just provided first line maintenance. Diagnosis has suggested that the MAF is dead. Its replacement costs about $400.00. Will that be cash or charge?

Ah Computers! .... Garbage In. Garbage Out.

The diagnosis provided by the test equipment is 100% correct. The meaning of the code displayed, however, is subject to misinterpretation. The fault code really indicates is that your Volvo's ignition computer is not receiving an electrical signal from the MAF. Does this mean that the MAF is dead?

One of my books (in fact my favorite automotive book), "The Bosch Automotive Handbook", was written by the mechanical and electronic designers responsible for most of the engine management systems in your late-model Volvo. Although the wise men and women at Bosch concede that breakages and failures do occur, they suggest that most common electrical malfunctions can be traced to the electrical wires and connectors which link components.

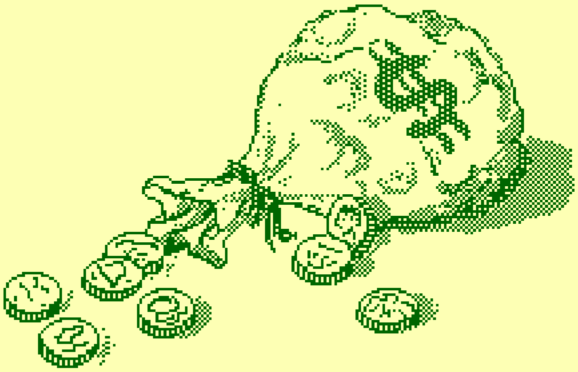


Salt spray, moisture, dirt and vibration can interrupt signal flow through an electrical connector. Simply separating, cleaning and re-connecting the correct wiring harness has been known to restore proper MAF functions. The repair (cleaning) of the MAF is second-line maintenance. If your mechanic found this procedure restored MAF functions, lubricating the contacts with conductive dielectric silicone would prevent a similar fault from recurring. This is third-line maintenance. The cost, about 30 minutes of labour, will get you out of the shop for about $40.00.

What's the Catch?

Granted, the MAF could really be dead. Your mechanic could clean everything up nicely and find that the problem remains. Taking into account MAF replacement, the bill could be $440.00. Nevertheless, the plug connector linking the MAF to the engine management computer would be clean and corrosion resistant, potentially preventing a future electrical fault.

All told there is no catch. It's a win-win situation. But the repair industry doesn't always work like that unless you push hard. This gets us back to our $25,000,000,000 lottery.



JACKPOT!

Using the 1979 NHTSA study as a guide, half of the money spent on car repairs are unnecessary. The bottom line, getting fair treatment, is determined by your basic understanding of automotive systems and familiarity with preventative maintenance procedures. Narrowing the house advantage is as easy as reading a few books, joining a local car club, or subscribing to a computer bulletin board system.

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The Gothenburg Bible Technical Archives

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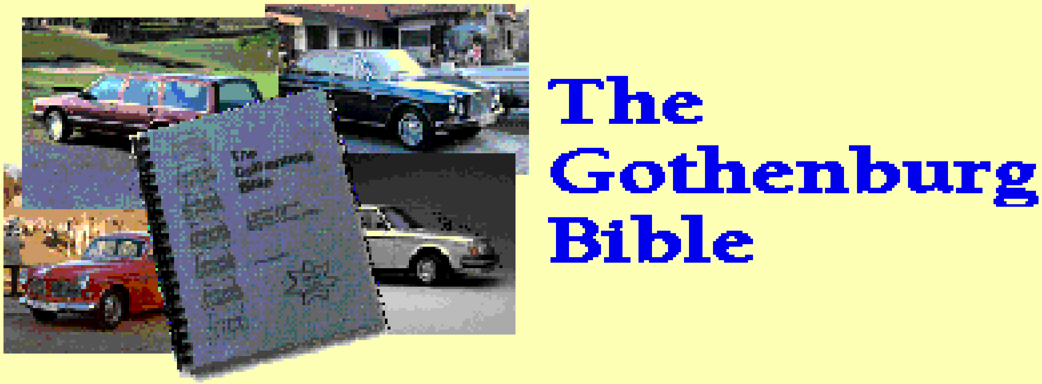

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Cylinder Head Modification

By Paul Grimshaw

Every enthusiast enjoys the prospect of getting more power from their car. Contrary to popular belief, older Volvos are not hopelessly restricted to the slow lane. With a little help they can be easily transformed into very quick and agile cars.

Bending the Rules with Good Engineering

The world of performance modification holds a number of "rules" that are more applicable to North American cars than their Swedish counterparts. They are:

1. *Stock exhaust systems rob power*. Not true for most Volvos. All contemporary normally-aspirated 4-, 5- and 6-cylinder engines produced by Volvo are fitted with remarkably efficient exhaust manifolds and generous exhaust pipe diameters. One exception is in the aftermarket mufflers in some 200- and 700-series cars where reflection type mufflers are fitted more for their low price and outright efficiency;

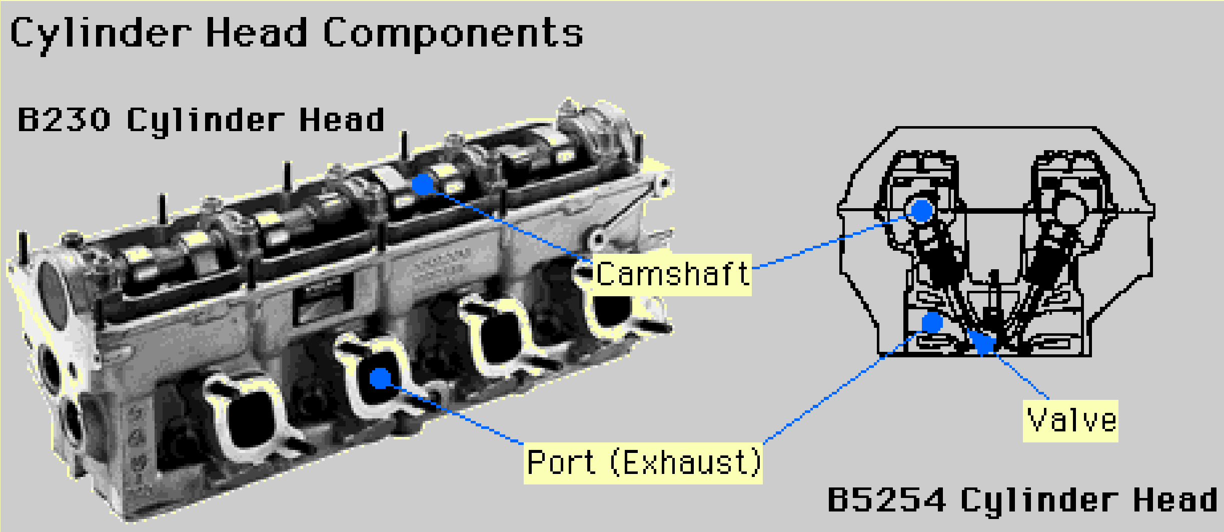
2. *Stock intake manifolds are constrictive*. Rubbish, at least for Volvos. All B21 & higher motors are fitted with exceptionally well-designed, tuned intake manifolds. True, Volvo intake manifolds can be worked to flow more efficiently, but the stock large plenum, multi-branched, single plane design remains worthy of units fitted to many "high performance" cars.

3. *Stock cylinder heads require re-working*. OK, two out of three isn't bad!

Cylinder Head Mods

Don't think of a cylinder head as a single part but a series of parts that in concert to manage airflow.

A cylinder head is first composed of the head, featuring a series of passages that **route** intake air into and out of an engine's combustion chambers. Next there's the combustion chamber itself that is composed of a concave space within the cylinder head, a small portion of the cylinders, and the crowns of each piston. The shape and size of the combustion chamber influences the efficiency with which the intake charge is burned. Finally there are the valves and camshaft. These **control** the flow of air.



The Seven Pillars of Cylinder Head Modification

1. Porting or increasing the diameter of the intake and exhaust ports - generally not required in most Volvo engines;

2. Polishing or smoothing intake/exhaust passages and combustion chambers;

3. Matching or carefully adjusting the fit of the intake and exhaust manifolds to the cylinder head so that the respective orfices line-up with extreme accuracy;

4. Precision valve seat grinding where the valve seats are precisely ground to a nearly continuous curve (5-angle job) or continuous curve (radiused) to allow air to more smoothly enter the combustion chamber;

5. Big Valve Kits where larger intake and exhaust valves are fitted to improve airflow. This modification does, however, reduce intake and exhaust velocities at low rpm, making the engine less responsive in stop-and-go city driving;

6. Valve stem and guide modification where special stainless steel valves featuring narrower stems are fitted to a cylinder head. Since the narrrower stems block less airflow, engine output is increased; and

7. Fitting a higher lift, longer duration camshaft -- an easy and extremely desirable modification as most Volvo engines are "under-cammed".

Stage One & Two-

The first (and most cost-effective) modification to be made is fitting a more aggressive camshaft. Although finding the correct cam for your car can be difficult, the Volvo Performance Handbook lists the designations for most high-performance camshafts stocked by AB Volvo. While not all Volvo dealers stock these items, registered owners of The Volvo performance Handbook can be introduced to the factory sources that are eager to meet the needs of the power-hungry!

There are a total of 8, 11, 2 and 2 available grinds for B18/20, B21/23/200/230, B5254, and B6304 engines respectively.

After fitting a performance camshaft, some recalibration of the fuel delivery system may be required. Engines fitted with Boshc LH fuel injection can, however, easily recalibrate themselves using the feedback loop provided by the Mass Airflow (MAF) and O2 sensors.

Stage Three -

The next step is to polish the intake manifold. This can be done manually or outsourced through companies listed in The Volvo Performance Handbook. This is followed by port matching and fitting a big valve kit. Apart from selecting the correct parts and sources, this stage demands the services of a specialist equipped to conduct professional modifications. If a tuner does not have a flow bench, they are not capable of taking-on Stage Three work. Period.

Stage Four -

Finally, there remains the task of polishing and re-working the shape of the combustion chamber and moving to a slightly higher compression piston to preserve the correct compression ratio. This is best conducted by a professional tuner well-versed in preparing professional racing engines. There probably only one or two shops in each state or province capable of such work -- and they don't advertise in the Yellow Pages! By the time you've made it past Stages One thru Three, however, you'll probably know the best local source for this kind of work.

Conclusion

Stage One & Two modifications can increase the power of a well-functioning engine by up to 20%. Stage Three will add another 20-25%, and Stage Four an additional 15%. Translates into the following gains:

B18/B20 ~ 180 Bhp

B21 ~ 160 Bhp

B23/230 ~ 185 Bhp

Other engines may achieve more or less, but the overall output will be dependent on how effectively the engine management systems are calibrated. OBD II cars are considerably more difficult to tune and may not react well to camshaft changes.

When it comes to cylinder head modification, one rule holds true:

Read thrice, plan twice, modify once and win forever!

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January Performance Tip - Improving Throttle Body Performance

Sponsored by: The Volvo Performance Handbook

Readers of enthusiast performance magazines will probably recall seeing advertisements for "oversized throttle bodies". The claims expound on improvements in engine breathing that follow from fitting a larger-than-stock throttle body to an automobile engine. What the sales pitches do not explain, however, is that the effective diameter of the intake system is only as large as its smallest opening -- generally the inlet of the intake manifold!

Improving What You've Got

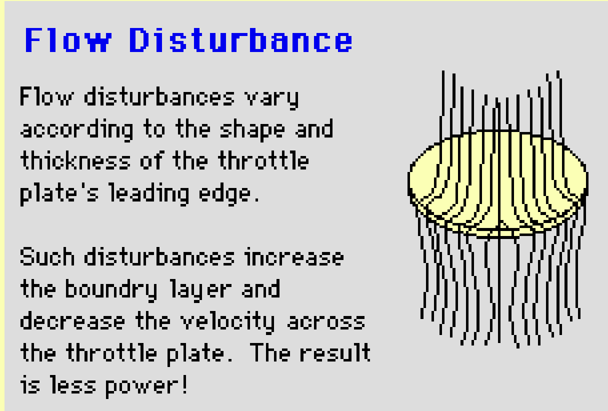
Although the size of the intake manifold inlet will eventually limit airflow, there are a number of simple throttle body modifications that will improve engine breathing at marginal cost. Two such methods are "knife edging the throttle plate" and "flush-fitting throttle plate screws".

Knife Edging

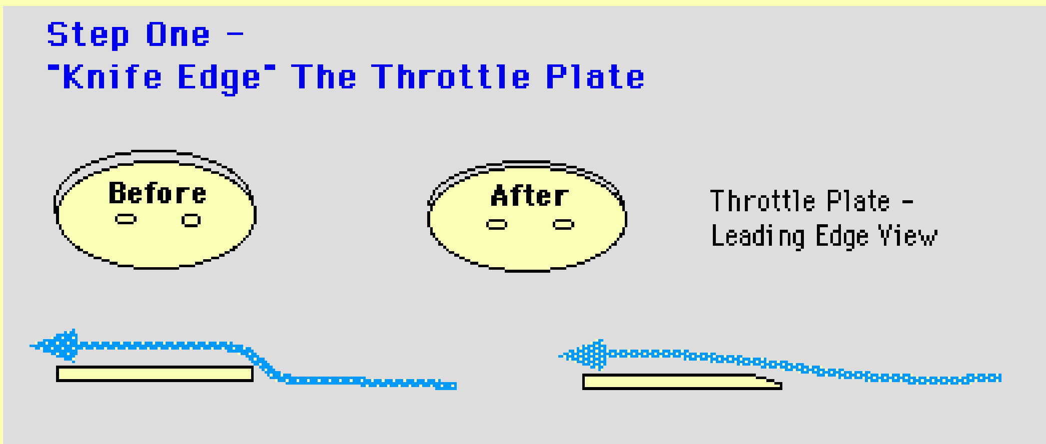
The volume and velocity of air passing through the throttle body will be determined by the aerodynamic properties of the throttle plate. Performance engine builders know this all too well and often fit complicated sliding throttle mechanisms to regualte airflow into their competition motors. Mainstream automobile manufacturers, however, often overlook the humble throttle plate when tuning an engine for optimum power.

Such is the case with Volvos where throttle plates are simply "punched" from thick brass sheet.

Punched throttle plates are characterized by their blunt leading edges that promote airflow separation at high velocities. The result is a throttle plate that will effectively regulate airflow, but fails to promote maximum breathing as engine speed rises.

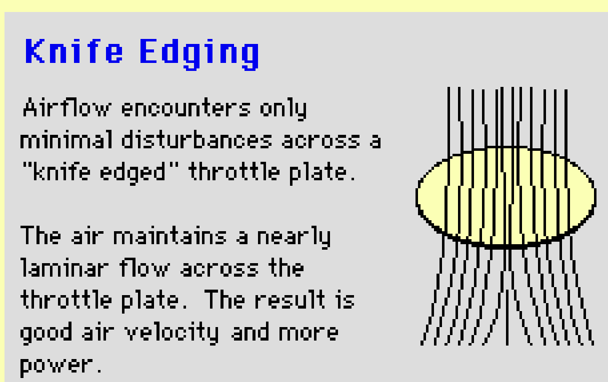


By carefully removing the throttle plate and beveling its **leading edge**, airflow through the throttle body will more closely resemble the theoritical limit afforded by the bore. Note that a trailing edge bevel is not required as the throttle shaft introduces virtually unavoidable turbulence at the thrttle plate's mid-point.



Readers will note that the edge of the leading edge of the "after" picture is **reduced**, but **not entirely eliminated** as sufficient material will be required to effectively seal the throttle body at idle!

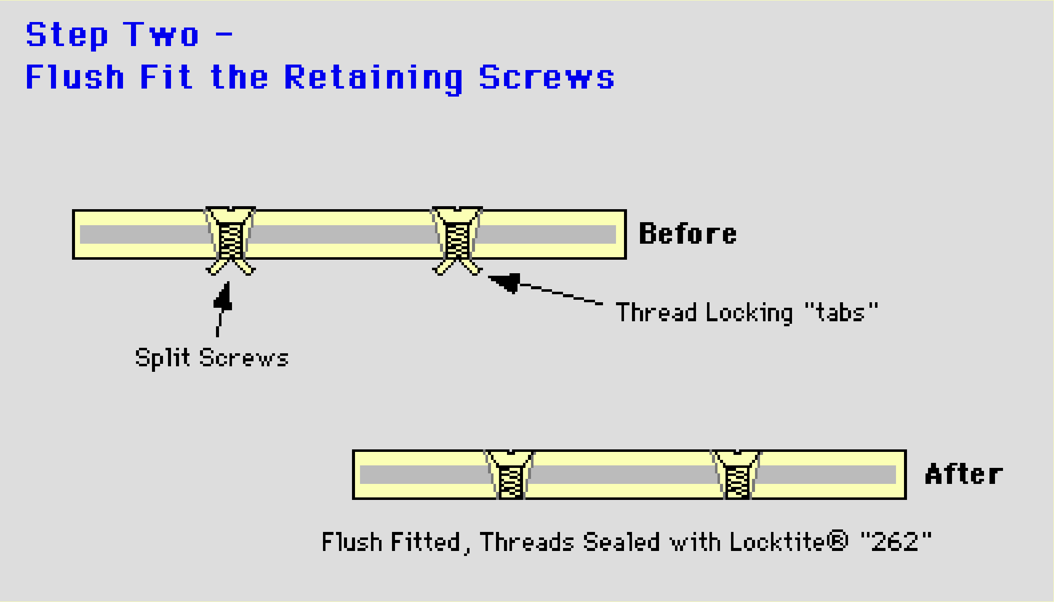
Flow across the throttle plate will be improved after careful modification. The result is greater power -- particularly at high rpm when airflow is at its greatest!



Flush Fitting Screws

The next "quick and dirty" little trick to improving throttle body performance is to flush fit the screws that retain the throttle plate to the shaft. In most cases, this is very straight-forward with the elinination of the thread locking tabs that prevent the screws from backing out. In situations where button-head screws protrude above the throttle shaft, however, an appropriate flat-head screw in carefully beveled seat will be required.

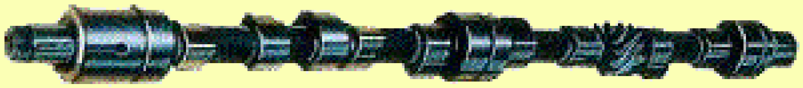
With the locking tabs removed, however, an appropriate thread sealer will be required to prevent the screws from vibrating free. One of the better products for this task is Loctite® "262", a high strength compound provides consistent results from -54C to +149C / -65F to +300F.



Excellence is in the Details!

For the cost of one hour's work and a few dollars worth of thread locking compound, it is possible to increase the flow through a Volvo throttle body by 3 to 5%. That equates to more power, less pumping loss, and improved fuel economy.

While this kind of preparation is what will set the keen enthusiast apart from the rest of the pack, a performance camshaft or free-flowing cylinder head won't hurt either. In fact depending on the engine, up to 40% more power may found by choosing the an appropriate camshaft from the Volvo parts bin:



Engine Variant	Camshaft Options*
Four Cylinder, Single Overhead Valve Engines **B16, B18, B20**	2 Mild 1 Moderate 5 Competition Cams
Four Cylinder, Single Overhead Cam Engines **B21, B23, B200, B230**	3 Mild 7 Moderate 3 Competition Cams
Four Cylinder, Dual Overhead Cam Engines **B204, B234**	1 Mild 1 Moderate Cam
Five Cylinder, Dual Overhead Cam Engines **B52x4**	2 Mild 1 Moderate Cams
Six Cylinder, Dual Overhead Cam Engines **B6xx4**	2 Moderate Cams

* As available through Volvo Dealer

For additional information on how you can improve performance, refer to Chapter Four of The Volvo Performance Handbook!

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Anti-Reversion Techniques

By Paul Grimshaw

The road to increased power is littered with the broken dreams of building strong, smooth engines. We all want more power, but few embrace the lumpy idle that seems to follow performance modification.

Stock camshaft profiles provide very smooth idle characteristics but are notoriously inefficient at upper engine speeds when a lack of lift and overlap consire to limit horsepower. Conversely, highly aggressive camshaft profiles provide sparkling power but fail to deliver a refined, smooth idle.

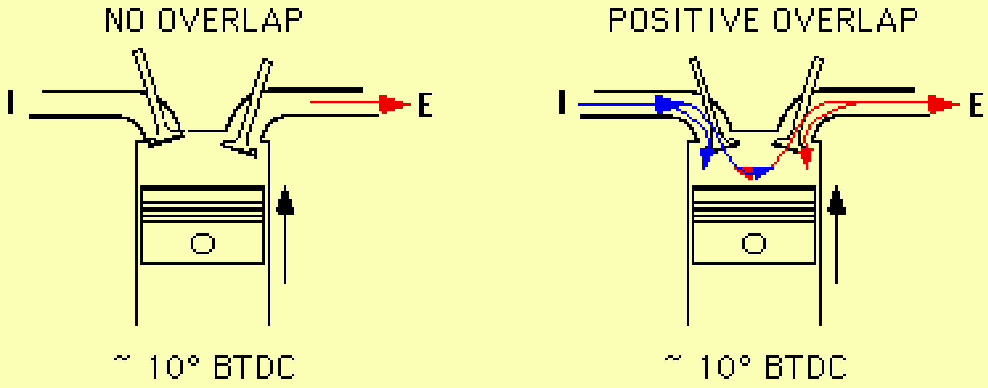
Why does power and refinement appear so elusive? The answer to this question is contained in how engines breathe.

ENGINE BREATHING

Diagram One - NO OVERLAP. Engines fitted with mild camshafts usually idle more smoothly because exhaust gases are allowed to escape before the intake valve opens. While the presence of end exhaust gases cannot be entirely eliminated, the intake charge is more idle-stable. Although such conditions promote smooth idle, cylinder filling is inhibited at higher engine speeds.

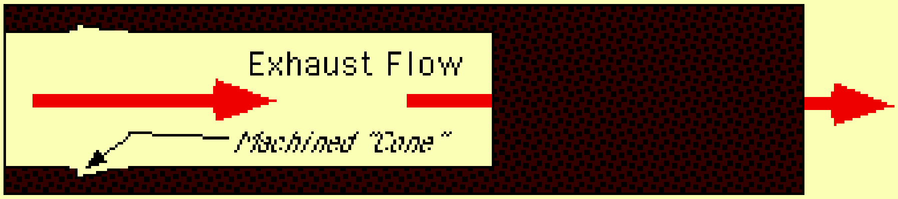
Diagram Two - POSITIVE OVERLAP. Engines fitted with more aggressive camshafts do not usually idle smoothly because the flow of exhaust gases reverses shortly after the intake valve opens. This condition, known as "exhaust gas reversion", upsets the intake charge and leads to a slightly rough idle. This roughness disappears as engine speed rises, Moreover, the elastic properties of the intake and exhaust gases promote extremely efficient cylinder filling at high rpm. The result is more power.

(see Chapter Four, "Valve Function & Timing" in The Volvo Performance Handbook for a detailed explanation)

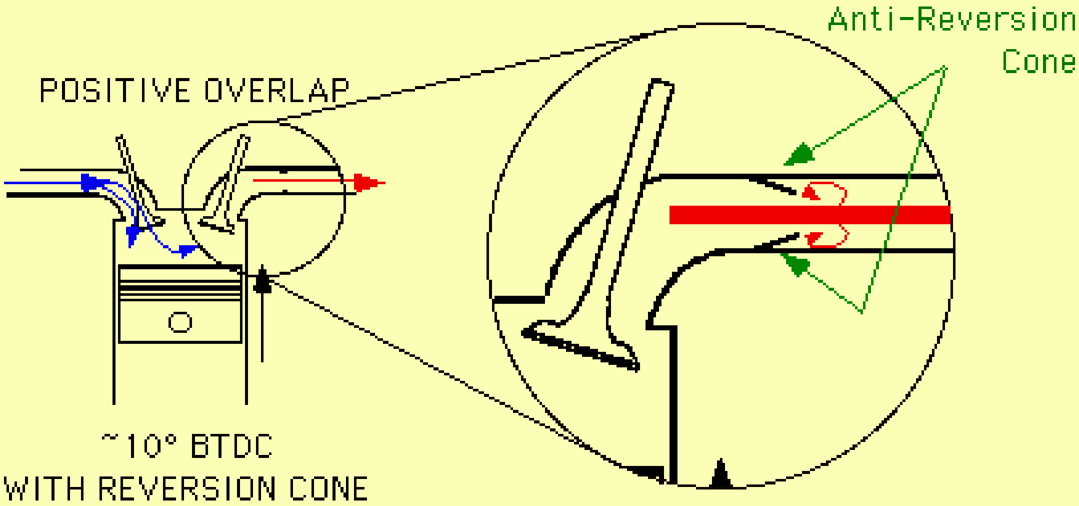


ANTI-REVERSION TECHNIQUES

Exhaust gas reversion can be minimized by machining a small "cone" into each exhaust port (within the cylinder head) or exhaust manifold runner (diagram below). While each are equally effective in reducing reversion, I prefer modifying each cast exhaust manifold runner due to the ease with which these parts may be removed and handled during machining. Should a tubular exhaust manifold be fitted your Volvo (obviously a modified part as Volvo did not use tubular manifolds in B18 thru 230 engiens), a reversion baffle will have to be precision-manufacturered and carefully and securely inserted into each runner.



The cone reduces, but does not entirely prevent, the backflow of exhaust gases into the combustion chamber (diagram below). The result is a smoother idle when using a positive overlap camshaft. Although this modification will theoretically yield additional engine power, it is unlikely to be felt by the driver or measured by a stop-watch. It is simply intended to overcome the roughness associated with high-performance camshafts.



Quality counts!

For additional information on how you can improve performance without losing refinement, refer to Chapter Four of The Volvo Performance Handbook!

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Selecting Correct Fuel Injectors for B21F Engines

By Paul Grimshaw

AN ENGINE'S REQUIREMENT FOR FUEL

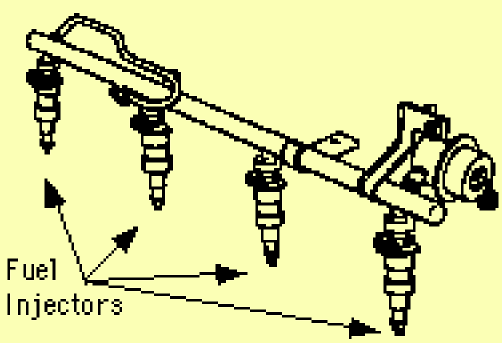
Most gasoline engines require the delivery of around one part of fuel for every 14.7 parts of air (by volume) during normal operation.

Effective performance modifications seek to increase the breathing capacity of an engine beyond the level originally conceived by the manufacturer. As a result, the overall requirement for fuel can rise dramatically.

Should an ill-conceived modification surpass the rate at which the fuel injectors can supply fuel, the engine will operate "lean" . This will increase combustion chamber temperatures and lead to "ping", a potentially destructive engine condition.

B21F FUEL INJECTORS

Most early 240s were fitted with Volvo's 2.1 fuel injected engine, designated by the company as the B21F. These engines featured a LH fuel injection system which relied on four electrically-operated fuel injectors -- each of which were engineered by Robert Bosch GmbH to provide a maximum of 10.2 litre/hr fuel flow at a working pressure of 300Kpa/43 psig and a maximum duty cycle (on/off) of 70%. The four stock fuel injectors were fed by a fuel pump capable of delivering 120 litres/hr flow at the working pressure specified.



CALCULATING POWER AT WHICH THE MAXIMUM STOCK FUEL DELIVERY WILL BE REACHED

With the specific fuel consumption of the B21F set at 0.47, the following calculation can be used to determine the maximum power at which the stock rate of fuel injection will be exceeded:

((Injector Flow Rate in litres/hr x 2.871) to yeild flow in lbs/hr
x (Number of Injectors x Maximum Duty Cycle)
____/ Specific Fuel Consumption

or

((10.4 x 2.871) x (4 x 0.70)) ÷ 0.47 = 177 Bhp

SUMMARY

Increasing the power output of a B21F from a stock level of approximately 104 Bhp to 177 Bhp can be accommodated by the stock fuel injection layout. The implementation of any modification which is expected to increase the power beyond 177 Bhp will require increased capacity injectors.

Although unlikely, increasing engine output beyond 270 Bhp will require a total re-engineering of the fuel injection system to include larger diameter fuel lines, a high flow fuel pump and, of course, a set of HUGE fuel injectors.

CONCLUSION

Every LH fuel injected engine in the Volvo line (B21, B23, B230, B234, B5234, B5252, B5254, B6304) is fitted with a set of injectors which flow at a specified stock rate. These stock rates are listed on page 69 of the "Volvo Performance Handbook" and may be used to determine the maximum power which your engine can theoretically produce before fuel injection modification is required.

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June Performance & Maintenance Tip - Spark Plugs and Wires

Sponsored by: The Volvo Performance Handbook & Gothenburg Bible

ENGINE BREATHING

Ignore the advertisements for Spark Plugs or High Tension (HT) wires which claim to increase engine output or mask worn ignition components. Such claims are fundamentally incorrect as power output is determined by the displacement, configuration, mechanical and thermal efficiency of the engine and the overall integrity of the distributor, cap & rotor, and/or coil(s). What a good set of properly-gapped plugs and efficient HT wires will do, however, support an optimum level of efficiency as dictated by the powerplant's design and integrity.

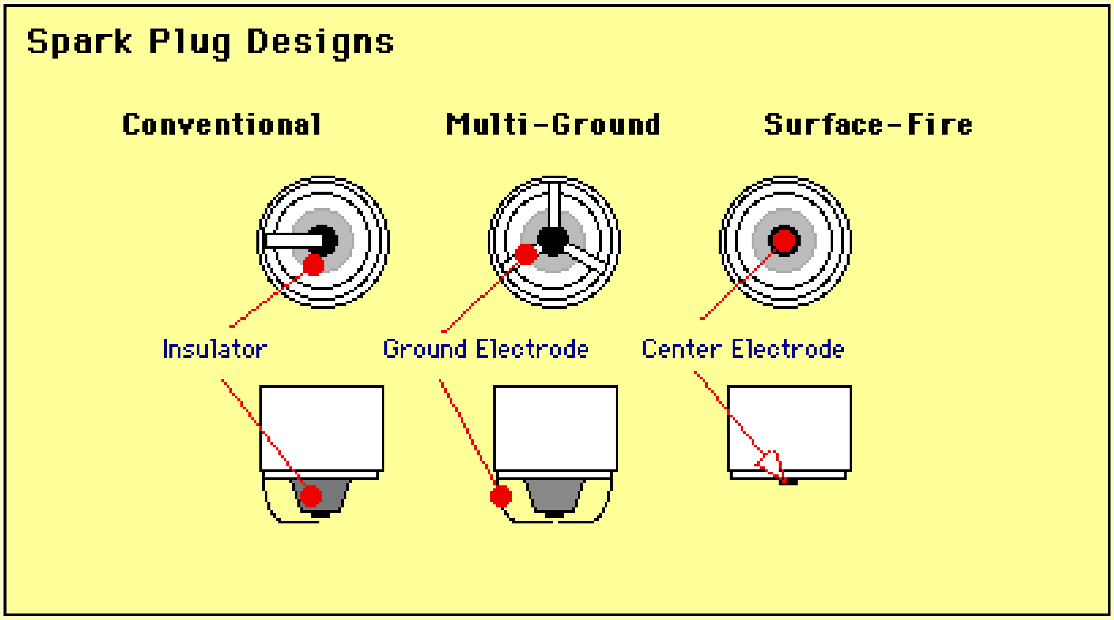
SEPARATING HIGH PERFORMANCE FROM "HIGH-PERBOLE"

SPARK PLUGS

High performance spark plugs start with top-quality materials for the connector, insulator, center and ground electrode. These generally include nickel alloys for the connector and ground electrode and ceramics or aluminium oxide matrices for the insulator. The materials used in center electrodes vary widely.

Nickel/copper alloys, while highly conductive, are poorly suited to operate at extremely high temperatures for prolonged periods. Silver, either pure or in alloy, delivers better heat resistance and conductivity than more common metals. Platinum is clearly the best electrode material on the market today. It is highly resistant to oxidation, even at high temperatures, wonderfully conductive, and easily able to withstand the highest temperatures of spark-ignition reciprocating engines. Platinum is, however, expensive.

One hundred years of spark plug development has yeilded three basic designs, each of which is based on the configuration of the ground and centre electrodes:



Conventional spark plugs are the most commonly found variety. Multi-ground plugs are found on many high-performance engines and, notably, many rotary engines. Surface fire plugs are quite rare, but nevertheless commercially available. They can be found on high-performance street and racing engines.

Spark plugs featuring a split ground electrode is a variety of conventional plug. Apart from a nominally larger surface to which a spark can jump, they offer little advantage. In fact, a number of commercially-available plugs of this variety rely on lower-grade copper/nickel alloys for the center electrode. This undermines the capability of the plug to result in a level of performance comparatble to that of a high-quality conventional spark plug.

HIGH TENSION WIRES

Performance high tension wires rely on top-quality materials to out-perform regular units. Silicone rubber, capable of withstanding up to 1000°F, is used in place of more conventional insulator jackets which will rapidly decompose at temperatures exceeding 500°F. Conductors are made from precisely-wound stainless steel or straded copper cable, vice graphite-impregnated fiberglass. These are terminated with brass or copper alloy connectors which provide a more reliable electrical connection than steel.

High tension wires destined for street/performance applications feature electro-magnetic interference (EMI) suppression which prevents ignition "whine" from interfering with car stereo or engine management operation. Although this adds to the resistance of the wires, it is preferable than having to endure frequent noise or engine operating anomalies.

ABOUT OEM VOLVO PLUGS AND WIRES

Volvo-brand spark plugs are conventionally-constructed and feature copper center electrodes. They are comparable in performance to over-the-counter Champion, Beru, Bosch, or NGK plugs and will deliver dependable performance for 2 years or 30,000 miles/50,000 km.

Volvo-brand HT wires feature wound steel conductors, terminated by brass connectors. While the use of such materials gives these wires a distinct advantage over many other OEM cables, the insulating jacket is susceptable to heat. One may expect these wires to degrade over a two year period -- roughly the replacement recommended by Volvo.

PERFORMANCE ALTERNATIVES

High performance conventional silver or platinum tipped plugs are available in sizes to fit your Volvo through Bosch, or NGK. These companies also manufacture multi-ground and surface-fire plugs, either of which may be obtained through special order.

Although OEM Volvo HT wires out-perform many alternative products, Accel Racing 8.8 mm and Magnecor KV 8.5 mm wire sets feature better insulation for more reliable ignition. Of note, these cost of these products cost approximately 30% more than OEM replacements, but offer much longer service life in return.

CONCLUSION

Buying the best plugs and HT wires won't increase engine output beyond its rated capacity. What it will do, however, is keep your engine operating at an optimum level. Such results are, incidentally, where good maintenance and performance tuning coincide.

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Modifying Engine Management Systems

By Paul Grimshaw

Chips which have been programmed by knowledgeable engine management engineers are able to raise engine performance significantly. That said, only a slim minority of Volvo owners can benefit from aftermarket chip technology since 200-, 700- and most 900-series cars feature Electronic Control Units (ECU) which lack the flexibility of the newest Motronic engine management systems. While a number of engine management modules and plug-ins exist to support older Volvos, this tip will concentrate on ECU modification for 850 and S/V/C 70 cars.

Motronic Upgrades

Motronic systems enable owners of 800-, S/V 70 & 90 to purchase a number of performance chips but each demand a common set of special needs. The requirement to use high octane fuels for detonation prevention, alterations to induction and exhaust systems to handle a deeper breathing engine, and, in extreme cases, fitting additional cooling in the form of competition-sized engine oil, coolant and transmission fluid heat exchangers are considered "de rigeur" for those interested in dependable performance.

While it is theoretically possible to obtain 300 bhp from a B5234FT (the 850 & S/V 70 turbo's) engine, respectable tuning companies concede that the most effective power increases are those that fall below the theoretical limits of volumetric efficiency. Careful modification can, however, yeild a tractable and reliable B234FT capable of producing 280bhp.

How Do Chips Work?

Aftermarket ECUs feature instructions to increase turbocharger boost settings and ignition curves to develop more torque (and therefore horsepower) across the rev range. While OEM rev limits are generally conservative, a responsible tuner will not alter the fuel and ignition cut-offs to prevent connecting rod damage.

Chips sold for road use in the United States will be engineered to meet 49 state emission control limits -- a significant benefit in those jurisdictions which demand successful annual smog checks as a prerequisite for licensing. Chips legal for road use in California will be sold with a California Air Research Board (CARB) certification number. In the case of road legal chips, tuners most often adopt relatively mild tuning across most of the engine's operating envelope and add program aggressive fuel, spark and turbo management during conditions of wide open throttle (WOT). WOT is not part of the CARB or EPA test cycles and thus does not play a factor in most smog checks.

Who Benefits from Aftermarket Chips?

Aftermarket chips are most applicable to the "enthusiast" which not only values power, but also understands the responsibility to more keenly focus on general maintenance such as frequent oil & coolant changes. This is especially true in turbocharged vehicles which are modified with an aftermarket ECU.

Of course, no matter what one does with a turbocharged car, there comes a time when the turbo simply wears out. The time at which this occurs probably depends more on driving habits (and certainly depends on maintenance) more than responsible revisions made to an ECU's read only memory. From this perspective, the turbo owner should look into the mirror when seeking answers to questions such as "how long will it last", "how much is enough" or "is it safe".

Additonal Information

A wealth of data on modifying all Volvo engines for increased output may be found in Chapter Four of "The Volvo Performance Handbook".

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Octane Solutions for Older Volvos

By Paul Grimshaw

The question of how much octane is needed for optimal engine performance is frequently posed to automotive technicians. The aim of this performance tip is to explain the impact that octane has on reliable engine performance, discuss changing octane requirements in worn engines; and suggest useful strategies for the vintage Volvo owner.

What is Octane?

Octane is a term used to describe gasoline's resistance to auto-ignition (knock) when mixed with air and compressed. Motor Octane Number (MON) and Research Octane Number (RON) are the units of measure used to express the auto-ignition resistance of a given gasoline blend in comparison to iso-octane (C_8H_{18}).

Distinct test procedures are used to determine MON and RON values, with the MON test being the most stringent.

Octane ratings in North America are expressed in Anti-Knock Index (AKI), an mathematical average of the MON and RON values. Much of Europe continues to use RON to express octane values of commercially available gasoline.

Octane is of many ways to measure the auto-ignition characteristics of gasoline. Other important fuel quality measurements are:

a. Heating Value & Specific Energy, or the amount of thermal energy released during combustion;

b. Chemical Expansion, or the volume of gases resulting from combustion;

c. Heat of Vaporization, or the cooling effect that a fuel has on the intake charge;

d. Volatility, or the boiling points of the various fractions of a fuel; and

e. Stability & Toxicity, or the safety of a fuel in real world conditions.

Octane's Effect on Engine Performance

The octane of a fuel has a profound impact on the power output and reliability of an engine. Use of gasoline with too low an octane value will lead to engine knock, a potentially damaging condition that elevates engine temperatures, increases cylinder pressures, and robs an engine of power.

Use of a gasoline with too high an octane value does not, contrary to popular belief, increase engine output. It just costs more at the pump.

"Equivalent Octane" Versus Real Octane

Since the requirement for octane in spark ignition cars is inversely proportional to altitude and temperature, standards are in place to adjust fuel octane according to many geographic factors. American Society of Testing and Materials (ASTM) standard D439 specifies 5 classes of anti-knock index reduction for altitude. As a result, what is normally labeled premium gasoline (AKI 92) in the mile-high city of Denver, Colorado may in fact be blended to AKI 90. The effect of such reductions go largely unnoticed -- even by the vintage car owner who expects the most octane for his or her dollar.

Reduction in Available Octane

Volvo specified "premium" leaded gasoline for many of its earlier engines, particularly the high compression B20E. Historical data indicates that the average 3.0 grams of tetraethyl lead blended into each gallon of premium gasoline, combined with the use of benzene, toluene and xylene aromatics, resulted in octane ratings of AKI 95, equating to around 102 RON -- roughly two to three points higher than today's fuels.

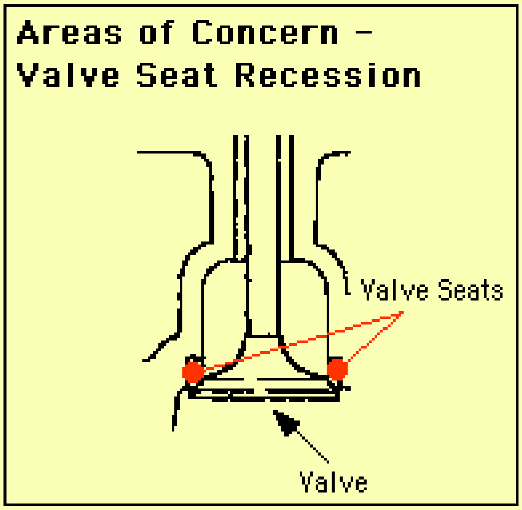
Although a few octane points may seem inconsequential, it is worthwhile to note that an engine's appetite for octane grows under the following conditions:

a. imprecise carb jetting, particularly those which lean the mixture;
b. wear-related blow-by;
c. valve or combustion chamber deposits; and
d. excessive engine temperatures.

Each of these conditions are common in well-worn, but otherwise functional, Volvo engines.

The Effect of Unleaded Fuels on an Older Volvo Engines

In addition to improving octane, tetraethyl and tetramethyl lead additives (TEL) were also credited with lubricating valve seats under extreme operating conditions. Nevertheless, the public awareness over potentially carcinogenic effects of organic metallic compounds led to the reduction and outright ban on the use of lead in road fuels.



The incidence of valve seat recession, a phenomenon where dry valves drive valve seats deeper into cylinder heads, is on the rise. Hard working Volvo B18 and B20 engines are equally affected by the disappearance of leaded fuels. Not surprisingly, owners of 544s, 120s, 1800s, and 140s continue to seek solutions to reduce, or halt, valve seat recession.

Octane Boosters & Lead Substitutes

Although Canada was one of the first nations to ban the use of TEL compounds, Ottawa has continued to permit the use of manganese compounds (commonly referred to as MMT) in most commercially available gasoline blends. Since MMT possesses similar lubricating properties as TEL, the incidence of valve seat recession in Canada is smaller than that of the United States and Europe.

Coincident with the ban on TEL, a number of chemical companies marketed "lead substitutes" and "octane boosters" to the public. These generally contain MMT and varying quantities of aromatic compounds to either improve valve seat lubrication under light-to-moderate use or improve octane rating by 1-3 points.

Oxygenates

The United States' 1990 Clean Air Act encourages the use of fuel additives which promote more complete combustion. Such additives, referred to as oxygenates, usually consist of methyl-tertiary-butyl-ether (MTBE) or ethyl alcohol (ethanol). These additives are present in at least 8 to 25% of fuels blended for use in the United States.

Although oxygenates can improve octane, they are commonly blended with adjusted base stocks to yield the same rating as other commercially available gasolines. Nevertheless, the higher oxygen content of fuels treated with MTBE or ethanol promote more complete combustion in older Volvos. The result is usually a slight improvement in fuel economy and less combustion chamber deposits.

Despite the many positive effects of oxygenates, their effect on the seals and adhesives used in older fuel systems is cause for concern. Nitrile butadiene rubber (NBR) a common elastomer used to seal older fuel systems, has been known to swell in the presence of some oxygenates in three percent of test fleets.

Other negative effects of oxygenates include:

a. increased engine wear, caused by the alcohol additives washing lubricants away from cylinder walls;
b. vapor lock, caused by the relatively low vapor points of oxygenated fuels; and
c. difficult cold weather starting, caused by the low heat of vaporization of alcohols

Aromatics

Aromatic hydrocarbons such as Toluene (CH3C6H5, AKI 114) and Xylene ((CH3)2C6H5, AKI 117) represent the most common octane boosters on the market today. The commercially available quantities of such boosters only improve octane incrementally -- 12 to 16 oz of either of these hydrocarbons will raise the octane levels in a tank of AKI 92 pump gasoline to approximately AKI 92.3.

If used in greater quantities, however, Toluene and Xylene can have more substantial effects on the octane rating of pump gasoline. Ten percent Toluene or Xylene in a tank of high octane pump gas will yeild AKI 94. Whereas twenty percent of either chemical will result in a blended octane of AKI 96. Large quantites of Toluene and Xylene may be purchased commercially for ~$10/gallon.

Significant health hazards and fire risks can arise from handling Toluene and Xylene, so home chemistry is not recommended. In addition, Xylene is a powerful solvent capable or eroding seals and quickly removing varish build-up form a fuel system. The use of Xylene could, therefore, lead to a number of fuel system disorders.

What About Aviation Fuel?

Aviation fuel, or AVGAS, is often touted as the panacea for all octane related disorders. While it is true that leaded aviation fuels such as 100/130 and 100LL have octanes well in excess of road fuels, their distillation curves feature proportionally larger quantities of paraffins. Paraffins are branched chain hydrocarbons that are capable of releasing high energy, but their lower Reid Vapor Point undermines crisp throttle response and frustrates cold starting. These factors, combined with the cost and federal laws prohibiting the use leaded gasolines in North American road cars, makes AVGAS a poor choice for the vintage Volvo owner.

Conclusion

Considering the rules, regulations and performance factors surrounding today's gasoline blends, the following highlights the best strategy for the vintage Volvo driver:

#1. **Ensure that your Volvo's engine is in good working order** and is professionally adjusted to specification. If you're planning an overhaul, consider the merits of having the combustion chamber and valves professionally cleaned, hardened valve seats and, if available, a thicker head gasket installed;

#2. **Wherever possible, use "premium" or "super" conventional gasolines rated to AKI 91, 99 RON or higher**. If such fuels promote pre-ignition in your vintage Volvo, try using a commercially available octane improver. Select products which promote valve lubrication. ALWAYS use care and caution with such products, as they often contain toxic metallic compounds;

#3. **If the only fuels available in your area are oxygenated with alcohols, frequently inspect the fuel filter for signs of debris**. A frequently clogged fuel filter normally signals a deteriorating fuel system. Have the tank and fuel lines inspected, cleaned and prepared to accept oxygenated fuels.

#4. **While there is potential merit in using Toluene or Xylene as additives at the race track, the cost and risk associated with these aromatic hydrocarbons are substantial.**

#5. **Stay away from AVGAS**. It's expensive, illegal and ill-suited to the automotive environment.

Happy motoring!

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Additonal Reading:

"Ask an Expert", Ottawa Citizen, Friday October 8th

Chapter Six (Tuning & Performance), The Gothenburg Bible, pages 45-47

Chapter Four (Great Power), The Volvo Performance Handbook, pages 44-76

Chassis Reinforcement

By Paul Grimshaw

A solid chassis is crucial to handling! To that end, it is recommended that any suspension project be preceeded with some chassis reinforcement. Chassis reinforcement will prolong the car's structure and allow shock absorbers, springs and sway bars to perform to maximum advantage.

Even though the Volvo 200-series cars are very ruggedly built, chassis reinforcement will yeild a better ride and improve handling potential on or off the track.

Reinforcing bars for 200-series cars may be found under Volvo PN 1246228 and 1246229 for left and right tower-to-firewall braces. The original fittings on a GT used a large aluminum washer and bolt. In its stock arrangement, the bars will shear through the washer/bolt and deflect in towards the engine compartment (not the passenger compartment) during a collision. This will help prevent any unwanted intrusion into the passenger compartment.

Mounting bars is very easy as most 200-series cars were built for, but not with, the reinforcement kit.

Instead of paying $100.00 or more for a new set, one may easily obtain all of the bars and hardware at a local automotive recycler for a nominal fee.

Find a set of bars (Hint: Look for a 242 GT in the junkyard as many of these cars came with the reinforcement bars as a stock item.), use rust remover to eliminate any surface rust and re-paint to a durable finish using several coats of automotive-grade paint. Spray light machine oil or rust-proofing compound into the weep holes of the bars to prevent internal corrosion.

Fit the bars to your 200-series car & enjoy!

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Tire & Wheel Combinations

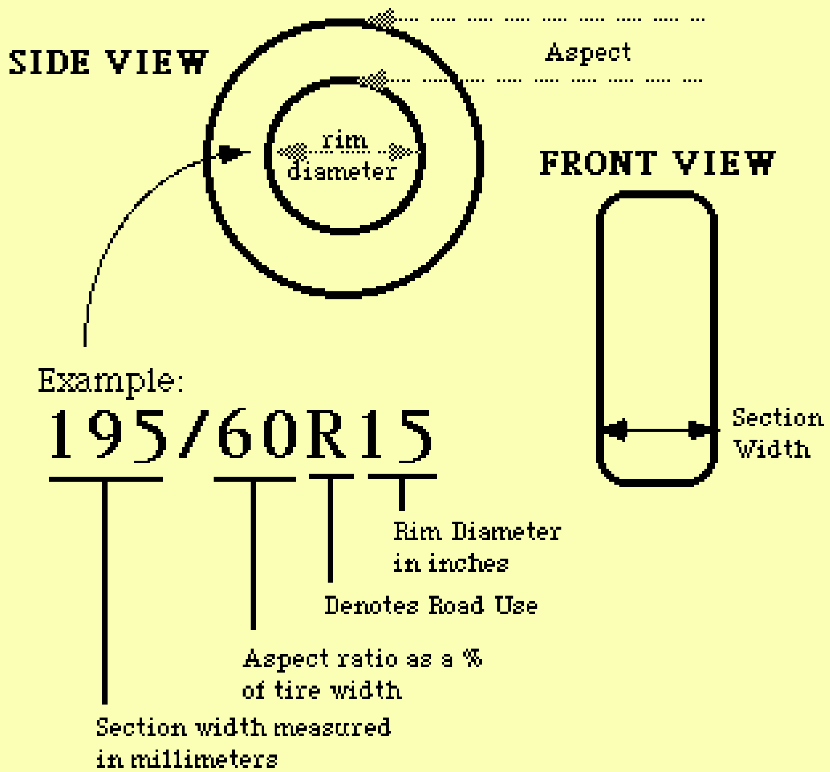
By Paul Grimshaw

Although a wide, low-profile tire has the potential to enhance road feel, turn-in and lateral grip, care must be taken to select a tire/wheel combination which does not interfere with your Volvo's chassis or suspension components.

Tire/wheel dimensions are expressed using a series of numbers. The first three-digit number is the section width. This is roughly equivalent to the width of the tire at the contact patch.

The second two-digit number represents the aspect ratio. Aspect ratio is the height of the sidewall as a percentage of the section width. Finally, the last two digits represent the rim diameter in inches.

An example of how tire and wheel sizes are expressed may be found below:



ROLLING CIRCUMFERENCES

It is preferable to select a tire which closely conforms to the OEM rolling circumference as this will:

(1) avoid interference with vehicle speed or ABS sensor calibration;

(2) prevent destructive rubbing or scraping on the bodywork; and

(3) ensure safe tire loading.

Rolling circumference may be calculated using the formula:

2 x pi x r

where "pi" equals 3.14159 and "r" equals the wheel diameter. Before calculating the rolling circumference, however, a common unit of measure must be selected. The metric "millimeter" unit of measure is prefered as most tire builders charts quote specifications in this form.

STOCK ROLLING CIRCUMFERENCES

The stock rolling circumferences for Volvo cars is 1930 millimeters for 200-, 700-, 900-series cars and 1932 millimteres for 800-, S/V/C 70-series cars. This equates to stock tire dimensions of 185/70 R14 and 195/60 R15 respectively.

MAXIMUM PERMISSIBLE CROSS SECTIONS

The largest cross-section which may be easily fitted to a 200-, 700-, 900-, or S/V90-series car is 215 millimeters. 800- and S/V/C-70 cars can easily accomodate section widths of 225 millimeters. These tire widths are considered to be more than sufficient for cars weighing between 1289-1600 kilograms or 2900-3600 pounds.

SUITABLE TIRE/WHEEL COMBINATIONS

Increasing the section width and rim diameter while decreasing the aspect ratio will yeild performacne benefits. The most popular and effective tire/wheel combinations for Volvos are:

200, 700-, 900-, S/V90-series --> 195/65 R14, 195/60 R15, or 205/50 R16

800-, S/V/C70-Series --> 205/55 R15, 205/50 R16

MORE INFORMATION...

Additional information on tire speed & load ratings, wheel offsets, aspect ratios, contact patches and their effect on handling may be obtained in Chapter Two of "The Volvo Performance Handbook".

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March Performance Tip -
Hub Spacers for Volvo 200-series

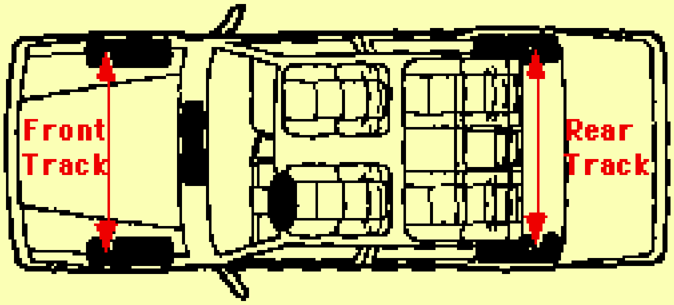
Sponsored by: The Volvo Performance Handbook

WHAT ARE HUB SPACERS?

Hub spacers are metal billets which fit between the rotor hat and the wheel to increase the track of a car. They typically increase lateral grip by allowing a greater weight transfer during cornering. Although hub spacers may be fitted to either axle, they are most commonly used to increase the relatively narrow rear tracks of 200-, 700- and 940 models.

STOCK TRACK DIMENSIONS

200-series: 1420mm (front)/1350mm (rear)
Note: add 10mm to bothe measurements for 200-series wagons.
700-series: 1471mm (front)/1460mm (rear)
940-series: 1471mm (front)/1460mm (rear)



BENEFITS, SHORTFALLS & WORK-AROUNDS

First, adding rear spacers will increase the track of the rear axle. This will increase the weight transfer under cornering and with it, rear grip. The result will be a car which exhibits a greater tendancy to understeer. Correcting the increased understeer may require alterations to front or rear sway bar diameters.

Second, an increase in the rear track will move the edges of the tires towards the fender lips. A 20mm increase (for each rear tire) will reduce the available space for rubber considerably. Whereas a stock Volvo 240 can accomodate a section width of 215mm, a car fitted with 20mm rear spacers would be limited to 195mm or less. 700- and 900-series cars will be limited to wearing 185mm rubber in the rear.

The tire/wheel combos which retain near-stock rolling circumferences at a 195mm section width would be 195/65 R14 (-1%) or 195/60 R15 (+0%). As a general rule, 65-series tires are very difficult to find in all brands. This will make replacement rubber frustrating and potentially expensive. If you decide to go this route, however, Pirelli and Yokohama offer some very good 65-series sport tires for around $100-130 (retail) each. For more information on rolling circumferences, see the February Performance Tip.

Of course, the rear wheel arches can be widened somewhat by fender lip rolling, but that would require additional prep and paint work.

Third, the material used for the spacers may cause problems in year-round use. If steel spacers are used, rotational mass will be added to the drivetrain. Rotational mass is of particular concern as it has a disproportionate effect on acceleration and braking.

If aluminum spacers are used, *extreme* care must be used to ensure that winter road salt does not make its way between the spacer and steel rotor hat where it can cause accelerated corrosion (metals of dissemilar potential + electrolyte + heat from brakes = rapid corrosion). If corrosion does occur, the aluminum (being the more noble metal) will act as a sacraficial anode and decay at a very rapid rate. Additional information on this phenomenon is contained on Page 5 of "The Gothenburg Bible".

SKIDPAD RESULTS

Properly configured, a 40mm wider track will improve lateral grip by 2-3%. This means that lateral acceleration will rise as high as 0.79 for a 200-series car, 0.80 for a 940, and up to 0.82 for a 700-series car. These figures, however, assume all other components are in original working condition and driven by a skilled driver under controlled (ie. skidpad) conditions.

PART NUMBERS & SOURCES

A pair of two 20mm spacers, suitable for use on 200-, 700- and 940 models, are available through Volvo under part number 8360083. An appropriately elongated set of rear studs can be ordered under part number 8360085. Both are also available through Steffansson Automotive under the same part numbers. Combined, the spacers and hardware will cost approximately $300.00 (US). Before committing funds, however, one should be mindful of the ramifications of this mod.....

ALTERNATIVES

Before deciding to buy, every enthusiast should consider the cost/performance index of a modification. A good set of premium sport tires can easily provide 3% better lateral grip while delivering better braking and improved road feel. Tires, however, introduce a cyclical cost which must be borne every 2-5 years, depending on use.

Larger/different diameter anti-sway bars can deliver similar performance benefits for around $200 with no added cyclical cost. They will have a very slight effect on ride isolation, but this is unlikely to upset an enthusiast.

CONCLUSION

Hub spacers are one of many parts available to serious enthusiasts. Like most performance equipment, however, the handling improvement provided by hub spacers is incremental and best applied to as part of a carefully considered suspension philosophy.

Additional information on Volvo performance figures and suspension modifications may be found in Chapters One and Two of "The Volvo Performance Handbook".

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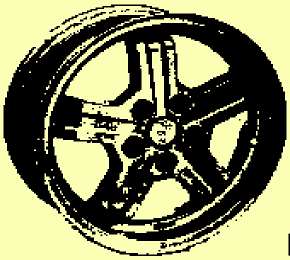
October Performance Tip - Selecting Alloy Wheels

By Paul Grimshaw

**Light alloy wheels enhance vehicle performance by reducing unsprung weight and rotational mass while providing a medium through which disk brakes can radiate heat. Each of these attributes augment performance in a special ways.**

Reducing unsprung weight minimizes the load placed on controlling the motion of the wheels and tires. This means that suspension springs and shock absorbers will have a greater reserve capacity to control body motion -- just as they were intended to! The result is better handling.

The use of light-weight alloys in wheels reduces rotational mass. This means that less requires energy will be required to accelerate the wheel. Given that each pound of rotational mass lost provides an equivalent performance gain as a 10 pound reduction in vehicle weight, the benefits of light alloy wheels on vehicle performance cannot be overlooked.

Most light alloy wheels are constructed of aluminum or magnesium, with varying trace quantities of other metals added for strength, corrosion resistance and ability to withstand fatigue. Both aluminium and magnesium possess thermal conductivity properties far in excess of steel. As a result, they act as heat sinks for the brake disks to which they are attached. The result is better brake cooling and more consistent performance in stop-and-start conditions.

With all of these benefits, will **any** alloy wheel provide better performance than stamped steel wheels? The answer is, "it depends".

The Challenges Facing Light Alloys

While light alloy wheels offer many benefits, the primary metals from which they are constructed tend to be porous and plastic. While porosity reduces strength, plasticity deforms in response to increasing load. Neither property is desirable in a road wheel.

Compounding these properties are the methods used to create alloy wheels. Poured sand casting techniques do little to prevent bubbles or air pockets from forming in the wheel. The sharp or rough edges that most casting processes leave behind give rise to stress cracks. Each of these imperfections can seriously undermine the structural integrity of a wheel.

During the manufacturing process, a manufacturer must also be mindful of how heat is applied to the finished alloys. Uncontrolled heating of aluminium or magnesium alloys after solidification will cause brittleness. The result will be the eventual formation of stress cracks.

The Good, the Bad and the Ugly

To minimize the incidence of structural imperfections, **quality** wheel makers "spin cast" or mill their products. Chrome flashing (which requires the application of heat to the finished alloy) is avoided in cases where maximum strength is desired. Surface imperfections and rough edges are smoothed to further avoid stress cracking. Really fanatical wheel manufacturers then slowly apply heat to the wheel under laboratory conditions to "temper" the wheel for maximum strength. If the wheel is intended for motorsports use (ie. the wheel is a competition quality product) , a quality manufacturer will x-raye or dye test the product prior to sale.

Wheels made for light road use are usually cast. Laquer is applied to cover cosmetic imperfections. The wheel is neither heat treated, nor inspected for internal imperfections. This results in a wheel suited for the average passenger car, but incapable of standing up to the rigours of motorsports use.

Wheels made primarily for "looks" are the poorest of them all. Their designs are marginal at best, as are the materials and manufacturing processes used. Hint: With some exception, many "chromed" alloy wheels can be lumped into this category.

Choosing Alloy Wheels

When it comes to purchasing alloy wheels, do not consider price to be an absolute indicator of quality. Look for information on the alloys used and manufacturing processes followed. Select a wheel which features at least five broad spokes that blend into the rim and hub (ie no sharp edges). Choose "spider web" designs with care.

Quality Manufacturers

There are three manufactuers which have a history of producing wheels of exceptional quality and strength. In alphabetical order they are BBS, Compomotive and Momo. Few other manufacturers even come close to there companies' products.

So there you have it! A quick, no-nonsense guide to selecting the alloy wheels best suited to your high performance Volvo.

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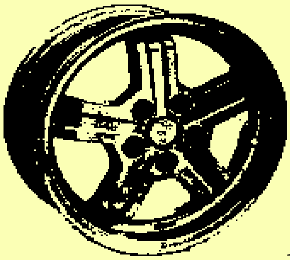
Alloy Wheel Care & Mounting Tips

By Paul Grimshaw



Alloy Wheels are great accessories. They reduce unsprung weight, resulting in quicker suspension response. They dissipate heat generated during heavy braking. And yes, they even improve a car's appearance! For all of these benefits, however, one must devote special attention to keep alloy wheels from deteriorating.

STEP 1: Clean your alloy wheels properly. At least once a season, remove each alloy wheel for complete cleaning. If you like dispensing elbow grease, use soap and water and a soft wheel brush. If, however, you know the exact composition of your alloys (machined aluminium, painted or clear-coated, anodized aluminium, polished aluminium, chromed steel etc.) use a commercially-available wheel cleaner. Don't guess on this one because some cleaning compounds, if incompatible, can ruin a wheel's finish. Between seasonal cleaning, wash your alloys with soap and water every time you clean your car.

STEP 2: Prepare your alloys for mounting. Because alloy wheels can "bond" to your brake rotors, smear a little anti-seize compound (lithium grease will do in a pinch) on the mating surfaces of the alloy wheel. This layer of lubrication will permit expletive-free removal of your alloy wheels by mechanics, loved-ones and the like.

STEP 3: Always use the proper OEM-style lugs to secure your wheels. Volvo alloy wheels are all located in relationship to the hub with lugs and nuts. For that reason they are refered to as "lug-centric". The fact that Volvo wheels are lug-centric, extreme care must be exercised to select the best type of fastener for the job at hand.

Volvo wheel nuts are divided into two groups, those which require a tapered-seat nut and those with a flat nut. Do not confuse the two as wheel centering and clamping force will be adversely affected by the wrong fastener.

STEP 4: Use a torque wrench to tighten the wheel to specification (remember to use a criss-cross tightening pattern). Many garages use air tools to secure wheels. The over-torque can damage the wheel, over-stress the lugs and bolts, and make wheel removal impossible. If you take your car to a garage, insist that they use a torque wrench. Always!

STEP 5: If your alloy wheels are clear-coated, make sure to repair any nicks in the plastic protective coating. Ladies' nail polish can enable quick emergency repair and comes complete with a built-in applicator.

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Wheel/Tire Combinations: Practical Performance vs. Poseur Pleasure

By Paul Grimshaw

For far too many years, aesthetics and appearance have shaped our view as to what constitutes "high performance". Such is the case with popular misconceptions concerning performance wheel and tire packages.

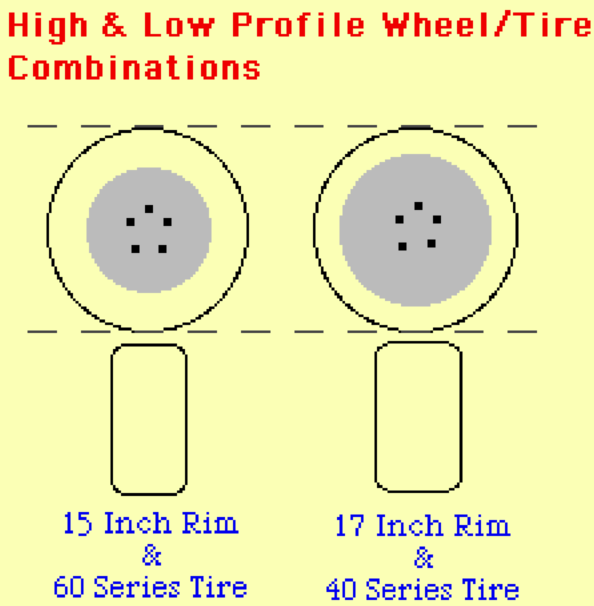
The aim of this Performance Tip is to dispell the myth that bigger, or wider, is better -- thereby sparing your bank account the embarassment of shelling out big bucks for little more than a stylistic trend.

SHOULDER COMPLIANCE VERSUS SIDEWALL STIFFNESS

A tire is a vital suspension component. The sidewall of a tire simultaneously supports the weight of a vehicle and acts as a damper to help absorb minor road irregularities -- thereby contributing to a comfortable and stable ride. As the obstacles on the road get larger, the sidewall of the tire forms the first line of defence against wheel and chassis damage by absorbing the initial shock of impact.

The taller the sidewall, the greater impacts can be absorbed by the tire without incurring wheel or chassis damage. Unfortunately, however, tall sidewalls are not conducive to achieving maximum cornering grip.

Tall sidewalls experience significant flex as the wheels turn in to negotiate a corner. Shorter sidewalls still flex, but to a far lesser degree. Too much flex can dull the turning "feel" of the car -- it can also undermine cornering ability by increasing the angular difference between the direction the wheels are pointing and the path along which the car is travelling. This latter measurement is known to performance enthusiasts as slip angle.



To be truly effective, a wheel and tire combination must strike an appropriate balance between stability and grip. This is where the surface of the road must be considered.

OUR CITY STREETS AND HIGHWAYS

Most roads in Africa, Asia, Australia, Europe and North America are in apalling shape despite our collective contributions in the form of licensing fees, gasoline and municipal, state and federal taxes. Potholes, crumbling verges and cracks have turned once-smooth ribbons of asphalt and concrete into bone-jarring pathways.

The result is that many large wheel/low profile tire combinations are unable to cope with these conditions. At best, the contact patch is distrubed to the point where performance advantages are lost. At worst, the sharp impact of the last pothole has forever warped that light alloy wheel. What is a driver to do?

PRACTICAL PERFORMANCE BEATS POSEUR PRIDE

Far too many seventeen inch wheels, wrapped in ultra-low 40-series tires will fail to endure the travails of everyday driving. Those that do survive will lack the compliance to adhere to the significant irregularities of public roads. To that end, acceptable, enduring solutions may be found in 15 and 16 inch wheels wrapped by tires sporting profiles of at least50 percent.

Arguably the best tire/wheel combination for modern, street driven Volvos will look something like these:

MODEL	TIRE	WHEEL
200-series	195/60	15 inch
700-series	195/60 or 205/50	15 inch or 16 inch (205/50)
800-, S/V/C 70	205/50 or 205/55	16 inch
S80	225/50	16 inch

Although some may rail at the thought of mounting a 195/60R15 tire/wheel combo on their project 240, this is the combination that was wisely chosen by Gothenburg for its "Volvo Cup" cars. Many 800- and S/V/C 70-series owners, on the otherhand, report bent rims, damaged tires and unpredictable rides on their 17 inch, ultra low profile tires.

CONCLUSION

Take it from the guy who posted the best competitor's time in both the stock and modified classes of the 1993 Volvo Club of America Annual Autocross -- big wheels and wide tires do not necessarily provide the best performance. A little compliance goes a long way towards posting consistently low, easily repeated lap times. Think about that the next time you go shopping for a good wheel/tire combination!

Additional data on a wide variety of stock and modified wheel and tire combinations may be found in Chapter Two and Appendix Two of "The Volvo Performance Handbook". A complete description of handing terminology can be found in Appendix One of the same publication.

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Lighting Upgrades

By Paul Grimshaw

Many of today's newest high performance cars are rolling off dealer show rooms with a revolutionary lighting system called **H**igh **I**ntensity **D**ischarge, or HID. Such systems represent the next generation in lighting systems where a high voltage arc between two carbon posts excites Xenon gas to produce a brilliant white light that outperforms all of the quartz halogen systems fitted to today's Volvos. While retrofitting HID systems to a car is possible, the $2000 price tag is prohibitively expensive.

The aim of this Performance Tip is to outline lighting upgrades that will enhance illumination and fit within the budget of most Volvo drivers.

THE FIRST STEP

Before deciding upon significant changes to your Volvo's lighting system, it is always best to have the stock headlights aimed, or adjusted to specification. The old method of using a screwdriver to adjust the headlights to specification is not as accurate as using a mechanical aiming device. Commonly available at most garages, mechanical aiming devices feature a bubble level to more accurately measure the direction and pitch of the headlights.

If aiming fails to yield the desired results, you may wish to look at the lamps themselves. Older Volvos fitted with sealed beam headlights should be retrofitted with three piece (separate reflector, lens and bulb) quartz halogen headlamp units of the correct size and specification. The result will be an automatic 30% increase in lighting efficiency.

1986 and newer North American specification Volvos will already be fitted with two large quartz halogen lamps with twin filament 65 watt high/45 watt low beam bulbs. Depending on the model of Volvo, such headlights are supplied by Bosch, Valeo or Cibie and feature relatively large, deep reflectors that deliver far better performance than many of the low-profile lamp systems on so-called "sporty" cars.

Nevertheless there are a variety of conditions when the stock lighting system cannot meet some drivers' needs. These include frequent trips in rain, fog or dusty conditions, mountain driving, and high-speed autobahn-style blasts. Auxiliary lighting systems can easily cope with such demanding conditions.

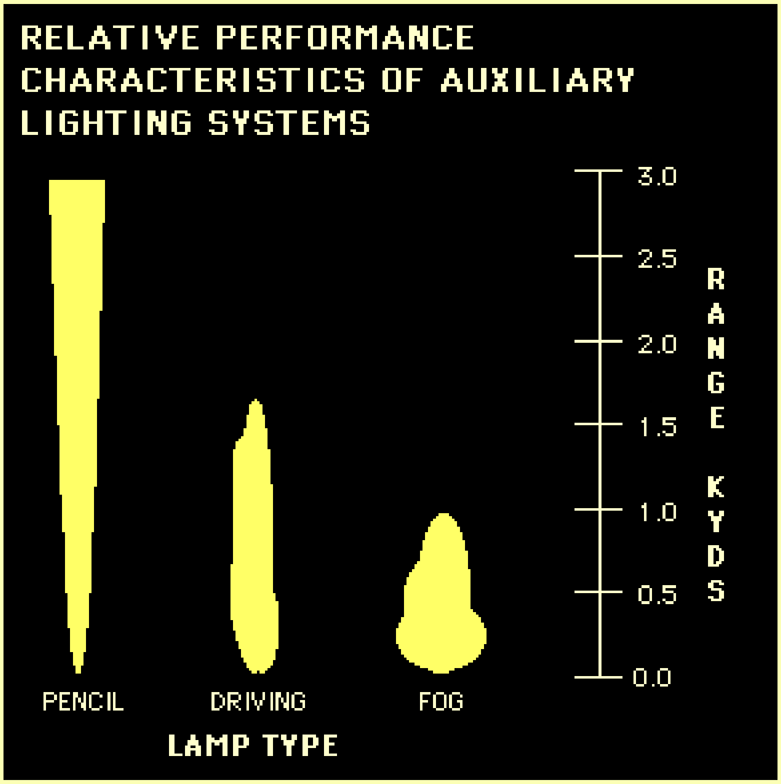
AUXILIARY LIGHTING SYSTEMS

ECE (Europe) and FMVSS (North America) regulations prohibit increasing a stock headlamps' bulb intensity beyond specified levels. There are two reasons for this. First, the light projected would dazzle oncoming traffic. Second, the extra current and heat of a high wattage bulb could either overload a vehicle's electrical system or damage the headlight reflector. The resulting accident or damage could result in injury and would most certainly require considerable expense to repair.

The only practical -- and legal -- way to increase vehicle lighting is with an auxiliary lighting system. These systems consist of a separate set of reflectors, lenses and bulbs contained within an aluminum or ABS plastic housing. Voltage is supplied by a separate wiring harness and relay -- the latter of which is particularly important to avoid electrical overload or fire.

Auxiliary lighting systems come in four basic types:

- Daytime Running Lights - a redundant set of lights designed to be used during daylight hours. Largely redundant in most modern cars, driving lights will not be discussed in this Performance Tip;
- Pencil Beams - a specialized light that throws a narrow, intense beam for illumination to the next corner;
- Driving Lights - a general purpose light that project a long beam similar in intensity and scope to a high beam headlight; and
- Fog Lights - a specialized light that projects a broad, flat and short range beam to minimize glare and improve peripheral vision in fog, smoke or haze.



SIZE, SHAPE AND PERFORMANCE

The following factors affect the performance of a auxiliary light:

- reflector size & shape;
- focal length;
- lens design; and
- mounting position.

Conventional Lighting Systems

The larger the reflector size, the more efficiently the light will be directed towards the lens. A relatively wide reflector will more efficiently project light laterally. A relatively reflector will more efficiently project light horizontally.

Reflectors of the same size can, however, perform differently depending on their focal lengths. Long focal lengths produce better narrow beams with improved long range illumination - ideal for a pencil beam lamp. Shorter focal lengths, on the other hand, produce broader beams with improved near-field and lateral illumination - ideal for a fog lamp.

Combined, the reflector and focal length are arranged in a classic parabolic form. A lighting system based on conventional parabolics can potentially double the area lit by conventional headlights.

While the relative intensity and shape of a beam can be affected by reflector size and focal length, the lens of a auxiliary lamp can better tailor the beam to meet an exact specification. Almost all of today's lamps are fitted with lenses with small, cylindrical dispersion elements. These provide minor beam adjustment compared with the older, and inherently inefficient frensel optics which continue to be used in brake and turn signal applications.

Projector Lighting Systems

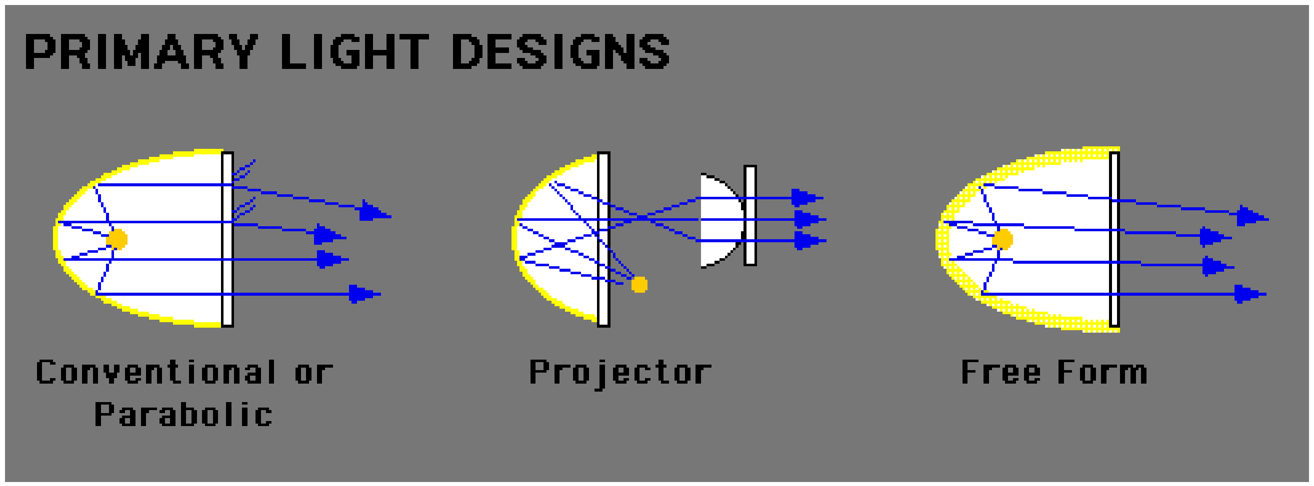
Projector lighting systems feature extremely small reflector size and very short focal lengths. Very effective beam shaping is determined by the shape of a thick lens which, if correctly designed, minimizes stray light. While such designs can be packaged very efficiently, the light output from projector style systems is generally inferior to most conventional lamps. This inherent disadvantage helps explain why few, if any, rally cars are fitted with projector style lighting systems.

Projector lighting systems will deliver slightly less long range illumination than one of conventional parabolic design.

Free-form Reflectors

In some cases, manufacturers dispense with parabolic reflectors in favour of ones designed by super computers that precisely tailor light in horizontal and vertical planes. Called free form reflectors, these lighting systems use an optically clear protective cover free of dispersion elements.

The result is a highly efficient lamp that is capable of projecting all light along a desired path. As there is no stray light emitted from a free-form reflector, expect illuminated areas to exceed that provided by conventional parabolic designs by 30%.



BULB TYPES

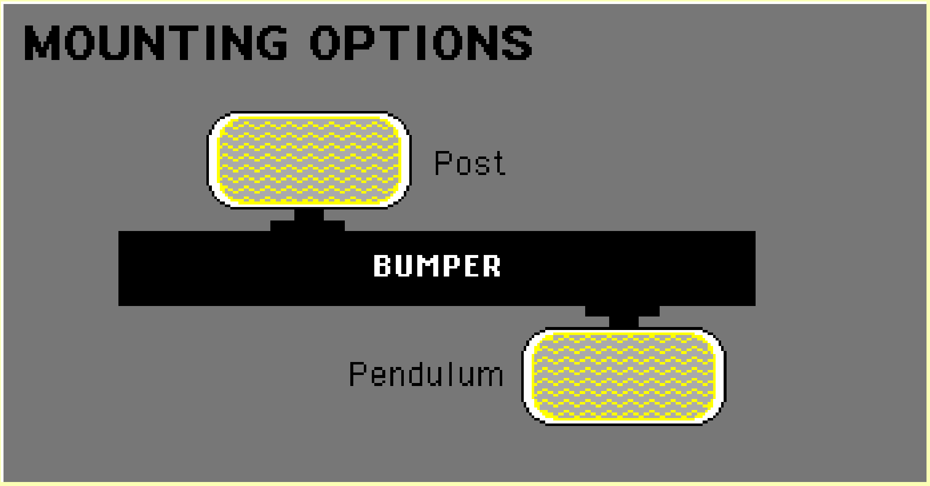
Most auxiliary lighting systems rely on traditional quartz halogen H1, H2 or H3 bulbs. While each of these bulbs are uniquely tailored to fit a given receptacle, they are inexpensive, easy to obtain, and available in a wide variety of wattages to suit on- and off-road driving needs.

The same cannot be said for several so called "ion" and xenon auxiliary bulbs used in several projector lighting systems. In some cases, the claimed performance advantages of specialty bulbs can be offset by their reduced life span, limited availability and replacement high cost.

The bottom line is to confirm the cost, wattage and availability of bulbs prior to committing to the purchase of any auxiliary lighting system.

MOUNTING OPTIONS

The placement of an auxiliary lighting system significantly impacts its overall performance. With the exception of fog lights, a properly aimed lamp placed in a high position will illuminate an object at a longer range than one which is mounted close to the ground. In an effort to prevent dazzling oncoming traffic, however, most transportation authorities stipulate that auxiliary lights be mounted at or below the level of stock headlights. The two most practical mounting solutions are "post" and "pendulum" arrangements.



The primary advantage of post mounting is that it raises the level of the lamp to a relatively high position. This not only improves range potential, but also minimizes the risk of lens damage from rocks and curb stones by elevating the lamp. The problem with post mounting in Volvo cars is, however, that the placement of the lamps will either interfere with the main headlights or radiator grille.

The advantage of pendulum mounting auxiliary lights in Volvo cars is that it is relatively easy to select a point clear of the air dam openings or tow hook receptacles. A pendulum mount does, however, raise the ugly possibility of lamp damage from flying rocks or curb stones.

PROTECTIVE MEASURES

Three ways to protect a set of auxiliary lights from damage are through the use of:

- lens covers formed from plastic and designed to cover the lamps when not in use;
- mesh grilles made from steel wire and designed to protect the lamps from flying rocks, such protection permits the immediate use of the lights at any time; and
- transparent plastic laminates that affix to the lenses.

Of these methods, the first and the second used in combination will provide excellent protection from flying debris. The plastic laminate protects the lens of the auxiliary lamps during use, whereas the lens covers prevent sand pitting and add additional protection during daylight hours when the lamps are less likely to be used.

Of course, it is impossible to prevent damage to the lights if the front valance is allowed to strike a solid object such as a curb or wall. For that reason, careful parking is obligatory.

CONCLUSION

Although auxiliary lights can provide increased driving safety , it is always best to first ensure that your stock headlamps are in good condition and aimed to specification. Next, select a system that best suits local conditions, performance needs and complies with local regulations. Mount the lamps to maximize performance. Finally, the use of protective covers will keep your new lights -- and capability -- in top condition.

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May Performance Tip - Brake Rotor Cooling

Sponsored by: The Volvo Performance Handbook

Energy cannot be created or destroyed, but may be changed in form. This principle, known as the First Law of Thermodynamics, provides an excellent back-drop to this month's Performance Tip on brake rotor cooling.

Brake Pedal Physics

Brakes operate according to the laws of thermodynamics by converting the kinetic energy of a moving car to thermal energy -- the latter created by high friction pads which squeeze against a rotating steel rotor. To appreciate the daunting task of hauling down a Volvo from highway speed, consider the following:

A lightly loaded Volvo traveling at highway speed on level ground possesses 438043.5 lb-ft of kinetic energy. To bring that car to rest will require the brake rotors to absorb and dissipate at least 563 BTUs of heat within 3 seconds. That's enough energy to bring two pounds of water to a boil in one second!

Although 563 BTUs are easily handled by a well-functioning brake system, consider the effects of increasing speed. Kinetic energy varies with the square of speed. At 130 miles per hour (a typical high speed autobahn run - or- maximum velocity attained on a one mile straight at your local track), the kinetic energy requiring conversion rises to 2252 BTUs -- enough energy to bring over 11 pounds of water from near freezing to boiling in one second. This energy, 80% of which will be have to be dissipated by two vented front rotors measuring between 10 and 11 inches in diameter, will make brake temperatures soar.

Brake Ducting - An Economical Way of Improving Brake Cooling

Although the stock Volvo brake system can easily cope with one or two successive stops from these speeds, repetitive high-speed braking can quickly overtax your car's ability to stop. In fact, excessive temperatures can cause a rotor to warp, brake fluid to boil, and pad surfaces to glaze as hard as glass. The result can be a reduction -- or complete loss -- of braking.

To offset the enormous amounts of heat generated during competition driving, cars can be fitted with scoops and hoses to blow fresh air into the rotor hat where it better cools the rest of the brake rotor.

These systems are extremely effective in reducing brake temperature but must be carefully engineered to avoid interference with moving parts.

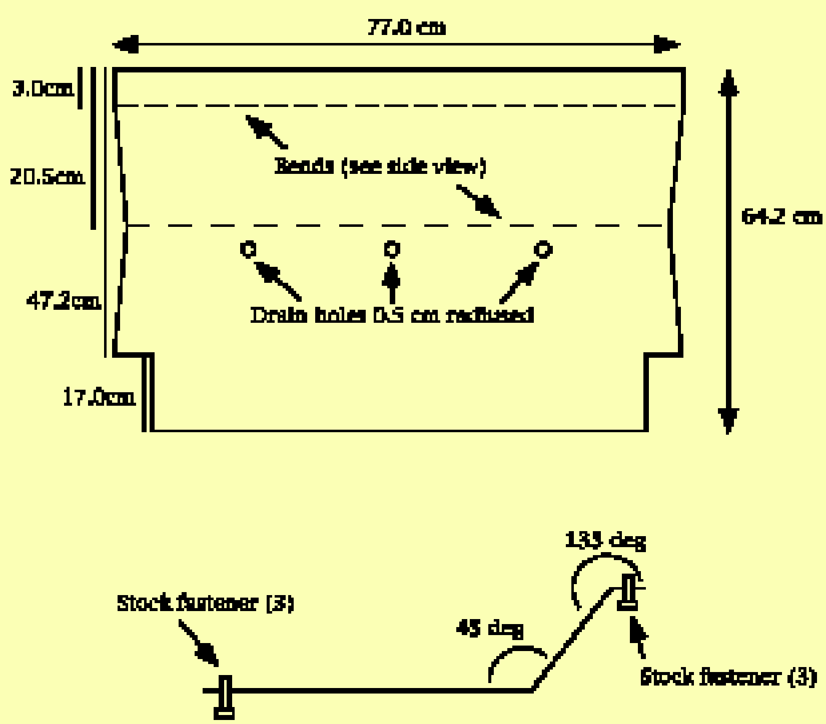
Other systems such as water cooled calipers and the use of carbon calipers, rotors and friction materials can also effectively improve brake performance, but their cost ($1000 to $25,000) is prohibitive for the average competitor.

Design Considerations

First, select an area where the air scoop will be placed. This area should be in a high-pressure area such as in a headlight bucket, along the air dam, behind the grille, or along the face of the engine tray. While each of these locations offer pros and cons, the latter location will require a screen filter to prevent road debris from being blown into the rotor hats.

Although the headlight bucket offers the best solution for track-driven cars, mounting one or more ducts in a custom engine tray offers two distinct advantages. Such a tray will better protect the engine from track debris and the discrete location of the duct work will simplify routing hoses to the brake backing plates.

To illustrate just how simple it is to construct a heavy duty engine tray, the specifications for a tray that I fabricated from .080 inch aluminum plate for my **240** is shown below:



Drawing not to scale. Measurements accurate to 0.2 cm.

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Routing the hoses from the scoop to each brake backing plate is relatively easy, but care must be taken to avoid contact with:

- engine drive belts or pulleys
- steering rack and bellows
- tie rod ends
- brake hoses or pipes
- lower control arm

Materials

The best ducts are constructed from:

- seam welded .080 inch aluminum sheet (considered mandatory if being mounted to an aluminum engine tray); or
- heavy duty ABS plastic.

The flexible hose should meet the following criteria:

- constructed of high temperature silicone, capable of withstanding at least 500°F;
- reinforced with steel wire core (stainless steel wire optimal);
- at least two inches in diameter to allow adequate airflow (three inches optimal).

The following brake backing plates are preferred:

- OEM brake backing plates, modified by welding a one inch steel flange to an area that does not interfere with the suspension's strut tube or the brake pipes and hoses leading to each caliper;
- Finished in high temperature paint; or preferably
- Plated with brass and chromium for corrosion resistance.

Each of the hoses should be clamped to the ducts with stainless steel hose clamps. After tightening, an application of Loctite® 242 thread lock compound should be used to prevent the clamps from backing off.

Cost (in US Dollars)

The following cost calculation may be used by those considering a good quality rig:

Under Tray - $40.00 for materials + $20.00 for bending

Duct - $100 for materials and custom fabrication (aluminum) or $25.00 for a simple plastic duct
Hoses - $50.00 for 10-12 feet of high quality silicone hose
Brake Backing Plates & Flange Installation - $200.00
Clamps - $10.00
Total - $355 to $430

Typical Results

Depending on the friction coefficients used, brake ducts will enable your braking system to deliver fade-free performance during successive stops from near-maximum speeds. This modification is suitable only for those cars with vented rotors (most 200-, 700-, 800-, 900-, S/V 70 & 90 models) but is particularly effective for front wheel drive models (S/V 70 & 90 and S80) where the task of braking is almost entirely borne by the front calipers and rotors.

As in all engineered solutions, you get what you pay for. Carefully design the system in collaboration with trained mechanics or engineers, use quality materials, employ skilled welders, and success in the braking zone will be yours.

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Post-Script: This article had originally been posted for 700-series owners. Many thanks to Ian Giles, a regular (and apparently very attentive) reader, for pointing out the different flow pattern of 700-series rotors which precludes the use of inboard ducting. - *Paul*

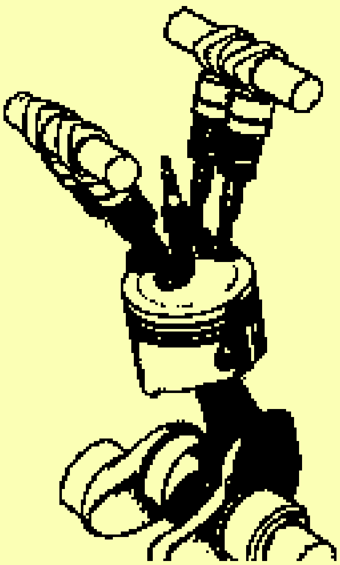
Reducing Engine Inertia

By Paul Grimshaw

Inertia is the property of matter that causes it to resist any change in its motion. Increase the mass and inertia will also increase. This principle of physics is particularly important to the tuner since the effects of inertia on rotating and reciprocating engine parts can determine engine life, power delivery and throttle response.

Reciprocating Parts & Their Effect on Performance and Durability

Pistons, connecting rods and valves constitute the major reciprocating parts within an engine. When operating, these components must frequently change direction along their vertical planes. The force required to effect such changes in direction rises with engine speed. If this force exceeds the yeild strength of structural metals, the result can be a thrown piston, broken connecting rod or snapped valve stem.



Below the yeild strength of major reciprocating components lies an area of harmonic instability. As valves operate at higher speeds, a phenomenon known as "valve float" occurs. Valve float prevents intake and exhaust valves from closing completely. The result is limited power and, in cases where the valve spring reaches its harmonic frequency, a broken valve spring.

Engine designers use their understanding of reciprocating mass within an engine to determine engine operating limits, also known as "the red line". Knowledgable tuners, however, may safely increase engine redline by:

a. reducing the mass of reciprocating components; or

b. selecting pistons, connecting rods or valve components constructed of stronger materials.

Why Increase the Redline?

In theory, reducing the weight of each piston and connecting rod set within a B21/23/230 engine without affecting the strength of the components will extend the rev limit from 6000 rpm to 7000 rpm. Installing forged connecting rods and stronger wrist pins will have the same effect on the rev limit. Since torque * engine speed = power, an increase in engine speed of the magnitude discussed can mean an additional 30 horsepower at the flywheel.

Avoiding Pitfalls & Correcting Errors

You don't have to be a mechanical engineer to make meaningful changes in your engine. In fact, there are instances where you can correct errors made by Volvo engineers!

During the early development of the low friction B230 engine, Volvo decided to use 152.0 * 9.5 mm connecting rods. The materials used to fabricate the rods wremained unchanged. The result was a lighter, but significantly weaker connecting rod that has a tendancy to break under load. This fault was not corrected until 1989, when Volvo used more robust (152.0 * 13.5 mm) connecting rods.

The bottom line is that tuners owning 1985-1988 Volvos fitted with B230F engines are encouraged to consider the advantages of upgrading their engines to later model connecting rods *before* embarking on any performance tuning projects!

Rotating Parts & Engine Response

Inertia impedes engine response. A motor fitted with heavy *rotating* parts will require more time to reach a given engine speed. Thus, the challenge is to reduce the weight of the heaviest rotating part within an engine -- the flywheel!

Flywheel Specifications

Four and five cylinder engines tend to have relatively heavy flywheels to improve idle and low-rpm quality. Although such quality is important, it is less of a concern in an engine which is:

a. precisely tuned; or

b. used in sporting or racing applications

As a result, stock Volvo flywheels (see sample table below) replaced by lighter units or may be machine lightened. The result will be a more responsive engine that is able to reach peak power without delay.

The old racers adage of one pound of reduced rotational mass equating to 100 lbs of vehicle weight holds true!

Volvo Flywheel Specifications

Engine Type	Mass (lbs)	Mass (lbs)
B30 (6 cyl)	24.1 lbs	9.5 kg
B18	25.4 lbs	10 kg
B20	25.4 lbs	10 kg
B21/23	24.6 lbs	9.7 kg
B 230	34.5 lbs	13.7 kg

Conclusion

A complete understanding of how the laws of physics affect an engine, coupled with good advice on where one may obtain quality performance parts, will result in measurable improvements on the dynamometer and pay dividends on the road or track.

Additional tuning information may be found in Chapter Four of "The Volvo Performance Handbook".

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Diagnosing Turbocharger Problems

By Paul Grimshaw

"The candle that burns twice as bright lasts half as long".

The relationship between energy and longevity has been the subject of intense debate within our increasingly technological society. The result is the emergence of the popular perception that powerful mechanical devices are subject to catastrophic failure -- a view reinforced by stories of exotic European cars scattering their internals during autobahn blasts.

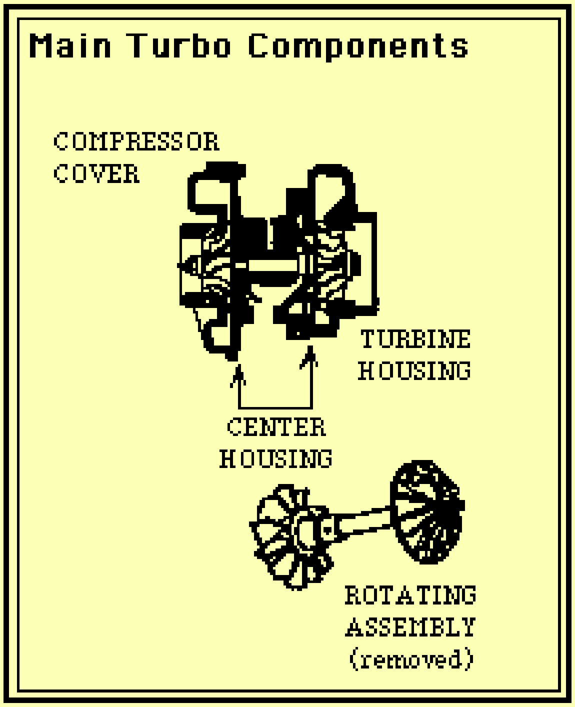
Changing the negative connotations of power is becoming increasingly difficult. Indeed, the first generation of high technology cars from the 1980s are reaching an age where many will require repair or replacement of major components such as multi-valve cylinder heads, fuel injection systems and turbochargers. Correcting major faults to each of these systems can easily cost more than the market value of a used domestic sedan.

While most components fitted to Volvos will last the life of the car, turbocharger failures frequently befall long-term owners of forced-induction engines. Unfortunately, the financial implications of replacing a turbocharger leads many owners to experience feelings of denial, apathy and despair before a proper diagnosis is completed. Not all turbo problems are serious, nor do they necessesarily lead to catastrophic failure.

The aim of this article is to help Volvo owners recognize the signs of impending turbocharger failure and select the most cost-effective repair strategy.

Turbocharger Components

A turbocharger is a device that increases engine power by using waste exhaust energy to pack more air and fuel into an engine's cylinders. Mitsubishi and Garrett turbochargers fitted to Volvo engines consist of four main components: a turbine housing, center housing, rotating assembly, and a compressor cover.



The turbine housing envelopes the rotating assembly's nickel alloy rotor. This rotor, placed within the exhaust gas stream, rotates as flow increases. Rotation generates torque along the shaft to drive the rotating assembly's light alloy compressor wheel. This wheel, hidden from view by the compressor cover, acts like a fan to pack extra air and fuel into the combustion chambers. The result is an increase in volumetric efficiency -- a fancy way of saying that the engine produces more power than its displacement would normally allow.

To work effectively, the rotating assembly must be capable of withstanding exhaust gas temperatures of up to 1750°F while accelerating to 100,000 rotations per minute in the blink of an eye. These operating conditions require rotating components to be precisely balanced, located and lubricated.

Amazingly, plain bearings, thrust washers and oil pressure within the center housing are sufficient to reliably locate and lubricate the rotating assembly.

Life Expectancy

A Volvo owners survey conducted in 1996 provided a great deal of insight into the effects that servicing has on turbocharger life. In compiling of the survey I had concluded the following:

- Turbochargers fitted to 200-series cars typically last between 100,000 and 250,000 kilometers, with the vast majority succumbing to some kind of mechanical failure by 180,000 kilometers.

- Turbochargers fitted to 700-series cars exhibit longer life due to the use of water-cooled center housings. Replacement is usually needed after 220,000 kilometers. Turbochargers fitted to 900-series cars, which share many of the same basic features as 700-series units, are expected to enjoy similar life spans.

Extrapolation of the survey's mileage figures, with allowances made for improved water-cooling and higher boost levels, suggest that the owners of 800 or S/V/C 70-series cars can expect turbo failures to occur after the first ten years of service has passed. Hence, the probability of turbo failure in the first generation of turbocharged 850 cars will rise with the passing of the millennium.

While statistics can be used as a guide for concerned owners, their conclusions are seldom accurate enough to serve all cars or all owners. For this reason, the mileage figures cited should be liberally interpreted by those who adequately maintain their cars at a level equal to, or better than, manufacturer recommendations. Those skipping critical service periods or abusing their engines will probably face diminished turbo life.

Common Symptoms and Problems

Regardless of mileage or servicing, there comes a time when turbochargers and their associated components wear out. Failure is rarely catastrophic with indications of upcoming failure common.

Before proceeding, however, be advised that the tips/procedures listed are intended for use by qualified mechanics:

Symptom #1 - Light whistling sound while accelerating.
Common Diagnosis - Normal, Adjustments or Repair Not Required.
Probable Cause - Transient resonance created air rushing through the compressor housing, past the throttle plate and into the plenum.
Fault Tracing - None Required.

Symptom #2 - Power drop-off while accelerating at or near full throttle.
Common Diagnosis - Minor Fault, Adjustments or Minor Repair Probably Needed.
Probable Causes - Engine out of tune, vacuum fault, engine knock or faulty knock sensor, waste gate out of adjustment, damaged turbo hose, or de-activation of air conditioning solenoid (normal if a/c is "on").
Fault Tracing - Conduct tune-up, carefully inspect intake system, verify use of proper fuel, check knock sensor signal and waste gate setting.

Symptom #3 - Low boost condition.
Common Diagnosis - Minor Fault, Adjustments or Minor Repair Probably Needed.
Probable Causes - Faulty wastegate, actuator or boost control solenoid, leaking intake system.
Fault Tracing - Test drive car to confirm low boost reading on turbo gauge. Carefully inspect intake system for vacuum leak(s), loose turbo hose clamp(s), damaged hose from compressor to airflow sensor, check waste gate setting.

Symptom #4 - Oil consumption in excess of 1 litre/1600 kilometers.
Common Diagnosis - Potentially Serious Fault, Close Inspection Required.
Probably Causes - Worn engine or damaged turbocharger unit.
Fault Tracing - Test drive car. Blowing smoke on overrun could indicate worn valve guides or damaged turbine oil seal. Blowing smoke on acceleration could indicate worn rings or damaged compressor oil

seal. Check for external engine leaks, inspect/clean oil return line from turbocharger, conduct leak-down test to determine potential ring or valve guide wear, inspect intake trunking for signs of excessive oil contamination, remove turbocharger and/or inspect center housing rotating assembly for physical evidence of seal failure.

Symptom #5 - High pitched screech during acceleration.
Common Diagnosis - Probably Serious Fault, Rotating Assembly may be Wearing Out.
Probable Causes - Shaft imbalance or bearing failure.
Fault Tracing - Remove hose from compressor section and inspect impeller edges for wear, feathering or breakage, remove waste gate assembly and check turbine for wear, feathering or breakage, check end-play of rotating assembly, turn rotating assembly by hand -- note shaft movement.

Symptom #6 - High boost reading.
Common Diagnosis - Serious Fault, Correct Immediately.
Probable Causes - Faulty waste gate, actuator or boost control solenoid, broken exhaust pipe.
Fault Tracing - Test drive car to confirm high boost reading on turbo gauge. Carefully inspect intake and exhaust system, check waste gate setting.

To Repair or Not To Repair?

There is no practical way to turn a turbocharged Volvo into an effective normally aspirated model unless you wish to absorb the cost of a replacement motor, wiring harness, ring and pinion, fuel injection and engine management system. Your options are to eventually repair, sell or scrap your car.

Repair Options

Minor faults are often the most difficult to trace. One should always consider the regular replacement of spark plugs, high tension wires, the rotor and the distributor cap as the unavoidable cost of owning a car. Ditto for waste gate adjustments. Other parts such as hoses are best sourced through a Volvo dealer as these offer the best value.

Prior to replacing the turbocharger on a high mileage Volvo for the second time, it may be beneficial to have the cylinder head removed and dye checked. This will prevent expensive repairs from being completed on an engine about to expire.

In situations where failure is confirmed to be limited to the turbo, replacing the center housing/rotating assembly is more cost efficient than purchasing a brand new turbocharger. Many varieties of center housing/rotating assemblies may be sourced from a local turbocharger distributor or purchased through ipd.

Be advised, however, that parts for older Garrett TB0313 (1980-85 B21FT), TB0379 (1988 B230FT), or TB2543 (1990-91 B230FT) turbochargers are no longer available through the manufacturer and will most likely require an updated replacement kit at additional cost.

Further cost savings can be realized if you possess the necessary skill and special tools to rebuild the turbocharger in your garage. While a job of this magnitude is beyond the scope of most Volvo owners, a comprehensive factory manual, a complete metric and SAE socket set, a torque wrench suited to inch-pound measurement, and a variety of dies, taps and extractors (for removing broken studs) will enable an experienced mechanic to complete the job.

In most cases a Volvo dealer is the best source for repair. Other garages may provide a lower estimate, but the quality of repairs at the dealership are well worth the extra cost.

Conclusion

Turbocharging is an effective way of increasing engine performance but there may come a time when specialized repair is required. When this time comes, fault tracing, cost analysis and the retention of qualified mechanical staff will help re-kindle the flame that powers your Volvo.

Other Articles in this site related to turbochargers:

Troubleshooting 200-, 700-, and 900-series Turbos

Turbochargers: An Owner's Guide to Preventing Catastrophe

Turbo Owner's Survey

Power to Weight Ratios - Tuning a Volvo into a Porsche

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Additional Reading:

Turbocharger Performance - The Volvo Performance Handbook
Increasing Turbo Life - The Gothenburg Bible

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Saving Synchros

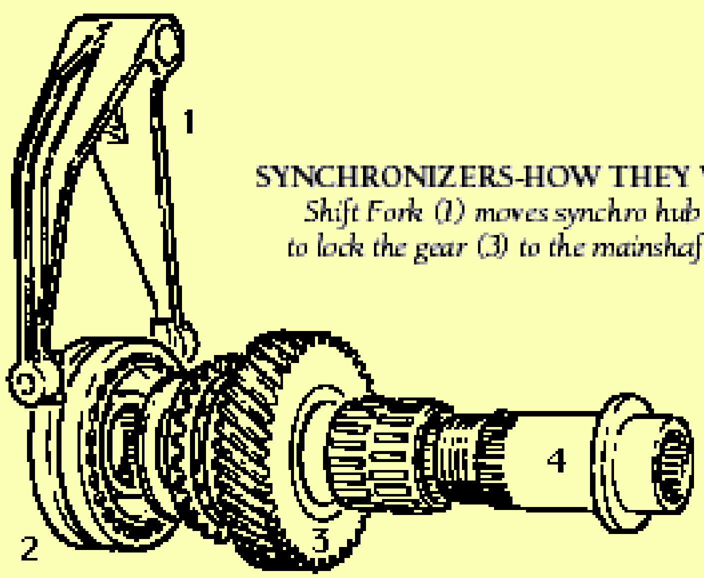
By Paul Grimshaw

The most common sign of manual transmission wear is the "crunch" of synchronizers heard during downshifts. Synchronizer problems often start out as minor irritations, building into major worries as the cost of a rebuild is realized.

The aim of this maintenance tip is to advise readers of ways to significantly reduce synchronizer wear in older Volvo manual transmissions and, in the event that this advice has come too late, suggest a shifting technique that will preserve whatever life remains in a gearbox.

Gearbox Components

Older Volvo gearboxes are of the two shaft variety, with the gears engaged on the main shaft used to transmit varying amounts of torque to the rear wheels via the output shaft. Provision must be made to align each set of splined gears with the mainshaft before smooth engagement can occur. The job of aligning the rotating assemblies falls to a series of synchronizers that use a pall and spring assembly to ensure smooth engagement.



SYNCHRONIZERS-HOW THEY WORK
Shift Fork (1) moves synchro hub (2) to lock the gear (3) to the mainshaft (4).

When the throttle is released and the clutch is disengaged, the transmission input and output shafts rotate at different speeds -- the input shaft turns at around 1000 rpm and the output shaft turns at a rate proportional to vehicle speed. When a lower gear is subsequently selected, the synchronizer for that gear must match input and output shaft speed before engagement can occur. This is marked by a "crunching" sound in cars with well-worn synchronizers.

A "crunching" sound signals mechanical stress and increased wear on the synchronizer. By the time that the synchronizer is worn-out, the transmission will be worn to the point where a complete rebuild or replacement is necessary -- an expensive and difficult undertaking in older H6 & M4 (444s & early 544s), M30 /31 (445s, later 544s, P210s & P1900s), and M40 /41 (120s, 1800s, later 544/P210s, 140s and early 240s) transmissions.

One note, however, is that the 1st gear of H6, M4, M30 and M31 transmissions were not fitted with a synchronizer assembly. That means that you'll either have to wait until the car is stopped before shifting down from second gear or use the double-clutch technique detailed below.

Influencing Factors on Synchro Wear

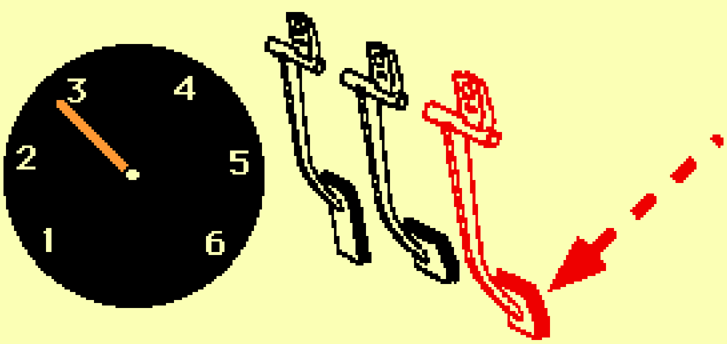
Synchronizers will wear slowly under normal driving conditions. Fast shifting will place greater strain on synchronizers as will marginal lubrication and the presence of dirt or particulate in the transmission fluid. Owners wishing to prolong the life of gearbox internals, therefore, are reminded not to "force" shifts or speed shift without using the clutch. Bi-annual transmission fluid changes are also a good way to keep synchronizers functional.

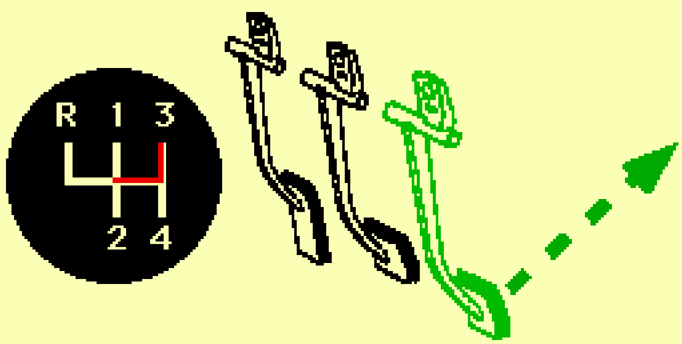
In addition to regular care, a shifting technique called "double-clutching" can significantly reduce - or eliminate - strain on synchronizers. In cases where synchronizers are already showing signs of acute wear, double-clutching can prevent the onset of more serious problems such as broken gear sets.

What is Double-Clutching & How Can it Help Prolong Transmission Life?

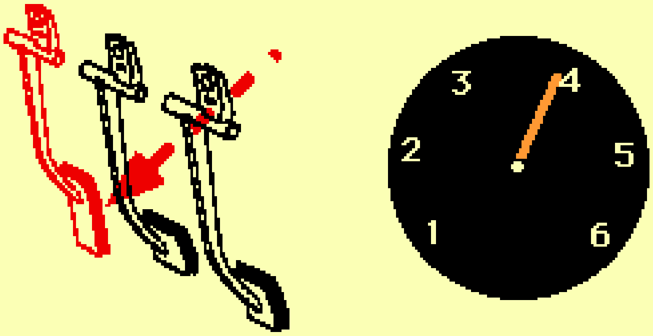
Double clutching is a technique used to match the rotational speed of a gearbox's input and output shaft during successive down-shifts. The technique sounds simple in theory, but requires some practice to become second nature for a driver.

STEP ONE - Note engine speed before the shift. To downshift, depress the clutch and guide the gearshift lever to the "neutral" portion of the shift gate. With the transmission in neutral, release the clutch pedal.



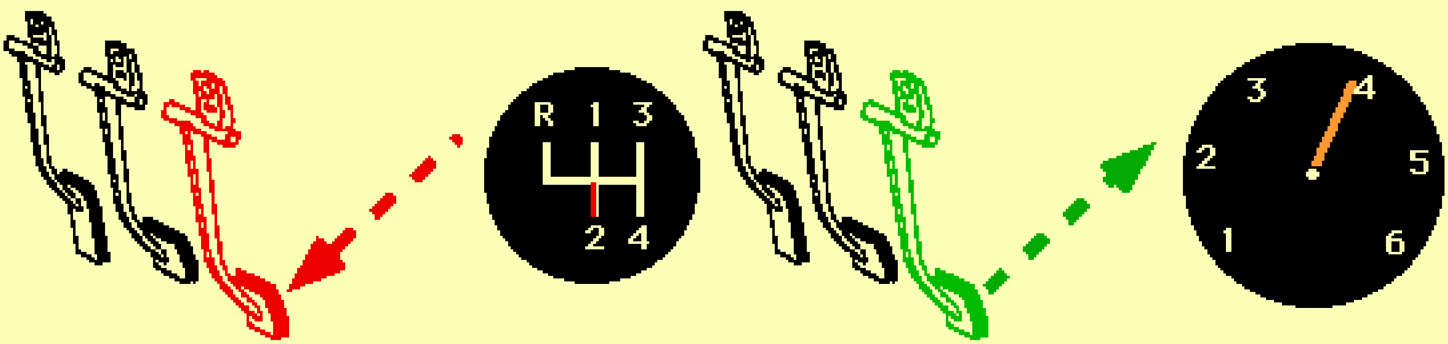


STEP TWO - Blip the throttle to the anticipated engine speed of the next lower gear. You'll have to rev the engine proportionally higher than the speed observed in step one.



STEP THREE - Depress the clutch. Guide the gear lever to the next lower gear. If done correctly, the gear level should slide into the next lower gear with ease -- the effort will be noticeably smoother. Release the clutch. If you've done things correctly, the engine speed should be very close to the rpms shown when you "blipped" the throttle.

If not, that's OK. Keep trying; it will come with practice!



A Helpful Tip

Do not try to quickly downshift using double-clutching. Instead, think of the successive clutch actions as two successive gearshifts -- one into neutral, the other into the next lower gear. With consistent practice, you'll be making successful double-clutch downshifts so quickly you'll hardly notice the difference.

The best part about double-clutching downshifts is that wear on the synchronizers will be significantly reduced -- even eliminated as the gearbox input and output speeds are consistently matched during every downshift.

When you've mastered the technique of double-clutching, it's time to try heel-and-toe shifting. I'll save that tip, however, for a future issue.

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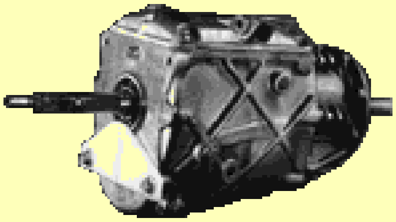


May Maintenance Tip - Curing Manual Transmission "Crunches"

Sponsored by: The Gothenburg Bible

Does your Volvo ever protest when shifted into reverse? Is your right arm growing stronger from trying to shift into 1st gear while the car is stopped?

If you answer "Yes" to either of these questions, chances are your Volvo is fitted with a M45, 46 or 47 manual transmission. Although these transmissions are known for longevity, the lack of refinement and an occasional need for service prevents these gearboxes from attaining unequivocal praise.

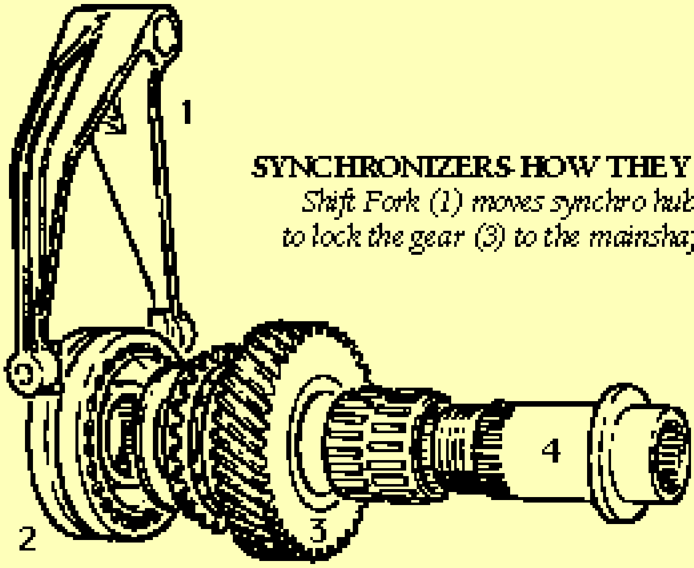
PRIMARY CAUSES OF GEARBOX "CRUNCH"

Most manual transmissions use synchronizers to match the rotational speed of the mainshaft to that of a particular gear. Just about all synchronizers use the viscosity of transmission fluid to slow down one or more gear sets. M45, 46 and 47 transmissions use two friction synchronizers for each gear, whereas 1996 and later versions of the M56 gearbox (fitted to 800-series and S & V70 models) which feature three friction synchronizer rings for the first three gears and sintered coatings on the 4th and 5th gears for improved shfting.

This is not to say, however, that the M45,46 and 47 tansmissions are without charm -- they just require more maintainance then those later model gearboxes developed for the newer, more stylish models.

In M45, 46 and 47 transmissions, ineffective gear synchronization can be traced to either:

a. a mechanical fault in a synchronizer; or
b. transmission fluid of inappropriate viscosity.



Mechanical faults in M45, 46 or 47 transmissions are commonly associated with the 2nd and 3rd gear synchronizers. Such faults are most prevalent in gearboxes with well over 100,000 miles/160,000 kilometers of service. If your Volvo's manual transmission does not shift cleanly (up & down) through the first three gears while underway, a synchronizer fault is possible. If, however, your Volvo shifts cleanly except for 1st gear and reverse, the gearbox may be filled with fluid of marginal quality.

THE CURE

Flushing your transmission with most "over-the-counter" fluids will not solve your gearbox woes. What you need is a fluid which offers higher viscosity stability.

Synthetic fluids are specifically engineered to provide a much higher degree of stability than their conventional counterparts. The top-quality synthetics are also designed to fully comply with the elastomers used in transmission seals. These synthetic fluids can be obtained in many of the weights and varieties common to most automobiles -- even the Automatic Transmission Fluid (ATF) Type "F" specified by AB Volvo.

Synthetic fluids may cost signifiantly more ($10.00 per quart/litre for synthetic vs. $2.00 for conventional transmission fluid), but their performance (and positive effect on transmission life) is outstanding!

HINTS

AMSOil and Red Line produce high-quality synthetic transmission fluids that compliment Volvo gearbox operation. Owners using products from these companies consistently report smoother shifting, reduced gear noise and improved service life. Although I have not been fortunate enough to try Red Line lubricants, I can personally attest to the effectiveness of AMSOil ATF Type "F" (Stock Number ATF-01) in curing shifting problems in three of my Volvos (1982 245 (M46), 1989 244 (M47 series I) and 1991 244 (M47 series II)).

If you can't find these brands in your area, remember this basic rule:

You get what you pay for; so choose the highest quality lubricants you can afford....... and enjoy shifting!

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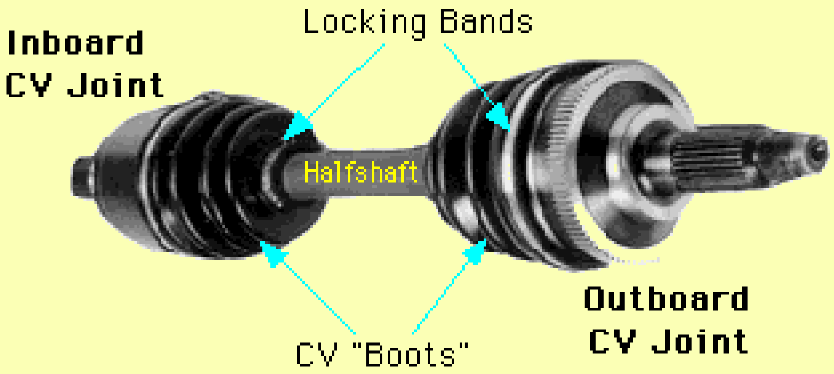
CV Joint Maintenance

By Paul Grimshaw

A Constant Velocity, or "CV" joint is a special type of flexible couple that allows a shaft to rotate at a fixed speed regardless of the angle at which it is bent. This joint has superceded universal joints in many applications, including in the rear suspensions of later model 700- and 900-series cars.



CV joints are used in most front transaxles of today's front wheel drive cars too! In fact, Volvo 800-, S/V/C 70 & 90 and Volvo's newest S80 models use CV joints as a key transaxle component.

While CV joints are extremely effective in maintaining constant velocity during extreme angles, they are vulnerable to premature failure if exposed to dirt or moisture. For that reason, constant velocity joints are protected with an accordian rubber boot that permits free movement but keeps the elements out. CV "boots" as they are called are connected to the half-shafts by a locking steel band or clip.

A CV boot is constantly exposed to road spray, dirt and foreign objects (such as road debris). As a result, it is not uncommon for CV boots to become punctured or torn. When this occurs, dirt can enter and damage the precisely machined bearing and race within the joint.

Torn boots never provide symptoms to the driver. Instead, the CV joint slowly self-destructs with a grinding, squeeking or clunking noise being heard only after the joint has entered its terminal phase of life. The only cure is to replace the worn joint at a cost of $500-$1000.

Preventing the premature wear of CV joints is accomplished by a visual inspection of the boots. The boots can be replaced at incremental cost (around $20-50) if they are found to be badly worn, torn or punctured. The high labor rates associated with suspension disassembly and half-shaft removal can be avoided entirely through the use of "split boots", shown in the figure below:

Split boots are available through aftermarket parts distributors in a number of sizes to fit your Volvo. If you have trouble finding a local source try a company called Bailcast® located in Chorley, Lancashire UK, makers of a neat self-adhesive product called the "Stickyboot" (shown above).

Split CV boots can be stored in the trunk for emergencies. Needless to say, V70 Cross Country owners who regularly conduct intentional trips across rough roads or fields should inspect the CV joints most frequently!

CV boot inspection is just one example where preventive maintenance can save a small fortune. Read about other ways to prevent costly breakdown in The Gothenburg Bible.

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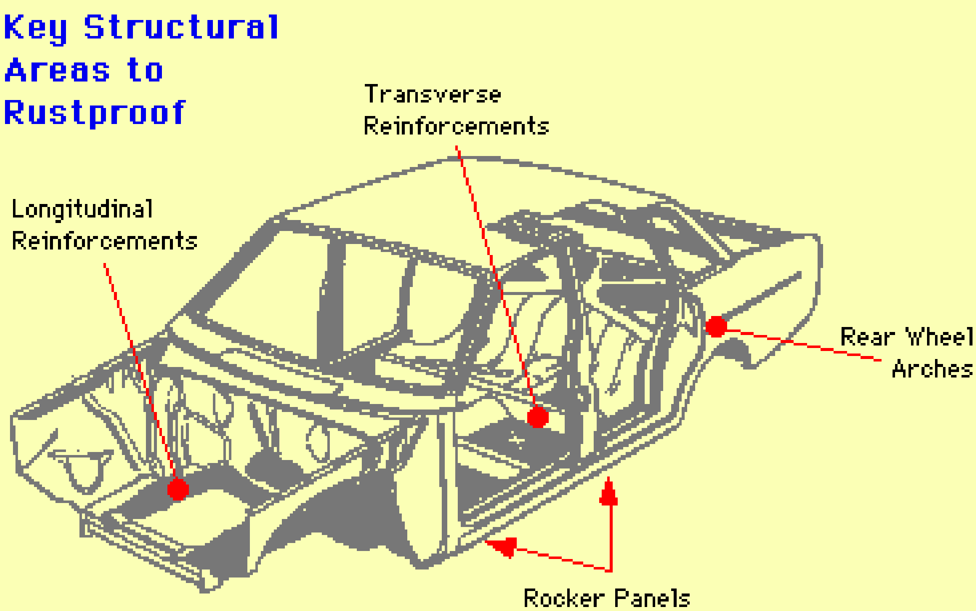
Rustproofing

By Paul Grimshaw

THINK ABOUT RUSTPROOFING NOW!

Its always a good idea to get rustproofing done before the end of September as the heat of late summer can help better distribute rustproofing into all the the cracks and crevices. This is especially important in spot-welded chassis (like those used by Volvo).



GETTING INTO TIGHT AREAS

Commercial rustproofers tend to use a drill in place of a brain! Seriously, there's no need to resort to drilling holes into a Volvo chassis in order to gain access to chassis sections -- Volvos generally have at least two drain holes per box section.

There are a number of access points into which you may extend a aerosol wand. The ideal way to reach practically all access points in one easy step is to remove the seats and carpet from the passenger compartment. Although this can takes about 45 minutes, it will enable you to vacuum any accumulated dirt/salt residue and make a compete assessment of the structural integrity of your car's floorpan.

With the interior removed you can remove 6 to 8 three inch diameter plastic drain plugs from the chassis. At least four of these plugs will permit access to the rocker panels which, if you park your car in a dusty area or under trees, will be partially full of dirt and tree residue. Removal of this debris will prevent moisture retention and ensure a professional rustproofing job.

The remaining plugs will be located on the "floor boards". These permit access to the transverse chassis reinforcements which run under the driver and passenger seats respectively. Again, expect to have to clean out accumulated dirt.

Dirt/debris is besk removed by a vacuum nozzle followed by a steady stream of water from a garden hose. After cleaning, the various components will have to dry out completely. It is probably best to leave the car for 12-24 hours to let the moisture evaporate (leaving the windows open a few inches helps!).

The area between the rocker panels and rear wheel arches can be reached by removing the side trim panels. Doors are best accessed by removing interior trim and coverings to reveal the inner working of the door. Each trim panel usually takes about 20 mintues to remove. I would recommend, however, that shade-tree mechanics exercise care and patience in dismantling the door panels as there are speaker wires and window switches/handles which will have to be removed with care.

If the rear hatch and chassis is in very good condition it is best to remove the trim pieces and interior panel for rustproofing. If this area is rusty, however, it is very easy to inadvertently tear away chunks of rusty metal during disassembly. Use care in removing exterior trim.

If you are not comfortable with removing the interior or door panels, most areas of the chassis can be reached from the underside of the car. Each rocker panel has 6 to 8 drain holes located on the lower lip. The doors also have three to four drain holes.

The transverse cross members have a number of holes, as do the longitudinal reinforcements which run from the engine compartment rails to the underside of each front seat. Prior to rustproofing, it is best to unplug any drain holes with a small piece of hangar wire, followed by a liberal water spray to loosen any dirt which may be inside the chassis. This is, however, far less effective than you will be able to achieve with the interior removed.

Rustproofing without removing the interior is darned messy work as you will have to crawl under the car with a hose. Allow two days of dry storage (indoors or outdoors) to ensure the chassis sections are dry.

Your favorite rustproofing can then be applied in aerosol form. If you're unsure of which compound to use, try consulting Chapter One of "The Gothenburg Bible". Prior to application, however, preparing the surface with a thin spray of WD-40 along the inner seams of the box sections and rocker panels will help any tar-based rustproofing seep into all of the nooks and crannies of the chassis.

THE REWARDS

Rustproofing does little to *improve* the outward appearance of your car. It will, however, preserve the structural integrity and general appearance over a number of years. The costs savings can be up to $4000.00 -- the cost of a comprehensive body job at today's labour rate.

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October Maintenance Tip - Winterizing Your Volvo

By Paul Grimshaw

For many in the Northern Hemisphere, the winds of October herald the coming of winter. While such weather may be welcomed by ski fanatics, winter temperatures in many places of the world can be deadly. If you live anywhere north of the the 30th parallel, the following is necessary to keep your Volvo (and you) in relative safety and comfort through the winter months that lie ahead:

THINGS FOR YOUR VOLVO

a. **A battery blanket** (an insulated, electrically-heated wrapper which keeps the battery warm overnight). It will prevent the battery from freezing and will aid in cold weather starts.
Cost: around $15.00;

b. **A block heater** (if not already fitted). I recommend the original Volvo block heater.
Cost: around $40.00

c. **A heavy duty battery.** Get the *largest* one which will fit. Generally around 700 to 800 cca (cold cranking amps) should do for most gasoline-powered Volvos. Of course, make sure that the battery cables are clean, tight and well crimped.
Cost: around $80.00;

d. **A grille cover.** This will prevent the rad from freezing while the car is underway (Remember that the wind chill at highway speed could be as cold as -70F). Just abount any brand will do fine if trimmed to fit.
Cost: $20.00

e. **The proper fluids.** Most usually forget this one, although using 5W30 synthetic motor oil and 80W90 synthetic gear lube for the rear axle will help fuel economy and reduce driveline strain. Although I'm a big fan of most synthetic oils/lubes, Mobil 1 has my vote because of its cold weather performance (it pours at -63F and flows at -40F). Try AMSOil gear lube for the final drive unit..... it has served me well.

f. **A set of *very high-quality* jumper cables** (8 ga wire).

Cost: $50.00.

THINGS ESPECIALLY FOR YOU

Equiping the car is the first step. Equiping yourself is the second. Having lived in the second coldest capital on the planet for the past 12 years, I recommend that every car carry the following:

a. a candle *and* matches

b. a sleeping bag;

c. a spare pair of gloves, winter boots and a hat; and

d. a few candy bars.

Armed with these items, a relatively fit motorist can easily survive a morning in the ditch, an evening in a frozen parking lot, or a night without gas!

VOLVO FUEL DELIVERY SYSTEMS & COLD STARTING

Equipment notwithstanding, there are several differences in Volvo fuel delivery systems which can affect cold weather starting and performance. K-Jetronic equipped cars start better in the cold since the higher fuel pressures improve atomization (remember, at -40F/-40F the fuel does not vaporize -- it remains in small droplets). LH-Jetronic and Motronic-equipped Volvos are quite acceptable. Carburated cars tend to stop working at temps lower than -35F, unless their block heaters and battery blankets are *always* "plugged-in". The same goes for diesels that must use high compression and the added heat of glow plugs to start in cold temperatures.

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Preventing Door Handle Breakage

By Paul Grimshaw

200- and 700-series cars are fitted with "pull-up" door handles. These handles integrate well into the lines of cars and minimize aerodynamic resistance along the side panels. Each door handle is attached to two cantelevered arms which extend into the door and actuate the release mechanism.

THE PROBLEM

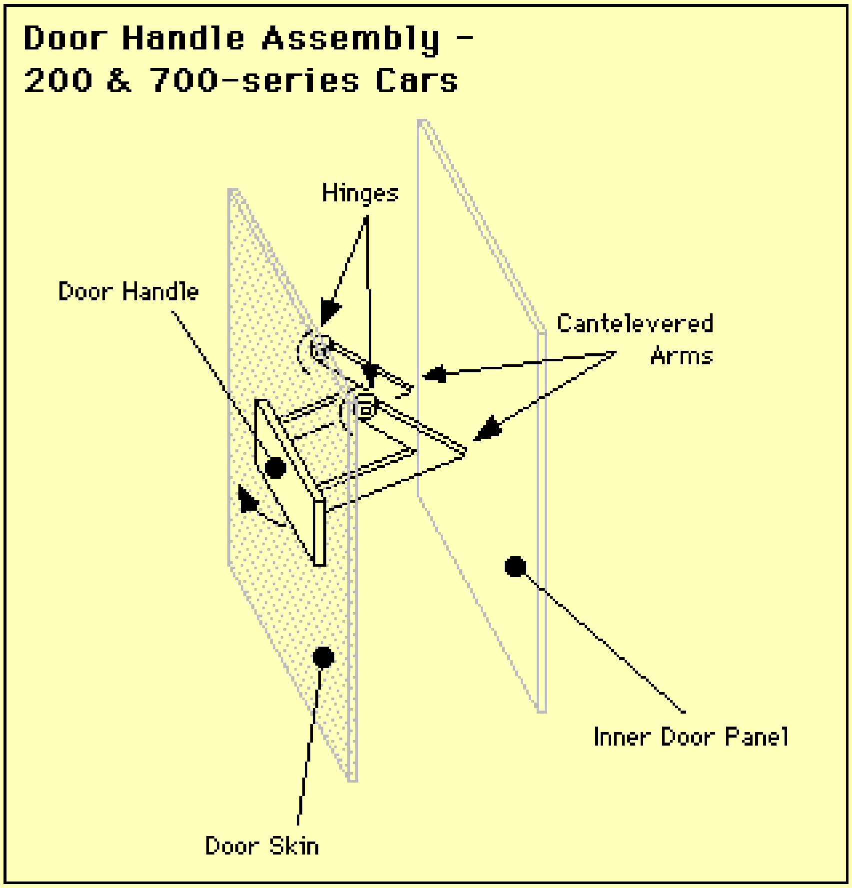
The linkage is well hidden between the door skin and inner door panel. For that reason, few garages attempt to lubricate the hinges of the handle. As a result, the hinges gradually stiffen with age. In time, the force required to move the handle exceeds the yeild strength of the metal hinge. The result is a broken door handle and a trip to the garage for a $150.00 repair bill .

Will that be cash or charge?

GREASING DOOR HANDLE HINGES

The best lubricant for the door handle hinge is lithium aerosol grease. Do not use graphite-based greases as they tend to dry and gum with age. Penetrating oils provide some lubrication, but they lack the film strength to remain within the hinge for a long period of time.

There are two ways to lubricate the door handle mechanism on 200- and 700-series cars. The first is to gently bend the tube which comes with the aerosol grease so that it may pass through the small holes in the outer door panel through which the cantelevered arms pass.



The second, and most effective way to lubricate the door handle hinge is to remove the inner door panel and directly spray lithium grease at the variety of hinges and slides which make up the door release mechanism. Details on how to correctly remove and replace the inner door panel are contained in most repair manuals.

REAPING THE REWARDS

After lubrication, the effort required to disengage the door catches and locks will be greatly reduced. Better yet, the risk of breaking a door handle will be greatly reduced thus saving you an expensive trip to the garage.

This basic bit of maintenance should be done every two to three years.

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Preventing Brake Squeal

By Paul Grimshaw

I hate squealing brake pads.

Has anyone ever done a post-mortem on an incessantly squealing Volvo brake pad? I have. The dust groove (optional) on the pads are either blocked with hardened lining material or the outer edges of the pad are square, not beveled.

The cure? Buy a Dremel® MotoTool & a new set of *quality* pads. Widen the dust groove (selected models only). Smooth edges of groove so that there are no hard edges/nooks for hot brake dust to bind. Bevel the outer edges of the brake pad. Reinstall the pads.

If your brake system is otherwise in good working order, there should be no brake squeal. Repeat this procedure anually. If there is plenty of lining left on the pads, simply clear the dust groove!

Seriously folks, have your mechanic try this one. It really works.

Volvo brake systems are superb! Long life, great performance. They just require care and understanding.

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Bleeding Brakes

By Paul Grimshaw

Bleeding brakes, a term used to describe the process of changing brake fluid, is an effective way to preserve the integrity of your Volvo's brake system and improve stopping power under extreme conditions.

BRAKE FLUIDS & THEIR PROPERTIES

The automotive industry uses two types of fluid to transmit braking energy:

(1) Glycol compounds; and

(2) Silicones.

Glycol compounds are the most widely-used compounds. Conforming to US Department of Transportation (DOT) specification, fresh DOT 3 and 4 brake fluids can withstand temperatures in excess of 200°C/390°F without boiling. This boiling point, however, decreases over time as moisture from the atmosphere is absorbed into the fluid.

The higher the moisture content, the lower the boiling point of the brake fluid. When brake fluid becomes saturated with water (at approximately 2% water by weight), the boiling point will have dropped by 60°C/100°F. This reduction of boiling point can lead to brake fade, a dangerous condition where braking force is diminished.

Of equal concern, water saturated fluid can corrode delicate brake components. In extreme cases, this can cause ABS pumps to fail, brake pistons to seize and master cylinders to fail; all of which will contribute to a large repair bill!

Silicone compounds, which are resistant to water absorption, are recommended for many new Volvo models. Nevertheless, water, in the form of condensate, can be still be introduced into the braking system. This can lead to localized corrosion within the braking system.

MAINTAINING BRAKE PERFORMANCE & LONGEVITY

It is important that the brakes be periodically bled -- regardless of the type of fluid used. The procedure, usually taking less than 30 minutes will:

(1) Remove dirt, sand and scale from the brake system, thereby helping to prevent seal damage;

(2) Remove any accumulated moisture in the system; and

(3) Renew the fluid, which contains anti-corrosion and anti-scuff compounds.

Depending on labor rates and materials used, owners can expect this service to cost $30-60.

HOW OFTEN SHOULD THE BRAKES BE BLED?

Volvo recommends that most of its braking systems be bled every two years, but adds that brakes subjected to severe use (mountain driving, routine exposure to high humidity levels, towing) should be bled annually.

Given the high cost of brake components, it is recommended that*all* Volvo brakes be bled annually using the correct fluid specified for your model. The minor inconvenience and cost associated with brake bleeding will be offset by trouble-free brake performance and long component life.

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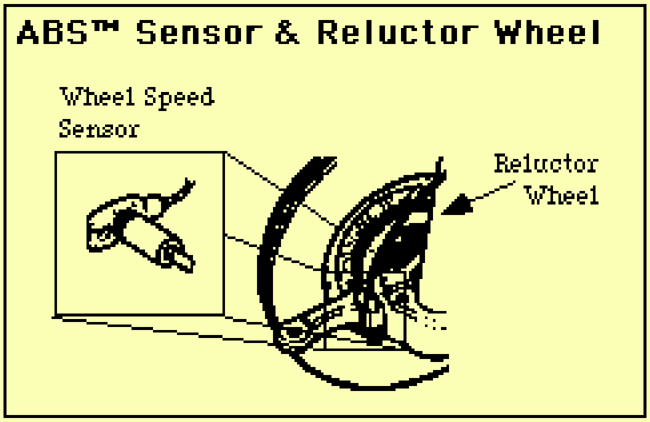
Anti-Lock Brake Fault Light:

A System Failure or Maintenance Oversight?

By Paul Grimshaw

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 as all Volvo drivers know, a lot of brake dust can be generated!



As accumultion of brake dust grows, heat fuses it into a carbon-like coating that attentuates 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.

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.

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.

ABS is an excellent driver's aid but should be carefully serviced by a professional mechanic whenever system faults are registered. I hope that this information proves helpful to you/your mechanic when investigating an ABS® fault light.

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Brake Hose Inspection & Replacement

By Paul Grimshaw

Active safety is a term that describes the ability of a vehicle to avoid an accident. While this term encompasses a number of mechanical aspects of automotive design -- engine, suspension, chassis -- the most important contributor to active safety lies in a car's braking system. Without good brakes, a car cannot adequately protect its passengers from harm.

Volvo's reputation for equipping their sedans, wagons, coupes and convertibles with excellent brake systems is renowned. The company's approach to safety was eloquently summarized by Road & Track's immortal automotive journalist, the late Henry M. Manney III as he reviewed the 1968 142S:

"My neighbour, an airline pilot, took a spin in it and raved about the seats, the phenominal brakes, the yawning trunk, and the London-taxi-like turning circle. He even raved that it went pretty well... quite an admission considering that he drives a 7-litre Brakeless Wonder. "What", he said after a long look, "am I doing driving that and frightening myself when I could be driving this?"

This month's maintenance tip concerns the flexible brake hoses that complete the connection between your car's master cylinder and brake calipers.

WHY DO BRAKE HOSES NEED TO BE REGULARLY INSPECTED?

Brake hoses run from your Volvo's chassis to the front and rear suspension. They are the medium through which hydraulic pressure motivates the brake calipers. The brake calipers, in turn, press the brake pads against the brake disk -- the friction from which slows your car in a progressive and predictable manner.

Brake hoses consist of an inner tube (through which brake fluid can pass), bonded to two layers of heavy duty nylon sheathing, and protected by an outer rubber cover.

The flexible nature of your car's brake hoses enables the suspension to move throughout its range of travel. Unfortunately, however, the combined effects of years of flexing, high pressure and exposure to the harsh environment of the lower chassis will eventually deteriorate your Volvo's brake hoses.

Should the inner tube of a brake hose rupture, considerable braking capability will be immediately lost. If the inner tube becomes separated from the nylon sheathing, it can collapse and prevent a brake caliper from releasing. The result is a dragging caliper, overheated brakes, and a potentially dangerous handling condition.

THE NEED FOR REGULAR INSPECTION

Although brake hoses can fail without warning, a keen eye and careful inspection will often detect signs of failure before it occurs.

The first sign of a distressed brake line is leaking fluid. This indicates that either the joint between the brake hose and the adjoining metallic brake lines is loose or that the inner tube of the brake line has ruptured.

Another common warning sign is one or more swollen or spongy brake hoses. This indicates that there is a slow leak in the hose's inner brake tube. This slow leak saturates the supporting nylon sheathing and swells the outer protective layer of the brake hose.

The final warning sign of an impending hose failure is a bulge in one or more brake hoses. This indicates that the leak is now serious and threatens to breach the outer layer of the brake hose.

Although such failures can come at any time, they are most commonly seen in cars that have been subjected to intentional or unintentional abuse (such as an object striking a brake hose) or in cars over 10 years old that have not yet had their hoses replaced.

COST FACTORS

Most Volvos have between three and six flexible brake hoses. Depending on the model, replacements can range from $40 to $60 per hose. While replacing brake hoses is not cheap, it is significantly cheaper than having to deal with the aftermath of an accident.

WARNING

Replacing brake hoses is extremely difficult and should be left to a qualified mechanic. In many cases, the hoses will have to be cut and the brake hose unions forcibly removed with a combination of vice grips, heat and brawn. This sometimes means that sections of adjoining pipe (particularly those sections that run from the brake hose to the caliper) will have to be replaced too, so don't take it too hard if a well-intentioned mechanic advises you of an additional parts requirement.

BACK TO THE AIRLINE PILOT

Potential accidents can be avoided by having your Volvo's brake hoses inspected on a regular basis. If any doubt as to their condition exists, have the hoses replaced by a qualified mechanic.

Airline pilots reading this tip will undoubtely agree that it is worth the peace of mind to enjoy a Volvo's phenominal brakes instead of contending with a brakeless wonder. Those who don't fly for a living will no doubt arrive at the same conclusion.

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Tire Care

By Paul Grimshaw

Your Volvo's ability to accelerate, stop and turn is ultimately determined by a contact patch measuring a scant 100 square inches. The integrity of the contact patch depends on the condition of the tire which creates it. To that end, tire maintenance is extremely important.

THE TEN COMMANDMENTS OF TIRE CARE

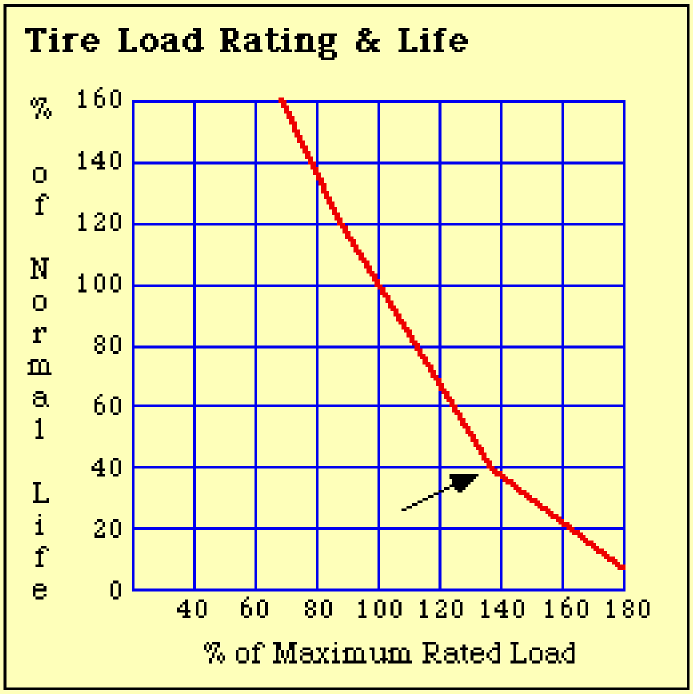
Tire care can be best summarized by reciting the following rules:

1. Never mix bias-ply and radial tires;
2. Never mix tire types (rain, snow, high performance) on the same axle;
3. Never travel without a spare;
4. Never attempt to repair a sidewall puncture;
5. Never abuse a tire through unnecessary severe braking, acceleration, or cornering;
6. Never use a tire which has been involved in a collision;
7. Never purposely alter tread blocks;
8. Never use a winter tire in the summer;
9. Never Under- or Over-Inflate a tire; and
10. Never exceed a tire's load or speed rating;

Although each of these commandments are described in "The Gothenburg Bible" and "Volvo Performance Handbook", this maintenance tip will focus on tire load and life to illustrate that tire care can save rubber, dollars and lives.

TIRE LOAD & LIFE

The graph below illustrates the importance of selecting a tire with the correct load rating for your Volvo:



As can be seen at the arrow, using a tire beyond its rated load can seriously undermine tire life. In the case illustrated, exceeding the maximum permissible load by 37% decreases tire life by a whopping 61%.

HOW CAN YOU VERIFY THAT YOUR VOLVO'S TIRES ARE UP TO THE TASK?

Your owner's manual will list the correct tire size and load index for your Volvo. The load index is a two digit number which corresponds to a load bearing capacity in kilograms. When multiplied by four, the load bearing capacity enables your car to safely be loaded up to its maximum recommended vehicle weight *and* handle the stresses of the road when at speed.

Below is a list showing the relationship between load index and load capacity in kilograms and pounds, as stipulated by the US Department of Transportation:

LOAD INDEX	LOAD (Kg)	LOAD (lbs)
75	387	851
76	400	880
77	412	906
78	425	935
79	437	961
80	450	990
81	462	1016
82	475	1045
83	487	1071
84	500	1100
85	515	1133
86	530	1166
87	545	1199
88	560	1232
89	580	1276
90	600	1320
91	615	1353
92	630	1386
93	650	1430
94	670	1474
95	690	1518

CONCLUSION

Selecting tires that possess sufficient load bearing capacity is just one of the ways in which you can maximize safety and performance while minimizing costs. The other nine ways are discussed in detail in our books.

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Choosing Your Next Set of Tires

By Paul Grimshaw

The following article is based on the author's response to a question on how to choose tires. It is representative of the general technical support that registered owners can expect from the author of "The Gothenburg Bible" and "Volvo Performance Handbook".

Tires, like shoes, are constructed to meet very specific requirements. Sport tires are designed to provide maximum performance at the expense of tread life. Touring tires trade handling potential for a little extra comfort.

Winter and Summer tires describe products that are based on materials and methods of construction that work best in specific climatic conditions.

"All season" is a marketing term that is misinterpreted by drivers to mean that the tire is capable of operating in the near-arctic conditions that prevail in much of North America in the months of December through March. This is completely false, as "all season" tires lack the compounds and tread designs to deliver the most basic level of traction in snowy, sub-zero conditions.

The selection of the right tire to meet your needs requires some careful thought. Tires should be viewed as investments in safety and performance. Their return on investment can be measured in their ability to provide life-saving traction in extreme conditions.

I would first recommend shoppers to shy away from tires that are advertised on the basis of their long tread life. A good quality tire cannot be expected to last any more than 5 years or 75,000 miles before the rubber compounds from which it is made harden. The resulting reduction in grip and sidewall cracking makes any tire older than five years old a potential liability. Exceptions to this rule would apply to tires that see partial use (such as a winter tire that is used for a portion of the year) between periods of careful storage.

I cannot recommend any all season tire that is suitable for year round use throughout Canada. Nor can I recommend any "all season" tire for full-time use anywhere north of the Mason-Dixon line.

Volvo operated year round in the north-eastern states should be fitted with good quality touring or sport tires during fair weather and winter tires during the cold weather months.

What Constitutes a Good Quality Tire?

Universal Tire Grade Quality indicator printed on the sidewall of all automotive tires sold in North America assigns an alphabetic rating to describe a design's traction, temperature and wear. The traction rating is a measure of the tire's ability to handle and brake in wet conditions. The temperature rating is a measure of a tire's ability to tolerate sustained hot weather, high speed or heavily loading.

Look for "A" or "AA" ratings for both temperature and traction ratings for touring or sport tires.

The wear rating is a subjective numerical rating denoting how the tire's life compares with other models in the manufacturer's range. The assigned numerical rating is highly subjective as it is measured against a specific reference tire. That said, ratings of between 200 and 400 are normally give to most general purpose tires. Racing or auto-cross tires are normally assigned ratings below 200.

Trusted Tires

For general Spring, Summer and Autumn use, I would select one of the following touring tires:

- Pirelli P4000 Super Touring (I have a set on one of my Volvos);
- Goodyear Eagle GT (fitted to my wife's 244)
- Dunlop D60 A2
- Dunlop D65
- Yokohama Avid H4
- Continental ContiTouring Contact CH95 (one of my potential future choices for my Volvo)
- Michelin Pilot XGT H4

Each of these tires has unique handling characteristics. The Pirelli P4000s trade some grip for superb predictability and excellent feedback. A pretty good rain tire, too.

The Goodyear Eagle GTs are even better in the rain, but their grip is about the same as the P4000s. They provide somewhat less warning of slide when cornered at high speeds, though.

The Dunlop D60 A2s provide more grip than the Pirellis but are not as complaint. The same can be said of the Yokohama Avids. The D65, however, is oriented more towards comfortable touring and is quieter than the D60s or Avids.

The Continental CH95 is perhaps the highest performance tire of this group, but is more difficult to find. The Michelin XGT H4 can be found just about anywhere but the higher price of admission does not translate into better performance on the street.

Winter Tires

The variety of winter tires is very steadily growing. This is probably in response to renewed customer demands for safety. This market demand is backed-up by Scandinavian studies that demonstrate that cars fitted with winter tires are 25% less likely to be involved in a cold weather crash.

The best indication of a winter tire's cold weather performance is the presence of the Rubber Manufacturer's Association (RMA) symbol for severe snow duty on the tire's sidewall, a jagged mountain peak super-imposed on a stylized snowflake. This symbol is affixed to tires that reach a threshold of performance on packed snow, unlike the M&S (Mud & Snow) rating that had been awarded solely on the physical characteristics of the tread design.

Good choices in winter tires are:

- Nokia
- Gislaved
- Bridgestone
- Dunlop
- Pirelli

I truly believe that Nokia, a Finnish tire builder, produces the best winter tires in the world. The Nokia Hakkapeliita 10 was absolutely marvelous in the snow, despite having been developed years before the RMA established their new standard for winter performance. Its traction and response in the most foul weather was akin to a professional rally tire. The only downside was that the Hakka 10s were very, very noisy.

Hakka 10s have been replaced by a newer model that should provide even better performance than earlier models.

Gislaved Nord*Frost 2s are available through most Volvo dealers and have done extremely well in recent Scandinavian tire tests, beating Nokias on several occasions. I believe that Nord*Frost 2s are worth more than a glance when shopping for winter tires.

Bridgestone Blizzak WS-50s are acceptable, with this tire's degree of market penetration a testament to aggressive advertising. Blizzaks will certainly outperform any "all-season" tire but are not in the same league as Nokias or Gislaveds. The same can be said for the Dunlop Graspic and Pirelli Winter S.

Speaking of winter tires, it is not uncommon for a Volvo with a good set of winter tires to be able to easily out accelerate just about any Audi, BMW or M-B in the snow. North American muscle cars cannot hope to keep up with a well shod Volvo operating in snowy conditions. This is not to say that one should buy tires to win stop-light wars, but the added performance of the correct tire is welcomed by many owners.

Price = Safety & Performance

Summer and winter tires share comparable price points. You can count on a quality tire, in the size and load range to fit a Volvo 200, 700 or 900 to cost between $60 and $90 (US) each. Count on slightly higher costs for appropriately sized 16" tires and up to 70% more for 17" tires.

I'm a bit of a perfectionist when it comes to tires, but I believe that a "discount tire" is not going to be constructed of the materials necessary to ensure a good margin of safety and performance in extreme conditions. Up to a certain point, you get what you pay for.

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Steering Gear Maintenance

By Paul Grimshaw

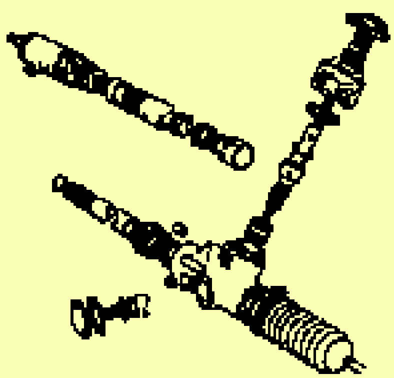
Modern steering systems depend on hydraulic pressure, provided by an engine driven pump, to assist in turning the front wheels. Vintage cars often rely on a drivers strength to actuate the steering mechanism. While power-assist and manual steering differ in complexity, both require periodic maintenance.

The aim of the tip is to outline a preventive maintenance strategy for Volvo steering systems.

DIFFERENT SYSTEMS, SIMILAR NEEDS

Volvo, like many other European automobile manufacturers, has adopted rack and pinion steering systems for its cars since 1975. Prior to this year, however, Volvos had used recirculating ball steering.

The advantage of rack and pinion steering systems is that road feel is improved for enhanced control. Performance comes at a price, however, as the precision machining of rack and pinion steering systems require excellent lubrication. Even if high-quality lubricants are used, the presence of dirt can score bearings, damage seals and render a $1600.00 steering rack inoperative.



Rack and pinion steering systems are precision manufactured assemblies that require good lubrication and clean conditions

Recirculating ball steering systems isolate road irregularities from the driver and generally provide longer service than rack and pinion designs. Nevertheless, marginal lubrication and dirt can just as quickly destroy this mechanical component. While replacement of a recirculating ball steering box costs less than would be the case with a rack and pinion system, parts availability for vintage cars is always a stressful affair.

Cost and availability are two important reasons why your should conduct periodic maintenance on your Volvo's steering system.

THE FIVE MINUTE INSPECTION

Rack and Pinion Systems:

Rack and pinion systems consist of a steering reservoir linked to the rack by two high pressure hoses. Wipe each of these components clean, take the car for a short drive, and (you or your mechanic) check for leaks. The most common problem areas on Volvo cars are:

- the reservoir cap;
- hose unions and joints; and
- the pinion seal located at the top of the rack.

If any of these areas are found to be leaking, repair should be arranged without delay. If all is correct, however, the only other areas requiring periodic checks are the left and right boots located between the steering rack and the tie rod ends.

Each boot should be free of tears and firmly clamped at each end. Any failure in this area will allow dirt to enter the rack assembly where it will quickly destroy the steering system.

Recirculating Ball Systems:

The only critical component that needs to be regularly checked is the steering box. This is located between the steering shaft (running from the firewall) and the myriad of links and rods that connect the steering box to the left and right steering knuckles. In the case of original or daily-driven cars, the steering box will be encrusted with grime. This must be cleared away using an automotive degreasing compound.

After cleaning and a short drive, inspect the steering box for leaks. The most common problem areas are:

- at the adjusting screw on top of the Pitman arm or the cover plate of the steering box;
- the bottom of the steering box (lower Pitman arm seal); and
- the area where the steering column enters the steering box.

If any of these areas are found to be leaking, repair should be arranged without delay. If all is correct, however, the only other areas requiring periodic checks are arms and links which must be periodically greased.

Regardless of the type of steering system in your Volvo, these checks should be carried out whenever changing engine oil or every three months -- which ever is sooner.

LUBRICATION

Draining and renewing the steering fluid is an effective way to prolong the life of your Volvo's rack and (if fitted) power steering pump. Depending on the model of Volvo, the steering fluid can be drained by removing the power steering hoses and draining the fluid into a catch container or using a mechanic's syringe to suck the fluid from the reservoir.

Replace the fluid with the type recommended in your owner's manual (usually a multi-viscosity engine oil or ATF Type "F" or "G" depending on the steering system and pump). **Ensure that you do not over- or under-fill the reservoir**. Drive the car for two or three days and **repeat the process**. The steering system will now be flushed with clean fluid.

If you are the inquisitive type, pour the old fluid into a glass jar. Hold the jar up to the light. Unless you change your steering fluid annually, the fluid will be blackened by contamination. At the bottom of the jar will be traces of sand, the grains of which could damage the seals within your car's steering pump and rack.

As it is very difficult to drain the fluid from a recirculating ball system (requires removal of the steering box), it is most practical to check that the level at the filling hole is correct.

The level of the steering fluid should be checked whenever changing engine oil or every three months -- which ever is sooner. Volvos rack and pinion steering systems should be flushed every two years. Those driving in dusty, desert conditions, however, should have the rack flushed annually.

CONCLUSION

Steering systems are expensive and affect the safety of your Volvo. A preventive maintenance strategy will save money spent on repair and enhance safety - a win-win solution for you and your Volvo!

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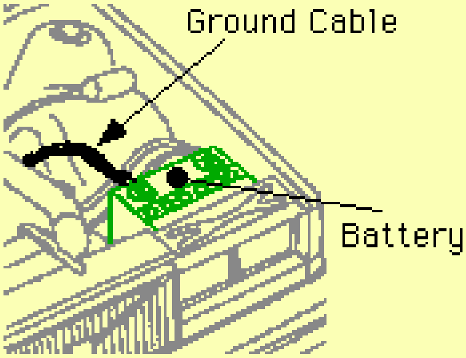
700-Series Battery Ground Cable

By Paul Grimshaw

The battery grounding cable on Volvo 700-series cars fitted with the 2.3 litre (B23 & B230) 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.

Such physical deterioration eventually takes its toll on the grounding cable--resulting in a poor electrical contact. Any ground failure, whether total or partial, can play havoc with your on-board electronic systems and can lead to the failure of the car's engine management computer and/or mass airflow sensor (total replacement with labour-$2200.00).

Given the risk of failure of this part, it's advisable to regularly inspect the ground cable and replace it as a precautione every couple of years.



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Exorcising Electrical Gremlins

By Paul Grimshaw

Volvo automobiles have very robust electrical systems featuring solid brass terminals within the fuse panel and on most accessories' contacts. Heavy gauge wire, protected by synthetic insulators completes a package which in most cases provides trouble-free service for an average of 8-10 years.

After roughly a decade of use, however, many owners complain of intermittent electrical problems. These electrical problems can be attributed to the following:

(1) High relative humidity leads to a moisture build-up in the various harnesses and connectors that link the engine management computers to injectors, sensors, and pumps. These can cause shorts and drop-outs along critically important sections of wire;

(2) Continuous exposure to engine bay heat damages sections of the main wiring harness to/from the engine management computer. The potion of the harness most affected is usually around/below the timing belt cover where constant exposure to heat, vibration and oil will destroy the insulation of the wiring harness. The result is serious electrical problems that can affect anything from engine management to convenience accessories. This fault is most common in turbocharged models;

(3) Exposure of the wiring to oil-based anti-corrosion treatments. This can, in some instances, destroy wiring insulation and lead to a number of non-specific engine faults. In severe cases, short circuits can lead to fire; and

(4) Corroded fuse panels and cracked fuses fail to handle the current necessary to power high-load systems such as blower motors, ignition systems, door locks and window lifts. Faults may be intermittent -- and frustrating!

SIMPLE FIXES

Although heat, moisture and its effect on wiring is well known, some wise preventive maintenance includes doing the following:

(1) Inspect and clean all under hood connections every three to five years. Lightly coat exposed terminals with non-conducting dielectric silicone as this will repel moisture build-up for many years. Dielectric silicone may be found at marine supply or auto parts stores and costs around $10.00 per tube. Use it sparingly;

(2) Annually inspect all major harnesses for wear. Common fault areas are around sources of heat and

where looms pass through bulkheads. If the insulation has been worn away in a small area, effective repairs may be made with electrical tape or heat-shrink tubing. More major insulation damage may be corrected through replacement of a particular wire or complete harness;

(3) If the harness has been damaged by heat, don't just replace it. Add a protective sleeve around the newly repaired wires to prevent recurrence. One company called Firesleeve® markets an aluminized foil with a fiberglass backing designed to keep wires cool. This stuff works wonders. Use it;

(4) Inspect fuse panels for corrosion every six months. Volvos fitted with European-style ceramic fuses are particularly susceptible to corrosion. Retrofitting stainless-steel capped glass fuses to these cars will practically eliminate future problems at the fuse panel and will increase inspection periods to once every year.

SOMETHING FOR NEW VOLVO OWNERS TO CONSIDER....

If owners of older cars have concerns over their wiring, just imagine what owners of newer cars will have to contend with when the buses serving Control Area Networks degrade. These networks rely on good connections to pass error-free 32-bit digital data to window lifts, alarm systems, throttle control, radio and air conditioning systems. Any degradation, no matter how small, will wreak chaos on these systems. So if you own a S80 or newer Volvo, adopt a preventive maintenance program today.

Critically analyzing potential electrical fault areas today will prevent expensive troubleshooting and repair tomorrow.

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Keeping Brake Light Cluster Clean & Dry

By Paul Grimshaw

Condensation, caused by changes in day time and night time temperatures, can create puddles of moisture in areas which do not have adequate drainage, or are sealed against the elements. One such are for moisture to collect is the rear light, or brake light cluster of 200-, 700-, 800- series Volvos.

The reason why moisture collected so readily in this area is three fold:

1. There is very little air circulation between the clusters, accessed from the trunk or cargo area, and the outdoors;

2. The neoprene seals that isolate the clusters from the chassis compress over time, allowing rain to enter; and

3. The design of the brake light clusters, consisting of segmented cells of bonded plastic, hold moisture very well indeed.

The result is that water can collect in the clusters, causing bulbs to prematurely fail, fittings to corrode, and internal reflectors to tarnish. If you live in a cold climate the condensed water can freeze, cracking the lenses. The result is a ruined light cluster and a parts bill in excess of $200.00!

Quick Fix

Regular inspection of the rear light clusters is highly recommended. Should significant moisture be discovered, remove and clean the cluster(s). Allow to dry completely. Before re-installing the cluster(s), carefully drill a 1/8 inch hole in the lowest part of the bottom of the cluster(s). This hole will allow future moisture to drain, keeping the bulbs and reflectors clean while preventing further damage from occuring.

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Special Article -

Turbochargers - An Owner's Guide to Avoiding Catastrophe

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by Paul Grimshaw
Author, "The Gothenburg Bible" & "The Volvo Performance Handbook"

I must admit to having been shocked at what I read. It was the summer of 1985 when, as a subscriber to *Road & Track*, I followed a tale of woe from a fellow Volvo owner:

"At about 55,000 miles (88,000 km) the tailpipe of my 1982 Volvo Turbo Wagon started smoking quite a bit, so I took it to the dealer. Their service representative told me that the turbocharger had to be replaced..... I bought the car because of its supposed longevity, but at $750 per turbo replacement (remember, the year is 1985) the longevity becomes expensive. I have always changed my oil every 2000 miles, despite the factory's 3750 mile recommended interval. Is this a common problem with turbo engines or is it just Volvos?"

A little unusual, perhaps? An unnamed Volvo spokesperson was quoted as replying:

"You have to look at turbochargers as a consumable component, something like brake pads or clutch facings; they just get used up." Apparently a turbo "works in a hostile environment, and the public should be educated about that".

While it is true that "the burned hand teaches best", the aim of this article is to provide some insight into the proper care of a Volvo turbocharger and hopefully spare a fellow owner from a large repair bill.

GAS (AIR) MANAGEMENT 101

During the early development of the automobile it was recognized that an air/fuel mixture, when properly compressed and ignited, was capable of producing mechanical work. The amount of work possible depended on two basic principles: (1) the larger the engine displacement, the more power may be produced and, (2) the more efficient the airflow through an engine, the more power may be expected. Combined, these fundamentals governed engine design and provided the impetus for the development of the Double Over-Head Camshaft (DOHC) in 1911. Although a DOHC allowed better valve arrangement and improved engine breathing, racing teams of the era were always looking for that added advantage... and they found it in the aero-engine industry.

Aircraft manufacturers knew for many years that air pressure decreased with altitude. Since air pressure is related to engine output, they set about designing a high volume pump to compress the air at altitude. The resulting invention was called the supercharger, a mechanically-driven pump which forces air into an engine to effectively increase its ability to breathe.

The aero-engine industry went on to discover that if a pump is geared to do more than offset the effects of altitude, it may be possible to increase the power output beyond its basic limits. In simplistic terms, this means that if one can force 3.0 litres of an air/fuel mixture into a 2.0 litre combustion chamber, the engine will produce almost 50% more power; effectively responding as a normal 3.0 litre engine would. Supercharging was born, heralding more powerful aircraft engines and leading to its subsequent introduction in road cars in the 1920s!

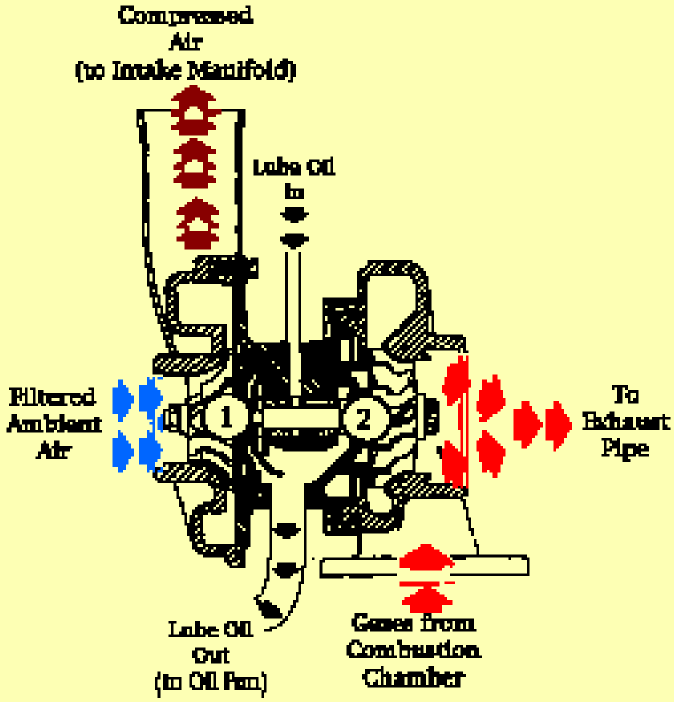
SUPERCHARGER SHORTFALLS

Although superchargers increased the overall output of engines, their mechanical drive systems were inefficient. At low, off-boost engine speeds, mechanical drag robbed engine power, whereas at higher, on-boost speeds, the act of forcing a large volume of air into a small space added huge amounts of heat to the combustion process. Catastrophic damage followed any backfire - in some cases knocking the supercharger clear off of the engine!

ENTER THE TURBOCHARGER

Seeking to eliminate mechanical drag while retaining the attractive rewards of forced induction, engine designers devised the turbocharger -- an air compressor driven by combustion byproducts (exhaust) exiting the engine. Even better, with no mechanical link between the charger and the crankshaft, backfires would not destroy the unit!

Following the diagram below should provide readers with good understanding of basic turbocharger operation:

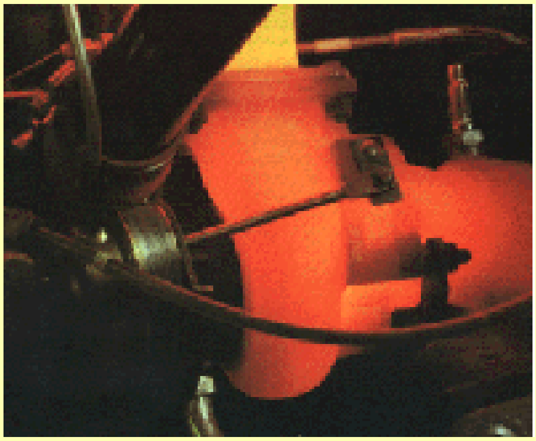


The flow of exhaust gas turns the exhaust turbine (1), driving the connected compressor turbine (2) which draws in filtered ambient air, compresses it, and forces it into combustion chambers via the intake manifold. At low-load the engine does not create the exhaust gas velocity necessary to drive the exhaust turbine. At high-load, however, accelerating exhaust gas velocities propel the turbines to 120,000 rpm to create full boost.

HEAT BUILD-UP & COOLING

Compressing ambient air* to a modest 1.5 bar/7 psig, will result in an intake charge of at least 93°C/200°F. This reduces its relative density, which decreases potential power output. To combat heat build-up most Volvo turbos use a special radiator called an "air-to-air intercooler" to cool the charge to a more reasonable 33°C/92°F, helping to maintain air density for improved performance**.

Although an air-to-air intercooler reduces the engine intake temperature, its location downstream of the turbocharger does nothing to reduce compressor temperatures. Exhaust heat also presents a problem. At peak loads, exhaust gas temperature may reach 900°C/1600°F. Combined, exhaust and compressor heat (an example of which is shown in the following photo of a Volvo turbo at operating temperature) undermine the effective lubrication of the turbocharger bearings.



Later 700s and all 800/900s models use turbochargers fitted with water-cooled center bearings, with engine coolant circulating through a specially machined water jacket in the turbine housing. Such turbochargers normally last longer and may be retro-fitted to earlier 200 and 700-series cars. For more information on the life expectancy of Volvo turbochargers, click here.

Whether your car's turbo is water cooled or not, turbo operation places higher thermal loads on the engine. This must be offset by an efficient cooling system, proper coolant levels, and the correct coolant/water mixture.

LUBRICATION

Even if your Volvo's cooling system is in peak condition, turbo protection ultimately falls to the lubrication provided by your engine oil. On start-up the engine oil must have flow characteristics to immediately supply the turbocharger whereas at high temperatures, it must have the film strength and temperature resistance to operate in a truly hostile environment. Only the best quality conventional and most synthetics meet the these requirements. Those (generally cheaper oils) that don't, shear back in viscosity or boil and create sludge. In either case, undermining the life of your Volvo's turbocharger.

Even with the best quality oils, however, the turbocharger's high rotational speeds and bearing temperatures eventually take a toll on the additive packages commonly used to give an oil its flow and protection characteristics. For this reason, turbocharged Volvos require more frequent oil & filter changes.

DRIVING HABITS

Temperature and lubrication requirements suggest that boost should not be demanded until the car has reached full operating temperature (ie. the coolant and oil temperatures are in their normal operating ranges). After demanding driving, the turbocharger must be allowed to spin down before the car is shut off and oil circulation stops. This may take up to 10 minutes of idling to accomplish, but it will extend the life of your turbocharger!

Keeping an eye on the boost gauge will help identify potentially-dangerous over-boost conditions, maintain acceptable fuel economy, and verify proper turbo response. Over-boost will raise cylinder pressures and temperatures beyond acceptable thresholds, damaging valves, pistons and/or the cylinder head. Staying within acceptable boost levels for prolonged periods, however, dramatically reduces fuel economy. When using a turbocharger correctly (ie. for extra power when maximum acceleration is needed) the boost needle should rise immediately prior to each gear change, dropping off slightly between shifts, or remaining in the "low boost" range when at cruising speed.

POWER & LONGEVITY - A PLEASING POST-SCRIPT

If parasitic drag and charge air heating is minimized, turbocharged engines can produce amazing power. Formula 1 racing teams have derived as much as 373 kW/500bhp per litre of engine displacement, whereas Volvo has managed a more ""streetable"" 78kW/104bhp per litre in its most potent turbocharged road car, the 850 T-5R. Available power adds to driving pleasure and, yes, even safety as a powerful car can use acceleration to its advantage to avoid a collision.

Nevertheless, all of this performance comes at a cost and you will pay one way or another. Balancing the lower incremental cost of frequent oil and coolant checks/changes and (cost-free) driving discipline against that of a $1500 turbocharger makes it easy to choose preventative maintenance over periodic replacement.

Other Articles in this site related to turbochargers:

Troubleshooting 200-, 700-, and 900-series Turbos

Turbo Owner's Survey

Power to Weight Ratios - Tuning a Volvo into a Porsche

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EXTRA READING

There are many books which discuss turbocharging. Information specific to Volvo turbochargers (and related oil, spark, coolant issues) may be found in "The Gothenburg Bible" and "The Volvo Performance Handbook".

Results from a recent Volvo Turbo survey may be found here.

AIR TEMPERATURE-DENSITY CALCULATIONS:

* Assuming sea level @ 20°C/68°F with compressor efficiency of 70%, the theoretical intake charge would be /189.16°F. With some limited heat conduction from the exhaust turbine (exhaust gas temperatures of 800°C/1495°F), the minimum intake temperature would be as shown.

** Assuming intercooler efficiency of 70% and an ambient air temperature of 20°C/68°F.

Special Article -

Technical Review: Volvo's New S/V 40 Line

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by Paul Grimshaw,
Author, The Volvo Performance Handbook

Volvo's newest car line brings several technical highlights, notably a new line of engines and an advanced unit-body. Although it is understood that both sedan (S) and hatchback (V-for versatile) versions will undergo Volvo's continuing product development, the new cars require some additional suspension tuning before dominating their class.

The S/V 40 line was introduced in Sweden on 1 June 1996 and should reached other European markets by August of that same year. The S/V 40 remains unavailable to North American customers.

The features can be broken down into four basic elements -- the chassis, suspension, power train and braking systems.

Chassis

Like the structure of most cars, Volvo's latest offering features a unitized body -- a construction method in which the body and floorpan of the car form a single stressed structure. Although not apparent from curb-level, the basic package is the result of a Swedish-Japanese-Dutch joint venture and shares the same track and wheel base with the Mitsubishi Carisma. Nevertheless, the S/V 40's chassis reflects a number of Volvo's core values.

The structure is reported to be incredibly stiff, with no squeaks or rattles noted in pre-production press cars. Occupant protection is reportedly very good with Volvo's Side Impact Protection System (SIPS) and safety-cage construction clearly incorporated into the design. Apart from protecting driver and passengers, the durable chassis of the S/V 40 helps reduce noise, vibration and harshness (NVH in industry-speak).

All in all, the press are praising the S/V 40 for its refined chassis and acknowledge that Volvo has the edge in this category when compared with similarly-priced offerings from Audi, BMW and SAAB.

Suspension

The basic suspension layout of the S/V 40 consists of coil springs over MacPherson Struts, located by lower A-arms up front and a multi-link, coil-over tube shock, twist beam rear axle. Front and rear anti-roll bars are fitted to all models. The Euro standard 6 x 15 inch alloy wheels are dressed in either 195/55 or 205/50 Pirelli P6000 rubber, the latter a feature of the an option trim package known as "Sport".

The suspension layout of Volvo's new car is calibrated more for comfortable touring than cat-like agility. Although the S/V 40 is said to handle potholes, broken tarmac and tar strips with ease, it suffers from Volvo's traditional body-roll and lamentable understeer. Handling of "Sport" models is said to be somewhat (but not considerably) better, grace á wider rubber, stiffer springs and firmer dampers.

To summarize, the S/V 40's suspension appears to be cast in Volvo's familiar mold of a regular family car. Predictable and dependable, but not quite up to the same tossable standard as that presented by Audi (A4) or BMW (3-series).

Powertrain

Motivation for the new cars hails from the same basic design as that which powers the European Renault Laguna. For Volvo, however, these all-alloy, four cylinder engines are referred to as the B4184F and B4204F, displacing 1.8 and 2.0 litres respectively, topped with 4-valve per cylinder heads and fuel injected.

Like most multi-valve engines, the B4184 and B4204 respond well to high engine speeds and produce 115 bhp at 5500 rpm and 137 bhp at 6100 rpm respectively. Torque peaks of 122 and 135 lb ft can be found in the 4000 rpm range. Such engine outputs are average for the class in which the S/V 40 is expected to compete.

Technophiles may be interested to learn that the 1.8 and 2.0 litre engines share the same 83mm bore as the 850's engine. This means that the smaller engine has been de-stroked, allowing it to rev smoother and presumably higher than it's two litre brother. It also suggests that Volvo's entire normally-aspirated, gasoline-powered family share similar, if not identical, pistons and valves -- in theory making these parts less expensive for the company to develop and manufacture.

Both 4 cylinder engines can be mated to a Renault-designed 5-speed manual transmission driving the front wheels. The S/V 40 is also available with an Aisin-Warner 4-speed autobox with lock-up torque converter. The engine/manual transmission package delivers 0-100 km/h (0-62 mph) sprint times of 10.5 seconds for the 1.8 litre and 9 seconds flat for the larger 2.0 litre engines. However, expect plenty of clutch slip and revs to match these results.

Automatic transmission-equipped cars are able to post acceleration figures within .5 seconds of these times.

The new models' limited frontal area and drag coefficient (0.31 for the S 40 and 0.32 for the V 40), combined with the power potential of the fitted engines, allows Volvo's new line to reach speeds slightly in excess of 200 km/h (120 mph).

Brakes

Volvos tradition of fitting powerful 4-wheel disk brakes to their models remains unchanged. S/V 40 features 256mm (10.25 inch) diameter disks all 'round with the front pair being ventilated for improved cooling. Anti-lock control is fitted at no extra cost.

The combination of large disk brakes, anti-lock circuitry and the tire/wheel combo should be able to haul the S/V 40 down from 100 km/h (60 mph) in under 45 m (150 ft) -- comparable to that of the 850 GLT and similar to distances posted by entry-level Audi, BMW, and SAAB products.

Summary of Engineering Features & Prospects for Future Development

Volvo's S/V 40 benefits from a superb chassis but requires additional suspension tuning and slightly more power to firmly post a win.

"The Company" is buzzing with rumors that a 175 bhp variant of the 2.0 litre power plant is being considered for a future upgrade. Although this would place specific engine output below the 96 bhp/litre figure attained by the entry-level 850 Turbo's B5234FT engine, it is a sound engineering goal.

Under-square engines (like the 1.8 and 2.0 litre designs) place proportionately greater load on main bearings and are prone to piston scuff due to the angles at which the connecting rods and crankshaft operate. These higher loads could be exacerbated by turbocharging and lead to greater wear and reduced engine life.

If Volvo was to pursue a turbocharging program for its 2.0 litre engine, it would likely be a "low-pressure" turbo operating in the region of .5 bar (7 lbs) boost. Using .5 bar as a guideline, a turbocharged, intercooled 2.0 litre design sharing comparable valve timing and induction routing as 850's B5234FT would be good for around 177 bhp -- very similar to the "rumor mill" and in-line with Volvo's commitment to engine longevity.

Fully developed, the S/V 40 line promises to be a real contender. Great power, a superb chassis and (hopefully) a lower price.

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Postscript: Since this article was written in 1996, Volvo has produced the S/V 40 in turbocharged form.

The force-fed engine produces 200 Bhp; quite an achievement for a 2 litre engine!

The Volvo Performance Handbook & The Gothenburg Bible

Special Article -

Volvo Electrical Systems:
Theory, Troubleshooting & Maintenance

by Paul Grimshaw

INTRODUCTION

Although most do-it-yourself mechanics feel comfortable with pliers, wrenches and ratchet, many quickly pale at the sight of test probes, ohm meters and On-Board Diagnostic (OBD) systems for this can only mean one thing -- electrical problem solving! Scarier still, many professional Volvo mechanics over the age of 30 have the same fear, inhibiting them from delving into electrical systems. The resulting ignorance usually leads to repair by replacement, a condition where knowledge is thin, troubleshooting non-existent, repairing by replacement is common and preparing high invoices is, well, almost certain.

Fortunately, Volvo electrical systems are fairly simple in concept and execution making them cooperative hosts for the shade-tree mechanic.

PART ONE: BASIC ELECTRICAL THEORY

All automotive electrical systems work on the common principle of charged particles (electrons) flowing throughout a closed path. These charged particles are measured according to their potential difference (voltage) and the volume, (or current) at which they flow (ampere). A unit of measure which combines the two (wattage, which equals volts x amperes) may also be used to define an electrical charge.

Electrons flow from an area of high potential (positive) to an area of low potential (negative). As previously mentioned they follow a closed path, or circuit, and drive electrical components by virtue of their voltage and amperage. Replenishment of the energy which was lost in creating work can be provided by an electrical generator.

The whole thing works somewhat like the water cycle. Water flowing down a hillside has energy capable of producing work. At a certain point, however, the water eventually reaches an ocean, loses its velocity and flow, and (in practical terms) no longer has usable energy. The sun subsequently promotes evaporation (through the input of energy) and the moist, warm air rises until it condenses in the lower atmosphere and falls in the form of rain. The rain then feeds the river, which flows downhill, providing the energy to drive a water wheel and the cycle re-commences.

The important thing to remember in this analogy is that the cycle will cease to function if the path is interrupted along any point.

Components & Systems

In its most simple terms, a typical automotive electrical system is composed of a energy storage device (battery), a means to replenish electrical energy (generator or alternator), and a conduit through which electrical energy may flow (wiring).

Automotive systems use conductive wires to supply electrical energy. However, since electrical energy must follow a closed loop, provision is made for the area of lowest electrical potential to act as a conduit as well. This part of any electrical circuit is called the "ground" and uses the car's metallic body structure to permit electron flow back to the battery.

Although most automobiles use many pathways to distribute electrical energy, there are three primary circuits which are common to almost all cars:

(1) The charging system is composed of the battery, alternator (or generator for older Volvos) and voltage regulator.

(2) The primary electrical system, fed by the battery, represents the bulk of a car's electrical components and includes most of the wiring, main computer (if fitted), electrical fuel pump(s), starter, lights, radio, door locks, etc.

(3) The secondary electrical system uses battery energy to convert high-current, low voltage (aka low tension) energy into high-voltage, low current (aka high tension) impulses which are used to fire spark plugs, igniting the air/fuel mixture within each cylinder to initiate the Otto Cycle, allowing the engine to "run".

Charging & Primary Electrical System

The Battery

The battery acts as the hub of a car's entire electrical system, storing energy produced by the alternator or generator and supplying it to those systems requiring smooth, uninterrupted, and continuous current (lights, fuel injection system, main computer). There are several types of batteries used in modern automobiles, each varying in performance and price.

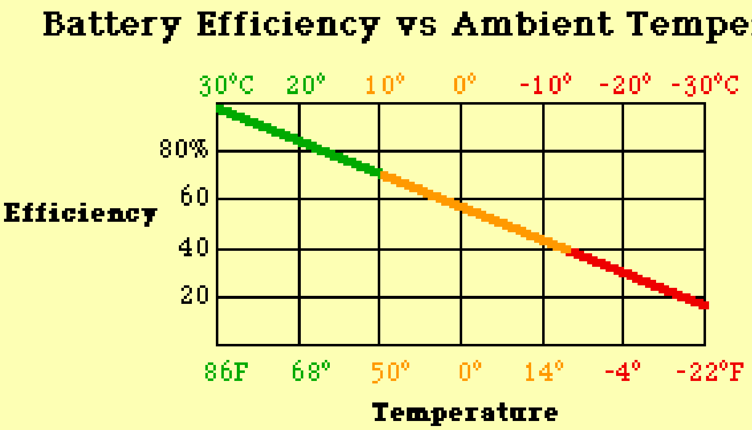
Batteries come in three varieties - conventional batteries (using a conventional lead-sulphuric acid matrix), low-maintenance batteries (using low-antimony content lead and sulfuric acid), and maintenance-free batteries (using lead-calcium matrices and an electrolytes of low vapor pressure).

Conventional batteries may be easily recognized by the presence of vent caps through which hydrogen and water vapor are expelled during the charging process. These vent caps must be removed periodically to add distilled water to the electrolyte.

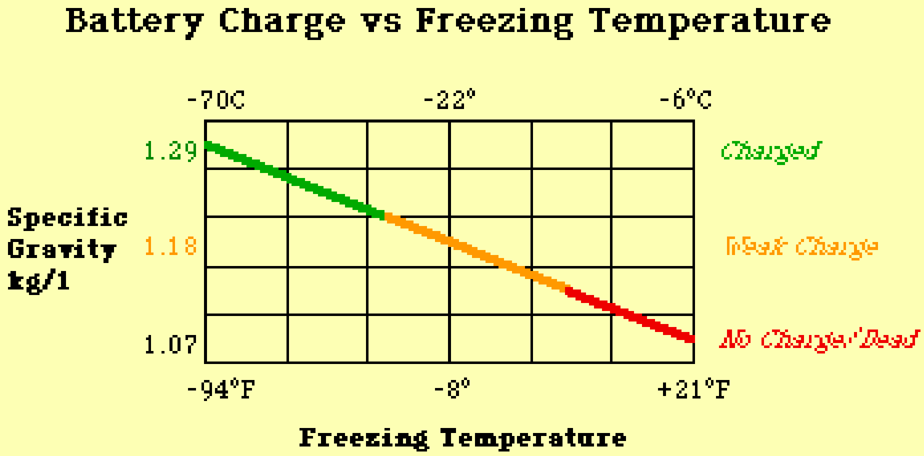
Low-maintenance and maintenance-free batteries have, at the most, four small vent holes. The alloys and electrolytes used, however, last for the designed life of the battery and should never require the addition of distilled water.

The aforementioned batteries can come in normal and heavy duty variants. Heavy Duty (HD) batteries are specially constructed to resist vibration and exaggerated discharge cycles which would ruin a less ruggedly constructed unit. Fiberglass matting and pockets prevent battery plate erosion, while the cast resin cases common to HD batteries resists knocks and bumps.

No matter what type of battery is fitted to your Volvo, ambient temperature will continue to be a factor in battery performance. Cold temperatures drastically reduce the conversion of chemical to electrical energy within a battery:



Although not directly related to the previous efficiency diagram, batteries which are at a lower state of charge are more prone to freezing. In the following diagram, electrolyte density (a very accurate measurement of the state of charge) determines the temperature at which a battery will freeze, thereby losing its ability to supply electrical energy:



Generators and Alternators

Generators and alternators are components of the charging system which turn mechanical movement into electrical energy. They do this by driving a series of wound iron and wires through a permanent magnetic field via an engine driven belt. As most students of science know, the conversion of one type of energy (mechanical) into another (electrical) is fairly inefficient using even the most modern systems. For this reason, less than one third of the mechanical energy used to rotate the generator is realized in electrical output. Alternators are somewhat more efficient, but seldom realize electrical outputs of more than 50 percent of the mechanical energy required to drive them.

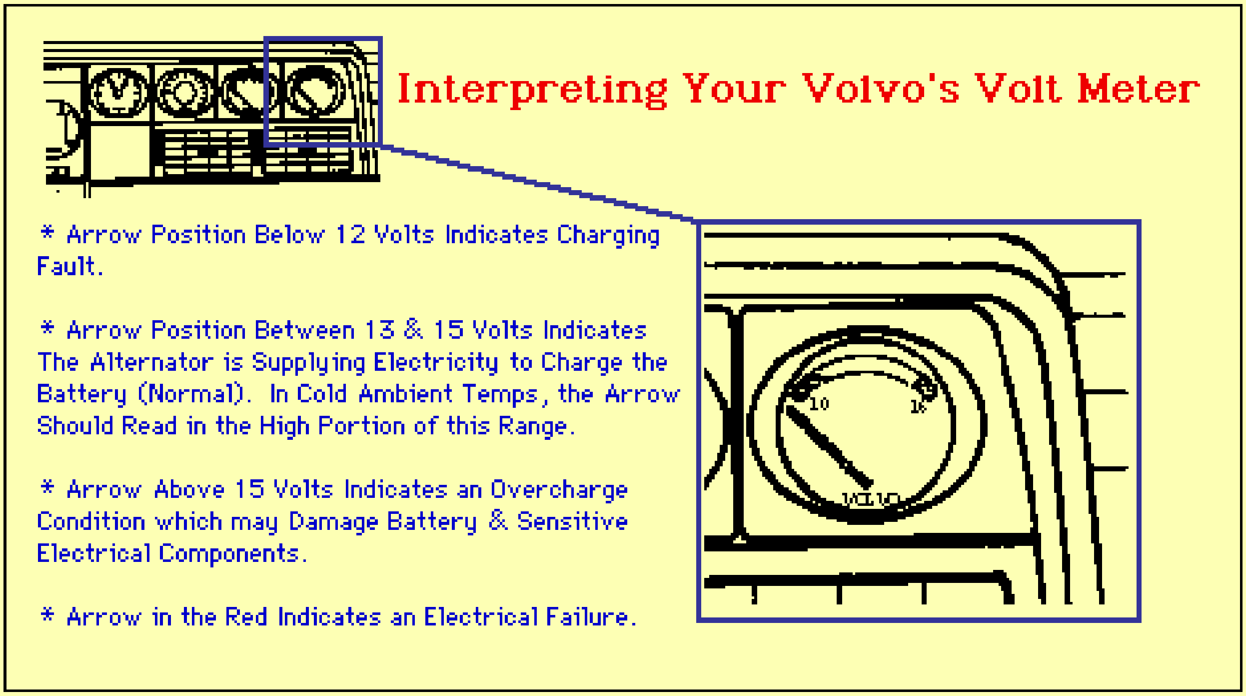
Although the operating principles of these two types of charging systems are somewhat similar, the design and execution are quite different. This gives an insight as to why alternators are more efficient than generators.

Generators produce direct-current electricity and in doing so, produces considerable heat. In addition, the mechanical energy required to drive a generator tends to be fairly high, so they only tend to start producing usable quantities of electrical energy at relatively high rotational speeds. The combination of high rotational speeds and heat undermine a generator's efficiency and service life. For these reasons generators have fallen out of favour with automobile manufacturers.

Alternators, on the other hand, produce alternating current - a far more easily controlled form of electrical energy. The mechanical energy required to drive an alternator is considerably less. This means that they can contribute to battery charging at minimal engine speed. Unit cooling is provided by a radial fan which allows ambient air to flow around the stator and rotor. The alternating energy is converted to direct current via integral diodes and rectifiers fitted to the rear of the unit. Accordingly, alternators have superceded generators and have been exclusively fitted to Volvos since the 1967 model year.

Both generators and alternators use devices called voltage regulators to limit current flow beyond what is necessary for charging the battery and energizing electrical accessories. Voltage regulators of older Volvos have the appearance of canisters and are commonly fitted to the engine compartment firewall. In contemporary models, however, voltage regulators are considerably smaller sub-assemblies of the alternator which contain, among other things, the alternator contact brushes.

Regardless of whether your Volvo is fitted with a generator or alternator, an instrument cluster volt meter is a useful tool in monitoring the charging system:



Of course, those vehicles lacking a volt meter are fitted with a warning light which illuminates when a fault in the charging system is noted.

Wiring

Automotive wiring forms the grid through which energy is supplied to various electrical components. To prevent electrical energy loss, wiring is often insulated by rubber (older cars) and vinyl (newer cars) compounds. To ease troubleshooting wiring is color coded by circuit and, in high quality vehicles, no two color combinations are used for the same piece of wiring. This makes tracing a circuit through large bundles, firewalls and frame structures relatively easy.

Even though considerable care is taken to adequately insulate each wire in a car's electrical system, repeated bending action (such as that found at hinges), high heat (near components such as turbochargers) and the presence of petroleum products (under-hood/underbody) can significantly weaken insulating materials. To prevent premature wear, however, automobile manufacturers use rubber and plastic sleeves to protect insulated wiring in high-risk areas.

Characteristics of Common Automotive Electrical Insulating Materials

Material	Max Service Temp	Resistance to: Gasoline	Diesel	Oil
Polyvinyl Chloride (PVC)	70C/158F	Nil	Poor	Good
Butyl Rubber	90C/194F	Nil	Nil	Nil
Chloroprene Rubber	80C/176F	Fair	Fair	Fair
Natural Rubber	70C/158F	Nil	Nil	Nil
Silicone Rubber	170C/338F	Nil	Poor	Fair

Connectors & Grounding Points

Various mechanical connectors are used to join wires either together or to components. Mechanical connectors, such as DIN and SAE fasteners, are prone to corrosion as the lugs within them are most often made of oxydable metals. Exceptions may be found in vital safety systems such as Air Bags and Side Impact Bags where the connector terminals are gold plated to resist corrosion.

Not to be forgotten is the role in which the ground plays in automotive electrical distribution. Generally speaking, positive wires are insulated and fused. The same cannot be said for grounds. Grounding devices are often made from conventional copper wire or stainless steel braided wire straps and are connected to electrical components or bodywork with mechanical fasteners such as sheet metal screws or bolts. Over time, sheet metal can deteriorate in the vicinity of mechanical fasteners. This can lead to an interruption of the ground, opening the circuit and preventing current flow.

Fuses

Fuses are small strips of conductive material which are designed to burn through in the event of abnormally high current flow, again opening the circuit to prevent flow. They are most commonly incorporated in the positive side of an automotive circuit and are often found centrally-located in a main "fuse box". There are three basic types of fuzes fitted to Volvos: "bullet-type" fuses fitted to 200-series and older models, "spade-type" fuses fitted to 700-series and later models, and "fusable links" which are sometimes used to protect larger circuits from massive overload.

Bullet fuses, particularly those located in fuse boxes in high humidity areas (as with the 200-series' driver's side footwell location), are more prone to corrosion than the newer spade variety. Each of these types of fuses normally protect circuits drawing current between 0-30 amperes.

Fusable links are extremely rugged and are normally used to protect very high current circuits.

Secondary Electrical System -

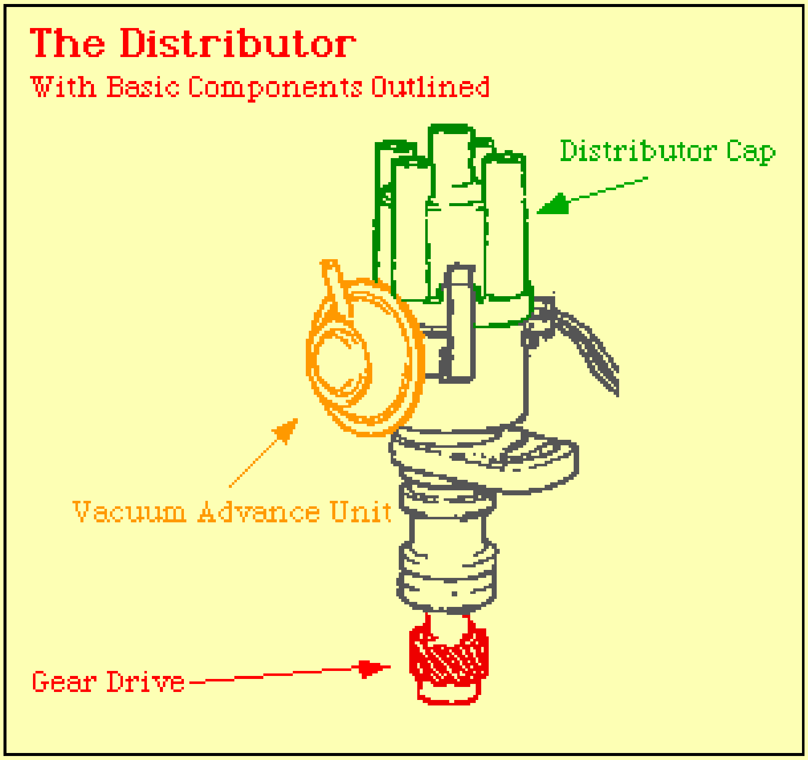
The Coil(s)

A coil is essentially a large capacitor which converts battery-supplied high current/low voltage charges into high voltage/low current impulses. To do this a coil works using the principles of electro-magnetic induction to create a magnetic field, then collapse it through a winding to create electricity. Because this type of conversion produces considerable heat, coils are often filled with a thermally-conductive resin or oil for cooling.

Conventional ignition systems normally use a single coil whereas direct-ignition cars such as the 850 and 960 use multiple coils to individually fire each spark plug or a pair of plugs.

Distributor & Condensor

A distributor is a mechanical device which is used to transmit a high tension electrical impulse to a given spark plug at a given time for a given duration. To do this, distributors are geared to the crankshaft and adjusted by either computer control or (in the case of earlier Volvos) by intake manifold vacuum and/or by inertially-driven counter weights.



Older Volvos, lacking solid state ignition systems, use a condensor to prevent the high tension charge from returning to, and grounding out, the coil. The condensor fitted to these older cars is really just a large capacity capacity capacitor.

High Tension Leads

High tension leads consist of stranded metallic wire or graphite core conductors wrapped in an insulated sheath. The purpose of the leads is to conduct the electrical impulse from the coil to the spark plugs via the distributor. Because of the extremely high voltages required to create an arc-over for each spark plug, the leads must have sufficient conductivity to carry a charge without any leakage.

Resistance across each lead varies slightly with length, but the Volvo standard for each wire is around 500 ohms per foot. This resistance allows adequate electrical transmission while limiting the amount of Radio Frequency (RF) interference.

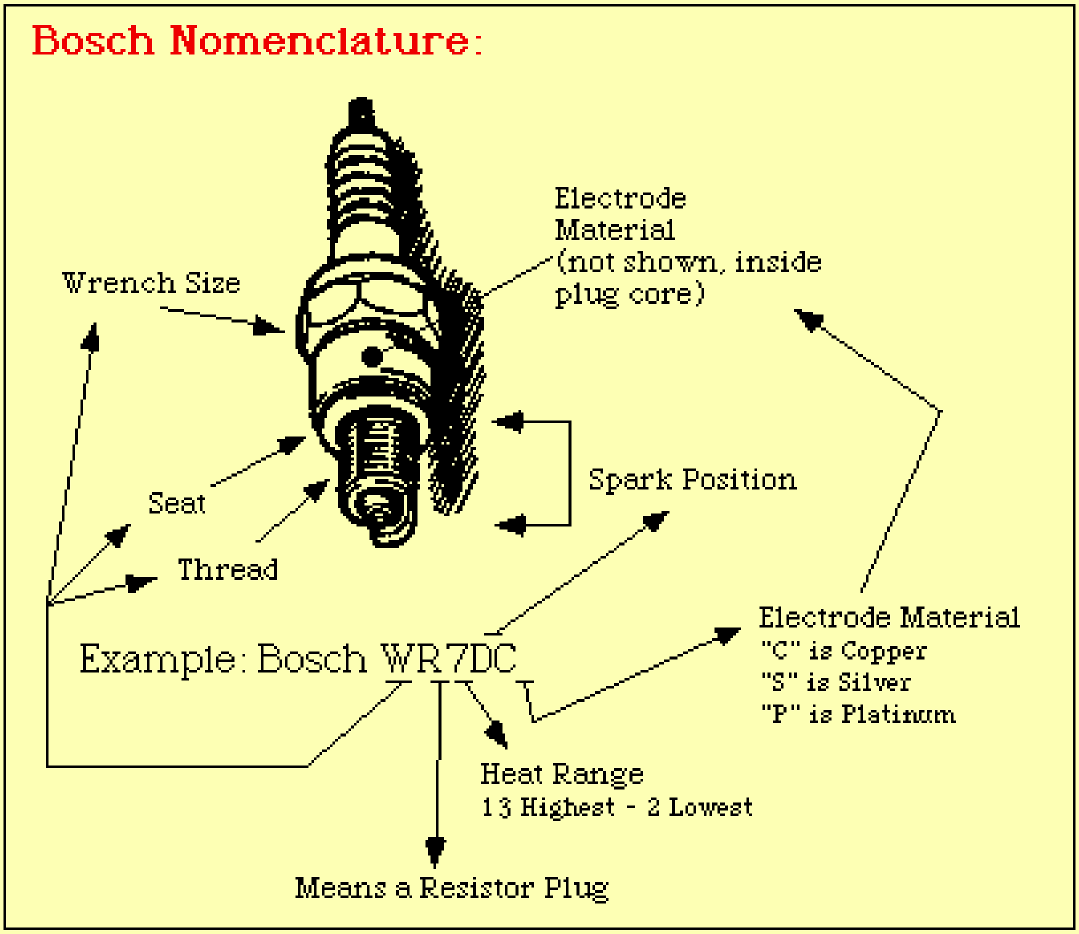
Each end of the high tension leads feature a brass fitting, either designed for connectivity with the distributor cap or spark plug terminal. Needless to say, it is imperative that any connection of this manner is clean and tight to prevent voltage loss.

Spark Plugs

Spark plugs are essentially a pair of metal contacts, protected and insulated by an aluminum oxide or porcelain shroud, designed to present an air gap to the flow of high tension electrical energy. To overcome the air gap, this high tension flow must "jump" or arc across the gap. This creates sufficient heat to initiate the combustion process with a combustion chamber. A threaded nickel base allows the plug to be securely fastened to the cylinder head, while a tapered seat or integral gas sealing rings prevent compression loss from within the combustion chamber.

Spark plugs are designed to very high tolerances because they must perform in some rigorous conditions. For instance, it is not uncommon for a spark plug to be exposed to heat in the order of 3000C/5400F the brief moment immediately following the ignition of the air/fuel mixture. Also, localized pressures within a cylinder during this combustion can reach as much as 40 bar/588 psia. These temperatures can, over time, lead to plug degradation. Electrodes wear and become slightly rounded, thereby increasing the effective gap. This larger gap must then be overcome by the high tension charge which, if of insufficient voltage, will fail to cause the arc necessary for ignition.

Spark plugs come in a number of sizes and heat ranges, each designed to compliment an engine's operating parameters. Each plug type an range is characterized by a series of numbers and letters denoting the design of the plug, its heat range, whether or not it is designed to reduce Radio Frequency (RF) interference and the materials which make up its design. Since most Volvo cars were fitted from the factory with Bosch plugs, I will outline the philosophy of the German electronics company's nomenclature system:



As shown on the chart, a number of conductive materials may be used in spark plugs. Copper is the best electrical conductor used in spark plugs, followed by Silver and Platinum. While this suggests that the quality of the plugs follows in this order, the melting points of the metals are Platinum at 1773C/3223F, Copper at 1083C/1981F, and Silver at 960C/1760F. These differences allow a Platinum electrode to be designed thinner, with a smaller surface area than that of the other materials. This small surface area allows for much lower arc-over voltages thereby reducing the incidence of misfire. Furthermore, the electrodes can then operate at a higher temperature, burning off carbon or hydrocarbon contamination common in vintage cars which tend to run with a slightly rich fuel mixture. So the bottom line is that a platinum plug usually performs much better than its copper or silver counterpart.

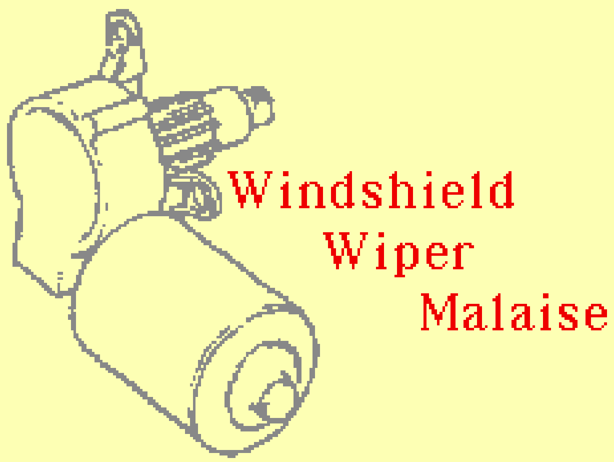
As one may expect, Volvo uses this and other companies' nomenclature to specify which plugs are recommended for their engines. You will note that many recommended plugs are of the copper variety. Volvo specifies copper-type plugs because of their low cost and easy availability!

Bosch Spark Plug Applications for Volvo Engines

Engine	Plug Designation	Comments
B16 A/B	W7E	
B18D	W7BC	
B18B, B20E & B30E	W5BC	
B30A	W6BC	Hotter Plug for reduced fouling
B21, B23, B230	WR7DC	Resistor Plug for Reduced RF Interference
B27, B28, B280	HR6DC	Conical, vice Flat Seat for these series of Engines
B5254, B6304	FR7DC	Flat Seat, different thread

PART TWO : TROUBLESHOOTING COMMON PROBLEMS

Instead of trying to repeat what is adequately covered in Chilton, Haynes, or Bentley repair manuals, I'll concentrate on those arcane tidbits which have been overlooked in those otherwise complete publications. The examples given may not prove to be the cause of your car's particular problem, but have been observed as problems particular to Volvos, especially high-mileage or older models.

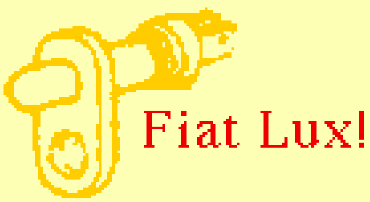


Symptom: Wipers fail to operate, but an ohm meter check on the wiring indicates that power is going to the wiper motor and switch. You cringe at the thought of a new wiper motor, but what are your alternatives?

Common Cause: Most Volvo wiper motors are made by Electrolux or SWF, companies which are well known for their quality electrical components. Nevertheless, the harsh environment in which these components work can often weaken the adhesives which bond the motor's magnets. When the magnets break free of the stator housing, they clamp onto the rotor, causing it to freeze.

Repair: Most shop manuals (such as those previously listed) provide easy to follow instructions on how to disassemble the wiper motor with little more than a slot screwdriver or an adjustable wrench. Once the motor is apart, remove the loose magnets, clean the metal motor housing with denatured alcohol and let dry. Using automotive epoxy, re-glue the magnet(s) back in place (tip: use the ridge of old glue as a guide in correctly placing the magnets).

Preventative Maintenance: If you have disassembled the wiper motor completely, the gear housing should be exposed. Liberally apply synthetic or lithium-based grease to the gear mechanism. This will reduce friction and prolong the life of motor brushes and windings. After re-assembling the wiper motor, gently clean the connector contacts with metal polish. Smear some dielectric silicone on the connections to prevent corrosion from forming at the connections.

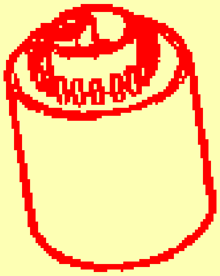


Symptom: Your Volvo's dome light does not work. You've replaced the bulb, set the selector correctly but still no light. The problem does not seem to justify going to the garage, but it is very inconvenient to fumble around in the dark!

Common Cause: The pin switches located in the door jams complete the electrical ground to illuminate the lights. Despite the little rubber booties which adorn each pin switch, damp environments can cause the connections of the pin switches to corrode slightly. This corrosion prevents the completion of the circuit.

Repair: Again, a simple repair with a screwdriver and some easily-obtained materials! Remove each pin switch and, using metal polish, clean each contact until they are bright and shiny.

Preventative Maintenance: Coat the contacts with dielectric silicone and put a single drop of light oil into each pin switch to help prevent internal corrosion. Work the pin switch. Continue to add a drop or two of oil if dirt flows from the switch. Reassemble as per your shop manual.



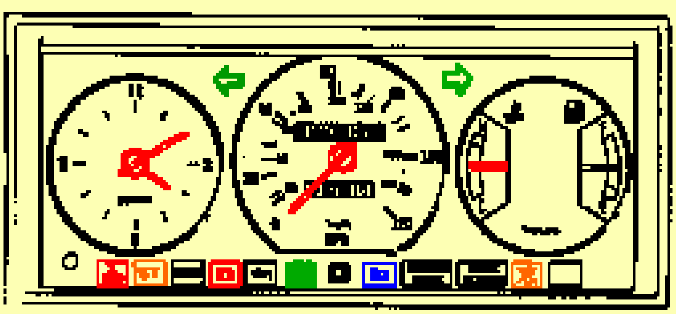
Seeing Red

Symptom: You have recently replaced a burned-out stoplight. Even though the bulb illuminates, the warning light on your dash continues to harass you every time you apply the brakes. You curse Swedish electrics and contemplate resurrecting your Lucas-equipped Triumph Stag!

Common Cause: Contemporary Volvos can (depending on the market) be fitted with a brake light warning sensor which reminds a driver of bulb failure. This sensor measures and compares the current from the left and right brake light circuits to determine if a fault exists. If one bulb draws slightly more current than the other, it can be misinterpreted as a bulb failure!

Repair: Differences in current required by bulbs is common, especially when using lamps from different manufacturers. Go back to where you originally purchased the replacement bulb and buy another. Replace the remaining older (but still functioning) bulb. The warning light should now be extinguished.

Preventative Maintenance: Clean the contacts of the bulb and holder annually. This will not prolong the life of your stoplights, but will help prevent corrosion from interfering in the current drawn by each bulb.



Electrical Gremlins

Symptoms: A broad range of electrical problems plague your 240. Starting problems, intermittent overdrive (OD) failure, warning lights, dysfunctional accessories...... you've had 'em all. There's nothing which points to one single fault, but you're afraid to go anywhere near a garage with stories of poltergeists.

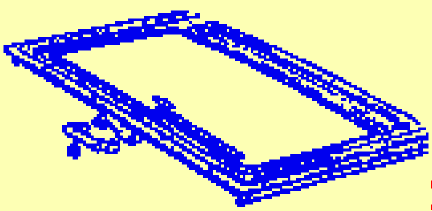
Common Cause: Most 200-series cars (and some earlier models) locate the fuse panel near the foot well, an area known for its dampness! Relatively little corrosion is needed to interfere in the current which must pass through the fuse panel. In extreme cases, the fuses themselves can corrode and develop small cracks -- this renders them nearly useless and has been known to strand many an owner.

700-series (and later models) have relocated the fuse panel but still rely on a grounding point behind a kick panel in the left foot well to supply electrical energy to heater fans, relays, turn signals, fuel pumps, control units etc. Corrosion can occur here too!

Repair: Remove the fuses and use metal polish to clean the fuse holders. A Dremel high-speed rotary tool will help since plenty of rubbing is usually required to get the brass holders shiny! Throw the old fuses out, replacing them with either new ceramic replacements or stainless-steel-capped, glass fuses.

If your 700-series car has a corroded grounding point, obtain a new grounding plate (available through your dealer). Before installing the new part, prep the mounting point by removing any surface rust.

Preventative Maintenance: Keep the foot well as dry as possible, emptying snow or slush as it accumulates. Coat the fuse or ground contacts with dielectric silicone to help prevent future corrosion.



Sunroof Blues

Symptom: Your 700-series electric sunroof has "gone south" and it isn't the first time. Burned out motors and solenoids are becoming commonplace.

Common Cause: Binding or sticking Volvo sunroof switches have been known to cause their share of solenoid and motor failures. Unfortunately, some repair facilities may replace the burned-out parts without questioning why they failed in the first place.

Repair: Replacing the switch has been known to rectify an "inoperable" sunroof motor although in most cases, damage to the motor or solenoid has already occurred. Whenever replacing a sunroof motor, make sure the switch is replaced at the same time. It's cheap insurance!

Preventative Maintenance: Annually inspect the sunroof switch, replacing it if it feels sticky. Shade-tree mechanics can easily dismantle and clean the switches with a penetrating oil (such as WD-40). Whether it's regular replacement or cleaning, it often avoids paying $400.00 in parts and labor.

This tip also applies to electric window switches!

Many drivers have become accustomed to the term "Maintenance Free Battery". Despite the improved lead-acid and lead-gel battery designs which dominate the market, critically-important power/grounding cables are often overlooked, leading to difficult starting, marginal charging, occasional brown-outs, and even blown main computers!

Common Cause: As a conductor, lead (even when alloyed with antimony or tin) is not all it's cracked up to be. In fact , from a conductivity standpoint, silver, gold, copper, and aluminum are far better, albeit more costly. Lead "films" in the presence of air, creating a barrier through which electrons must flow.

Despite these shortfalls, lead (and its alloys) is used for the battery posts, battery cable clamps and in some grounding harnesses. In some 700-series cars, corrosion at the grounding strap can cause arcing to occur within the Electronic Control Unit (ECU). This quickly kills a very expensive component.

Repair: Annually inspect the grounding and power cables leading from/to the battery, replacing them if the insulation, stranded wire or lugs are damaged.

Preventative Maintenance: Super keen "shade-tree" mechanics have been known to make their own improved cables using jacketed high-conductivity stranded copper wire & lugs, soldered together with silver solder (silver conducts much better!). Whether it's stock or modified, the cables much be attached to clean surfaces at the battery (clean the posts), grounding points (scrape any rust), and electrical junctions (polish the copper connections).

A LAST BIT OF FRIENDLY ADVICE

According to Robert Bosch GMbH (one of many OEM electrical parts suppliers), 90% of "component failures" are actually caused by faulty wiring leading to or from the suspect device. In some cases, simply unplugging, cleaning and re-connecting a wiring harness or connector will rectify an electrical fault. This has been known to cure faulty Mass Airflow Sensors (MAFs), Idle Control Valves (IACs) and even main computers. Although Volvo suggests that mechanics clean connectors before contemplating repair, the company acknowledges that the proper use of dielectric silicone helps prevent electrical system degradation.

CONCLUSION

Despite many myths that suggest only M.I.T. grads can work on today's electrical systems, troubleshooting the most common problems requires little more than a grasp of the basics, a few simple tools, "insiders" tips, and a relatively inexpensive repair manual. Readers are strongly urged to purchase a Chilton, Haynes, Bentley, or Volvo shop manual before undertaking any of the procedures briefly outlined in this article. These publications take considerable care in listing the precautions and safety equipment which must be used before any electrical system work. Working safely is just as important as driving safely.

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Special Article -

Direct Gasoline Injection:
Adopting Mitsubishi Technology in Volvo Automobiles

by Paul Grimshaw

Background

Volvo's decision to use the Mitsubishi 1.8 litre Gasoline Direct Injection (GDI) engine is both a reflection of the strategic alliance with the Japanese automaker as it is an acknolwedgement of the technology of the latest "diamond-star" design. The current partnership grew from the ashes of the failed plan to merge Volvo-Renault in 1993. At that time, Volvo began to search for a new strategic partner through which engineering, production and certification costs could be shared. The result was a series of agreements between AB Volvo and Mitsubishi Heavy industries that has seen the joint operation of a facility in Holland called "NedCar".

Mitsubishi's 1.8 Litre Gasoline Direct Injection (GDI) engine is now used to power European-market Volvo S/V 40 automobiles

NedCar produces the Volvo S/V 40 and Mitsubishi Carisma (spelling intentional!) on the same assembly line -- a testament to the growing link between the two automakers.

The History of Stratified-Charge Technology

Mitsubishi's development of its Gasoline Direct Injection engine is an extention of long term Japanese research into fuel and induction systems that can create a precisely layered air/fuel mixture (or stratified charge). The Japanese interest in this technology can be traced back to the 1970s when Honda developed its CVCC engine for use in the Civic. The benefits of stratified charge engines include:

a. cleanliness of operation. Stratified charges tend to burn in a more progressive fashion. End gases are ignitable, with 10% improvements in vehicle emissions common. If the engine uses a higher compression ration, however, the higher NOx emissions will have to be reduced by a special catalytic converter;

b. resistance to pre-ignition, even with extremely lean (20:1) mixtures. Since a homogeneous mixture is impossible to achieve in spark-ignition gasoline engines, engineers select port, valve and piston crown designs that will reliably structure the air/fuel intake charge to prevent auto-ignition of end gases;

c. improved throttle response. A direct injection, stratified charge engine need not have a power-robbing thottle plate. Engine output is determined by fuel flow (not airflow as is the case in conventional spark-ignition engines) which can be delivered in a more progressive and efficient manner ; and

d. better fuel economy. A stratified charge engine's ability to safely tolerate lean mixtures can translate into a gain in fuel economy.

Step Two: Direct Injection

Improvements in stratified charge technology was required to move to the next step in fuel delivery -- direct fuel injection. While this technology had been in use for many years in diesel applications, the continued dependance on expensive (and somewhat imprecise) mechanical injection systems prevented its wide spread use in gasoline-powered passenger cars. One notable exception to this was the 1955 Mercedes Benz 300 SL which used a very effective, though extremely costly, mechanical gasoline injection system.

The development of electronically-controlled stratified charge GDI engines was an extremely costly undertaking, collectively costing the auto industry hundreds of millions of dollars. To date, Mazda and Mitsubishi have brought cost-efficient GDI engines to market. In doing so, these Japanese manufacturers now hold several patents on a technology that promises to deliver clean, powerful, responsive, and fuel efficient engines to market.

Outsourcing Engine Development

So why would Volvo choose to adopt the Mitsu engine in the S/V 40 instead of developing its own system? Cost, pure and simple. The Swedish automaker is too small to front the capital expenditure needed to develop a proprietary design which, at the end of the day, may continue to be dependent on the technologies patented by the current industry leaders.

The Result

The output of the GDI B4184SM (M - for Mitsubishi) is rated at 125 Bhp@5500 rpm/128lb-ft@3750 rpm versus the conventional injection engine's (B4144S) output of 115 Bhp@5500 rpm/122lb-ft@4100 rpm. The most dramatic result is, however, in fuel economy where the GDI engine uses 15-20% less fuel than its conventionally-injected counterpart.

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Special Article -

Chronology of Volvo Engine Development

by Paul Grimshaw

As a follow-on to the article on Volvo Engine Designations , I have put together a list of engines fitted to Volvo cars since 1935. Readers will note that the dates of introduction of the engines listed do not necessarily match the first model years of the cars in which they were fitted. This is because Volvo frequently unveils new engine technology in advance of their use in production models. With this in mind, the use of "introduction" dates in this article better reflects the era in which specified engines were designed.

Due to the huge variety of induction and fuel delivery options, the suffixes listed in the "Volvo Engine Designations" article have been omitted. Furthermore, a streamlined approach to listing engine outputs has been adopted. That said, the significant differences used to measure SAE Gross Horsepower (SAE J245) and SAE Net Horsepower (J1349) will undoubtedly cause some confusion.

Pre-1972 engines were rated using the more liberal SAE J245 standard which allowed output to be measured without the parasitic drag of generators/alternators, starters, emission control equipment, and a full exhaust system. Post-1972 engines were required by law to be rated using the SAE J1349 (or "net") system. This stipulated that engines must be tested in fully equipped form, less optional equipment such as air conditioners and power steering.

As a rule of thumb, multiply SAE Gross by 0.85 to arrive at a fairly accurate SAE Net rating.

The format used to to display information in this article is:

ENGINE DESIGNATION -- ASSOCIATED CAR MODEL
Configuration: ie. valve train configuration, number of cylinders and layout
Displacement: engine size in litres

Output: Brake Horspower (Bhp)
Notes: Year of introduction & significant features

To assist in finding details on a particular era, readers may click on the milestones of Volvo engine development they find most interesting. Otherwise, readers may use the "find" command within their browsers to locate a particular engine.

The Overhead Valve Era (1935 to 1974)

Volvo produced a wide variety of overhead valve engines rangin in displacement from 1.4 to 3.7 litres. Of these, the B18 were the most popular due to their use of 5 main bearings, large journal diameters, and bullet-proof valve trains. The test regime for B18s engines were impressive, with the final versions capable of being run at full load and rpm for 500 hours without incident.

EB/EC/ED - PV651/2, TR671/4, PV653/4, TR676/9, PV658/9, PV36, PV51/2, PV53/6, PV801/2, PV821/2, PV831/2 and PV60
Configuration: OHV Inline 6-cylinder
Displacement: 3.670 litres
SAE Gross Output: 80 Bhp - 90 Bhp
Notes: Introduced in 1935. Volvo's longest in-production engine (1935 -1958). Simple cast iron 4-main bearing engine.

B4B - PV 444
Configuration: OHV Inline 4-cylinder
Displacement: 1.414 litres
SAE Gross Output: 40 Bhp - 70 Bhp
Notes: A simple cast iron 3-main bearing engine introduced in 1944.

B16 - PV444, PV544, 120
Configuration: OHV Inline 4-cylinder

Displacement: 1.583 litres
SAE Gross Output: 60 Bhp - 85 Bhp
Notes: Introduced in 1956 and first fitted in the 120 chassis. The first of the "Red Blocks".

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First 5-Main Bearing Engine (1960)

B18 - PV 544 Sport, 120, 1800, 144
Configuration: OHV Inline 4-cylinder
Displacement: 1.778 litres
SAE Gross Output: 75 Bhp-115 Bhp (latter output for B18B)
Notes: Introduced in 1960 as Volvo's first 5-main bearing engine. This extremely rugged and well-build engine was first fitted to the 1800 chassis. Since that time, the B18 has become renouned for its ease of repair, excellent flexibility and impressive longevity.

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The Fuel Injected Era (1970 & up)

Volvo's use of injection dates back to the 1970 1800 which used a Bosch D-Jetronic electronic fuel delivery system. Since that time, Volvo has used high pressure (K, K-Lambda) and low pressure (L, LH, and Motronic) fuel injection systems. The latest Volvo cars use German-designed Seimens and Japanese-designed Mitsubishi fuel injection systems. The latter variant is of direct injection layout, with the fuel being directly administered to the cylinder via a high pressure nozzle.

B20 - 1800, 140, 240
Configuration: OHV Inline 4-cylinder
Displacement: 1.986 litres
SAE Gross Output: 82 Bhp-130 Bhp (latter output for B20E)
Notes: Introduced in 1968 and first fitted in the 120 and 140. Later variants of this engine were the basis for Volvo's first fuel injection system. The B20 was fitted to 240s in the 1975 model year only.

B30 - 160
Configuration: OHV Inline 6-cylinder
Displacement: 2.978 litres
SAE Net Output: 130 Bhp-160 Bhp (latter output for European Market B30E)
Notes: Introduced in 1971, the B30 was another well-build and robust engine designed by Volvo. Variants of the B30 were used in marine and military applications.

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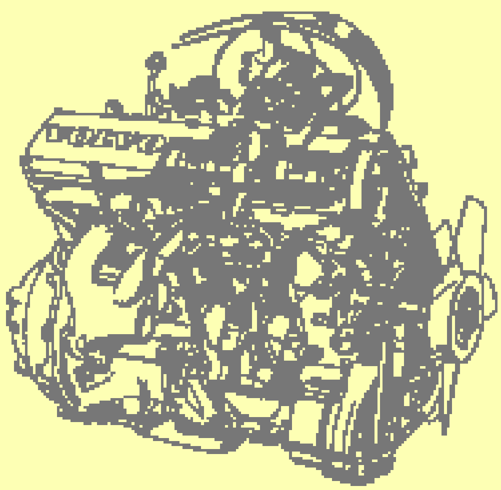
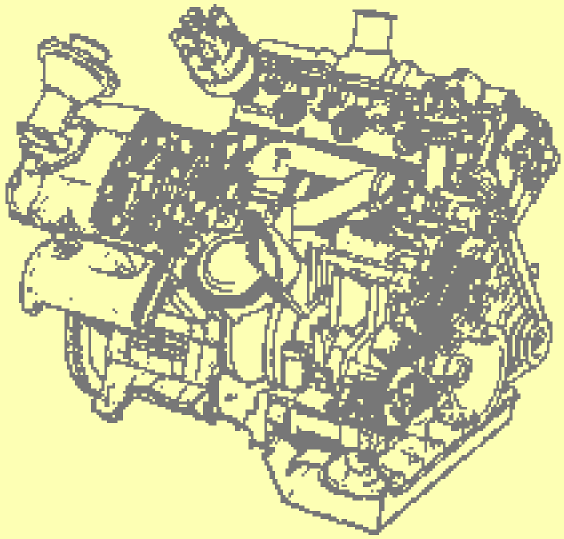
Overhead Cam Technology (1974 & Up)

B21 - 240
Configuration: OHC Inline 4-cylinder
Displacement: 2.127 litres
SAE Net Output: 97 Bhp-155 Bhp (latter output for European B21ET)
Notes: Introduced in 1974 as Volvo's first overhead cam engine with an alloy cross-flow cylinder head, the B21 replaced the B20 in 200-series cars. The basic design of this engine supported all forms of Volvo 4-cylinder powerplant production until 1990.



B27 - 260, 760
Configuration: OHC Vee 6-cylinder
Displacement: 2.664 litres
SAE Net Output: 125 Bhp-140 Bhp (latter output for German-spec B27E)
Notes: Introduced in 1974, this all-alloy engine was the result of a joint Peugot-Renault-Volvo agreement. For that reason, the B27/28 is sometimes referred to as the "PRV-6". The design of this engine was unusual in that the block was assembled from a number of inter-connected pieces, vice the single cast block that is most common to the automotive industry. Liquid gaskets were used to seal the various pieces including an oil pan that also served as the lower main bearing cap. This method of construction would later be featured in Volvo's modular engine family.



Although the basic design of the B27 was later improved, this engine did not live up to previous engines' reputation for reliability. The reasons for this are three-fold. First, few mechanics had the training and experience necessary to repair the V-6 engines. Second, the oil passages in the B27's cylinder head could not adequately supply lubrication to the camshafts -- leading to premature wear. Third, when the engines were disassembled for repair, re-sealing the components with the elastomers of the era was a hit-and-miss affair. The result was an engine that often lacked the proper service, ate camshafts, and leaked oil. Not the stuff of legends.

B19 - 340, 360
Configuration: OHC Inline 4-cylinder
Displacement: 1.986 litres
SAE Net Output: 85 Bhp-118 Bhp (latter output for rare "R-Sport" 1981 343)
Notes: Introduced in 1976 as an underbored version of the B21.

B17 - 240
Configuration: OHC Inline 4-cylinder
Displacement: 1.778 litres
SAE Net Output: 88 Bhp
Notes: Introduced in 1978 for use in Scandanavian Markets until 1988.

B28 - 260, 760, 780
Configuration: OHC Vee 6-cylinder
Displacement: 2.849 litres
SAE Net Output: 129 Bhp-170 Bhp (latter output for European-spec B28F)
Notes: Introduced in 1980, this variant of the B27 featured an improved lubrication system and slightly larger displacement. Although this engine rectified many earlier concerns generated by the B27, it continued to suffer from a bad reputation.

B23 - 240, 740, 760
Configuration: OHC Inline 4-cylinder
Displacement: 2.316 litres
SAE Net Output: 104 Bhp-173 Bhp (latter output for European B23ET)
Notes: Introduced in 1982 as essentially an over-bored B21. Although the basic variant of this engine (the B23F) was not noted for its power, later high performance versions (B23E and B23FT) would boost Volvo's reputation for performance.

B18 (New Series) - 440, 460, 480
Configuration: OHC Inline 4-cylinder
Displacement: 1.721 litres
SAE Net Output: 90 Bhp-120 Bhp (latter output for European B18T)
Notes: Introduced specifically for 400-series cars.

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The Low Friction Powerplants (1984 & up)

B230 - 240, 740, 760, 780, 940
Configuration: OHC Inline 4-cylinder
Displacement: 2.316 litres
SAE Net Output: 104 Bhp-182 Bhp (latter output for European B230ET)
Notes: Introduced in 1984 as a low friction derviative of B21/23 engines, the B230 featured improved efficiency without undermining Volvo's hard-earned reputation for quality. This engine would equip most Volvo cars until the early/mid 1990s.

B200 - 240, 740, 760, 780, 940
Configuration: OHC Inline 4-cylinder
Displacement: 1.986 litres
SAE Net Output: 103 Bhp-160 Bhp (latter output for European B200ET)
Notes: Introduced in 1985 as a reduced bore version of the B230 low friction engine. European Market only.

B280 - 780
Configuration: OHC Vee 6-cylinder
Displacement: 2.849 litres
SAE Net Output: 170 Bhp
Notes: Introduced in 1986 as a low friction derivative of the B28. Although this engine rectified many earlier concerns generated by the B27, it continued to suffer from a bad reputation.

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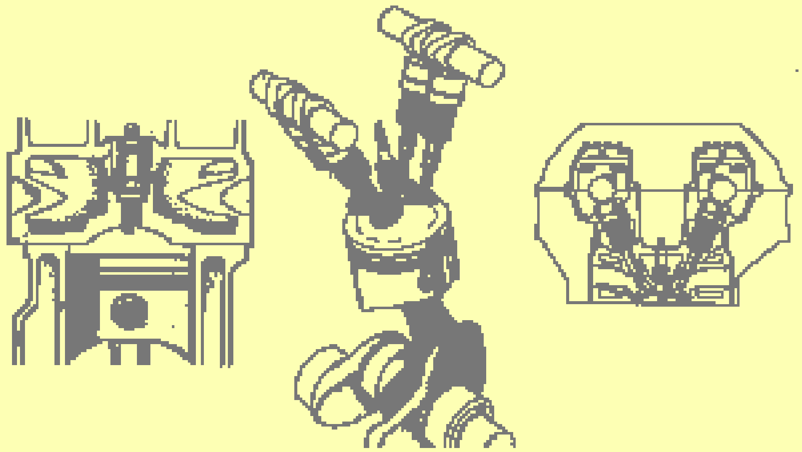
Multi-Valve Technology (1988)

Although a late user of multi-valve technology, Volvo has since incorporated 4 valves per cylinder into most of its engine designs. This improves engine breathing, particularly at high rpm, and accounts for the favorable power output from these motors.



B234 - 740, 760, 940
Configuration: DOHC Inline 4-cylinder
Displacement: 2.316 litres
SAE Net Output: 155 Bhp
Notes: Introduced in 1988 as Volvo's first dual overhead cam, multi-valve engine. This variant reached North America in 1988 & later 740s.

B204 - 740, 760, 940
Configuration: DOHC Inline 4-cylinder
Displacement: 1.986 litres
SAE Net Output: 130 Bhp- 200 Bhp (latter output for Italy's B204FT)
Notes: A reduced displacement variant of Volvo's first dual overhead cam, multi-valve engine. Marketed in Europe only.

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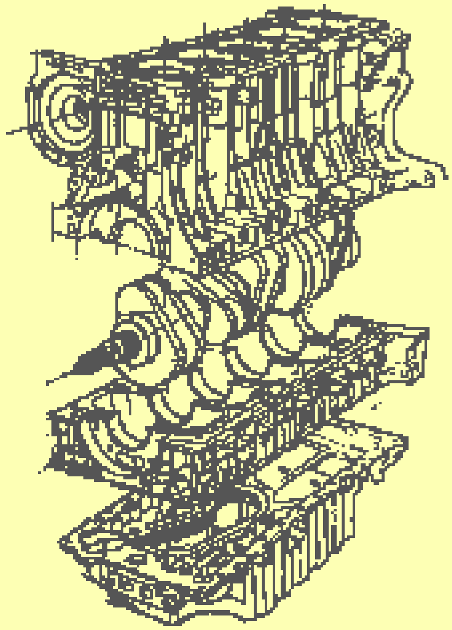
"Modular" Engine Configuration (1990 & up)

Volvo's search for a modular series of engines ended with the development of 4-, 5-, and 6-cylinder designs -- the lineage of which can be traced back to the B6304 engine. This engine was developed with the assistance of Porche's famous Weissach (pronounced Vie-Sock) Technical Centre. The result is a series of engines that can share major components such as pistons, valves and bearings. This approach to engine design reduces part inventories, accelerates assembly line processes, and reduces manufacturing costs.



Of note, the modular engine family shares an unusual design feature with the earlier "PRV-6". The engine blocks in this series of engines are assembled from a number of inter-connected pieces, vice the single cast block that is common to the automotive industry. Liquid gaskets are used to seal the various pieces including an oil pan that also serves as the lower main bearing cap.

B6304 - 960, S/V 90
Configuration: DOHC Inline 6-cylinder
Displacement: 2.922 litres
SAE Net Output: 180 Bhp - 204 Bhp
Notes: Introduced in 1990. Volvo's first in a series of modular engines developed with the assistance of Porsche's Weissach Engineering Centre.

B6254 - 960, S90
Configuration: DOHC Inline 6-cylinder
Displacement: 2.5 litres
SAE Net Output: 170 Bhp
Notes: An underbored variant of the B6304 introduced as an option in Europe.

B5254 - 850, S 70
Configuration: DOHC Inline 5-cylinder

Displacement: 2.435 litres
SAE Net Output: 170 Bhp
Notes: Introduced in 1991.

B5252 - 850, S/V 70
Configuration: DOHC Inline 5-cylinder
Displacement: 2.435 litres
SAE Net Output: 140 Bhp - 144 Bhp
Notes: 2 Valve per cylinder variant of B5254 engine.

B5202 - 850, S/V 70
Configuration: DOHC Inline 5-cylinder
Displacement: 1.984 litres
SAE Net Output: 126 Bhp
Notes: Reduced bore variant of B5252 engine introduced as an option in Europe.

B5204 - 850, S/V 70
Configuration: DOHC Inline 5-cylinder
Displacement: 1.984 litres
SAE Net Output: 140 Bhp - 225 Bhp (latter represents European model B5204FT turbocharged version)
Notes: A reduced bore variant of B5254 engine introduced as an option in Europe.

B5234FT - 850, T5/R, S/V 70
Configuration: DOHC Inline 5-cylinder
Displacement: 2.319 litres
SAE Net Output: 225 Bhp - 240 Bhp (latter represents T5R and S/V 70 variants)
Notes: Reduced bore, turbocharged variant of B5254 engine.

B4184 - S/V 40
Configuration: DOHC Inline 4-cylinder
Displacement: 1.731 litres
SAE Net Output: 115 Bhp - 125 Bhp
Notes: Introduced 1995 with the B4204 engine. Engines designated with the suffix SM (introduced in mid-1998) are Mitsubishi Gasoline Direct Injection engines displacing 1.8 litres and producing 125 Bhp.

B4204 - S/V 40
Configuration: DOHC Inline 4-cylinder
Displacement: 1.948 litres
SAE Net Output: 125 Bhp - 140 Bhp

Notes: Introduced 1995 with the B4184 engine.

B4164 - S/V 40
Configuration: DOHC Inline 4-cylinder
Displacement: 1.635 litres
SAE Net Output: 105 Bhp
Notes: Introduced in early 1997 as an underbored variant of the B4184.

B4194 - S/V 40
Configuration: DOHC Inline 4-cylinder
Displacement: 1.948 litres
SAE Net Output: 200 Bhp
Notes: Introduced in mid 1997 as an under-bored, turbocharged variant of the B4204 engine.

B6284T - S 80
Configuration: DOHC Inline 6-cylinder
Displacement: 2.783 litres
SAE Output: 268 Bhp
Notes: Twin turbo variant of the new-series B6304 engine introduced in 1998. Variable exhaust valve timing and drive-by-wire throttle control. Meets California Transitional Low Emissions Vehicle (TLEV) standards.

B6304 (new-series) - S 80
Configuration: DOHC Inline 6-cylinder
Displacement: 2.922 litres
SAE Net Output: 201 Bhp
Notes: Introduced in 1998, this engine is a revised version of the earlier (1990) variant. The new-series engine is specifically designed for transverse mounting in the S 80. Variable intake valve timing and drive-by-wire throttle control. Meets California Transitional Low Emissions Vehicle (TLEV) standards.

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Diesel Engine Technology (1978 & up)

Depite being the largest truck manufacturer in the world, much of Volvo's diesel technology has been borrowed from other car manufacturers. Volkswagen and Audi components can be found in many diesel engines fitted to Volvo automobiles. This all changed in 2002 with the introduction of the D5 - a high-tech multi-valve, variable nozzle turbocharged, direct injection diesel engine.

D20 - 240
Configuration: SOHC Inline 5-cylinder DIESEL
Displacement: 1.958 litres
SAE Net Output: 68 Bhp
Notes: A Volkswagen design first introduced by Volvo in 1978.

D24 - 240, 740, 760, 940, 960
Configuration: SOHC Inline 6-cylinder DIESEL
Displacement: 2.383 litres
SAE Net Output: 82 Bhp - 122 Bhp (latter represented the intercooled D24TIC engine)
Notes: A Volkswagen design first introduced by Volvo in 1978, later updated with a turbocharger in 1982.

D19 - 440, 460, S40/V40
Configuration: SOHC Inline 4-cylinder DIESEL
Displacement: 1.870 litres
SAE Net Output: 90 Bhp
Notes: All engines of this type were turbocharged.

D5252 - 850, S/V 70
Configuration: SOHC Inline 5-cylinder DIESEL
Displacement: 2.460 litres
SAE Net Output: 140 Bhp
Notes: A Volkwagen/Audi design, marketed in Europe.

D5 - V70, S60, S80
Configuration: DOHC Inline 5-cylinder DIESEL
Displacement: 2.4 litres
SAE Net Output: 163 Bhp
Notes: Volvo's first indigenously designed and manufactured diesel engine introduced in mid 2002 in Europe. Features common rail direct injection and a variable nozzle turbocharger. This engine is unusual, as its aluminum block/head design is a departure from the more conventional use of iron in diesel applications. Reported to be based on the block of the gasoline-powered B5234F.

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Special Thanks to John Laughlin & Rob Funnekotter who provided excellent tips and suggestions on the data contained herein.

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Turbo Owner's Survey

by Paul Grimshaw

The aim of this survey is to provide an assessment of Volvo turbo ownership on the basis of operating cost, durability, and owner satisfaction.

SURVEY METHODOLOGY

Volvo owners were asked a number of questions concerning their experience with turbocharged cars. Only those currently owning cars with 25,000 miles or more were surveyed. The mileage figure was adopted after responses had been taken to correct for what were essentially new cars, still under warranty, and unlikely to exhibit any significant wear.

Thirty-five responses were examined according to model (200, 700, 900 series). Although three responses from 850 owners were received, none were above the mileage threshold nor had reported any problems worthy of note.

240 TURBOS

Model/Useage:

Nine responses were gathered. The average model year of those surveyed was 1983 with 167,398 miles on the odometer. The cars were mostly equipped with manual transmissions (60%) and were driven moderate distances each day. 20% of the cars surveyed were used for towing, 40% negotiated hilly terrain during daily life, and 33% were routinely operated in low ambient temperatures (less than -20F). Although the cars were driven in the moderate to hard range, 67% of owners reported idling their cars down over 1 minute prior to shut-down.

Servicing:

On the service side of the house, all 240 Turbo owners reported doing their own servicing, with one using independent garages for "the major stuff only". Oil changes ranged from a frequent 2000 miles to one owner who reported regular changes at the 10,000 mile mark or every 6 months. The median for oil changes was, however, 3000 miles with everyone replacing the filter with a new Volvo (40%), Mann (30%) or Purolator, Bosch or Fram unit.

Many 240 Turbo drivers used Mobil 1 (40%) or Castrol GTX (40%) engine oil. Air filters were reported changed after an average of 27,000 miles (no unusually high replacement values) and fuel filter changes averaged 37,142 miles, although admittedly one driver replied with a question mark suggesting that he/she was unaware this unit needed changing at all. The average grade of fuel used was AKI 91 with only 20% of respondants using fuel additives such as Techron cleaner (marketed by Chevron). Of note, no one reported using oil additives.

Servicing Costs & Problem Areas:

Although two of the respondants did not have any idea of what their annual servicing costs were, those who replied paid an average of $639.43 annually -- remember they were exclusively self-servicers. All 240 owners reported having replaced their turbochargers at least once. The average turbo life was 113,555 miles, but the worst of the lot had to be replaced after just 61,000 miles (only to be rebuilt further down the road at 120,000 miles). The best turbo out there lasted 160,000 miles. 10% of cars had required cylinder head replacement (expensive!!), but none required a bottom-end rebuild, or suffered from any electrical gremlins. A few problem transmissions were identified; mostly rough-shifting autoboxes.

Owner Satisfaction:

On a scale of one to ten, owners rated their 240s an "8" for power (low-4/high-9.5) and "5" for fuel economy (low-1/high-9). All in all, owners rated their satisfaction with servicing costs as 7, with 90% saying that they would buy another Volvo turbo.

700 TURBOS

Model/Useage:

Twenty-three responses were gathered. The average model year of those surveyed was 1987-88 with 123,988 miles on the odometer. The cars were mostly equipped with automatic transmissions (60%) and were driven moderate distances each day. 13% of the cars surveyed were used for towing, 26% negotiated hilly terrain during daily life, 21% were operated in high ambient temperatures (+100F) and 8% were routinely operated in low ambient temperatures (less than -20F). Although the cars were driven in the moderate range, 34% of owners reported idling their cars down over 1 minute prior to shut-down.

Servicing:

When it comes to keeping in cars tune, 40% of 700 turbo owners reported doing their own servicing, with 35% using independent garages, and the remainder using the dealer. The average oil change interval was 3304 miles, with 60% changing filters with oil. An significant number of 700 Turbo drivers used Castrol engine oil (60%), followed by a few Mobil and Valvoline users. Two 700 turbo owners regularly used oil additives (no brand was specified, though).

Air filters were reported changed after an average of 29,000 miles and fuel filter changes averaged 41,500 miles. Like 200 turbo owners, a few of the newer car owners used a "?" to respond to fuel/air filter changes.

The average grade of fuel used was AKI 89 with a slightly higher 26% of respondants using fuel additives such as Techron cleaner.

Servicing Costs & Problem Areas:

Although four of the respondants did not have any idea of what their annual servicing costs were, those who replied paid an average of $896.12 annually (low-$200/high-$2700). Unlike the 200 owners, however, most 700 owners had someone else do the servicing.

Of the 23 owners surveyed, 5 had replaced their turbos at an average of 136,400 miles. The winner of the turbo longevity award goes to an individual who's turbo is still going after 220,000 miles. Three owners, however, had to replace their cars' cylinder heads and two reported needing a cylinder re-bore (at 133,000 and 241,000 miles respectively).

One car had severe gremlins with almost half a dozen air mass meters, a main computer and transmission problems accounting for the chronic driveability problems.

The best turbo out there reportedly lasted 247,000 miles and is still going strong. Of note, the owner of this car indicated an oil change interval of 2500 miles.

Owner Satisfaction:

On a sclae of one to ten, 700 owners rated their models "8" for power (low-7/high-10) and "6" for fuel economy. Fuel economy statistics were quite diverse, however, suggesting that driving style ranged from mild to wild.

All in all, owners rated their satisfaction as 8.8/10 and 96% said that they would buy another Volvo turbo.

900 TURBOS

Only three 900-series owners' responses had enough mileage on their cars to meet the threshold of the study. The average odometer reading was 35,666 miles. No problems were reported. Those not covered by the free servicing arrangement paid dealers and independents an average of $730 per year in servicing. Oil was changed at the 5000 mile mark, except for the owner who took his/her 900 to an independent who changed the oil every 3000 miles. Little else could be ascertained from the figures.

MODEL COMPARISON

700 series cars' turbos lasted an average of 25000 miles longer than those fitted to 200 series cars. This may be due to water-cooled units and/or intercoolers, but little definitive data was obtained to corroborate this. This extra longevity, however, appeared to cost 700 owners an average of $250 more per year in servicing costs.

Although most Volvos surveyed were relatively trouble free, a few were cash cows. Drive it like you hate it may have been a catchy 1960s advertising slogan, but the Volvo turbo owner who boots it will pay significantly higher maintenance and repair costs.

SERVICING TRENDS

There was a general, but certainly not absolute, correlation between servicing and longevity. Neverhteless, so many abberrations existed, I wonder if folks used the same base number to calculate their annual expenses.

Admirable, however, is how I would comment upon most respondants' servicing habits. The value of frequent oil changes is generally well recognized here, with most owners changing the lubricants every 3000 miles. It would have been interesting to ask what the coolant/thermostat change interval had been (20/20 hindsight), especially since some head failures were noted.

Despite religiously adhering to oil changes, many simply replied "?" when asked to comment on fuel and air filter changes. Turbos are close tolerence devices, so risking dirt ingestion through the induction or fuel system does not make sense! Maintenance tip: Change those Filters!

CONCLUSION

Force-fed Volvos are generally durable beasts, but appear to require a new turbocharger at around 120,000 miles.

On the whole turbo owners seem to drive their cars in the moderate-to-hard category, suggesting that finding a lightly used Volvo turbo is rarer than one may think!

If you can handle paying between around $800 per year for maintenance, enjoy high engine output and can live with average fuel economy, then a turbocharged Volvo may be well received.

Other Articles in this site related to turbochargers:

Troubleshooting 200-, 700-, and 900-series Turbos

Turbochargers: An Owner's Guide to Preventing Catastrophe

Power to Weight Ratios - Tuning a Volvo into a Porsche

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Brake Mean Effective Pressure & Engine Wear -A Study of Volvo Engines

by Paul Grimshaw

Many enthusiasts gauge the performance of an engine by its output in horsepower. The better informed, however, will note that the measure of horsepower depends on torque, the amount of real work that an engine is capable of producing.

The direct link between torque and engine capacity spawned the 1960s saying among drag racers that "there's no substitute for cubic inches". That saying generally holds true today, but is increasingly difficult to rationalize in a world that places value on efficiency and longevity.

MEASURING ENGINE EFFICIENCY

Engineers have recognized that successful engines develop pressure within their cylinders to draw-in an air and fuel mixture, compress that mixture to increase its potency and, when ignited, utilize the pressure created by hot expanding gases to accomplish work. Brake mean effective pressure, or bmep, is the measure of efficiency that they have chosen to express engine output relative to engine displacement. Simply put, bmep is the average effective pressure of the cylinders as they progress through intake, compression, ignition and exhaust strokes.

MY ENGINE IS BETTER THAN YOURS

Those who judge engine power without any references to size, weight or displacement are ignoring standards that have governed the motorsports industry for decades. Throughout the history of LeMans, winners of the efficiency index have attracted considerable attention. Porsche established its rich engineering credentials in this way, as has the aerospace engineering company Matra.

Before any particular Volvo owner beats his or her chest over power, the are a few indices that must be considered. In terms of net output, the B6284FT is the most powerful engine to equip a production Volvo. This power doesn't necessarily translate into the top ratings for power -to-displacement and power-to-weight categories. The winner in those categories is the in-line five cylinder turbocharged engine known as the B5234FT (in limited production T-5 trim).

Engine displacement and weight play a factor in the ratings. The multi-valve B5254F and B6304F comparable levels of rated efficiency, despite the obvious differences in displacement. The lower weight of the iron block B234F helps it achieve a better power-to-weight ratio than the slightly more powerful B5254F.

In the two-valve per cylinder class, the B20E and the B30F offer some attractive advantages. Note how the higher net horsepower and portly weight of the B30 is offset by its very low bmep. (Save the B21F, it has the lowest bmep of the engines shown!) It is also interesting that the bmep of the B20E comes very close to matching those of early turbos (see B21FT and B230FT).

Table One - Power Density Ratings - Selected Volvo Engines from 1944 to 2000

Engine	Displacement (cu ins)	Power (Bhp)	Torque (ft-lbf)	Weight (lbs)	bmep (psi)	Bhp/in3	lbs/bhp
B6284FT	170	268	280	460	175	1.58	1.62
B5252F	148.5	138	152	380	154.6	0.93	2.75
B5234FT	141.4	240	221	427	236.0	1.57	1.92
B5254F	148.5	168	162	389	164.7	1.13	2.36
B6304F	182	204	197	405	163.4	1.12	1.99
B234F	141.5	155	150	360	160.1	1.09	2.32
B230FT	141.5	162	195	360	208.1	1.14	2.22
B230F	141.5	114	137	330	146.2	0.81	2.89
B23E	141.5	136	137	365	146.2	0.96	2.68
B21FT	129.9	127	150	380	174.4	0.98	2.99
B21F	129.9	98	112	340	130.2	0.75	3.47

B21A	129.9	102	122	340	141.8	0.79	3.33
B30F	181.7	138	154	450	127.9	0.76	3.26
B20F	121.4	112	115	340	143.0	0.92	3.04
B20E	121.4	135	124	340	154.2	1.11	2.52
B20B	121.4	97	109	341	135.6	0.80	3.52
B18B	108.6	115	100	341	139.0	1.06	2.97
B16B	96.2	85	87	341	136.6	0.88	4.01
B14B	86.6	70	75	341	130.8	0.81	4.87

Horsepower and torque ratings for the engines shown vary slightly by market. The values depicted in the table are those that were available to the author and have been measured using the applicable SAE standard in effect during the periods in which the engines were produced. Engines produced before 1972 were rated using the SAE Gross standard. This standard results in about 15-20% higher horsepower ratings than would be measured using the newer SAE Net system.

ESTIMATING ENGINE LONGEVITY

Since bmep describes the average effective pressure affecting an engine's cylinders, it is logical to conclude that this pressure is subsequently transmitted through the connecting rods to the crankshaft. Engine output is proportional to this pressure. So too is engine wear as the main and connecting rod bearings help prevent metal to metal contact between the rods, crankshaft and engine block.

The thrust and force vectors affecting connecting rod and main bearings are not constant. They do not lie along any single plane, but follow a distorted figure eight pattern that is influenced by the cylinder firing sequence and, ultimately, the inherent balance of an engine. In general terms, however, the orders of force affecting most reciprocating engines are defined by the number of cylinders within that application.

Of the commonly available engines in today's cars, V-12s (twelve cylinder engines in which the pistons are arranged in two banks of six cylinders separated by 60 degrees of angular distance) and inline and opposed (aka boxer) 6 cylinder engines are capable of possessing the best inherent balance. V-8s also have very good potential, as do inline fours. Inline threes, fives and V-6s have the highest potential for generating free forces and moments of intertia affecting the crankshaft. This is why drivers of cars with these type of engines will often note a certain "roughness" at low rpm.

Assigning a mathematical value on the effect that engine design, including the number of cylinders and arrangement, has on engine wear is virtually impossible. Instead, the chart below simply compares bmep and main bearing area to arrive at a theorectical "wear index" for Volvo engines. The potential for wear against the crankshaft, the largest working element in a reciprocating engine, rises with wear index. In other words the higher the wear index, the greater the potential for wear in the engines shown.

Table Two - Calculated Wear Indices of Selected Volvo Engines

Engine	Main Bearing Area (in2)	bmep (psi)	Wear Index - bmep/main bearing area
B6284FT	57.6	175.0	3.0
B5252F	49.4	154.6	3.1
B5234FT	49.4	236.0	4.8
B5254F	49.4	164.7	3.3
B6304F	57.6	163.5	2.8
B234F	54.3	160.1	2.9
B230FT	54.3	208.1	3.8
B230F (1989 & up)	54.3	146.2	2.7
B230F (1985-88)	42.9	146.2	3.4
B23E	54.3	146.2	2.7
B21FT	54.3	174.4	3.2
B21F	54.3	130.2	2.4
B21A	54.3	141.8	2.6
B30F	76.6	127.9	1.7
B20F	54.7	143.0	2.6
B20E	54.7	154.2	2.8
B20B	54.7	135.6	2.4
B18B	54.7	139.0	2.5
B16B	32.8	136.6	4.2
B14B	32.8	130.8	4.0

Note the differing bearing areas of later and early versions of the B230F. The revised design of engines built in 1989 added to the size of the main bearing journals. The "K" engine (the letter denoting Model Year (MY) 1989, is sometimes erroniously believed to be the only B230F with the larger bearings. This is untrue as the modifications made for MY 1989 were carried on throughout the remaining production life of the B230F.

Although wear indices are theoretical mathematical expressions, it is interesting to note that the B30F (with a very low wear index of 1.7) was chosen by Volvo engineers in the 1970s as the engine of choice for high duty-cycle applications in the defence and marine sectors (they were used to power tracked and all-terrain army vehicles and for the motive power for a variety of commercial stern drive applications).

It is also interesting to note that the highly touted B18 offered significantly lower wear potential than that associated with earlier B14 and B16 designs. There is truth in advertising!

Of course, we all know from practical experience that turbocharged motors are subject to significantly higher wear than their normally-aspirated counterparts. The indices shown for B21FT, early B230F, B230FT and B5234FTs reflect their higher potential for wear. It is surprising, however, to see that the wear index of the normally aspirated B5254F was almost as high as that of the turbocharged B21FT! This is a function of the former engine's very small bearing area.

WEAR INDEX AND ITS IMPACT ON MAINTENANCE PROCEDURES

Not all engines are created equal. The best maintenance procedures for a normally aspirated inline fives and their turbocharged variants should differ signficantly from those of other engines. Indeed, any high output engine should be maintained according to its output, not cylinder count.

If I were driving a car fitted with a turbocharged engine, I would ensure that the best lubricating oil (i.e. synthetics that meet the manufacturer's recommended quality and viscosity indices) was changed every 2500 to 3000 miles. I would ignore any advice that suggested that I should adopt a longer oil change interval.

If I were operating an engine with limited bearing area (i.e. B14, B16, early B230F, B6304, B5xxx), I would follow the advice given above for turbocharged engines.

If I were operating an engine with moderate to low wear potential (normally aspirated B18, B20, B21, later B230 and B234), I would select a very good quality conventional lubricating oil and change it every 2500 to 3000 miles.

Of course, an anal retentive owner (such as myself) may adopt an even more conservative approach to lubricants. I have changed the synthetic oils in my later version B230Fs every 2500 miles since day one. Perhaps after a few million miles, I'll have a reason to rebuild the engine.

CONCLUSION

What is written here is the opinion of the author and is based on sound engineering principles and a 20 year history of maintaining cars. Those with access to destructive and non-destructive test results may hold additional data on the subject of output and wear. If so, I'd appreciate receiving the results and observations.

At the end of the day, however, the owner is the final arbiter for decisions on output and its implications on maintenance. Choose wisely.

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Matching Tires & Wheels for Maximum Performance

Sponsored by: The Volvo Performance Handbook

The following article is based on the author's response to a question on the correct tire and wheel application for a specific model of Volvo. It is representative of the type of detailed, model-specific support offered to registered owners of "The Gothenburg Bible" and "Volvo Performance Handbook".

Q: For the past several weeks I have been thinking of upgrading to aftermarket alloy wheels. But a pretty experienced and long time Volvophile, just recently informed me he has always had outstanding performance from certain types of tires on 205/70R14 stock, steel wheels. He also told me the difference for street use between the 14 and 15 inch is probably marginal, and if strictly interested in handling, don't waste my money on the high price alloy wheels. This individual has been into performance for a long time, is a 25 year Volvo tech, and seems to know the vehicle as well as anybody. He also claims the 205-70 tires easily fit on the 14 inch steel wheels with no problems. Could you clarify this information for me?

A: I am assuming that your wish to switch to a wider, lower profile tire for better lateral grip. If this is the case, success will depend on two important factors:

a. width of the contact patch; and
b. sidewall stiffness.

A tire with a wider cross section will have a greater lateral contact patch. Sidewall stiffness is a function of profile and mounting. Tires measuring 205/70R14 or 205/65R14 will have much taller sidewall heights of 133.25mm and 143.5mm respectively, compared with stock sidewall height of ~120mm.

The stability of a tire's sidewall is also determined by the width of the rim on which it is mounted. The narrow 5 1/2 inch rim is not wide enough to properly support the 205/70R14 tire's bead and sidewall. This will undermine the tire's stability as it is subjected to the kind of lateral loading that you will encounter while cornering.

The result will be significantly poorer handling than a stock tire/wheel combination - guaranteed!

Apart from factors relating to size, alloy wheels are much lighter than their steel counterparts. Stock 14" Volvo steel wheels weigh 18 lbs each. By comparison, the lightest OEM Volvo 14' alloy wheel is PN283075-0 (the so-called "dished" alloy) that weighs in at 12.5 lbs, with others ranging from 13 to 14lbs. It is, therefore possible to remove a whopping 22 lbs of unsprung weight from the suspension.

More importantly, a wheel's unsprung weight contributes to the driveline inertia encountered by the engine. A 22 lb reduction in rotational mass from the driveline will have the same effect on acceleration and braking as lightening the chassis by roughly 220 lbs!

In summary, your best options are as follows:

a. 195/65R14 tires on stock steel wheels;
b. 195/60R15 tires on alloy wheels measuring between 6 and 6 1/2 inches wide; or
c. 205/50R16 tires on alloy wheels measuring 6 1/2 inches wide.

A high degree of performance is determined by how the driver applies power to the road. The rest is physics and the application of conventional practices. It may be helpful to point out the latter to your technician as his advice on tire and wheel combinations for your 240 is incorrect.

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Stock Camshafts in Volvo Red Block Engines

by Paul Grimshaw

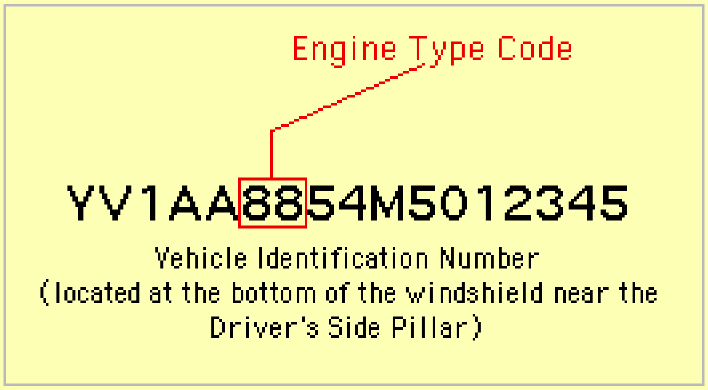
A recent e-mail from a friend highlighted the difficulty in determining which camshafts were fitted to iron block in-line four cylinder (aka "Red Block") Volvo engines. Although alphabetical designations are stamped on the end of the billet, one must remove the cam to read them. There must be an easier way...

VEHICLE IDENTIFICATION NUMBERS

All Volvos leaving the assembly line are allocated a unique Vehicle Identification Number, or VIN, that contains information on the factory in which the car was built, the market for which it was designed, and the engine and transmission package fitted.

ENGINE TYPE CODES

A VIN for 200- , 700-, and 900-series car contains 17 characters. The sixth and seventh characters of the VIN denote the engine type code for North American models.



The following is a list of the type codes used to describe the most popular engines fitted to 200-, 700- and 900-series North American and European Volvos (For a general overview of Volvo engine designations, refer to the following link):

ENGINE TYPE CODE	ENGINE DESIGNATION	MARKET
24	B200E	Europe (1985-)
27	B200F	Europe (1985-)
41	B21A	All except U.S.
44	B21E	Europe (1975-83)
45	B21F-5	All (1976-84), U.S. & Canada (1976-82)
46	B21ET	Europe (1981-85)
48	B21F-8 (LH-Jetronic)	All (1982)
49	B21F-9 (aka B21F-MPG)	All (1981-82)
47	B21FT	North America (1981-85)
81	B23A	Canada & Europe
82	B230GT	Europe
83	B230F (LH 3.1) & B230FD	All (B230F), Europe (B230FD)
84	B23E & B230E	Australia, Canada (B23E only) & Europe
85	B230FX & B230FB	Europe
86	B23ET	All (1982-84)
87	B230FT	All (1985-)
88	B23F & B230F (LH 2.4)	All (B23F 1983-84, B230 F 1985-)

CROSS-LINKING ENGINE TYPE CODES TO CAMSHAFTS

The following engines were fitted with the camshafts listed in the right-hand column:

ENGINE(S)	CAMSHAFT
B21A, B23A & B23E (Canadian 1983 Models, All Other 1984 Models)	A
B21F-5, B23ET	B
B21E	D
B23E (All 1979-1980 Models)	H
B23E (1981-1983, less 1983 Canadian Models)	K
B21F-9	L
B21F-8, B23F, B230F, B230FD, B230FT, B230GT	M
B21FT, B23FT, B230FT	T
B230FX & B230FB	VX (aka VX3)
B200E, B230E	V

HOW DO THESE CAMSHAFTS AFFECT ENGINE PERFORMANCE?

Some of the camshafts enhance engine power at high rpm, whereas others are specifically configured to promote low-end torque. This can translate into a 25% power difference between engines of the same displacement! Refer to "The Volvo Performance Handbook" for an in-depth explanation of camshaft characteristics and how you can improve the power and performance of your sedan, wagon or coupe!

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History, Features & Troubleshooting 200-, 700-, and 900-series Turbos

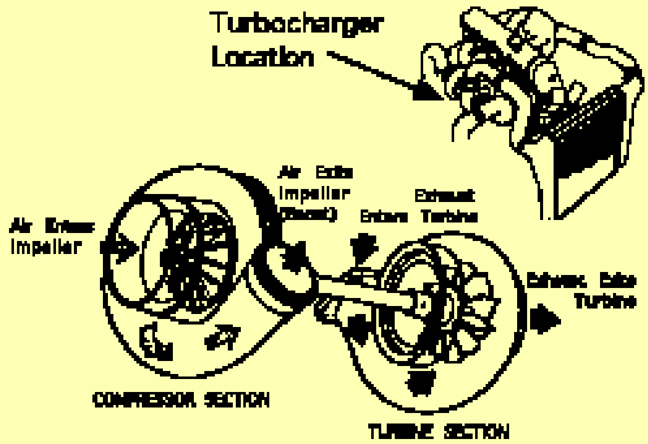
by Paul Grimshaw

The turbocharger was patented by Dr. Alfred Buchi in 1905 to improve the performance of aircraft. His original idea was based on the premise that the power of exhaust gases could be harnessed to offset the effects of diminishing air density at high altitudes.

THEORY & HISTORY OF DEVELOPMENT

Turbocharging theory based on the principle that an engine's power is determined by the density of the air and fuel consumed. A turbocharger effectively increases the density of an intake charge by using spent exhaust gases to operate a high efficiency air pump, or compressor.

As air enters the compressor, it is moved outwards by the blades of the impeller. This accelerates the air to near supersonic speeds. As the high speed air travels along a gradually widening diffuser, its kinetic energy is transformed into pressure. This pressure is referred to as "boost".



Theory of Operation

Pressure raises the density of the intake air. This results in an increased charge density, higher combustion temperatures and greater power.

A turbocharger must move from rest to 100,000 rpm within half a second to deliver boost on demand. To do this, the turbine, impeller and shaft must be strong, light and exceptionally well balanced.

The turbine must be capable of withstanding temperatures of 1100°F to 1400°F during engine operation. The bearings used to support the shaft must be kept cool and well lubricated. When assembled, seals are used to separate coolant, oil, exhaust and intake gases.

THE VOLVO NEXUS

Volvo is one of the five major car companies that have offered optional turbocharged engines in their passenger cars for twenty years of more. During this period of time, two manufacturers have supplied Volvo with turbochargers.

Allied Signal was Volvo's exclusive supplier of turbochargers from 1982 to 1987. The original Garrett TB03 turbochargers fitted to 1982-1985 240s featured an oil lubricated, air cooled, center bearing.

At the same time that turbocharging was introduced to 200-series cars, Allied Signal was introducing a version of the TB03 with water-cooled center bearings for greater durability. This new design quickly superceded oil cooled turbos on the replacement parts shelf and became the Volvo production standard in 1985. Limited availability of oil-cooled Garret TB03 turbochargers since the early 1990s means that watercooled replacement turbos have already been fitted to most Volvos.

Early model 700-series Volvos equipped with B230FT and D24T engines used Garrett TB03 and TA03 turbochargers. This changed in 1987, when Volvo fitted Mitsubishi turbochargers on some of its 700- and 900-series wagons. Since that time, the use of Mitsubishi turbochargers has been expanded throughout the Volvo line.

Most high-performance Volvos were fitted with one of the turbochargers shown below:

Years	Model(s)	Engine(s)	Turbocharger	Production Status
1980-85	240	B21FT	Garrett TB03	Originally air cooled. Water cooled variant phased into production for 1981-85 (240 models) and 1983-86 (740/760 models). Water cooled replacement now available as retrofit kit for both models. Original air cooled variant not available.
1983-92	740/760	B23FT 230FT		
1984-86	760	D24T	Garrett TA03	Air cooled. Available.
1986-87	760	D24T	Garrett TB03	Air cooled. Available.
1987-88	740/760/780	B230FT	Mitsubishi TD05	Water cooled. Available.
1990 -->	740/760/ 780/940	B230FT	Garrett TB25	Water cooled. Available.
1991-93	940	B230FT	Mitsubishi TE04H	Water cooled. Available.
1994-96	940	B230FT	Mitsubishi TD04HL	Water cooled. Available.

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PERFORMANCE BY DESIGN

Garrett and Mitsubishi compressors have some notable differences.

The Garrett turbochargers feature backward-curved impeller blades. The blades are designed to address incoming air at a shallow angle. This reduces aerodynamic shock and allows the impeller to operate more efficiently at higher speeds. The Garrett turbochargers chosen for Volvos, with the exception of the TB25, feature slightly larger dimensions than comparable Mitsubishi designs. The larger size and unique impeller designs allows Garrett turbochargers to operate more efficiently at high rpm.

The straight impellers used in Mitsubishi turbochargers provide a more linear boost response. TD04HL compressor wheels have blade tips at two heights, alternating high and low, to reduce the shock loads that occur when the incoming air strikes the straight blades of the impeller. In general, Mitsubishi designs produce better initial boost at low rpm.

The Mitsubishi turbochargers fitted to Volvo cars have an integral compressor bypass valve which relieves the pressure in the intake system when the throttle is quickly closed. This design reduces the stress on the compressor section of the turbocharger.

FAULT TRACING & SYMPTOMS

Early air-cooled turbochargers typically require replacement by 120,000 miles, whereas more modern water-cooled models can last almost twice as long.

Lubrication problems account for half of turbo failures. Regular oil and filter changes, gentle warm-up and cool-down cycles will greatly extend the life of a turbocharger.

The next most common cause of turbocharger failure is a restriction in the intake system caused by a dirty air filter or a collapsed hose.

Oil seals within the turbo depend upon a positive air pressure to "push" the oil inside the bearing housing. Intake restrictions will force oil past the turbo seals. Prolonged leakage of this kind will eventually cause permanent damage to the turbocharger seals and shaft.

Intake restrictions can raise temperatures to the point where the turbine housing will crack. Elevated temperatures can also cause catastrophic turbine failures. When this occurs, the turbine or compressor wheel explodes causing permanent damage and raising the risk of fire.

Regular inspection of air filters and intake hoses are highly recommended for those hoping to get good service life from their turbochargers.

Foreign objects damage is the third most common cause of turbo failure. Sometimes pieces of the air cleaner will break loose and strike the impeller. In other cases, a careless mechanic can accidentally leave loose nuts or bolts in the intake system where they'll be ingested by the turbo.

The table below is a general guide to summarize common symptoms and faults associated with turbochargers (graphic best viewed after printing):

SYMPTOMS							
Reduced Power or Hesitation	Black or Blue Exhaust Smoke	Turbo Leaking Oil	Turbo Leaking Coolant	White Exhaust Smoke	Grinding Noise from Turbo	CAUSE	REPAIR
●	●	●				Clogged Air Filter	Replace Air Filter
●		●				Intake Hose Fault	Check for holes, loose clamps, soft areas. Replace if necessary.
●						Wastegate Fault	Adjust wastegate. Replace (Garrett), replace turbo (Mitsu)
	●	●				Blocked Oil Return Line	Replace oil return line.
●	●	●	●	●	●	Cracked CHRA	Replace CHRA.
●					●	Worn Compressor Blades	Replace CHRA.
●						Dirty Compressor Wheel	Clean compressor wheel. Inspect radial play or wheel & shaft.
●	●	●	●	●	●	Damaged Housing	Replace Turbo.
	●	●	●	●		Worn Turbo Seals	Replace CHRA.

REPAIR SOLUTIONS

When a turbo fails, it must be repaired or replaced using new parts. It is neither practical nor advisable to attempt to operate a B21FT, B23FT, B230FT or D24T without a functional turbocharger.

The six basic turbocharger models shown in the first table are further divided into at least twenty different specifications and trim levels for various Volvo 200-, 700- and 900-series applications. This makes it difficult to find the correct replacement turbo at your local "pick and pull".

Repair usually entails replacing a portion of the turbocharger called the "center housing rotating assembly", or CHRA. The CHRA consists of the compressor wheel, shaft, center bearing assembly and turbine wheel. These parts normally come pre-assembled.

A quality supplier will recommend that all bolts, locking tabs and sealing rings be replaced as part of a turbocharger repair project. This adds very little to the overall cost of repair and helps ensure that the rebuilt turbocharger functions correctly.

If a turbocharger suffers a catastrophic failure (burst compressor or turbine wheel or broken shaft), it frequently damages the casing of the unit. The only option is to replace the entire turbocharger with a new or rebuilt unit.

Depending on whether repair or replacement is warranted, correcting a turbo fault in a late model rear wheel drive Volvo usually costs between $1500 and $3000.

CONCLUSION

Quality lubricants, regular servicing and responsible driving can greatly extend turbocharger life. There will, however, come a time in every turbo car's life when more serious repair work is required. When a problem occurs, basic fault tracing can be used to make sound maintenance decisions. If repair is deemed necessary, the use of quality parts is essential.

Other Articles in this site related to turbochargers:

Turbochargers: An Owner's Guide to Preventing Catastrophe

Turbo Owner's Survey

Power to Weight Ratios - Tuning a Volvo into a Porsche

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Basic Aerodynamic Principles

Affecting Volvo Cars

by Paul Grimshaw

The thought of air flowing over the body of a moving car is something that we typically visualize when attempting to understand automotive aerodynamics.

In reality, a car moves through a body of relatively stationary air. When this occurs, a column of air is parted by a moving automobile. The air molecules that make up the air column are forced over, under and around the car's chassis.

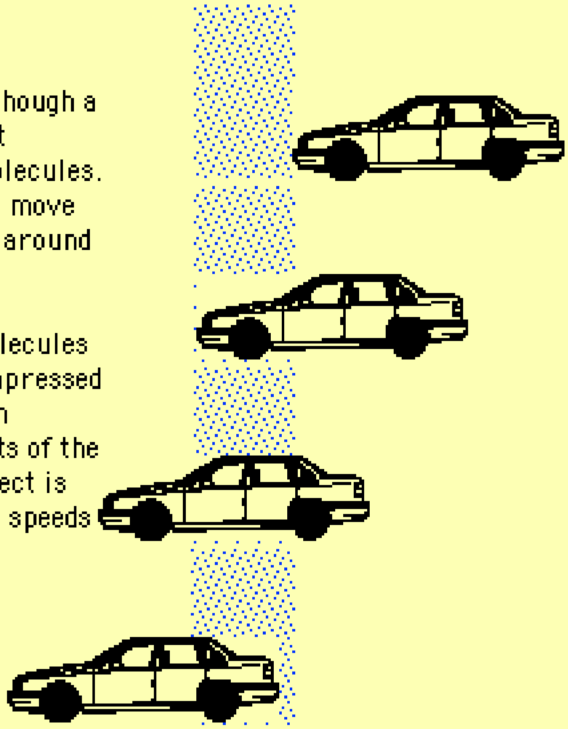


Figure 1

As a car moves though a column of air, it displaces air molecules. These molecules move over, under and around the chassis.

Although the molecules are slightly compressed as they approach vertical elements of the chassis, this effect is negligible at the speeds travelled by automobiles.

Understanding Air Velocity

Velocity is a function of distance over time. Air velocity will increase when its molecules travel over a greater distance within the same period of time.

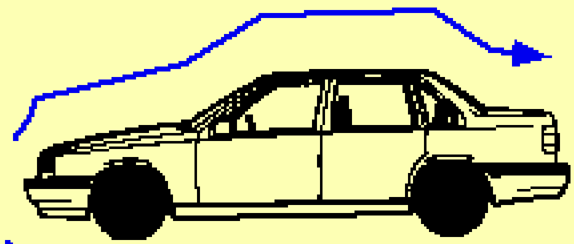


Figure 2

If we magnify and trace the path of the molecules flowing over and under the chassis, we find that the path taken by the molecules moving over the car is longer than that of the molecules moving under the car.

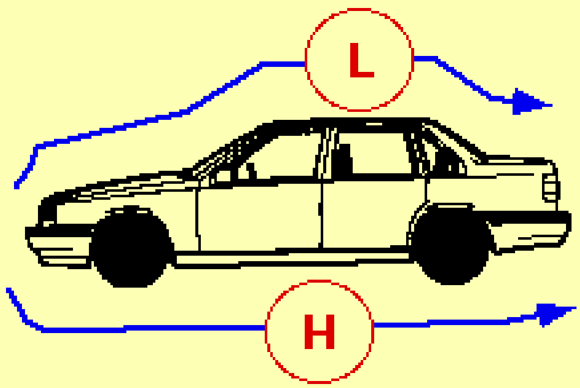
The velocity of the molecules is a function of the relative distance that they travel over a period of time. Because the time taken for the car to pass through the column of air is constant, the velocity of the molecules moving over the car body is higher than that of the molecules moving under the car body.

Velocity & Bernoulli's Law

Bernoulli's law of aerodynamics states that air pressure affecting a body is inversely proportional to velocity. Under this law, a low pressure area will be formed over the portions of a chassis that experiences the highest air velocity.

Figure 3

Using Bernoulli's Law, it can be concluded that the pressure over the upper portion of the car will be lower than the pressure under the car. This results in lift.



The most effective forms of generating down force occur when steps are taken to substantially increase underbody air flow in a controlled manner. The only manufacturers to have made fundamental changes to their designs to reduce lift in this way are McLaren (for the McLaren F1 super high performance road car) and Ferrari (for the F50 and Modena sports cars).

Other measures, such as the use of wings and spoilers, can be used to fine-tune lift or down force over a specific area of the chassis. Although many manufacturers fit wings and spoilers to their road cars the size and placement of such devices are more often a function of styling than performance.

Lift, Drag & Volvo Cars

It is worth noting that Volvo wagons typically experience less overall lift at high speed than their sedan counterparts. This is because the distance that the air must flow over the top of a wagon is less than that of a comparable sedan. That said, the massive separation of airflow behind a wagon increases overall drag and can contribute to somewhat greater lift over the rear wheels.

To reduce aerodynamic drag, Volvo fits a small spoiler the trailing edge of wagons' roof lines. This spoiler effectively extends the point at which flow separation (and flow reversal) occurs. The most apparent result is a reduction in the amount of road spray reaching the back window. A more subtle result, and one that the average owner is less likely to notice, is a minor reduction in drag.

Not all aerodynamic devices increase downforce. Some move air from one area of the chassis to another, where it can be more effectively managed. Other devices reduce drag.

Some devices are designed to make a unique styling "statement" without imparting any significant performance advantage. Such statements are subject to varying interpretations. What may appear "cool" to some owners may be considered idiotic by others.

I guess that there's no accounting for taste.

Buyer Beware

The role of air dams, splitters, wings, spoilers and styling aids to improve vehicle performance should be taken into consideration before purchasing any aerodynamic device.

Additional information on lift, drag and devices to improve the aerodynamic peformance of Volvo automobiles can be found in Chapter Six of "The Volvo Performance Handbook".

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The Volvo Performance Handbook & The Gothenburg Bible

Rebuilding ATE™ Rear Brake Calipers

by Paul Grimshaw

This article will outline do-it-yourself techniques for the inspection, troubleshooting and repair of ATE™ two-piston rear brake calipers fitted to Volvo 200-, 700-, and 900-series cars.

History

The acronym "ATE" (pronounced as Ah-Tee) stands for Alfred Teves Engineering, a German firm that specializes in the manufacture of automotive hydraulic components and, most recently, anti-lock braking systems. ATE™ has been an original equipment manufacturer to Volvo for the past 30 years. It was through this relationship that Volvo selected ATE™ rear brake calipers as standard equipment for most 200-, 700-, and 900-series cars.

Caliper Inspection & Identification

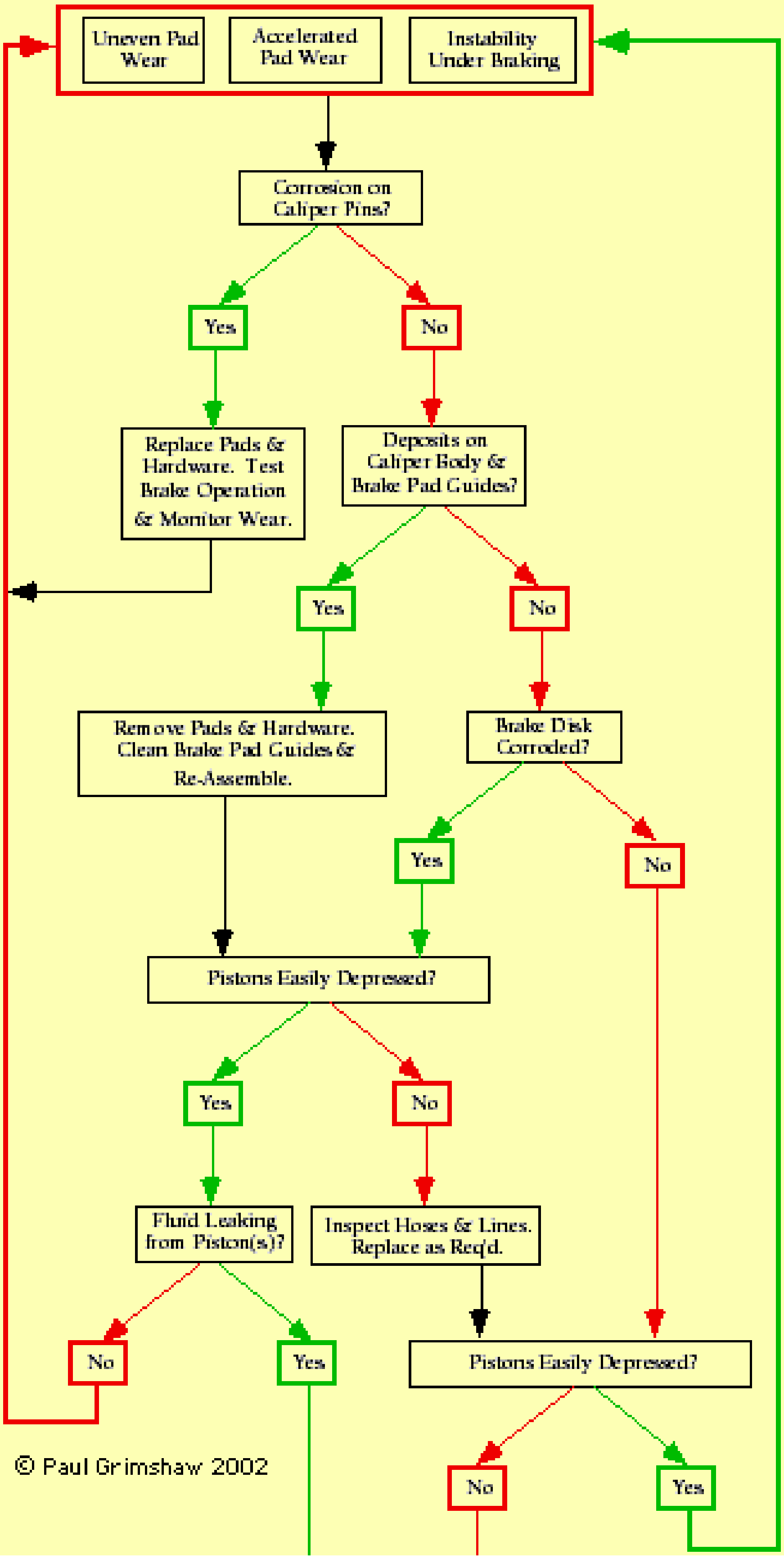
The symptoms of rear caliper failure include uneven or accelerated brake pad wear, presence of corrosion on one side of the brake disk (typically occurring on the inboard side), instability under braking, or leaking fluid from one or more calipers. With the exception of corrosion on the inboard side of the brake disk, which is obscured by the brake backing plate, all other symptoms are easy to spot when the wheels are removed.

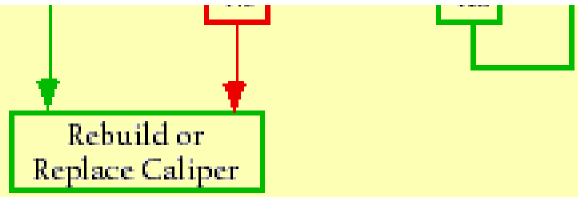
Much has been written on how to differentiate between ATE™, Girling™ or Bendix™ rear calipers. The simplest way is to look for the scripted ATE™ logo on the outside of the brake caliper body. This logo can be found after removing old layers of rust and paint with a steel wire brush.

Another way to confirm caliper models is to refer to the part numbers used during a previous brake job. Volvo part numbers 271702, 271668 and 271824 refer to brake pads for ATE™ calipers. Volvo part number 272643 refers to the pins and shims that make up the ATE™ rear caliper installation kit.

Troubleshooting

The following chart can be used to determine the extent of most ATE™ rear brake problems:





Rebuild or to Replace?

The term "rebuild" is used to describe the process where worn parts are systematically replaced with new components by an owner. This is different than "replace" which involves the process of exchanging an entire assembly with one that is known to be fully functional.

The reasons for rebuilding range from maintaining a high degree of originality and ensuring a defined standard of quality control to refurbishing an assembly that is no longer in active production. The first two reasons make sense where owners have a complete set of hand tools and a substantial amount of practical experience. Parts availability is not a significant concern, since Volvo maintains a complete inventory of new and refurbished ATE™ rear brake components.

The following problems or conditions will, prevent a caliper from being safely repaired by a shade-tree mechanic:

a. physical damage that alters the shape or structural integrity of the caliper;

b. pistons damaged during disassembly or as a result of dirt and moisture within the brake system;

c. bores that are heavily pitted or scratched during disassembly or as a result of dirt and moisture within the brake system; and

d. removal of the special torque-to-yield bolts that join both halves of the caliper body.

Procedures for Rebuilding an ATE™ Rear Caliper

1. Wear the appropriate safety equipment (impact resistant goggles and filter mask).

2. With a small catch basin under the brake assembly, remove the brake line from the caliper. Unbolt the caliper from its mounting point on the rear axle. Remove the caliper assembly, rotating it to drain any remaining brake fluid into the catch basin.

3. Remove the cotter pins from the brake pad retaining pins. Using a small drift and hammer, drive the brake pad pins from the caliper body. Exercise care, as the anti-rattle spring can eject itself from the caliper.

4. Using a pair of Channel Loc™ pliers, press on the edges of the brake pad backing plates. This will safely compress the pistons and allow the pads to be removed. Wiggle stuck pads back and forth using locking pliers. Eventually, the pads will loosen enough for removal.

5. Pack the brake line receptacle with cotton gauze to prevent any debris from reaching internal components of the caliper. Bead blast the caliper to remove all signs of rust. Using compressed air, remove all traces of blast media from the caliper body.

6. Repaint the caliper using high temperature paint. Use thin coats of paint.

7. Using a thin bladed screwdriver or steel scribe, pry the dust caps off of each piston. The dust caps are affixed to the caliper body with a thin steel band. This band is often bonded by many years of rust and carbon build-up. With care and persistence, it can be removed.

8. Remove the pistons from the caliper body. Pistons which continue to move freely within the caliper body can be gently pried-out by using a large screwdriver to apply leverage under piston flange. Work carefully around the edge of each piston, prying them out a little bit at a time. Careful persistence, not force, is required.

9. Seized pistons can be released using a propane torch. Heat the <u>inside of the piston</u> until its surface is a dull red. Allow to cool before attempting to remove the piston using a large screwdriver. Successive heating and cooling cycles may be required to loosen a recalcitrant piston.

10. Inspect the pistons or bores for corrosion or damage. Trace amounts of corrosion can be removed by wet sanding with 1000 grit emery cloth. Take care not to remove metal or distort components.

11. Remove the cotton gauze from the brake line receptacle. Clean the pistons and bores with methyl alcohol (methanol), brake cleaner or fresh brake fluid. Do not, under any circumstances, use petroleum-based products such as WD-40 or gasoline or lacquer thinners such as turpentine.

12. Replace piston seals using new parts obtained from your Volvo dealer or ATE™ wholesaler. Lubricate the seals with a light coating of fresh brake fluid.

13. Place the pistons over the bores, ensuring that the cut-outs on the pistons are aligned downwards at an angle of 30 degrees. Drive the pistons home with firm and even finger tip pressure.

14. Install a new set of pads. Replace the pins and springs using Volvo Caliper Installation Kit #272643.

15. Carefully secure the caliper to the axle using new bolts supplied by your dealer. Re-attach the brake lines and torque fasteners to specification (refer to Volvo, Chilton, Haynes or Bentley repair manuals). Bleed the brakes using fresh brake fluid as specified in your owner's manual.

Servicing Tips

Pistons seize when moisture is allowed past the dust seals. The time taken to carefully install the dust seals will be returned in longer service life.

Avoid the use of pry bars as leverage to retract the pistons or a hammer to "tap" brake pads into the caliper body. Doing so will damage the dust seals.

Don't use brute force to remove pistons from calipers. Heat and patience are the key to success.

Tap gently on the end of the bleeder screw with a copper- or lead-faced mallet before attempting to loosen. If bleed screws are seized, heat can be used to break a corrosive bond.

Don't use generic or "no name" components to repair an ATE™ caliper. Such parts are typically sub-standard.

Never use any petroleum lubricant on brake components. The olefins within such lubricants will distort brake system seals and significantly reduce component life.

DOT 3 and DOT 4 brake fluids are flammable. Ensure that caliper bodies are drained of all fluid before using a torch to loosen a piston.

DOT 3 and DOT 4 brake fluids will remove paint from body panels and damage skin and eyes. Reduce the splash hazard by storing such fluids in closed containers.

Conclusion

The proper function of brake calipers is essential for safety. Owners are encouraged to seek professional assistance when rebuilding brake components.

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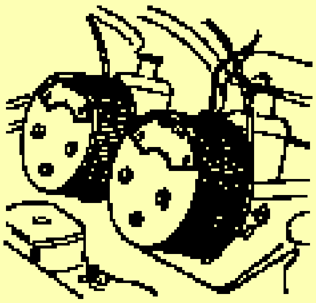
Special Article -

Vintage Cars & Emission Control Regimes

by Paul Grimshaw



Learning to Live with the Dinosaurs

Do you ever notice how time affects perception? It's a common fault that we all experience as nostalgia and logic get muddled in the ever-increasing pace of the world. This leads to conclusions which damn all things new and seek a return to the way things used to be.

It's a common trap -- one which I am prone to every time I see a well-preserved vintage car, twin SU carbs gleaming and a staccato exhaust note brashly challenging the logic of today's politically-correct world with the aroma of benzene and 30-weight oil. Such sights, sounds and smells awake my nostalgic yearning and almost immediately induce a trance -like state while I reflect upon what it was like, or what it could be like (again). That's when logic takes over, snapping me back from the precipice with the force of an opening parachute.

Why should I allow any interruptions to my dream? Could it be that I am not a true automobile aficionado? Read on, but save the damming criticism and e-mail bombs until you have finished the whole thing.

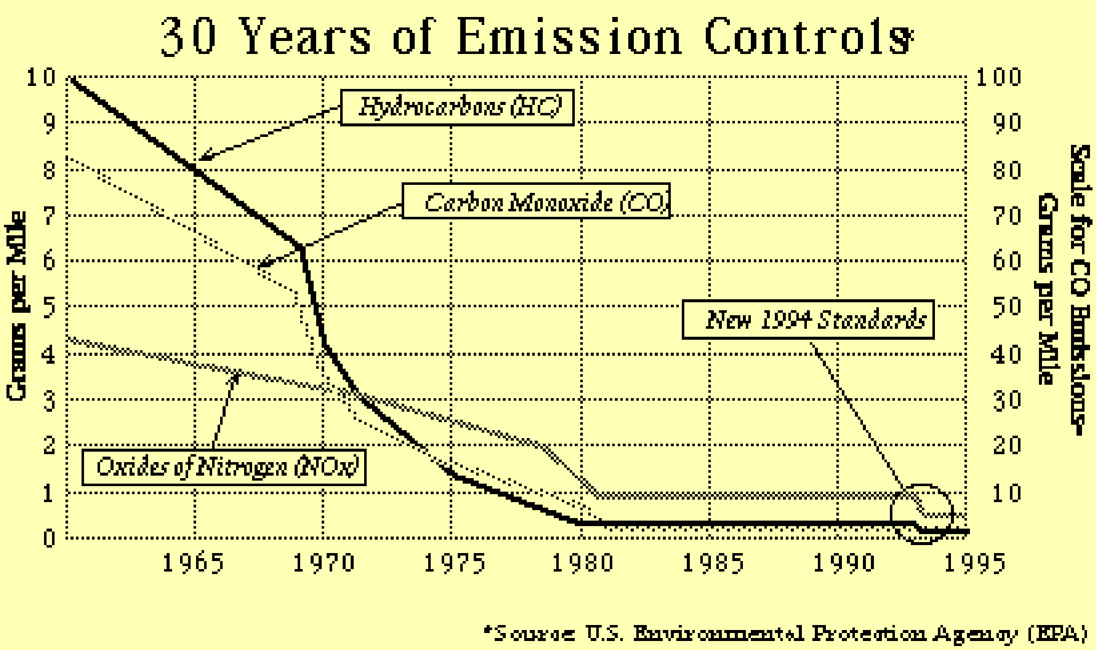
Diverging Points of View

One of the true constants in life is the debate concerning the future of cars on our road. Rabid environmentalists continue to call for the eradication of the automobile, while crackpots yearn for the days of the 8 litre oil-and-gasoline burning dinosaurs to rule the planet again. Government, that great (sometimes befuddled) sounding board of society, is caught in the middle.

No matter what our affiliation, we probably concede that the protection of environment rates as a key area of concern. Not trusting the diametrically-opposed arguments of the radical fringe places us in an awkward position. If automobile emissions have been drastically reduced over the past 30 years or so, can we consciously allow older cars to share the road?

Figures Don't Lie (and Liars Seldom Figure)

A review of the facts reveals that automobile-induced pollution has been dramatically slashed over the years. Since 1960 the propensity for cars to belch nasty combustion by-products such as Carbon Monoxide and Hydrocarbons have been reduced a whopping 98% while Oxides of Nitrogen have been cut by 80%+!



In clinical terms this means that about 50 of today's new cars, if simultaneously running, would emit about the same noxious chemicals as one vintage car. And this assumes that the vintage car is running to factory specification -- something today's newest models must do for 160,000 km in order to gain certification under current Federal laws.

How have such improvements in auto emissions taken place? They've been legislated. Despite the advances made, however, society realizes that quite a few older cars still ply our highways, blunting any advance in emissions control technology. As a result, many are now trying to come to grips with the danger posed by the older (pre-catalyst) cars.

The California Experiment

Recent attempts to improve air quality in certain locales has taken an interesting turn. One Californian gasoline company did its part by purchasing 800 old "beaters" and sending them to the crusher. A random sampling of the cars suggested that the net effect of taking these dinosaurs off the road was equivalent to removing over 10,000 newer cars from the road. The program was voluntary, owners were paid up to $1,000 for their cars, and everyone seemed happy.

Alarm bells started ringing almost immediately. Hysterical vintage car clubs felt that this was the first step in the master plan to remove their cars from the road. While radical environmentalists were only too happy to twist the knife, fringe elements of the vintage car clique started to over-react. I recall reading a quotation from one vintage car owner in Saõ Paulo, Brazil who emphatically stated that emission standards weren't followed where he lived, and everyone seemed happy. Unfortunately, the Editor of the publication in question used the letter as the basis for his argument without realizing that urban air quality in Brazilian cities is notoriously poor! Objectivity was lost, perception overshadowed logic and people started getting silly.

What had been forgotten between the story and the perceived implications was that the "beater" buy-back program had been voluntary and the cars crushed were truly filthy. Taken as it had occurred, the program was a total success and should be expanded. But where do you start and where do you end up? A voluntary program is nice, but eventually an owner will be found who thinks it is his/her god-given right to drive a polluting vehicle.

Collectors Versus Garbiologists

First of all, I believe that the bulk of society (and the true auto enthusiast) is in favour of getting "beaters" off of the road. Such cars are, in the majority of cases, simply rusted-out, oil-burning hulks waiting for either accident or fatal decay to end their careers. Within this automotive segment, common practices such as disconnecting exhaust gas recirculation (EGR) systems and evaporative cannisters combined with over-zealous choke and idle settings to compensate for that "damned leaking" Stromberg or SU carb have rightfully marked these beasts for termination.

The true collectable car is popularly regarded as a higher order of species. Owned by automobile aficionados, these cars are under constant and meticulous care. While it is true that the specifications of their day still make them relatively dirty when judged by contemporary standards, the low mileage traveled by these cars combined with the historical value they represent should guarantee their continued legal use -- assuming that each one is in proper working order*.

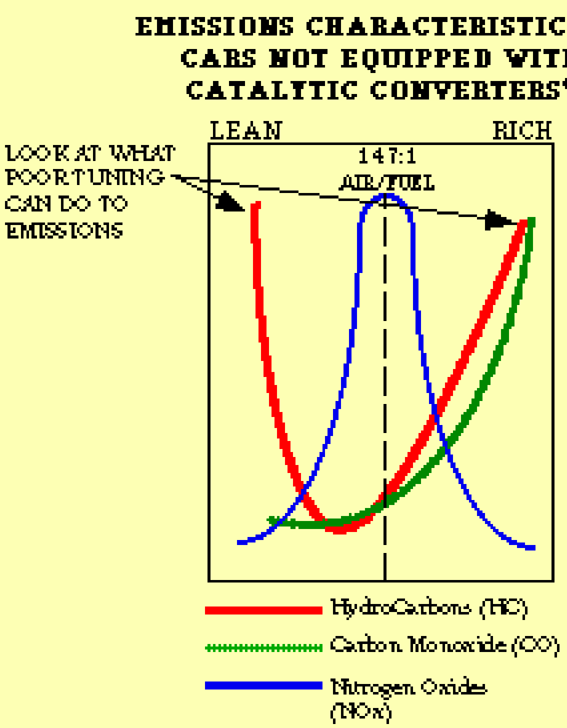
But what of the newly-acquired and yet to be restored classic? The reply is simple: They should be kept off the road until the mechanical components can be restored to original specification. Besides, any real automotive enthusiast would be embarrassed to be seen driving a jalopy held together by chicken wire, dripping a rainbow of lube oil/coolant and billowing smoke.

*Time for a Reality Check

Although my proposal has made provision for the continued use of "collector" cars, you'll note the asterisk qualifying my endorsement. I believe that it is fair to require each vintage car applying for road use to submit to an annual smog check. Such a program, however, raises an interesting problem: Will the tinkerer who tunes his/her car by ear be able to get a car certified? Probably not!

All motor vehicles, contemporary and vintage, are designed to efficiently operate within very narrow tolerances. To ensure perfect air/fuel mixtures, an exhaust gas analyzer must be used when setting up a carb. Similarly, obtaining the maximum energy from every drop of gasoline requires the use of a timing light and dwell meter to set the spark to within 1° or less of specification. To do it any other way is just guessing. After all, if all of our olfactory and auditory functions were able to discern imbalances in engine performance, engine knock, idle run-on and spark plug fouling would simply not exist.

If you're still skeptical, have a look at the emission chart and imagine what the consequences could be if your vintage car was mistakenly (or intentionally) set to run a little rich or lean.



Wanted: One Bullet-Proof Vest

I know that what I propose will not make me more popular. The radical green fringe will damn me for even suggesting that cars have a place on our roads. Fellow vintage car owners will suggest that any proposal to scrap cars infringes on the "rights of the individual". At any rate, the salty e-mail will be interesting to read.

Whatever the outcome, vintage car owners must face the reality of the 90s. Griping, bitching and fighting public concern will fail just as it did for the chemical and logging companies during the 1980s. If you wish your voice to be heard, it must ring with reason and good judgement. Spend the time and money maintaining your engine's components. Cut loose the oil burning hulks! Silence the backyard grease-monkeys! Introduce sound engineering. Apply attainable and realistic standards. Above all else, seek the middle ground. It soon may be the only place above the water line.

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Special Article -

Responsible Engine Tuning

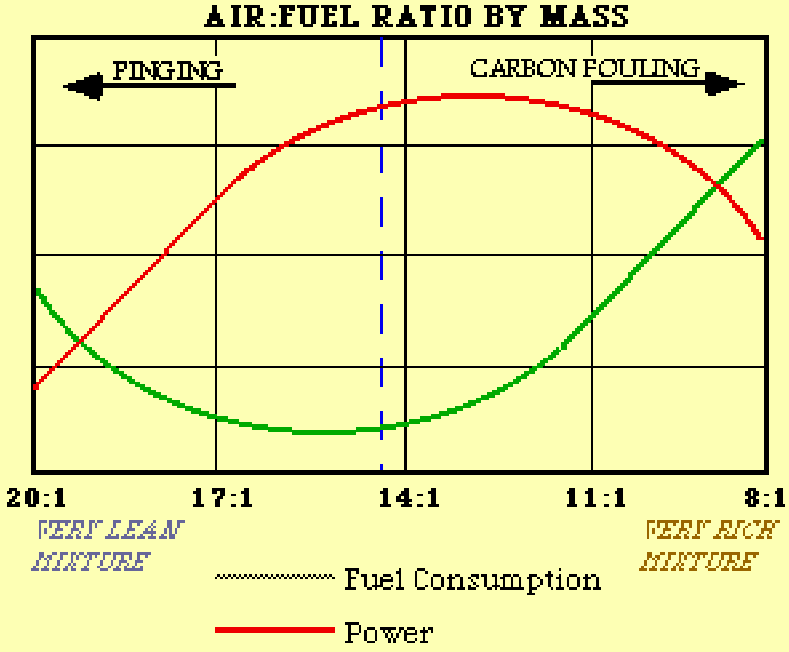
by Paul Grimshaw

"It's never what you do, it's how you do it" goes the old saying. While there is no escaping the fact that all automobiles (gasoline or electric) are responsible for pollution, the degree at which they mess up our planet directly relates to how they are used and maintained. If your car hasn't had a tune-up, spark plug change or fails to operate like the day it was purchased, it could be releasing up to 300% more pollutants into the atmosphere than the manufacturer intended.

This article will examine the causes of noxious emissions from gasoline powered vehicles and will discuss what you can do to minimize pollution by keeping your Volvo's engine management system or mechanical systems in tune.

The task of any fuel management system is to mix a given amount of fuel with a quantity of air to create conditions suitable for combustion. Although just about any fuel/air mixture is capable of burning, contemporary automotive engineers attempt to design a system capable of extracting the maximum power from the least amount of fuel. This is especially true of automotive engineers at Volvo who have always designed small, efficient engines (even when the trend has favoured large 8-cylinder motors).

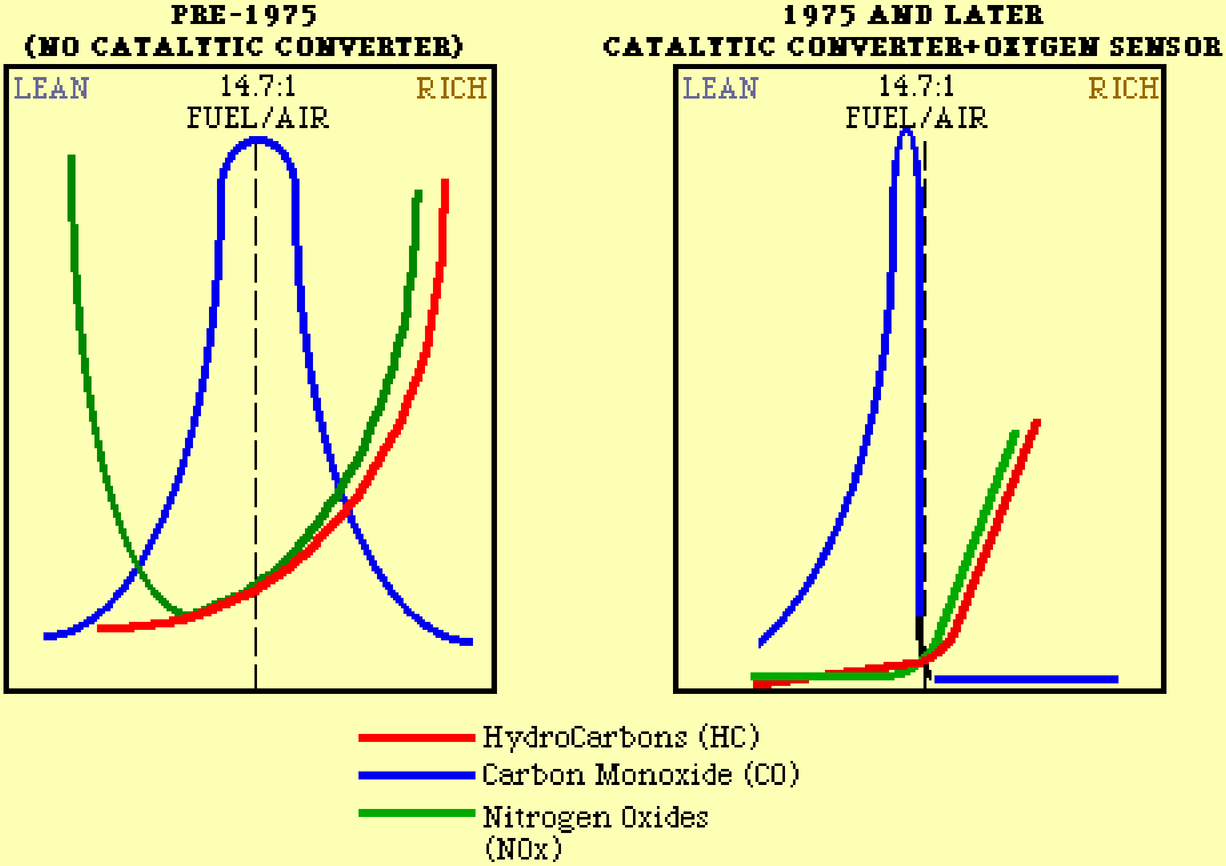
Within the confines of an internal combustion engine, air/fuel mixture is important since an overly weak mixture, while efficient, can lead to destructive "pinging" or pre-ignition. On the other hand, using a mixture too rich in fuel can carbon foul the engine and deliver poor fuel economy. Striking a balance between lean and rich mixtures to achieve both an efficient and powerful blend is not as easy as one might think. As you can see on the graph below, choosing a mixture which results in maximum power and minimum fuel consumption is impossible. There does exist, however, a range of fuel/air ratios where acceptable power/economy compromises can be made.



While the curves on the show that a range of combustible mixtures yielding good power and acceptable fuel economy can be found, each particular mixture results in noxious emissions in one form or another.

Gasoline is blended from the Parafin, Napthene and Aromatic Series of hydrocarbons. As the Greek word "hydrocarbon" implies, both Hydrogen and Carbon are the main elemental constituents of gasoline. Air, on the other hand, is itself a cocktail of elements. The air we are breathing right now contains about 78% Nitrogen, 22% Oxygen with traces of Argon, Xenon and a host of exotic elements. When the substances we know as gasoline and air are mixed, compressed and ignited, such as in a car engine, chemical bonds are broken (releasing energy) and reformed, creating new chemical compounds. When you change the relative quantities, or the mixture of fuel and air, the concentration of certain compounds change.

As the diagrams below show, the quantity of polluting exhaust chemicals vary with the fuel/air mixture in cars with, and without, catalytic converters and oxygen feedback sensors.



In addition to the Lambda Sond and a catalytic converter, certain Canadian B21A, B21F and B23E engines were fitted with Pulsair, a system which introduces air into the exhaust system to promote burning of emissions. A visual check of the hoses for signs of cracking is usually all that is required to verify the system is operational. If you are in doubt, unplug the Pulsair hose at cleaner (just to the left of the bottom of the battery) while the engine is running. If you can feel a vacuum on the hose when you place your hand over the opening, the Pulsair is probably in good working order.

Regardless of your opinions on exhaust emissions, the time is fast approaching when you will have to get your car "environmentally certified" at regular intervals (it's already part of the safety check when registering a vehicle in many states and provinces). Adding to the pressure to invoke regular testing, several transportation studies have shown that the majority of vehicles on the road are out of tune (newer cars included).

I won't use this forum to debate the logic of vehicle emission controls in light of few, if any, regulations governing smoke-stack emissions. But I will urge readers not to use the common cop-outs that "you don't drive your car enough to make a difference", "the cost of cleanliness is not worth the effort", or "I'm only going to keep the car a while longer".

Action and perseverance solve problems, apathy and denial accomplish nothing.

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Special Article -

Graduated Licensing - A Requirement for All

by Paul Grimshaw

How many readers remember their first licensed "solo" driving experience? I certainly remember mine. After successfully manoeuvring around the streets of my hometown and executing several textbook three point turns and that classic of all driving tests, the parallel park, I had the chance to drive home in blissful solitude.

Of course what I fail to mention was that the adjectives associated with my driving exploits of the time were based on perception rather than reality. In truth, a crisp parking job was one which involved less than 5 minutes, avoided severe impact with the cars around me and didn't attract the gaze of curious onlookers. Besides, if anyone did stop to watch, I'm sure it was to observe my technique.


"I CAN DRIVE BETTER THAN FANGIO"

Times really haven't changed. Driving is an activity that we all take rather personally--resulting in those occasional warps of perception necessary to face each new day with confidence. Indeed, if our self perceptions are challenged (either by the rumour of refresher training, or a warning from the local constabulary) we often react negatively. Freud may have had a medical term for this phenomenon, but Jackie Stewart kept it simple when he pointed out that driving, like love making, does not readily abide criticism.

In making this observation, Mr. Stewart underscored the very reason why the vast majority of drivers are not professional; it's difficult to sharpen skills when constructive criticism isn't taken to heart.

Unfortunately, lives are lost when perceptions and inexperience mix.

HI! I REPRESENT THE GOVERNMENT
(LEAVE THE DRIVING TO US, JUAN MANUEL)

Governments are just as guilty of upholding ridiculous perceptions to protect their own fragile positions. For our entire motoring lives we have heard slogans like "Speed Kills". Although this statement is simplistic enough to be believed when viewed through the bottom of Coke bottles, anyone with a casual knowledge of physics knows that two objects travelling in the same direction at dizzying speeds cannot collide unless the pilot of one (or both) of the objects makes an error in judgement. (If you doubt that accidents can occur in this manner, erect a lawn chair beside the Queensway on any wet, snowy, dry or sunny day.)

The fact is that poor judgement turns even simple driving situations into disasters. To the government, however, providing drivers with the proper training appears to cost money while writing speeding tickets generates money. Wrapped up in this conspiracy, insurance companies have jumped on the bandwagon, linking rates to our current roadside taxation programme. The result is a system which seems to feed on its own inadequacies.

A BITTER PILL TO SWALLOW

If constructive criticism and driver education is the medicine, how do we administer it? This is an interesting question in itself since we live under a series of perceptions which is leading to our collective downfall. Right now it's easy to be armchair philosophers and suggest that it is only the young who need driver education. Under such a programme, we would once again be turning out drivers who perceive themselves to be masters of the wheel as I once did.

To say that an entire cradle-to-grave, government sponsored driver education system would work would be equally short-sighted. None of us are advocates of crushing taxes. If, however, we urged our governments to set standards for levels of driver training beyond the basic licensing programme, driving schools would see the benefit of incorporating these standards into their commercially-available programmes.

STEERING OURSELVES CLEAR OF THE BRINK

Despite the occasional re-emergences of my alter ego, I am certainly no expert. From what I have seen on the road, however, any graduated and progressive system would be better from what we have now. A suggestion for the future:

- 365 DAY LEARNER'S PERMIT-PROVINCIALLY RUN

Must be 16
Must be under supervision of adult (+18)
Day only
Medical Certificate signed by M.D.
Zero Alcohol Tolerance

- BASIC DRIVER TRAINING

Traffic Rules
Basic Mechanics (change tires, bulbs, belts & check tire pressure, oil)
General Driving Instruction & Test
Zero Alcohol Tolerance
RESULT--Basic Driver's License (daylight hours only)

- LICENSE LEVEL TWO (for drivers w/2 yrs experience or more)

  Rules Refresher

Intermediate Mechanics (braking systems, drive line types, engine types, passenger/equipment loading, centre of gravity)
Intermediate Driving Theory & Test (refined threshold braking, controlled acceleration, accident theory, basic collision avoidance)
Level I First Aid
RESULT--Intermediate Driver's Licence (day/night)

- WINTER DRIVING COURSE-PRIVATELY RUN (for drivers w/2 yrs experience or more)

Skid Control/Threshold Braking as it applied to season
Acceleration Control
Precision Cornering
Defensive Driving
Level II First Aid
Road Test

- HIGHWAY/AUTOROUTE DRIVING COURSE-PRIVATELY RUN (for drivers w/2 yrs experience or more)

Skid Control/Threshold Braking as it applies to season
Evasive Manoeuvring/High-Speed Cornering
Defensive Driving
Advanced Mechanics (braking systems, suspension dynamics, capacities & capabilities, accident theory, advanced collision avoidance)
Level II First Aid
Road Test

- ADVANCED DRIVING CERTIFICATE

Must have completed all of the above courses
Must pass a written exam
Must be accident (fault)/conviction free for 5 years
Medical Certificate signed by M.D.
Result: Full Insurance Rebate unless voided
by accident record

- REVIEW PROCESS EVERY 20 YEARS

Rewriting applicable exam:(Basic/Intermediate/Advanced)
Medical Certificate signed by M.D.

People arriving from another jurisdiction with a recognized and valid driver's license would be exempt from the Basic and Intermediate Programmes. They would, however, be required to take the privately available courses to obtain an Advanced Driving Permit and the insurance benefits those accredited drivers enjoy.

Such courses would cost you and I a few dollars but the price could be defrayed by insurance benefits (Even $50.00 (5-10%) off every premium for the next 40 years would add up to an incredible amount!). Would the insurance company play along? Of course they would if pressured into logic by a motivated government. Despite all of the bellowing, underwriting automobiles still provides insurance companies and their stockholders with an acceptable profit margin.

After once again having solved the problems of the world from my computer keyboard, I'm taken back to how it could have been for my first solo drive :

Sure I'd still be that famous five-time World Driving Champion Juan Manuel Fangio, skilfully aiming my Mercedes W196 down the straights at the '57 German Grand Prix.

Okay, Okay....maybe in reality a good parking job would still be the one that took under 5 minutes. But the ride home from my driving test would not have been entirely blissful, since I'd know that more study and experience was required before I could take a girl out for an evening date. After all, what's a World Driving Champion without a social life?

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Photo Essay -

Chronology of Volvo Styling

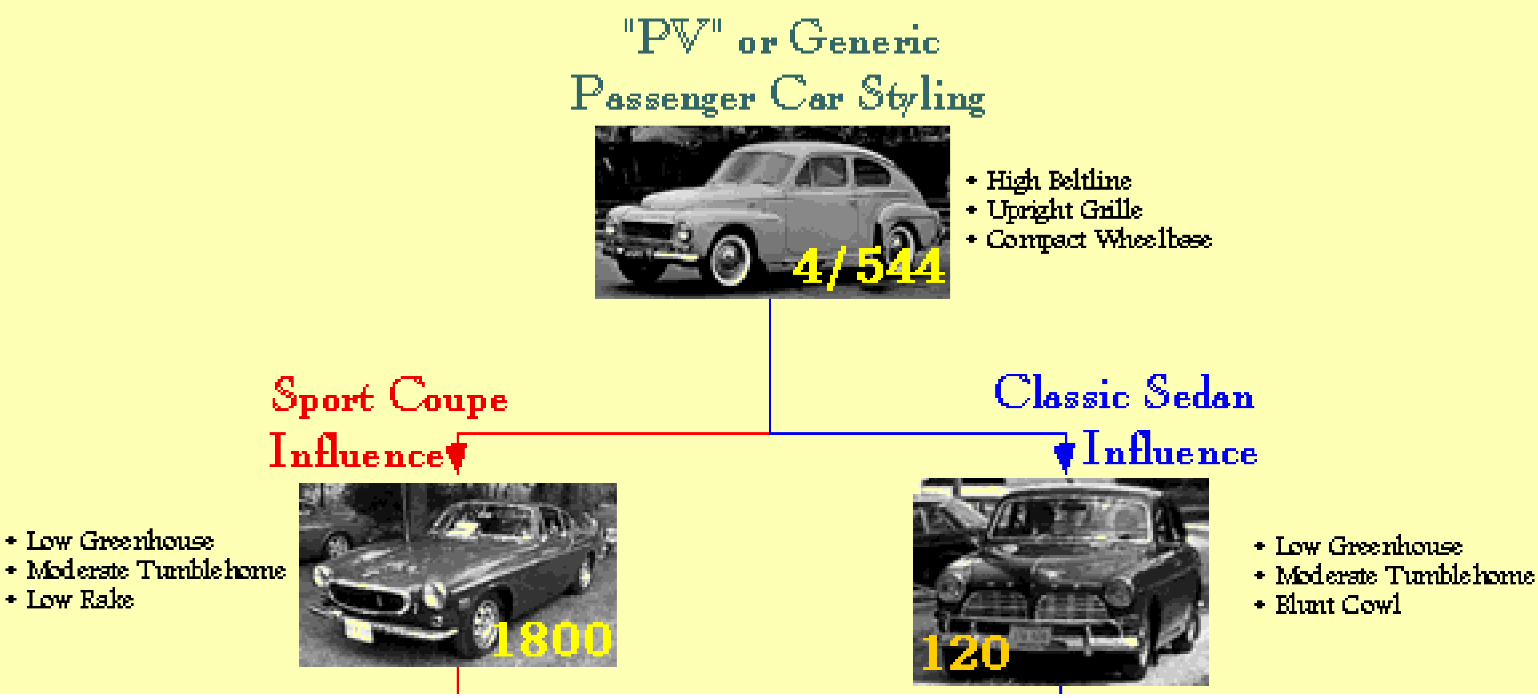
by Paul Grimshaw

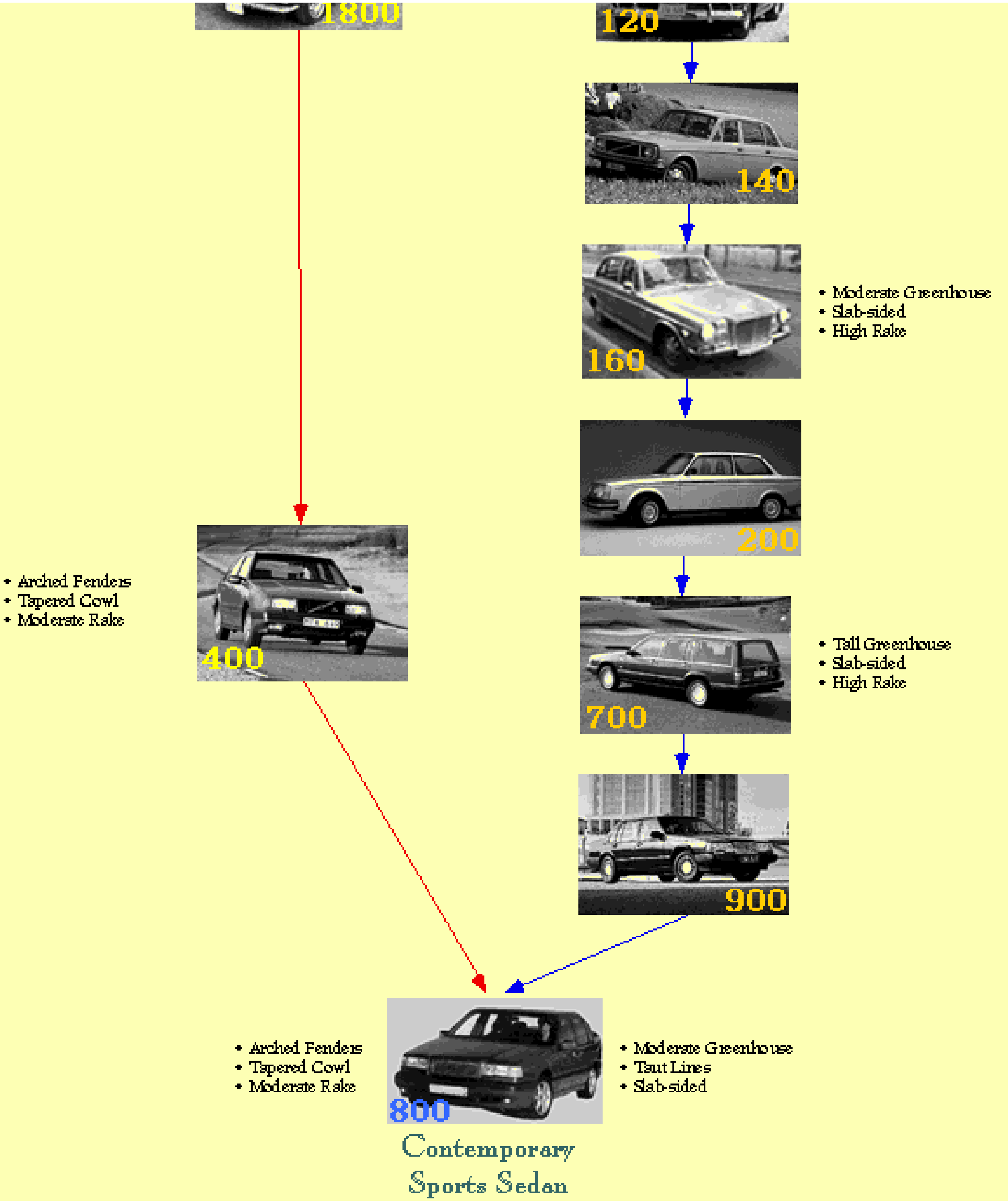
There are many who believe that Volvo's recent styling marks a corporate renaissance; a single styling theme that embraces the cues of previous designs.

These cues can be traced back to the PV 444 and 544 -- sedans that provided a departure point from which trendy coupes and classic sedans were developed.

The introduction of S/V 40, 70 and 90 represents a harmonization of these two stylistic forces.

Contemporary Volvo cars feature taut hood and fender lines that flow into smooth greenhouses and softened rear facia. The effect is a powerful image of dependability and vitality.





© Paul Grimshaw, 1998 *(Styling Pure Volvo!)*

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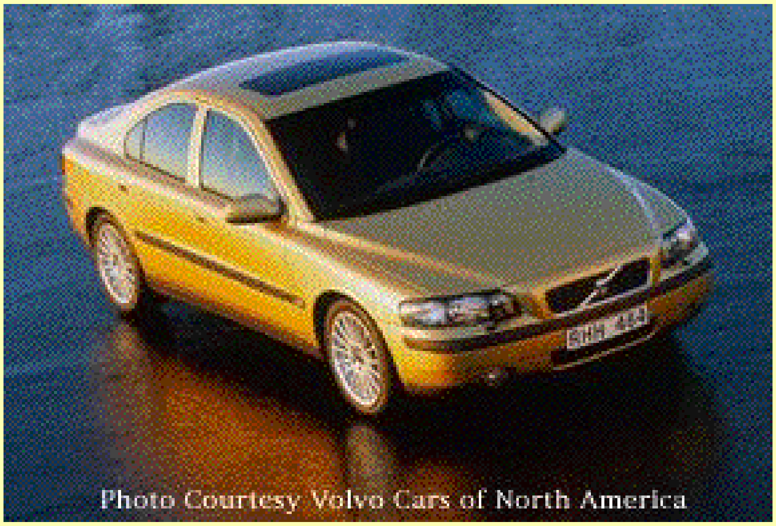
The Volvo Performance Handbook & The Gothenburg Bible

Savvy Engineering for the Socially Responsible - A Technical Review of the 2001 Volvo S60

by Paul Grimshaw

The following article was published on January 26th in "The Ottawa Citizen's" Wheels Section:

Any company's quest to deliver a rewarding car to the motoring public is an incredibly complex task that requires equal parts of engineering expertise and enthusiast's élan. This is an even greater challenge for Volvo, a company better known for its advances in automotive safety than its ability to deliver passionate products. Regardless, the S60 incorporates enough interesting technology to captivate the interests of technophiles and driving enthusiasts.



The S60 chassis is based on a front-wheel drive platform that has been under development by Volvo designer Peter Horbury for several years under the code name P2. Originally intended to enter series production before the last generation 70-series sedans and wagons, the project was delayed in the wake of Ford's $6.5 billion acquisition of the Swedish company announced on January 28th, 1999.

The car's wheel base, at 106.1 inches, is more compact than other models in the Volvo line. Contrasting this are 61.1 and 60.9 inch front and rear tracks that are comparable those of the larger 70- and 80-series cars. This wide track is complimented a four-link fully independent rear suspension.

Using a classic double wishbone set-up as the central theme, Volvo uses a large trailing link to maintain correct suspension geometry for better tracking at highway speeds. One of the three lateral links uses the torque from the rear stabilizer bar to adjust toe during heavy cornering. The result is more predictable tracking by the rear wheels during evasive maneuvers and very rewarding handling for those who enjoy driving at the limit of adhesion.

This suspension layout is thankfully carried over to other Volvo models which had previously relied upon a twist-beam rear axle design that probably appealed more to cost-conscious corporate accountants than enthusiast engineers or discerning drivers.

The S60's grip is further enhanced by wheel and tire packages measuring 195/65 HR 15, 205/55 HR 16, and 215/55 HR 16 in standard and two optional trim levels. The more aggressive and lower-profile 16 inch wheel and tire packages promise crisper turn-in for those accustomed to sports sedan handling.

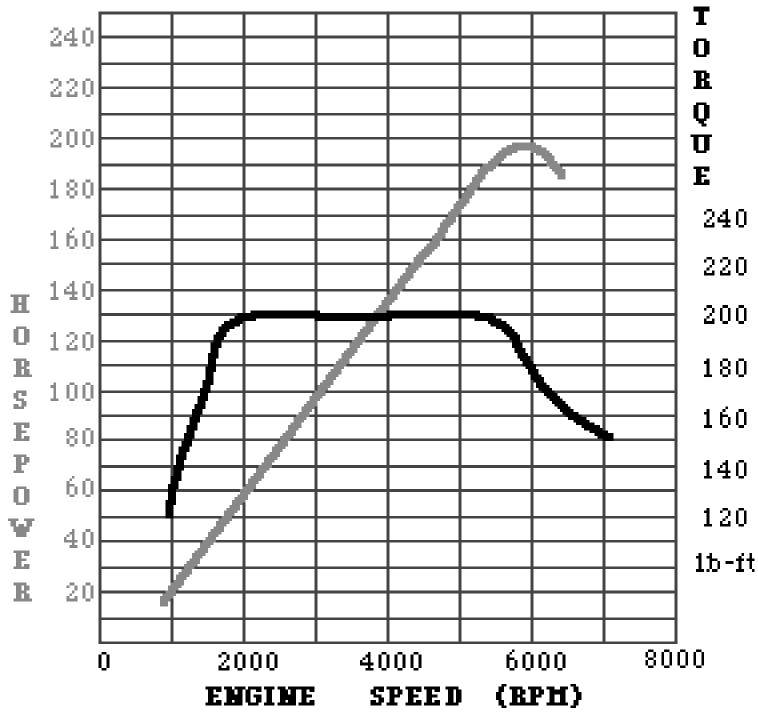
Although the S60's willing chassis and tuned suspension has the features expected by technophiles, available engine and transmission packages reflect Volvo engineers' determination to capture the hearts of enthusiast drivers.

Drawing heavily from its modular engines developed in the early 1990s with Porsche engineering assistance, Volvo's "RN" engine family delivers high-performance and low emissions. Three of these engines are available with the S60:

ENGINE	DISPLACEMENT	HORSEPOWER	TORQUE
B5244S	2.44 litres	168 bhp @ 5900 rpm	170 lb-ft @ 4500 rpm
B5244T (Low Pressure Turbo)	2.44 litres	197 bhp @ 6000 rpm	210 lb-ft @ 1800-5000 rpm
B5234T (High Pressure Turbo)	2.30 litres	247 bhp @ 5200 rpm	243 lb-ft @ 2500-5200 rpm

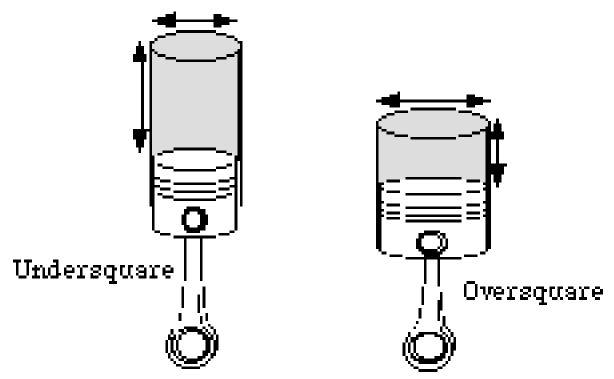
Figures alone do not adequately address the incredible effect that variable intake valve timing, dual runner intake manifolds, and integrated spark and fuel injection have on broadening the engines' torque curves. Top-of-the-line high-pressure turbocharged engines are capable of delivering 240 lb-ft of torque from 2300 to 5300 rpm. The low-pressure turbo engines are very impressive performers, with a little over 200 lb-ft of torque available from just above the engine's idle speed to over 5000 rpm:

The B5244T Low Pressure Turbocharged Engine Delivers Impressive Torque Across a Broad Rev Range



Even in normally-aspirated, base engine trim, gobs of torque can be found anywhere throughout the rev range!

Careful engine design and impressive emissions control technology provide socially responsible underpinnings for Volvo's newest five cylinder engines. Today's designs are based on an "undersquare" cylinder arrangement in which the swept volume of each piston is longer than it is wide. This reduces the distance that the flame path has to travel before igniting the air/fuel mixture. It also minimizes the risk of harmful detonation at the 8.5:1, 9.0:1 and 10.3:1 compression ratios used on the S60's available high-pressure turbocharged, low-pressure turbocharged and normally aspirated engines respectively.

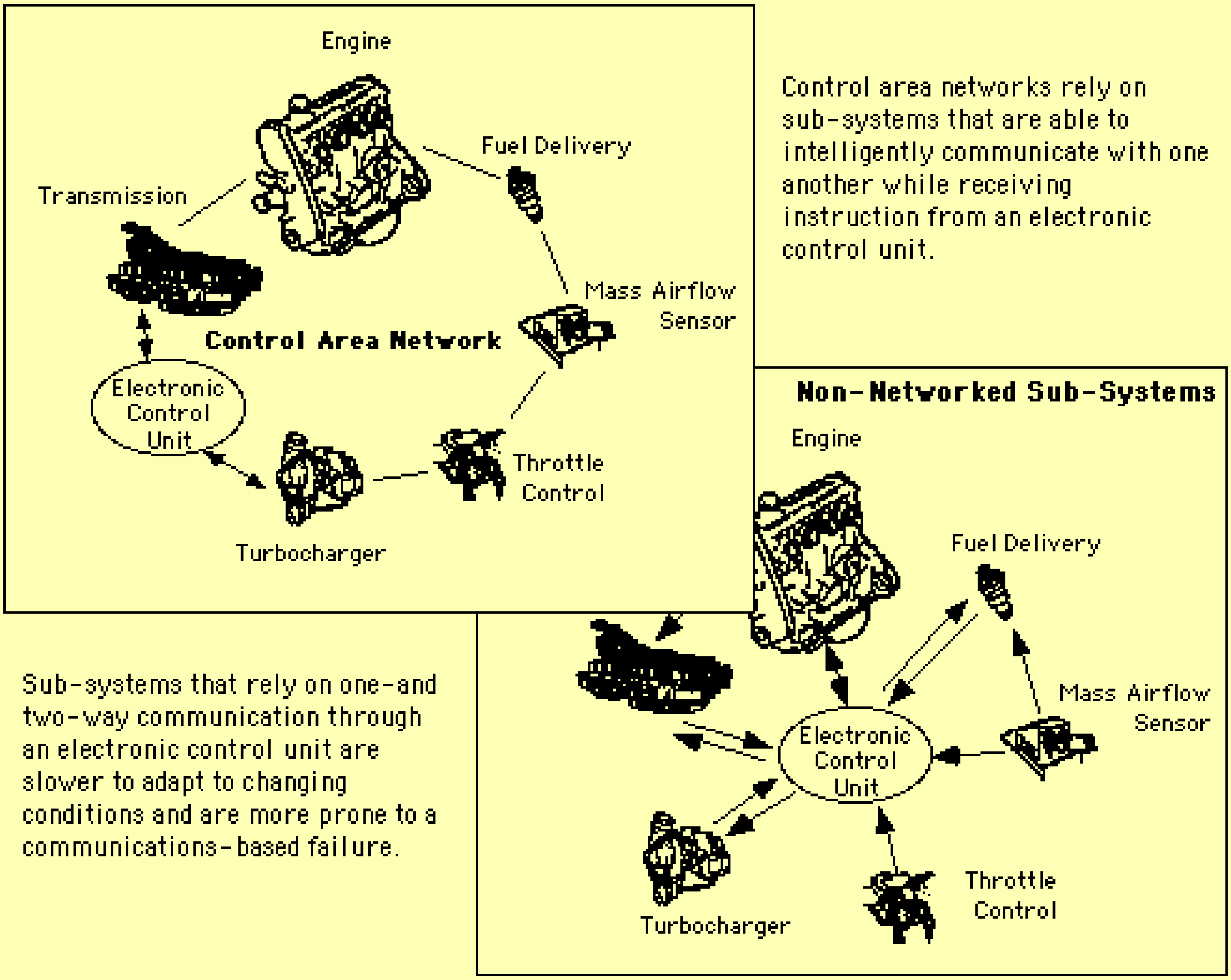


For a given displacement, undersquare cylinder configurations minimize the risk of detonation at higher compression ratios. Their shorter lateral flame paths also promote better burning to reduce hydrocarbon emissions.

The size and placement of the catalytic converter and twin heated oxygen sensors allow the normally-aspirated 2.4 litre engine to be designated as a "Ultra-Low Emissions Vehicle", or ULEV, for the stringent California market. Its effect in Canada, while not specifically mandated by provincial or national regulations, is one that will nevertheless be appreciated by Mother Nature. All other engine variants meet broader US and Canadian standards for National Low Emissions Vehicles (NLEV).

Receiving, interpreting and adjusting engine management and emission control devices is increasingly complex. Since 1992, Volvo has been incrementally incorporating Control Area Networks (CAN) into its automobiles. The latest version of this technology is available in the S60, which uses a high-speed computer network to control the throttle-by-wire system.

Network technology delivers three distinct advantages to automobile manufactuers, owners and repair facilities. First, a reduction in the amount of wire cabling needed for a networked automobile speeds assembly-line processes. Second, the smaller numbers of connectors and shorter cable runs reduce the possibility of short circuits and intermittent grounding that can occur as the car ages. Third, control area networks facilitate diagnosis of problems as a scan tool (or properly configured PC) can probe almost any of the car's electronic devices from a number of access points in the network.



The S60's control area network technology is not unique among car makers, but its use by a relatively small player in the market demonstrates that the merging of electronic and mechanical technology into smarter machines is accelerating.

Perhaps the most elegant example of technology in the S60 line is a specially coated radiator that is designed to reduce ground level ozone. Called "PremAir" the system consists of a coating on the fins of the radiator that, when operating at normal engine temperatures, chemically reduces up to 75 per cent of the ground level ozone contained in the passing air. PremAir is a very innovative way to use cutting edge emissions control technology without introducing unnecessary complexity, undermining performance, or affecting fuel economy!

Volvo offers two transmissions to get the S60's power to the road. Arguably the most popular for the North American market will be the very compact Aisin Warner 55-50 five speed automatic transmission. This transmission features a particularly high final drive of 2.44:1 to offset its lack of overdrive ratios. Options for the Aisin Warner transmission include a driver-selectable shift gate called Steptronic that allows enthusiast drivers to aggressively change gears within the rev limits imposed by the transmission's electronic brain.

More sporting drivers of normally-aspirated and high-pressure turbocharged models may opt for Volvo's own M56H five-speed manual transmission. This transmission has been in use since the introduction of the 850 in 1991. Fourth and fifth gears are overdrive (0.87 and 0.70:1 respectively) for quiet and fuel-efficient highway cruising.

The Stability and Traction Control system, or STC, remains the final arbiter in getting the S60's engine power to the tarmac. STC uses the anti-lock braking system (ABS) to better control spinning drive wheels below 40 km/h. Above 40km/h, however, the system reduces fuel to the engine to assist driver control in slippery conditions. Unlike earlier traction control systems in use throughout the automotive industry, Volvo's STC intervenes unobtrusively as the limit of traction is approached.

At all other times, the S60's Teves ABS controls the four wheel disk brakes to minimize the risk of wheel lock. Single piston sliding calipers are used in combination with ventilated 12 inch front and solid 11.3 inch rear rotors. Pedal travel is acceptable for this class of car, but a disturbing "dead spot" in the first few inches of pedal travel challenges smooth modulation. Whether the dead spot, which has been noted by other members of the automotive press, can be attributed to the design of the brake booster/master cylinder or the Electronic Brake Force Distribution (EBD) system fitted to the test car is unknown.

Like all Volvos past and present, the S60 features a number of passive and active safety features to protect the driver and occupants in the event of an accident. Dual airbags and front-seat side-impact head and torso airbags protect those most vulnerable to the effects of frontal impacts. All passengers, regardless of where they are seated, can depend upon three-point seatbelts (a Volvo invention that made its international debut in the 1959 Volvo 544) and the patented reinforced cabin, known in factory circles as the "Safety Cage".

Compared with models of the past, the Volvo S60 is a technological tour de force that offers an alluring blend of excellent engineering and enthusiastic engine tuning without sacrificing the company's reputation for safety. Think of it as an artful Swedish compromise for a discriminating North American market.

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Power to Weight Ratios -

Tuning a Volvo into a Porsche

by Paul Grimshaw

The title of this article is very misleading. It's impossible to "tune" a Volvo into a Porsche.

Adding the first few horsepower is easy. Carefully choosing suspension components can yeild some great handling. But it's simply unrealistic to expect that a few thousand dollars in parts and backyard know-how will turn a family wagon into a vehicle with comparable performance to that of a purpose built sports car -- no matter what the tuner mags will try to tell you.

It's also nigh on impossible to turn a vintage Volvo into a "streetable" machine capable of out performing Gothenburg's current crop of turbocharged, multi-valve, traction-controlled techno-wonders. So stop trying.

The table below illustrates the significant impact that engine technology has had on the performance potential of our most cherished marque -- seven of the potentially quickest Volvos on today's roads were manufactured within the past 10 years. A vintage Volvo would either require a severe diet or substantial modification to keep pace with the newer, mostly turbocharged, engines.

Model & Designation	Engine & Trim	Power (Bhp SAE Net*)	Curb Weight (lbs)	Power to Weight Ratio (lbs/Bhp)	

S80 T6	B6304 T6	268	3700	13.8
S60 T5	B5234 T5	247	3500	14.2
850 T5R	B5234FT	240	3400	14.2
850 T5	B5234FT	222	3400	15.3
740/760 Turbo	B230FTI+	188	3200	17.0
960	B6304	201	3500	17.4
S80	B6304F	201	3600	17.9
XC90 AWD T6	B6304 FT T6	268	4740	17.7
240 Turbo	B21FTI	162	3000	18.5
740/760 Turbo	B230FTI	168	3200	19.1
C70	B5234FT T3	190	3700	19.5
S/V 70 AWD	B5254T	190	3700	19.5
850 GLT	B5254F	168	3300	19.6
940 Turbo	B230FTI	168	3400	20.2
240	B230FX	140	3000	21.4
164E	B30E	160	3500	21.9
122 GT	B20B	110	2500	22.6
740 DL/GL	B230FD	140	3300	23.6
240 Turbo	B21FT	127	3000	23.6
1800	B20B	100	2400	23.9
164	B30F	138	3500	25.4

Q U I C K E S T

S L O W

760 GLE	B28, 280F	130	3300	25.4	E
260	B27F	125	3200	25.6	S
240 DL/GL	B230F	114	3000	26.3	T
740	B230F	114	3200	28.1	
544	B18B	77	2200	28.8	
242GT	B21F	101	3000	29.7	
544	B16B	72	2200	30.4	
122S	B18D	77	2400	31.4	
* Based on manufacturer's SAE Net ratings or equivalent. Pre-1972 figures: (SAE Gross * 0.85)= nominal SAE Net					

To keep your brick competitive, you could add 57 horsepower to your 740 turbo or just over 100 horses to the base atmo model. What about putting your 240 on a diet? You'll need the automotive equivalent of an Ultra Slimfast menu to pare1400 lb from the chassis if your objective is to stay nose-to-nose with an S80 turbo. Maybe a 10.5:1 rear axle ratio would help?

Perhaps you have a hot new S80 turbo and you're itching take on something quicker. You'll need at least another 100 horsepower to be a contender in the stoplight wars against the Audi S8 (11 lbs/bhp), C32 AMG (10.61 lbs/bhp) or BMW M3 (10.21 lbs/bhp) or M5 (9.5 lbs/bhp). Just where you'll find that much power, in a relable state of tune is unclear as it's difficult to think of any roadworthy engine that pumps out 130 Bhp per litre of displacement or has a Brake Mean Effective Pressure of 300 psi.

Such objectives are not realistic. Nor are they going to be reliably acheived without the investment of huge sums of money, the majority of which will be spend on technical development costs.

Tuning can, however, provide some significant performance gains that will make your car more responsive to your particular needs. Meeting these needs will justify long-term ownership which, when combined with sound maintenance, can provide you with an economic advantage. This advantage will make it easier for you to own, operate and modify your car.

Take heart in knowing that Volvos are fine automobiles with performance that equal or exceed all but their rarest contemporaries. The cars are relatively easy to tune for significant increases in performance. While this does not imply that it is realistic to seek supercar performance out of a vehicle originally designed as a luxury coupe, sedan or wagon, a carefully modified Volvo can reward its driver in more than just the stoplight wars.

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An Author's Guide to Building an Automotive Reference Library

By Paul Grimshaw

Good books are like fine wine. They provide equal enjoyment from atop a dusty shelf as they do from a fireside table. They age gracefully, with special vintages or first editions promising a dated, but nevertheless unique, experience.

Like wine, books are judged by their ability to compliment a particular occasion. Just as it may be imprudent to uncork a vintage Rothschilds before throwing a few "shrimps on the barbee", a shadetree mechanic may wish to consider the merit of dropping couple of hundred dollars on technical books in preparation for a simple oil change.

In either case, discretion is the key.

The aim of this article is to highlight a strategy for building an economical technical library. It is in this regard that 20 years of shadetree mechanics, 15 years of Volvo ownership, and seven years of technical writing have reinforced my appreciation of technical writing.

Technical Writers Are Dull, Not Boring

A good technical writer must be able to explain the mechanical world. A good novelist, however, is characterized by a superior ability to embellish upon what we hold to be true. Both may be writers, but they operate in different worlds.

Technical writers, and many publishers of their works, concentrate on factual content first and jacket design last. This explains why most technical books are adorned with sans serif fonts and cut-away drawings. Those rare individuals with artistic talent sometimes choose to enhance their books with a picture of some arcane contraption that anyone, with the help of a hundred pages of text and a few scatter graphs, will recognize. In general, however, the Lancaster County look is "in".

The layout of the contents of a good technical book should resemble the dashboard of a Ferrari 250 GT California Spyder - simple, uncluttered and purposeful. A few quirks may be evident, such as the ignition switch on the left hand side of the steering column), but the layout must not get in the way of interpreting important data.

Regardless of the technical work, a glossary serves as the reader's reward -- particularly in a complex theoretical study or repair manual when the terminology, spelling or level of technical ability of the target audience can vary. If you can easily understand what is written in the glossary, you will certainly be able to grasp the most complex technical issues raised in the book.

The bottom line is not to judge a technical book by its cover. Instead, choose a book that covers an appropriate or interesting subject, scan the layout and examine the glossary. If you're buying from a catalog retailer, stick with respected authors or publishing houses.

Better yet, ask a friend. Preferably one that owns a car that runs!

Dawn Perignon

Cheap technical books have the same effect on the human body as cheap wine. They're easy to purchase, but devouring their contents can leave one blind or befuddled. Value, not cost, is the key to obtaining either the right technical book or a pleasing grape.

Value is usually proportional to utility. Basic mechanical books, such as those that describe the general principles of automotive design, are good for the first time buyer. More focused books on design or engineering theory are always a wise investment for the developing enthusiast. Repair manuals, however, must cover the exact year and model of car owned to be of any use whatsoever.

Driving books must be oriented to your car(s) design philosophy as the technique for cornering or braking a rear engine, rear wheel drive car (such as a Porsche 911) will be significantly different than that of any Volvo. The same applies to driving books dedicated to "muscle cars" which address piloting techniques suited to vehicles with huge motors, diminutive brakes and limp steering.

The only type of technical book where price loses its worldly meaning is in the general interest category. Maybe the idea of owning an older fuel injected ALFA sedan sounds appealing. In this case, an inexpensive general interest book is the automotive equivalent of safe sex. Whether you spend one dollar or ten, the risk of having to visit a professional to examine the drip from your Spica is low.

In other cases, however, general automotive books can be quite expensive. It is not uncommon for pictorials and bound photo essays to sell for $100 or more. Receiving such an item as a gift is an overwhelming experience in which the value of the gesture far exceeds the cost of the book.

In general, however, there are few useful technical books to be had for less than $20.00. Given most enthusiasts' discretionary budgets, there are probably fewer useful books in excess of $50.00. This places technical books on a much higher plane than most table wines and explains why the visual and mental acuity of automotive enthusiasts can wane with age!

A Sample Library...

General Mechanical Principles

The biggest mistake in compiling my technical library was failing to appreciate the value of a good book on the general mechanical principles of automobiles. As a result, I had often found myself unable to refer young or developing shadetree mechanics to a suitable first book. In addressing the errors of my ways, however, I have become aware of a number of excellent books on the subject.

My recommendation would be to scour the used book stores for books on general mechanical principles published by the British Automobile Association (AA), American Automobile Association (AAA), or the Canadian Automobile Association (CAA). Such works are typically hard bound, cloth covered and richly illustrated with cut-away and wire frame diagrams depicting generic automotive chassis, suspensions, electrical systems, and engines. As used books, they usually cost less than $20 and represent outstanding value.

Engineering Theory & Design

Good engineering theory and design books review critically important mechanical principles, illustrate a broad range of potential applications, and impart a level of awareness beyond the range of mortal shadetree mechanics. As a result, such books are the cornerstone of a sound technical library and the mark of an inquisitive mind. I was fortunate to recognize the value of such books from an early age and have spent that past decade enjoying some of my favorites:

A Racer's Encyclopedia of Metals, Fibres and Materials. Aird, Forbes. Osceola, WI: Motorbooks International, 1994. ISBN 0-87939-916-8.
This work is an introduction to the world of automotive engineering materials. Although most practical content is prefaced by primers in chemistry or physics, the book's strength is its tabular information on the composition and strength of most structural alloys and fiber/resin combinations. A Racer's Encyclopedia of Metals, Fibres and Materials, at $26.95, is an excellent choice for automotive enthusiasts and developing shadetree mechanics.

Engineer to Win. Smith, Carroll. Osceola, WI: Motorbooks International, 1984. ISBN 0-87938-186-8.
Engineer to Win is a practical guide dedicated to the correct use of structural materials, joints and fasteners, automotive plumbing and a variety of vehicle components. Most useful chapters are preceded by brief chemistry, math or physics refreshers. The result is a detailed book that is highly informative and eminently useful to automotive enthusiasts and developing shadetree mechanics. A must for anyone interested in automotive competition. At $34.95 this is not a cheap book, but its rich technical content makes it a sound value.

<u>Prepare to Win</u>. Smith, Carroll. Fallbrook, CA: Aero Publishers, 1975.
Prepare to Win examines the broadest aspects of sports and racing car preparation. Taking over where Engineer to Win left off, the book describes how one may design and construct chassis reinforcements, linkages, and bearings, assemble and operate suspensions, engines and gearboxes, and conduct an effective quality assurance and testing program. Some duplication with Engineer to Win is evident, but the holistic approach to preparation that Mr. Smith advocates will be most welcomed by shadetree mechanics who prepare vehicles for competition. A good buy at $25.00.

<u>The Bosch Automotive Handbook</u>. 4th ed. Stuttgart: Society of Automotive Engineers, 1997. ISBN 1-56091-372-4.
The Bosch Automotive Handbook is a comprehensive tome tailored to meet the interests and needs of graduate mechanical engineers. Packed full of factoids, cut-away drawings, and complex formulae, it provides definitive information on modern vehicle design and operation. Despite its level of technical detail, The Bosch Automotive Handbook is easily read and understood by serious automotive enthusiasts and developed shadetree mechanics. A true bargain for $34.95!

<u>High Performance Automotive Fuels & Fluids</u>. Hartman, Jeff. Osceola, WI: Motorbooks International, 1996. ISBN 0-7603-0054-2.
Really smart aficionados can never seem to read enough about motor oil and gasoline! Fortunately for them, Jeff Hartman's book meets most readers' needs with comprehensive coverage of liquid and gaseous fuels, conventional and synthetic lubricants, and a variety of specifications. At $29.95, this book is recommended for the new or intermediate shadetree mechanic or drivers wishing to extract reliable power from gasoline or diesel engines.

<u>How to Build & Modify Cylinder Heads</u>, Camshafts & Valvetrains. Watson, Ben. Osceola, WI: Motorbooks International, 1993. ISBN 0-87938-790-4.
This book's focus on push rod technology makes this a useful addition to most car owners' libraries. Chapters on matching combustion chambers, selecting and degreeing camshafts, and preparing valve seats are of great utility to owners of cars with engines of overhead cam design. Even if you don't do your own valve train work, How to Build & Modify Cylinder Heads, Camshafts & Valvetrain is an interesting read for $29.95.

<u>Practical Gas Flow</u>. Dalton, John. Croydon, UK: Motor Racing Publications, 1989. ISBN 1-899870-08-3.
Considered modern classic by many, Practical Gas Flow supports the rich British tradition of backyard engine modification. Although the book remains true to its roots, few will be daring enough to use this book as the basis for serious modification. Its value in the North American market is defined by the book's coverage of those basic gas flow principles that receives too little attention in other works of this genre. A good value for around $30.00.

<u>Bosch Fuel Injection and Engine Management</u>. Probst, Charles O. Cambridge, MA: Bentley Publishing, 1989. ISBN 0-8376-0300-5.
The author, a former Chairman of SAE's Technical Training Force, clearly and concisely addresses the design and operation of Bosch mechanical and electronic fuel injection systems including Motronic.

Moreover, the author and editor have chosen an effective layout incorporating scores of easy to read tables, graphs and photographs. This is an ideal technical book on the subject of fuel injection and one which adequately covers systems common to most European cars. Highly recommended. A bargain for around $30.00.

The Scientific Design of Exhaust and Intake Systems. Smith, Philip & Morrison, Dr John . Cambridge MA: Bentley Publishers, 1962. ISBN 0-8376-0309-9.
A riveting book covering the scientific theory and practical engineering considerations used in the design of intake and exhaust systems. Despite this book having been first written in the 1960s, the authors' thoroughly professional approach to the subject makes The Scientific Design of Exhaust and Intake Systems a "must read" for anyone contemplating exhaust or intake system upgrade. At $34.95, this book provides immense value.

Turbochargers. MacInnes, Hugh. Tuscon, AZ: HP Books, 1976. ISBN 0-912656-49-2.
An "oldie but a goodie", Turbochargers is essential reading for those interested in turbo ownership issues, design or modification. Highly recommended for the all owners of turbocharged vehicles and those contemplating turbo modification. Very good value for around $20.00.

Maximum Boost. Bell, Corky. Cambridge, MA: Bentley Publishers, 1997. ISBN 0-8376-0160-6.
A brilliant book covering all aspects of turbocharger design and performance, Maximum Boost takes the reader from theory to advanced design and construction in a smooth and progressive manner. A must have for anyone contemplating boost kits and turbo or associated exhaust system upgrade. $50.00

Pro Engine Blueprinting. Watson, Ben. Osceola, WI: Motorbooks International, 1997. ISBN 0-7603-0424-6.
A good primer on the subject and a handy read for those facing an engine rebuild. Pro Engine Blueprinting may not tell you everything you need to know about the subject, but it will arm most with the facts needed to identify and engage professional engine blueprinter. $23.95

Performance Tires & Wheels. Mavrigian, Mike. New York, NY: HP Books, 1998. ISBN 1-55788-286-X.
A very thorough review of wheel and tire design that will enable the reader to better choose equipment for the road or track. Although chapters on drag racing, Indy Car, and circle track racing may have limited utility to the everyday driver, enthusiasts will quickly assimilate the information to augment their knowledge of road tires. Clear, concise glossary for the neophyte. A good value for $23.95.

Race Car Aerodynamics. Katz, Joseph. Cambridge, MA: Bentley Publishers, 1995. ISBN 0-8376-0142-8.
The most accessible and authoritative book on automotive aerodynamic principles on today's book shelves, Race Car Aerodynamics is a must for anyone operating a vehicle at high speed or contemplating the installation of air dams, wings, spoilers or splitters. A true bargain for the intermediate or advanced enthusiast at $50.00!

How to Make Your Car Handle. Puhn, Fred. New York, NY: HP Books, 1981. ISBN 0-912656-46-8.
Although the title may be reminiscent of a book on driving technique, How to Make Your Car Handle

provides tips and strategies for setting up a chassis for the highway or closed circuit. Basic physics and elementary geometry are the order of the day in Fred Puhn's work, providing the reader with just enough background to confidently tackle suspension tuning. My only criticism with this book is that the book has not kept pace with rapidly changing tire technologies. At $21.00, How to Make Your Car Handle is a wise purchase for those interested in making the leap from pure theory to practical performance applications.

Troubleshooting & Repair

Armed with a good appreciation of general mechanical principles and a firm background in engineering theory and design, one may confidently move on to repair manuals. Such books are written solely as repair references and are rarely entertaining or educational. This no-nonsense approach is ideal for the experienced mechanic but frequently disastrous for hobbyists who dive into complex procedures without the experience or tools to successfully complete the task at hand.

Many shadetree mechanics intuitively know how to complete basic troubleshooting or repair. Those who wish to do the job correctly have at least one of the following books on their work benches:

The Volvo Problem Solver, Gerhardt, Robert N

Although the format and layout of "The Volvo Problem Solver" is a little unrefined, the book's content represents a good compendium of tech tips for the average owner of 1970s and 1980s vintage 200 & 700-series cars. The price, at $69.95, places it at a disadvantage to Haynes and Bentley Manuals which cover many repair topics with greater depth.

The Volvo Performance Handbook, Grimshaw, Paul, Ottawa Canada: ZOD Publishing 1997
& The Gothenburg Bible, Grimshaw, Paul, Ottawa Canada: ZOD Publishing 1995

The objective of this article is not to dwell on the merits of either of the books that I ahve authored. It is, however, appropriate that drivers interested in either of these books browse this web-site and seek the opinions of other Volvo enthusiasts before committing to a purchase. The price of my books varies from $25-30.00 (direct through the author) to $29.95-34.95 through your National Volvo Club, ipd or Motorbooks.

Haynes Workshop Manuals. Somerset, UK: Haynes Publishing Group, various.
Although Haynes Workshop Manuals are oriented towards UK models, reflecting these books' country of origin, they remain acceptable general repair guides for the junior shadetree mechanic. Models covered include 120, 130 & 1800 Series (#203), 140 Series (#129), 164 (#244), 240 Series (#270), 260 Series (#400) and 700 Series (#1550). The list prices of each book are around $20 but frequent discounts by most automotive supply stores results in typical prices in the $12-15 range.

The Bentley 240 Service Manual. Cambridge, MA: Robert Bentley Publishing.
An extremely comprehensive service manual that straddles the chasm between Haynes workshop manuals and AB Volvo's more complete Technical Publications. This should come to no surprise as Robert Bentley has produced high quality factory repair manuals for Austin-Healey, Audi, MG, SAAB, Triumph, and Volkswagen for the past ten years. "The Bentley 240 Service Manual" is highly recommended for the 240 owner contemplating his/her servicing. Price ranges from $45-60.

AB Volvo Technical Publications. Gothenburg, Sweden: AB Volvo & Ken Cook Publications, various.
These are the same manuals used by the dealers, so they usually represent the last word in repair and servicing techniques. Volvo Technical Publications are expensive (a full set for a late model 200, 700, 800 or 900 can cost up to $800.00), but can be purchased one section at a time. They are the only repair manuals that receive my unequivocal recommendation and are a must for those contemplating advanced repair and refurbishment. Find out which best meet your needs by visiting:
http://www.kencook.com/vcna/volvo.html

Volvo Tech Tips. Rockleigh, NY: Volvo Cars of North America, various.
These are the so called "Service Bulletins" used by dealers. An excellent resource which many private garages overlook. Available by subscription through VCNA for around $25.00/year.

The presence of the latter two publications on the work benches of a professional mechanic can help establish the bona fides of an independent repair facility. Those which do not rely upon AB Volvo Technical Publications are invariably using customers' cars and money to side-step factory approved repair techniques.

Driving

Principles of High Performance Driving, 2nd ed. Stewart, Jackie. Richmond, UK: Hazelton Publishing, 1992. ISBN 0-905138-91-0.
Jackie Stewart's racing career of 27 Formula One victories stands on its own. So too does his reputation as one of the first professional racing car drivers to advocate safety, fitness and mental preparation. It is therefore not surprising that Principles of High Performance Driving reads as one part autobiography, one part text book in which "driver attitude" is a recurring theme. This book is ideally suited to situating new drivers to the realities of the road. A good book in its own right, the flavor of Principles of High Performance Driving is improved by the video cassette Behind the Wheel with Jackie Stewart , each of which retail for around $30.00.

The Technique of Motor Racing, 12th ed. Taruffi, Piero. Cambridge, MA: Bentley Publishers, 1997. ISBN 0-8376-0228-9.
A forward written by five time World Driving Champion Juan Manuel Fangio serves as an introduction to The Technique of Motor Racing, a book that has achieved cult status among professional racing car drivers. This conservatively illustrated work, dating back to 1958, is considered to be the forebear of all

driving books. As in the later works it inspired, The Technique of Motor Racing highlights attitude and physical fitness as the cornerstones to effective driving. A great deal of emphasis is also placed on using the gearbox, clutch and brakes to enhance chassis balance -- techniques that are as applicable to road cars as race cars. A fine book for any driver at $25.00

Sports Car & Competition Driving. Frere, Paul. Cambridge, MA: Bentley Publishers, 1992. ISBN 0-8376-0202-5.
Sports Car & Competition Driving is just the kind of book one would expect from Paul Frere, a professional engineer, an accomplished road racer of the 1960s, and an articulate sportsman. Shorter and more accessible than Going Faster (below), Frere's work approaches each topic with the vigor of a Le Mans racer. My favorite chapter, entitled "From Slipping to Sliding", is the best of its kind in automotive writing. Three appendices outlining intermediate physics makes Sports Car & Competition Driving a logical next step. Good value indeed at $26.00.

Going Faster! Mastering the Art of Race Driving. Lopez, Carl. Cambridge, MA: Bentley Publishers, 1997. ISBN 0-8376-0227-0.
As an instructor with the Skip Barber Racing School and author of this fine book, it is clear that Carl Lopez is a seasoned practitioner of racing and automotive literary lines. The book is divided into five comprehensive sections entitled: "The Fundamentals", "Developing the Basics", "Honing Your Skills & Strategies", "The Role of Hardware" and "Becoming a Race Car Driver". Clear graphics, combined with photographs taken from the cockpit make this book the next best thing to a racing school. Going Faster! is an absolute steal at $45.00!

General Interest

General interest books provide a welcome relief from technical manuals. While it would be presumptuous to choose the "best" general interest automotive books, I can think of a number of unique books that offer a subtle blend of art, history and technical content. The really good general interest books, in which the history of an event or period are chronicled, are costly to produce and expensive to buy. Their real value, however, is established by the spirit in which they are given.

Just about any pictorial by Ranier W. Schlegelmilch is sure to please. Two such books, Portraits of Formula One and Ferrari were gifts from a close friend and loved one respectively. Veterans of the Road by Wolfgang Roediger and Siegfried Herrmann, however, was a used book store bargain. The hard-covered cloth binding, superb watercolor plates of classic sports cars and intricate pen and ink drawings belie the communist-bloc East German origins. Each book holds a special place on my book shelf.

Conclusion

Whatever the technical need, I am convinced that there is a book that can satisfy the Volvo owner. If you're lucky, you'll receive one as a gift. Otherwise the challenge is, like that of fine wine, striking an acceptable balance between taste and budget.

Sante!

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| Order "The Gothenburg Bible" ! |

Volvo Performance Benchmarks

by Paul Grimshaw

Performance is a relative term that requires benchmarks against which subsequent modification can be measured. The more passionate enthusiasts can take their cars to specialized test tracks. It is at these tracks that cars are subjected to a number of instrumented tests to measure speed, grip and dynamic control.

Complex measurement instruments are both accurate and precise. As slick as these devices are, a great deal of usable data can be gathered using a digital stop watch and distance tape. By calculating velocity as a function of distance over time, and lateral acceleration as a function of radius over velocity, the automotive enthusiast gather useful performance benchmarks that can be subsequently compared following major modifications.

Those wishing to skip the slide rule math can purchase good quality accelerometers capable of displaying instantaneous g-force, sustained g-force, 0-60 mph acceleration, 60-0 mph braking, and 1/4 mile times at the press of a button. One example of such a device is a G-Tech Pro, manufactured by Tesla Corporation and available through Volvo specialists such as iPd. Retailing for around $140, a G-Tech is a very useful tool for measuring performance with far greater precision than a stopwatch and distance tape.

Regardless of the device used to measure vehicle performance, it is essential to have access to benchmarks so one may objectively compare their car's performance against a "new car" standard.

The performance characteristics below have been gathered from hundreds of media sources over the past 30 years and are averaged by model year, engine type, and trim level. Although corrections for altitude, air temperature nor lanch technique have not been applied, the figures shown are judged to be accurate to within 0.02g and 0.3 seconds for a stock vehicle in "as new" condition.

Stock Performance - Based on Media Reviews of Cars during the Model Years Specified			
Year	**Model**	**Cornering (g)**	**0-60 mph (sec)**
1950	PV444	No accurate data available	24.9
1957	PV444	No accurate data available	14.3
1958	PV444	No accurate data available	13.0
1962	122	No accurate data available	14.6
1965	PV544	No accurate data available	14.1
1965	1800S	No accurate data available	13.9
1966	122S	No accurate data available	14.2
1970	1800E	No accurate data available	10.1
1972	142E	No accurate data available	12.6
1975	242 GL	0.67	14.2
1976	265 DL	0.68	13.5
1977	265 DL	0.68	13.0
1978	242 GT	0.76	11.3
1978	262 Bertone Coupe	0.70	11.1
1979	242 GT	0.76	11.0
1980	262C	No accurate data available	11.7
1980	244 GL	No accurate data available	14.2
1981	242 GLT Turbo	0.74	9.6
1981	240 Turbo	0.76	10.2
1981	244 Diesel	n/a	18.5
1982	760 GLE Turbo Diesel	0.73	12.3
1982	240 Turbo Intercooled	No accurate data available	10.2
1983	760 GLE (V6)	No accurate data available	11.4
1984	244 Turbo Intercooled (man)	No accurate data available	7.9
1984	245 Turbo Intercooled (auto)	0.74	10.1

1985	740 Turbo	0.75	8.4
1988	760 GLE (V6)	No accurate data available	9.6
1989	740 GLE Turbo	0.78	9.6
1990	240 DL	n/a	12.0
	744 Turbo	0.80	7.2
	745 Turbo	0.81	7.8
1993	850 GLT	0.81	7.8
1994	855 Turbo	0.81	8.5
	854 Turbo	0.81	6.1
1995		No accurate data available	6.7
	960		9.2
1999	C70	0.78	8.0
	S70 T5	0.79	6.1
	V70 AWD	0.80	7.0
	S80	No accurate data available	8.9
	V40		8.3
	V40 T4		7.2
2000	S80 T6	0.79	6.6
2001	S60	n/a	7.5
2002	S60 T5	0.82	7.0
	V40	0.71	7.9
2003	XC90	0.77	9.0

Volvos have a lot of performance potential, making it relatively easy to improve on these figures by a substantial margin. Those interested in improving their Volvo's grip and acceleration are encouraged to consult "The Volvo Performance Handbook".

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Special Article -

Replacement Parts - Fact, Fiction & Hype

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by Paul Grimshaw,
Author, The Gothenburg Bible

It has been said that many of today's people are label conscious. I suppose there is some truth in that. Most peoples' closets usually contain one item of clothing designed by a particular individual or company. In fact, one of the constants of the universe may very well be that at least one article of clothing in everyone's drawer has a trade name or label displayed on the outside of the garment! Why?

Market research suggests that the following criteria are used to rationalize a purchase:

- cost
- perception of quality
- style
- fit and/or finish
- habit

These criteria transcend fashion; they affect us every time we seek replacement parts for our Volvo.

Since Volvos tend to outlive their warranty periods, it is natural to assume that some owners either perform their own maintenance or seek service from an independent garage. If you are one of these owners, there will come a time when you have to choose between "Genuine Volvo", "NOS", "OEM", "High Performance", "Quality Replacement", "Re-built or Re-manufactured" or "Gray Market" parts.

Making any kind of choice without an understanding of the meaning or implications of these terms could either leave you in the poor house or the morgue.

A DEFINITION OF TERMS

Genuine Volvo Parts

Genuine Volvo parts describe those components which are manufactured either by AB Volvo or by a company acting on its behalf. In the case of the latter, specifications proposed by AB Volvo are translated into a unit cost by the actual manufacturer. A final price/quality formula is agreed to by both parties and a limited production run is initiated to confirm adherence to the quality control limits set.

Although Volvo sets very high standards for its parts, it must examine every transaction with a view to bottom line costs -- after all, it has stock-holders to answer to! Special dies must be constructed to stamp selected parts with a Volvo part number, that familiar Volvo-blue packaging must dress each part, and a separate parts distribution organization must be maintained. Each of these special requirements adds cost, not quality.

There are times when Volvo can pass on the benefit of its purchasing power to its customers by offering a high quality part for less money. At other times, however, the customer is expected to pay top dollar for average quality. Buyer beware!

Although I may have painted a grim picture of Volvo parts pricing considerations, it would be unfair to overlook Volvo's reputation for fit, finish and customer support.

Volvo parts rarely, if ever, fail to perform to a customer's highest expectations. They are very well designed, offer a precise fit, come with warranty coverage, and adhere to the legal requirements stipulated by your country's transportation authority.

N.O.S.

A term commonly used in the parts business, New, Original Stock refers to parts for older cars which were approved by the manufacturer at time of construction but, for a variety of reasons, have remained unsold, unused and in-stock for a number of years. Pricing strategies for these parts is somewhat complicated. Some dealers see N.O.S. parts as a liability and sell them at discount prices. Others, however, see such parts as being extremely valuable for vintage Volvo owner's seeking originality and charge accordingly.

While the value of N.O.S. parts may be in the eye of the beholder, the engineering specifications to which they were manufactured many years ago should be examined. Many N.O.S. parts do not benefit from those advanced chemical, metallurgical and manufacturing processes which are commonplace today. Also, years of storage can take its toll on rubber parts, making them lose their natural elasticity and resistance to wear.

O.E.M.

Original Equipment Manufacturers (or O.E.M.) describe those companies which have been working under contract by AB Volvo to produce Genuine Volvo parts. Most O.E.M. parts can be purchased directly from company distributors, removing the "middle man" and saving the purchaser from bearing the cost of secondary distribution and overhead. One must bear in mind, however, that the distributors are not as familiar with Volvo products as the dealer. This places the onus on the purchaser to be the final arbiter in choosing the correct part for a particular application.

Although some of the processes used by O.E.M. companies to produce Genuine Volvo parts may be protected by copyright, most are not. Chemical, metallurgical and manufacturing processes and fit and finish are often identical -- after all, if your reputable company's name was stamped on a product wouldn't you strive to make it perform as well as the Volvo part? O.E.M. parts almost always conform to the safety regulations specified by your transportation authority.

Common O.E.M. suppliers to AB Volvo are Bosch, Lucas, Cibie (Electrical Suppliers), Varta (Batteries), Sachs (Clutch & Friction Surfaces), ZF or Zahnradfabrik Friedrichshafen, Aisin-Warner, Borg-Warner (Steering Racks, Automatic Transmissions), Bilstein, Boge (Shock Absorbers), ATE, Lucas-Girling, Brembo (Brake Master Cylinders, Calipers and Rotors) and Mahle (Pistons, Rods & Rings).

Rebuilt or Re-manufactured

Rebuilding or re-manufacturing describes a process where used O.E.M. or Genuine Volvo parts are brought back to new specification through a mechanical or chemical process. Worn surfaces or bearings are replaced and tolerances are restored to the same specifications demanded of a newly manufactured part. Because many rebuilt parts retain a number of the original components, they are often significantly less expensive.

Warranty support is a fairly good indicator of a rebuilt part's quality. Parts rebuilt by the O.E.M. suppliers offer warranties comparable to those of new parts, whereas the more obscure parts refurbishers give few promises. Bosch and Volvo offer their own re-manufactured parts which are reasonably-priced, of consistently high standards, and backed by generous warranties.

Not all rebuilt parts are legal for road use in some countries or states. If in doubt, check with your transportation authority.

High Performance

A term somewhat over-used in today's marketplace, High Performance refers to parts which are designed to greatly exceed the operating specifications of an original part. Unfortunately, some manufacturers and consumers think that style is the predominant factor in performance parts -- a perspective which generates laughter in the professional motor sport business.

Differences of this nature make it difficult for the average owner to correctly choose a bona fide high performance part. As a rule, however, one should expect a high performance part to come with longer warranties, quantifiable performance claims, and flawless fit and finish. Because of this, high performance parts carry substantially-higher price tags.

Not all high performance parts are legal for road use in some countries or states. If in doubt, check with your transportation authority.

Gray Market

It is unlikely that the average owner will be offered a gray market part in an up front manner. Instead, some unscrupulous suppliers will offer sub-standard, third-world parts packed in an O.E.M. supplier's box. Such parts are subject to very little quality control and are subject to either premature or catastrophic failure.

This illegal but highly profitable practice is carried out in just about every city in the world, so buyer beware. If you suspect that gray market parts are being sold to you, take the part directly to the manufacturer or its agent. If the part is an illegal knock-off, you will probably be offered a new part in return for your testimony in a criminal or civil suit against the parts supplier.

Gray market parts are illegal. They violate copyright laws and can often fail with catastrophic results.

WHERE DO YOU DRAW THE LINE?

A responsible owner must weigh the cost/benefit of purchasing replacement parts. Price is a general, but not absolute, indicator of a part's performance or longevity. Select parts carefully; your money and your life depends on your decision.

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Volvo By Numbers

by Paul Grimshaw

Genesis of Vehicle Identification Numbers, or VINs

In the 1950's American automobile manufacturers began using identifying numbers on cars and their parts. The purpose was to give an accurate description of the vehicle regardless of the numbers of vehicles produced by a manufacturer.

In the early 1980's the U.S. National Highway Traffic Safety Administration required that all road vehicles to display a 17 character VIN to identify the manufacturer, model, body type, model year, assembly plant and chassis number of automobiles. The format used corresponded to a format developed under International Standards Organization (ISO) Standard 3779 in February 1977.

The European Union has issued a similar directive for all road vehicles manufactured for European Union member states. This directive complies with ISO Standard 3779 but the use of a year digit or factory code in the VIN is not mandatory. Cars manufactured for the European market are not obliged to use a descriptive code to identify specific vehicle attributes within the VIN.

The ISO 3779 Data Format

The ISO VIN can be broken down into three sections:

World Manufacturer Identifier, which uniquely identifies the maker of the vehicle. It occupies the first three positions of the VIN.

Vehicle Descriptor Section. Six characters that occupy positions four through nine of the VIN and may be used by the manufacturer to identify attributes of the vehicle.

Vehicle Identifier Section. The last eight characters of the VIN used for the identification a of specific vehicle.

In the VIN-code, capital letters A through Z and numbers one through zero may be used, except the letters I, O and Q which could be otherwise confused for digits one or zero. No symbols, signs or spaces are allowed in the VIN.

Volvo by Numbers

VINs for late-model rear wheel drive Volvos can be found in three locations:

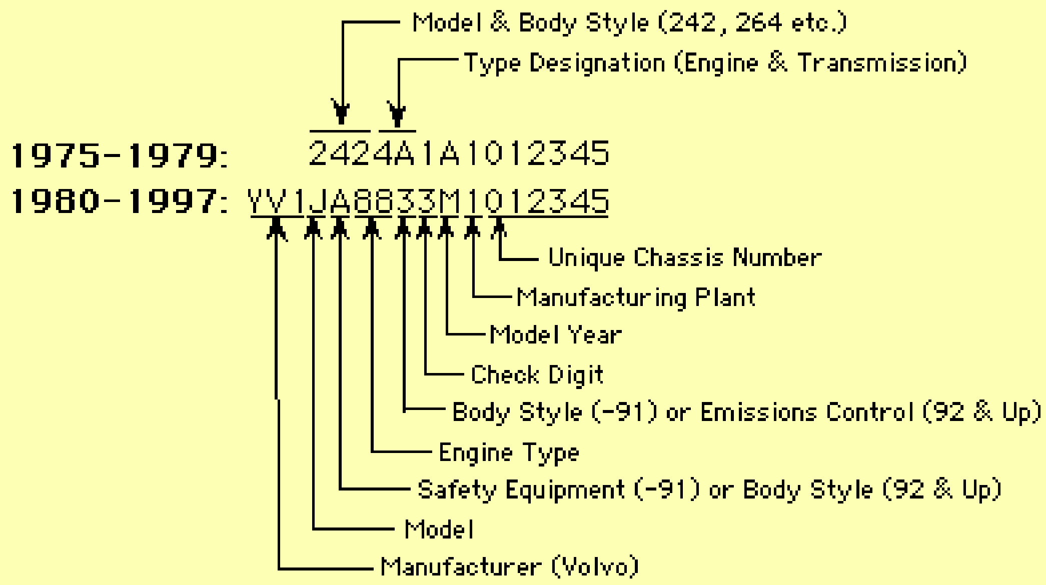
- on a small metal strip that's riveted near the base, or along the inside edge, of the driver's side (left) "A" pillar;

- engraved into the right front door post; and

- embossed on an underhood Product Plate that's riveted to the chassis between the top of the right front headlight and the suspension tower.

VIN Code Locations
200-, 700- & 900-series

A VIN for a late model Volvo can contain as many as nine distinct data fields:



Volvo VINs from 1980 to present begin with "YV1", the approved International Standards Organization designator for the Volvo Car Corporation (Y = Sweden, V = Volvo, 1 = Passenger Car Division). The characters that follow are used to describe the car in greater detail.

The most fascinating codes are those used to describe the engine options. Although a complete explanation of this subject goes beyond the scope of this article, readers may wish to refer to the following web pages for additional information:

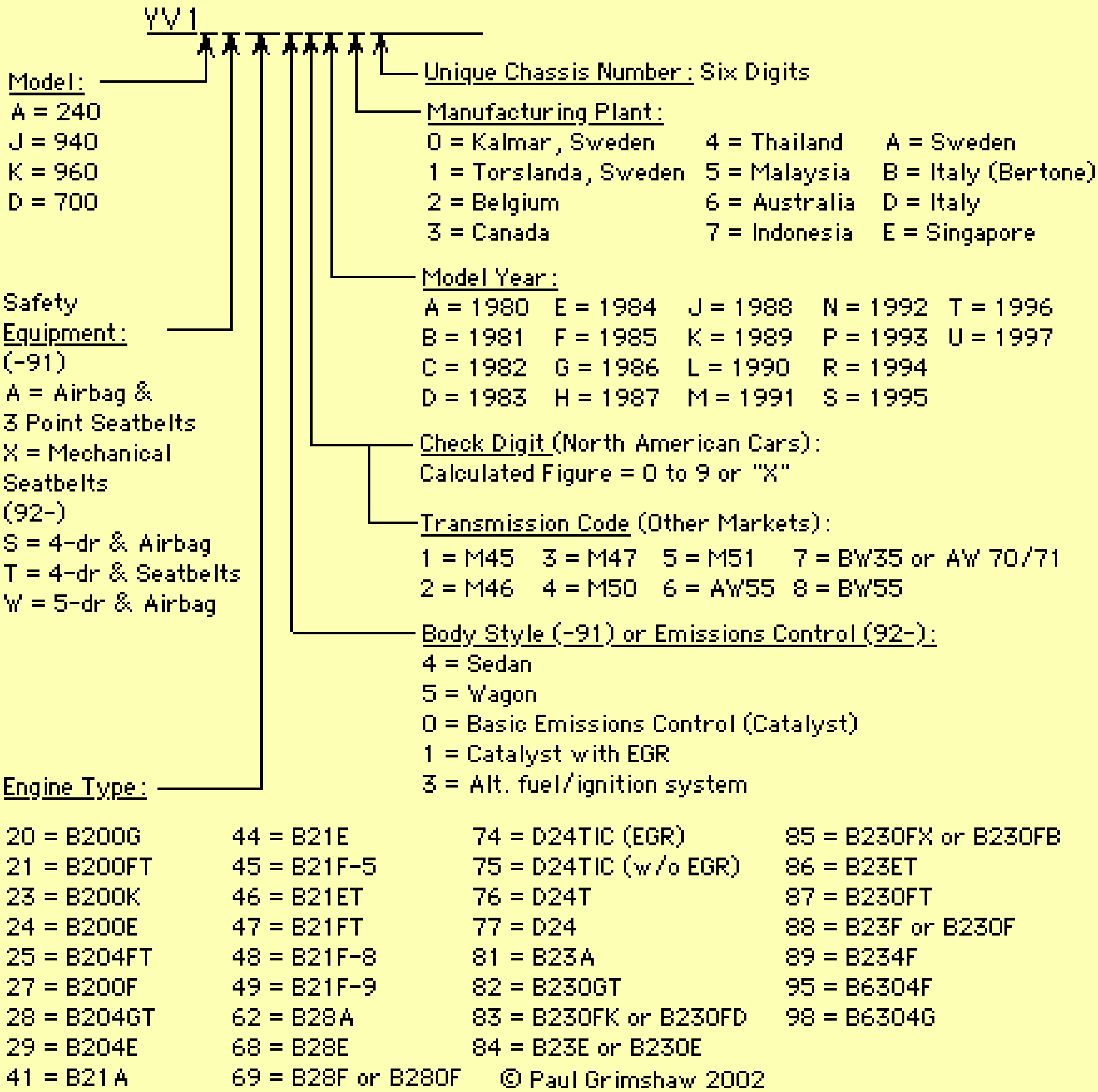
http://www3.telus.net/Volvo_Books/specart5.html
http://www3.telus.net/Volvo_Books/specart11.html

A VIN can be used to verify the model year for which the car was built. This is not to say that this was the date of manufacture, as most factories start producing cars in the late summer or early autumn of the previous year. The VIN can also confirm whether your car was built in Sweden or at one of the five overseas factories operated by Volvo Car Corporation through the period 1975 to 1997.

Regardless of the manufacturing plant, a unique chassis code is assigned to each car. This code may be cross-referenced to factory records to ascertain the exact date that the vehicle was built and which, if any, alterations were made as part of a mid-model specifications change. Needless to say, management of these codes required a high degree of coordination until the establishment of Volvo's corporate wide area network in the late 1980s.

Unlocking the Secrets of Your Volvo's VIN Code

The form below will help you to decrypt VINs for 1980 & newer rear wheel drive cars. Simply insert your late-model rear wheel drive Volvo's VIN into the blank fields and trace the paths back to determine the car's original factory configuration.



The Role of the Check Digit (North American Models Only)

North American VIN Codes feature a check digit to verify that the VIN is a numerically valid and logical code that adheres to the ISO 3779 standard. It also provides a degree of security against less-sophisticated car thieves or unscrupulous retailers who might attempt to alter the VIN code to conceal the true identity of a particular car.

This is how the check digit works:

1. Assign a mathematical value to each character in the VIN::

A=1, B=2, C=3, D=4, E=5, G=7, F=6, H=8, J=1, K=2, M=3, N=4, P=7, R=9, S=2, T=3, U=4, V=5, X=7, Y=8, Z=9

2. Multiply the assigned mathematical value for each character, as it occurs sequentially in the 17 character VIN, by the weighting factor specified:

1st Character x 8, 2nd Character x 7, 3rd Character x 6, 4th Character x 5, 5th Character x 4, 6th Character x 3, 7th Character x 2, 8th Character x 10, 9th = check digit, 10th Character x 9, 11th Character x 8, 12th Character x 7, 13th Character x 6, 14th Character x 5, 15th Character x 4, 16th Character x 3, 17th Character x 2

3. Add the products from steps 1 and 2 and divide the total by 11.

4. The numerical remainder is the check digit which would appear in the 9th position in the VIN. If the remainder is 10, then the letter "X" is used for the check digit.

Transmission Codes (Other Markets)

The space normally provided for check digits in North American VIN Codes are used to describe the transmission in cars manufactured for the European market.

Better Living through VIN Codes

The term "matching numbers" is used to describe vehicles that have the same serial numbers throughout. Deviations exist when major chassis components have been replaced to correct damage caused by a major collision. Verifying that VINs match will help confirm whether a previously-owned Volvo has been wrecked and subsequently re-assembled from junk-yard parts.

Your Volvo's VIN can be used by the dealership to more accurately order parts for future servicing. As some already know, obtaining the correct part can make the difference between a day and a weekend in the shop.

Motor vehicle authorities can use VINs to conduct background checks for a nominal fee. The results can be used to verify odometer readings, highlight previous insurance claims against the vehicle and warn of financial liens that have been made against the car by creditors.

Your local Volvo dealer can use your a VIN to determine if your car is affected by an outstanding recall. This could make the difference between paying for service and receiving it free of charge!

Enthusiasts can quickly search for that special parts car, since many automotive recyclers maintain an inventory of cars by VIN. There's no sense crawling around a junkyard to discover that the "turbo" on the lot requires diesel fuel, not high-octane gasoline.

Finally, concours judges can use VIN codes to honor the best kept, most original and most senior Volvo within a particular class. The result is a common standard of judging and respect for the elderly.

Conclusion

Vehicle Identification Numbers contain useful information that can be used to purchase, maintain, rebuild or show a car.

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Special Article -

Volvo Engine Designations

by Paul Grimshaw,
Author, The Gothenburg Bible

General

Volvo Car Corporation has used an alpha-numeric system to classify its engine by fuel type, size, induction system and accessories since the 1950s. This system makes it relatively easy to differentiate between gasoline and diesel, large and small, old and new, carburated and fuel injected, and normally-aspirated and turbocharged engines.

Designation Systems

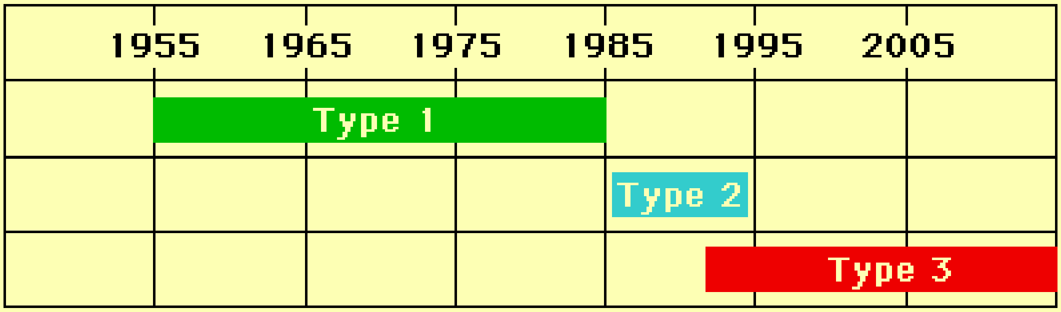
Over the past 50 years, the alpha-numeric system has undergone a number of modifications to appropriately reflect changes in engine design and the availability of special features. To help readers better understand Volvo engine designations, the alpha-numeric system is broken down into three types:

Type 1 - For cars produced for Model Years 1955 to 1985. These include 544, 120, 1800, 140/160, 240/260, and 740/760 models;

Type 2 - For cars produced for Model Years 1985 to 1994. These include 240, 740/760/780 and 940 models; and

Type 3 - For cars produced from 1993 onwards. These include 850, 960, S60, S/V/C70, S90, and XC90 models.

Separate guides have been developed to explain each designation system. Select the designation system by clicking your mouse on the appropriate area of the graphic below.



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Additonal Reading: Chronology of Volvo Engines

The Gothenburg Bible Technical Archives

On-Line Support For Our Readers

The archives are intended to further describe systems and procedures addressed in "The Gothenburg Bible". Readers are encouraged to first read the appropriate chapters within the book before browsing they will answer most questions on long term, cost-efficient Volvo maintenance.

Registered Owners of "The Gothenburg Bible" may use this page to request technical support via EMail. **Please quote your name and book serial number for prompt service.**

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Safety Sway Bars

Manufacturer: IPD OF PORTLAND, OREGON, USA
Cost: $200-300 (USD) + SHIPPING
Installation Time: 1.5-3.5 HOURS
Observed Fit & Finish (out of a possible five):
Observed Performance (out of a possible five):

Introduction

My early years were spent reading everything from technical dissertations to retrospective coverage of some long-forgotten Mille Miglia. I suppose very little has changed. I remain a proud subscription holder of at least half a dozen car magazines and spend a great deal of my free time scanning the contents from cover to cover.

Of course, the advertising copy always seemed to get in the way. After all, how could a small ad showing "before and after" shots of a Volvo being cornered near the limit change my life? I was destined to drive a Porsche by my 21st birthday, a BMW for my 30s, and a Mercedes-Benz when I entered my geriatric phase (thought to be anytime after my 40th birthday!).

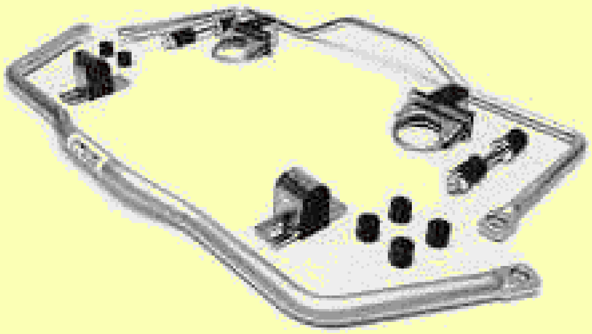
At some point between then and now I was introduced to car insurance reality. Just who was going to underwrite a 21 year old with a Porsche? How would I keep the joyriders out of my Bimmer? And the Mercedes? Well, let's just say that my agent explained the financial consequences of impaling someone on a three pointed star!

Nevertheless, lessons of reasonable sufficiency were learned early enough for me to own a new Volvo in my late 20s. Fabulous braking, great comfort, good fuel economy, and ease of maintenance almost made up for my Volvo's tendency to corner on its door handles -- something which I recalled as having been characteristic of my least favourite car, the Citroen 2CV.

Don't get me wrong, stock Volvos handle in a safe and honest manner, but there is a fine line between what amount of body roll constitutes feedback and what amount sacrifices handling potential. Although I pride myself in being a controlled and safe driver, I felt that my Volvo had the potential to help me be a better driver if only it could react more quickly to steering input, have better "on center" feel and exhibit more stability through the esses.

In search for improved handling, I went back to those old magazine ads showing "before" and "after" photos of a Volvo rounding a curve. The fine print revealed a company in Portland, Oregon, USA called ipd (short form for "International Products Development"), which had developed a wide array of suspension upgrades for Volvos.

The purpose of this article is to evaluate ipd's Safety Sway Bars which are said to dramatically improve Volvo handling.



Choosing the Right Set-Up

A quick scan of ipd's catalog shows a variety of Safety Sway Bar Applications for 120s (1960's vintage) to the newest models. The sway bar thicknesses listed tend to correspond to their torsional rigidity and, as listed, are significantly stiffer than the stock units fitted to most Volvo models. A knowledgeable tuner may select various front and rear bar thicknesses to meet his/her needs, although ipd's technical support staff are available to recommend the set-up which best meets your needs. The most common set-up appears to be a 1 inch/25mm front bar and a rear bar ranging in diameter from 3/4 inch/19mm to 1 inch/25mm. These thicknesses wisely retain some mild understeer when the car is placed at its handling limit, making course corrections safe and predictable.

Installation

ipd suggests two scenarios for installing its Safety Sway Bar Kit ---- by a mechanically-inclined owner highly skilled in Volvo repair or by a professional mechanic familiar with Volvo cars. Falling into the former category, I completed the installation myself (although I strongly urge readers without an extensive background in suspension repair to take the car to a professional mechanic).

After carefully reading the installation instructions, I backed my Volvo out of my garage and set about to remove the stock bars and replace them with my upgraded units. The tools required for the job included a socket set, a torque wrench (optional), two heavy-duty axle stands and a sturdy floor jack in the 2.5 to 3 ton range. The instructions were clear and straight forward which, combined with the exacting fit and finish of the ipd hardware, made for an uneventful installation.

After checking and double-checking my work, I refitted my Volvo's wheels and carefully lowered the car. Total installation time was 3.5 hours. This included a bit of preventive rustproofing and general tinkering. A professional repair facility with hydraulic and pneumatic tools could easily reduce installation time to 1.5 hours, making this a wise and inexpensive alternative.

The Handling Pay-Off

It will come to no Volvo owner's surprise that there are many roads which favour smaller, lighter cars. Most of these demand a combination of turning and acceleration or turning and braking -- taxing activities indeed for a 3,000 lb sedan. ipd's Safety Sway Bars improve the handling prowess to such a degree that these previously challenging roads are handled with confidence and stability.

In fact, a Volvo so equipped will be able to challenge several "sports" cars in the handling department. Adding further suspension upgrades (such as higher quality or lower-profile tires, alloy wheels, and chassis bracing) can transform the uptight Swedes into a "sleeper" -- a conservatively styled sedan with razor sharp performance. Whether your preferences are to have a crisp handling car or dominate the autocross circuit, ipd's Safety Sway Bars represent the most logical "first step".

In short, here's what you get for your money:

· crisper turn-in
· greatly-improved stability during transient and steady state manoeuvres
· significantly-reduced body lean
· much higher cornering potential

What Price, Glory? (or Handling)

Apart from the initial cost of the bars and installation, the average Volvo owner is unlikely to experience any objectionable degradation of ride quality. Sway bars tend to affect suspension movements only when one side of the car is placed under additional load, such as when the car rounds a corner. Normal city streets are unlikely to impart any harshness to an ipd Safety Sway Bar-equipped Volvo. Even cobblestone or ice-pocked streets can be traversed without undue harshness, true testament to the handling/ride control balance which has been obtained through the careful selection of bar rigidity and bushing compliance.

Recommendation

ipd 's Safety Sway Bars provide impressive handling gains at minimum cost. Quality parts, superb engineering and wonderful fit-and-finish are evident throughout. If your motivation is to get from point A to point B with the maximum handling confidence, you should seriously consider purchasing ipd 's Safety Sway Bars.

Demon Tweeks/OMP Strut Brace

Manufacturer - OMP
Retailer - Demon Tweeks, Wrexham, UK
Cost - £44.73 (about $100-120)
Shipping - £26.00 (about $50-70)
Observed Fit & Finish (out of a possible five):
Observed Performance (out of a possible five): Not Observed -- See Text.

You may recall the following passage from one of our recent performance tips:

A solid chassis is crucial to handling! To that end, it is recommended that any suspension project be preceeded with some chassis reinforcement. Chassis reinforcement will prolong the car's structure and allow shock absorbers, springs and sway bars to perform to maximum advantage.

With these words in mind, I diverted from the usual fix of fitting AB Volvo's chassis reinforcing kit by considering the OMP chassis reinforcement bars listed in the 1998 Demon Tweeks catalog. Although I could sum up the experience in an expletive or two, I encourage Volvo enthusiasts to read-on!

Staff Support & Ease of Ordering

On October 5th, I ordered a strut brace for a Volvo 240 Sedan. Prior to completing the transaction I confirmed with Demon Tweeks staff that OMP brace #MA1600, as listed in their1998 DBR Issue catalogue, was designed to fit **all** models of 240 including 2- and 4-door models. The staff appeared to be keen and attentive with good on-line access to the company's parts distribution center.

Shipping

The brace was shipped via Purolator Air. The good side is that the service proved to be extremely fast, resulting in a three-day delivery period from the UK to Canada's West Coast. The downside was the cost - a hefty £26.00, or about $50-70 which was not fully explained by the good staff at Demon Tweeks!

Quality & Fit

Visual inspection of the brace revealed an appalling lack of quality control on the part of the manufacturer. The welding used by OMP to fabricate the brace was extremely crude, with a number of air pockets and "splatter" noted along the bead joining the bracket and bar ends. The paint application is best described as "child-like" with a number of areas left unprotected.

If the quality control was bad, then the fit of the OMP strut brace was even worse. Attempts to secure the brace to a variety of Volvo 200-series cars failed miserably. Difficulties included obstruction with the master cylinder's fluid resevoir and interference with the throttle pulley -- each of which could easily lead to a failure in braking or engine speed control. In most cases, the adjustable nut on the bar precluded the correct bar length from being selected.

Summary

As an automotive author, technician and weekend competitor, I am aware of the difficulties faced by parts manufacturers attempting to market "bolt-on" parts for any model of car. Such difficulties are mitigated, however, by the fact that the Volvo 240 chassis remained largely unchanged throughout its 19 year history. In areas where engine peripherals (throttle pulley, ABS master cylinder brake resevoir) interfere in the routing of the strut brace, thought should be given to marketing more than one part the entire Volvo 200-series model range. This is the case for Volkswagens where the Demon Tweeks catalogue lists 10 braces for the Golf "Mk 2" model alone!

This less-than-ideal experience gives rise to the thought that as a group, Volvo drivers are poorly supported by aftermarket parts and accessories. Of the few companies that do offer parts, some are clearly less inclined to conduct proper research and development of their parts prior to sale. The OMP struct brace marketed by Demon Tweeks fits into this category and casts a pall over a mail order company that normally supplies top-quality equipment for a variety of road and track uses.

Recommendation

The OMP struct brace #MA1600 is unadulterated junk with a poor finish covering parts of marginal build quality. That such a product is marketed with a straight face is a testament to efficacy with which money can be parted from customers. Moreover, the OMP strut brace is a poor product with serious design defects that could easily be improved through product development.

Where to Go From Here....

As form follows function, one can take comfort in knowing that the OMP strut brace disassembles for easy disposal in the family recycling bin. As for the Demon Tweeks catalog from which it was purchased, let's just say that a wise Volvo aficianado will give the strut brace a "pass" proceed with caution when ordering any performance parts from retailers lacking in extensive Volvo experience.

Note:

Prior to this article going to press, Demon Tweeks was asked to explain the serious deficiencies in the strut brace. In a letter dated October 23rd 1998, Chris Turner, the Sales Manager of Demon Tweeks, deflected criticism by saying that his company had sold 16 strut braces this year without negative comment. He went on to admit to limited product knowledge with Volvo cars but provided a thinly veiled caution about placing "misleading information" on a website. No offer of refund was made.

Regardless of Mr. Turner's words, we stand by our product review.

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Post Script:

The May/June 1999 edition of "Rolling", published by the Volvo Club of America, featured a review by Steve Seekins entitled "Strut Barce Wars". In that article the following observations were made on OMP braces:

OMP Brace for 240 - "... we were unable to adjust the bar short enough to fit", "... the adjusters were apparently not threaded enough into the bar", "...manufacturing quality is questionable"

OMP Brace for 850 - "... no provision for adjustment of bar length", "...we could not test the barace because we could not mount it on the test vehicle", "...the necessity to re-drill mount holes and the lack of length adjustment would seem to mae this (bar) a poor choice"

Paul Grimshaw's Open Comment to Chris Turner: The position taken by your company to defend a product of apparently dubious quality undermines this author's faith in you entire product line. In the interest of preserving your customer base and dispelling concern over your company's credibility, I would suggest that you:

(1) provide follow-up refunds to Volvo owners of OMP strut braces;

(2) cease selling OMP Strut Braces for Volvos; and

(3) seek a different supplier for future strut brace kits.

... Stay Tuned for the Demon Tweeks Reply...

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High Temperature Coating

Manufacturer: The Eastwood Company, Malvern, Pennsylvania, U.S.A.
Cost: $19.95 (USD) + Shipping
Tools Required: Wire Brush, Paint Brush - Rotary Tool Optional
Additional Work Required: Sandblasting preferred. Good quality bristle brush or air brush required. Area must be perfectly dry.
Observed Finish (out of a possible five): ★★★★★
Observed Performance (out of a possible five): ★★★★

Introduction

No matter how many times I've exhaust manifold and warm air induction shroud with run-of-the-mill high heat paint, the finish would turn chalky and start to flake off within weeks. A longer-lasting alternative would need to be found.

Enter The Eastwood Company with their exclusive "High Temperature Coatings". Available in gloss black or silver, these coatings have been used for years by detailers and car show contestants to prevent pitting in gray cast iron intake manifolds by forming an attractive and durable protective finish. We chose satin black for a conservative and aesthetically-pleasing look.

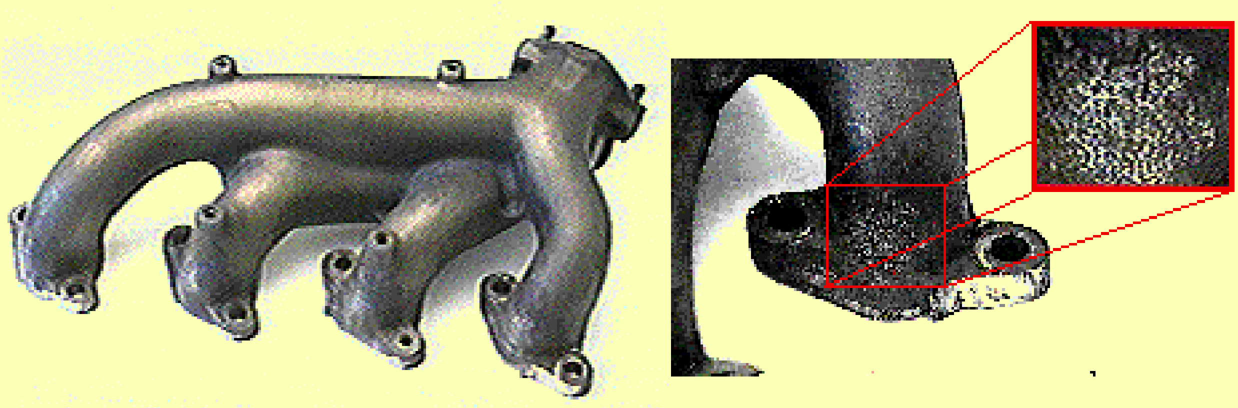
Surface Preparation

After careful cleaning, careful prep work commenced. While Eastwood recommends that the part to be painted should ideally be sand-blasted, it acknowledges that careful preparation with a wire brush will yeild satisfactory results. Wanting to prepare the part as simply as possible, we chose the wire brush -- with a little help from a rotary cleaning (Dremel®) tool.

The part was then dried by placing it in an oven set slightly above 100C/212F.

Paint Application

A two-step application was carried out. The first coating was a "scratch coat", a very light application for maximum adhesion. This was followed up several hours later by a regular coating to produce a wonderful finish which concealed light pitting (see area inside red box on the "before" photo) without hiding the stock pebble finish common to most cast iron parts. After several weeks use, the finish on the exhaust manifold remains perfect.

BEFORE - 

AFTER - 

I successfully used Eastwood's product on a project car's brake calipers -- another high-heat iron component prone to rusting!

Conclusion

The Eastwood Company is no stranger to car care -- in fact it is probably the world's largest retailer of restoration parts and processes. Their "High Temperature Coating" lives up to the company's heritage of quality and is a worthy product for those seeking a smooth, OEM-type finish to their Volvo's manifolds, tail-pipes or calipers.

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Maintenance Charts:

120,000 mile/200,000 km --> 330,000 mile/524,000 km

Sponsored by: The Gothenburg Bible

Volvos last a long time. Properly cared for, it is not uncommon for the life of the car to exceed the maximum mileage listing in the "Maintenance Records" Booklet which comes with 200-, 700- and 940-series cars. That's where "The Gothenburg Bible" comes in. By following a number of preventive maintenance procedures, it's possible to reap the rewards of extended vehicle life -- even if it does mean growing out of your current factory maintenance record booklet.

To help keep your maintenance records in one booklet, a series of supplemental service interval charts have been prepared. Print, clip and append to your maintenance records booklet as required.

125,000 mile
200,000 km
Oil and Filter Change/Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

130,000 mile
208,000 km
Maintenance Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

135,000 mile
216,000 km
Oil and Filter Change/Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

*See Driving Conditions Chart

Service Intervals

140,000 mile 224,000 km Maintenance Service	145,000 mile 232,000 km Oil and Filter Change/Service	150,000 mile 240,000 km Maintenance Service
(Or at time interval*, whichever occurs first)	(Or at time interval*, whichever occurs first)	(Or at time interval*, whichever occurs first)
Dealer Stamp	Dealer Stamp	Dealer Stamp
Date Serviced	Date Serviced	Date Serviced
Odometer Reading	Odometer Reading	Odometer Reading
Serv. Mgr. Signature	Serv. Mgr. Signature	Serv. Mgr. Signature
Repair order no.	Repair order no.	Repair order no.
Additional Service Required:	Additional Service Required:	Additional Service Required:

*See Driving Conditions Chart

Service Intervals

155,000 mile 248,000 km Oil and Filter Change/Service	160,000 mile 256,000 km Maintenance Service	165,000 mile 264,000 km Oil and Filter Change/Service
(Or at time interval*, whichever occurs first)	(Or at time interval*, whichever occurs first)	(Or at time interval*, whichever occurs first)
Dealer Stamp	Dealer Stamp	Dealer Stamp
Date Serviced	Date Serviced	Date Serviced
Odometer Reading	Odometer Reading	Odometer Reading
Serv. Mgr. Signature	Serv. Mgr. Signature	Serv. Mgr. Signature
Repair order no.	Repair order no.	Repair order no.
Additional Service Required:	Additional Service Required:	Additional Service Required:

*See Driving Conditions Chart

Service Intervals

170,000 mile 272,000 km Maintenance Service	175,000 mile 280,000 km Oil and Filter Change/Service	180,000 mile 288,000 km Maintenance Service
(Or at time interval*, whichever occurs first)	(Or at time interval*, whichever occurs first)	(Or at time interval*, whichever occurs first)
Dealer Stamp	Dealer Stamp	Dealer Stamp
Date Serviced	Date Serviced	Date Serviced
Odometer Reading	Odometer Reading	Odometer Reading
Serv. Mgr. Signature	Serv. Mgr. Signature	Serv. Mgr. Signature
Repair order no.	Repair order no.	Repair order no.
Additional Service Required:	Additional Service Required:	Additional Service Required:

*See Driving Conditions Chart

Service Intervals

185,000 mile
296,000 km
Oil and Filter Change/Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

190,000 mile
304,000 km
Maintenance Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

195,000 mile
312,000 km
Oil and Filter Change/Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

*See Driving Conditions Chart

Service Intervals

200,000 mile 320,000 km Maintenance Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

205,000 mile 328,000 km Oil and Filter Change/Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

210,000 mile 336,000 km Maintenance Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

*See Driving Conditions Chart

Service Intervals

215,000 mile 342,000 km Oil and Filter Change/Service	220,000 mile 350,000 km Maintenance Service	225,000 mile 358,000 km Oil and Filter Change/Service
(Or at time interval*, whichever occurs first)	(Or at time interval*, whichever occurs first)	(Or at time interval*, whichever occurs first)
Dealer Stamp	Dealer Stamp	Dealer Stamp
Date Serviced	Date Serviced	Date Serviced
Odometer Reading	Odometer Reading	Odometer Reading
Serv. Mgr. Signature	Serv. Mgr. Signature	Serv. Mgr. Signature
Repair order no.	Repair order no.	Repair order no.
Additional Service Required:	Additional Service Required:	Additional Service Required:

*See Driving Conditions Chart

Service Intervals

230,000 mile 364,000 km Maintenance Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

235,000 mile 372,000 km Oil and Filter Change/Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

240,000 mile 380,000 km Maintenance Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

*See Driving Conditions Chart

Service Intervals

245,000 mile
388,000 km
Oil and Filter Change/Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

250,000 mile
396,000 km
Maintenance Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

255,000 mile
404,000 km
Oil and Filter Change/Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

*See Driving Conditions Chart

Service Intervals

260,000 mile 412,000 km Maintenance Service	265,000 mile 420,000 km Oil and Filter Change/Service	270,000 mile 428,000 km Maintenance Service
(Or at time interval*, whichever occurs first)	(Or at time interval*, whichever occurs first)	(Or at time interval*, whichever occurs first)
Dealer Stamp	Dealer Stamp	Dealer Stamp
Date Serviced	Date Serviced	Date Serviced
Odometer Reading	Odometer Reading	Odometer Reading
Serv. Mgr. Signature	Serv. Mgr. Signature	Serv. Mgr. Signature
Repair order no.	Repair order no.	Repair order no.
Additional Service Required:	Additional Service Required:	Additional Service Required:

*See Driving Conditions Chart

Service Intervals

275,000 mile 436,000 km Maintenance Service	280,000 mile 444,000 km Oil and Filter Change/Service	285,000 mile 452,000 km Maintenance Service
(Or at time interval*, whichever occurs first)	(Or at time interval*, whichever occurs first)	(Or at time interval*, whichever occurs first)
Dealer Stamp	Dealer Stamp	Dealer Stamp
Date Serviced	Date Serviced	Date Serviced
Odometer Reading	Odometer Reading	Odometer Reading
Serv. Mgr. Signature	Serv. Mgr. Signature	Serv. Mgr. Signature
Repair order no.	Repair order no.	Repair order no.
Additional Service Required:	Additional Service Required:	Additional Service Required:

*See Driving Conditions Chart

Service Intervals

290,000 mile 460,000 km Maintenance Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

295,000 mile 468,000 km Oil and Filter Change/Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

300,000 mile 476,000 km Maintenance Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

*See Driving Conditions Chart

Service Intervals

305,000 mile 484,000 km Maintenance Service	310,000 mile 492,000 km Oil and Filter Change/Service	315,000 mile 500,000 km Maintenance Service
(Or at time interval*, whichever occurs first)	(Or at time interval*, whichever occurs first)	(Or at time interval*, whichever occurs first)
Dealer Stamp	Dealer Stamp	Dealer Stamp
Date Serviced	Date Serviced	Date Serviced
Odometer Reading	Odometer Reading	Odometer Reading
Serv. Mgr. Signature	Serv. Mgr. Signature	Serv. Mgr. Signature
Repair order no.	Repair order no.	Repair order no.
Additional Service Required:	Additional Service Required:	Additional Service Required:

*See Driving Conditions Chart

Service Intervals

320,000 mile 508,000 km Maintenance Service	325,000 mile 516,000 km Oil and Filter Change/Service	330,000 mile 524,000 km Maintenance Service
(Or at time interval*, whichever occurs first)	(Or at time interval*, whichever occurs first)	(Or at time interval*, whichever occurs first)
Dealer Stamp	Dealer Stamp	Dealer Stamp
Date Serviced	Date Serviced	Date Serviced
Odometer Reading	Odometer Reading	Odometer Reading
Serv. Mgr. Signature	Serv. Mgr. Signature	Serv. Mgr. Signature
Repair order no.	Repair order no.	Repair order no.
Additional Service Required:	Additional Service Required:	Additional Service Required:

*See Driving Conditions Chart

Service Intervals

[..... Higher Mileage Charts -->]

The Volvo Performance Handbook

Forward

Mass-produced cars are built to criteria established in the boardroom. They seek a balance between cost and refinement, handling bias and suspension compliance, engine output and fuel economy, aerodynamics and style, and crashworthyness and safety. In most cases the balance isn't intended to be ideally suited to all environments and markets in equal measure. Nor is it expected to appeal to both the commuter and driving enthusiast. It is, much like vanilla ice cream, intended to appeal to the broad range of tastes as defined by the global market.

It is difficult, however, to equate the enjoyment derived from the best vanilla ice cream to that of high performance cars. Products from carrozzerea Alfa Romeo, Bugatti, Delahaye, Ferrari, Jaguar, Maserati or Porsche didn't achieve fame through universal appeal but rather from the accolades bestowed upon them by those few discerning drivers and preeminent racers fortunate enough to explore their limits on public roads and closed circuits. Function was the prime determinant of the cars' success, with form later heralded (or criticised) by the masses.

Such is the case with Volvo. Until recently, the company had been sharply criticised by the public for its boxy automotive designs whereas the marque's traditionally robust chassis, supple suspensions and strong engines were praised by enthusiasts. The dichotomy between the marque's public image and performance potential has resulted in a unique combination of advantages and disadvantages for the automotive enthusiast.

Regardless of their vintage, Volvos remain a reasonable used car buy. This allows many enthusiasts to comfortably purchase a Volvo as a project car. The marque's staid image also results in lower insurance costs, allowing the budget-minded enthusiast to devote a greater percentage of disposable income to modification. Finally, most Volvos benefit from conservative styling. This makes them less-prone to unwanted attention by law-makers and law-breakers.

The disadvantages, namely a lack of reliable information on performance modifications and readily available "Volvo-friendly" sources of enthusiast parts and accessories, will be addressed by this book.

"The Volvo Performance Handbook" is not intended to a step-by-step guide to vehicle design, maintenance or modification. It is, however, written to help enthusiasts address performance concerns regarding late model Volvo cars in consultation with licensed mechanics and/or parts distributors.

Of course, any consideration of performance upgrade can only take place after the car's basic mechanical systems are certified to be in excellent operating condition and the owner made aware of any warranty implications which modification would entail. To this end, readers are urged to consult with owner's manuals, factory technical directives, aftermarket repair guides, and preventive maintenance publications before commencing work on their project car.

I wish you luck in attaining your car's performance objectives and trust that you will enjoy reading The Volvo Performance Handbook.

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Suspension FAQ

Q: The right front suspension in my 740 is making noise since my son hit a curb and trashed the alloy wheel, driving light and air dam. My alignment guy says the control arm is bent but it looks exactly like the one on the left. He also noted the ball joint should be replaced as well as all the bushings and while I've got it all apart it would be a good time to replace the strut cartridge and tie-rod ends.

The dealership wants $260.00 for one hub assembly. The aftermarket ones are about $180 and are made in some backwater third world country and of questionable quality. Maybe I can press out the old AC bearing set and buy a replacement. Is there a tapered-roller bearing set-up to replace the factory angular-contact (AC) bearing set in the front wheel hub assembly?

What are my repair options?

A: The lower control arm on a 740 is made from cast steel. It's very rugged, but it sounds as if the car was driven into a tall curb with considerable force. This force could have bent the control arm somewhere between the ball joint flange and the cross member. A bend would be difficult to detect. Symptoms could include abnormal camber or caster. Since camber and caster cannot be adjusted in a 700-series front suspension, a fault in this area would indicate either badly worn bushings or a bent suspension component.

Following a hard impact, I would replace the ball joint, check the control arm strut (the thin lateral rod connected to the lower control arm), and tie rod end as a safeguard against sudden catastrophic failure and the loss of control that would follow.

Your decision to replace the left side components will depend on when they were last changed. If its been five years or more, replacing components on the other side is recommended.

Unlike multi-piece hubs for 240s, the dealership sells the entire assembly for 700-series cars. This is expensive to replace, but will be much more reliable than an aftermakret part of questionable quality. If you have any doubt, spring for the OE part.

Q: Nowadays I'm very sensitive to the vibration when I drive. The car has been very sensitive to the every surface I thought it was because of the worn shock absorber and I have changed to the KONI adjustable shock. However, no improve except for the handling. Is there any way to solve this problem?

A: I'm assuming that your car is driven on smooth roads and uses a wheel/tire combination of 17" or less in diameter. I'm also assuming that the car has not been in an accident, nor has it left the road and suffered suspension damage.

There are a couple of potential causes for vibration. The first, and most common, is an imbalance in the wheel & tire assembly. This can be caused by the following:

a. incorrectly balanced tires (wheel weight location incorrect);
b. bent wheel; and
c. damaged tire

The best way to balance tires is by match mounting. This requires removal of the tires, precise measurement of the rim flange using a dial indicator and synchronization of the low point of the rim flange to the high point of the tire, the latter of which is marked on a new tire with a spot of paint. Match mounting will reduce the radial run-out, reduce the requirement for wheel weights and smooth out the ride.

To be successful, the wheel must be within manufacturer's specification (depending on the type of wheel, Volvo specifications are no more than 0.6mm radial and lateral run-out. A wheel that exceeds these run-out figures could be damaged. If so, it would be both difficult and ill-advised to use the wheel. It must be either professionally straightened or replaced. I advocate the latter as straightening aluminum is difficult. It stretches and loses its tensile strength.

A damaged tire should be replaced. Signs of a damaged tire include scarring of the side wall or tread, noticeable bumps or lumps, persistent loss of air pressure (after the valve has been checked for leaks), and directional instability (after the camber, toe and caster has been checked).

Vibration can also be caused by worn or improperly adjusted wheel bearings, warped brake rotors, worn suspension bushings or damaged CV joints. These items can be verified by your dealer.

Q: My mechanic says that I need a front-end alignment. What is required to align the front suspension and how will it affect my car's handling?

A: An alignment brings caster, camber, and toe into factory specifications. Caster is not adjustable on a 240, that is unless you swap ball joints, thus altering the angle by about 2-3 degrees. This will make the car somewhat more "darty", but not necessarily pull to one side. Camber may be adjusted by moving the upper strut attachment in or out.

The Specifications for 240s are:

Camber .50 degrees (+/- .25 deg)
Caster 3.50 deg (+/- .50 deg)
Total Toe .27 deg (+/- .13 deg)

You do not mention if the control arm bushings have been inspected. If they are worn, you could get a pull under braking. If the ball joint(s) are damaged and out of alignment, you may also get a pull... not under braking, mind you but when cruising. Try checking the alignment of the engine cross-member. This is often out of alignment on Volvos which have been in an accident (even a minor one).

Q: Is design intent of the 850 suspension to provide true handling characteristics or did they run out of money?

A: In your question concerning the design intent of the 850 Turbo's suspension, I assume that you seek comment on the rear (Delta Link) rear suspension; the front MacStrut set-up is basically the same as those dating back to the 1970s.

I suspect that Volvo selected a twist beam reear axle (the Delta Link is just a fancy name for a semi-articulated twist beam) because of its small packaging (allows greater passenger/trunk space and, as you suggested, price. The design of the axle suggests that ultimate handling was not the intent; for that Volvo would have likely chosen a double-wishbone independent design.

Q: I purchased a rear bushing replacement kit. I would like to replace the same on my own, but realize the tremendous amount of labor involved. (I did 3 of the 4 front bushings without a press). Although I will have access to a press this time around, I am concerned about removal and replacement of the trailing arm bushings attached to the car/axle.

Do you have any advice concerning the purcase or rental of any special tools for this procedure? I know Volvo makes special tools for all thse bushings, but obviously I am not in the market to purchse them for a one time job.

A: Although I prefer to use Volvo special tools, I'll admit that they are expensive and often difficult to source. I would suggest that you give your local "Snap-On" distributor a try. There are no deals to be found in the specialty tools market, so go for quality.

In reference to your Volvo's trailing arm bushings, it is not uncommon to have to torch-cut the retaining bolts; they get quite rusty. Also, sometimes the bushings need to be pressed, other times cut or burned out. As you can imagine, all of the moisture and heat under the car bakes/rusts parts together.

Q: How do I stop the front bushings of my 745 groaning every time I go over a bump, without replacing?

A: If the suspension groans over bumps, one or more faults may be present:

(1) The bushings are worn (incurable, without replacement); or
(2) The ball joints are worn and/or contaminated (again, replace
ment necessary).

Spraying any lubricants on the bushings and/or ball joints mask, but will not cure the faults. Replacement is the only effective solution. I recommend bushing replacement every 80,000 to 100,000 miles; more if the car is extensively driven aggressively.

Sorry to be the bearer of bad news....... but if you replace the bushings, your car will perform much better!

Q: Front end handling seems very boat like. Could be tires as I just replaced the trailing arm bushings and torque rod bushings. Front end ball joints seem OK. Can you think of any other parts that could be causing the poor handling?

A: I will address your Volvo's handling problem (front end handles like a boat) from most likely to least likely. I am assuming that your car has never suffered any significant front-end damage, nor has any obvious signs of catastrophic failure.....

Worn Shocks -- highly likely. If your car's suspension floats and lacks a positive feel at highway speed, then the shocks are likely shot. The average, cheepie shock ($30-60) lasts about 2 years. Stock-quality shocks ($70-100) tend to last for about 5 years max. Up-rated shocks ($130+) such as Bilstien can last a decade or more. Quick math reveals which one represents sound value.

Worn Ball Joints -- possible. Worn ball joints can manifest themselves in many ways. The best way to check out lower ball joints is with the car safely raised. Grasping the top and bottom of the wheel, try to rock the wheel. If it feels loose, and it has been more than 5 or so years since they were last done, the lower ball joints are shot.

Tie Rod Ends -- possible. Similar test as ball joints only grasp sides of tire/wheel and try to turn..... the steering rack will move, but your looking for a loose feel here. Same time/life considerations as ball joints.

Springs -- unlikely. OEM Volvo springs are wound from very high quality steel and tend to last the entire life of the car..... yes, even as long as 20 years or more. Nevertheless, the are affected by mileage and load, so if you've been flogging the car hard, measure thedistance between the fender lip to the ground (you need to start with very level pavement to avoid error). Any discrepancies between left and right side suggest a problem with the springs, although one must obviously use some judgement in deciding whether a 1/16th of an inch difference indicates anything at all!

Tires -- unlikely. True, tires have a spring rate, but they do not change their response (much) over their useful life. The only differences in handling come in the wet, or if the compound becomes so hard that small stress cracks are visible.

Bushings -- unlikely..... you've already replaced them! Otherwise, a likely culprit. Average life: 5-7 years under normal use.

Q: General suspension advice.

A: There has been a few postings on the net regarding suspension set-ups...

While it is true that shocks, springs, anti sway bars, camber/caster settings and chassis bracing can be viewed in isolation, it pays dividends to look at the philosophy of the total package. While some suspensions will go the traditional route of large sways, hard shocks etc, one must consider the smoothness of the terrain being followed in order to arrive at the best set-up. Having coal-cart stiff suspension will do you little good when the road is uneven -- you car will lose contact patch as it skitters across the surface under foot (wheel?!). Nor will a soft, long travel suspension be able to maximize chassis capability when the road is ribbon smooth.

I submit that chassis tuning is a highly individual thing, with a number of set-ups possible. Roll stiffness, jounce/rebound control, turn-in, chassis stiffness etc run the risk of being compromised when your parts order goes something like this:

Cut down springs
"Really stiff" shocks (front and rear)
"Fore-arm" thick sway bars
Big, Wide Tires.... you get the point.

I think what most of us are trying to find is a set-up which responds lightly and positively, retains most of our fillings, and can handle a pothole or two. To get this set-up requires some serious and careful consideration, a good knowledge of suspension dynamics and, above all else, a clear statement of what is being sought.

I'm not sure that these kind of answers come from a box (even one marked R-sport) but through careful study and
even some experimentation

For those who are frustrated with their suspension set-ups, I would recommend a cold beer (useful for many things), some graph paper, any one of a number of good suspension books (Race/Prepare To Win & The Volvo Performance Handbook come to mind as a fairly good primer(s)) and some graph paper before even opening up your wallet/purse. Isolating each design element and making some fundamental decisions will put you ahead of the "buy and try" group.

Q: I must do strut replacement and need suggestions for a performance strut/shock setup. I want my 745 turbo to handle solid and corner flat but I don't want to spend a lot of money!!

A: Although I can sympathize with your desire to have a better handling car, I suspect that someone has steered you wrong on just what needs fixing. Shock absorbers damp suspension movement but do little to (efficiently) reduce body lean..... that's the role of front and rear anti-sway bars. In this case, you would want heavy duty anti-sway bars.........

But if you really want shocks, Boge offers a pretty good emulation of the stock Volvo set-up. For high performance, however, go with Bilstein shocks; their single tube, high pressure design is simply the best performance upgrade for a Volvo.

Q: I own a 97 855R and would like to lower it. I am having trouble getting information regarding the "automatic self-leveling" rear shocks that come with the 850 R Wagon. Is there a way to adjust them to level at a lower height than stock (about 1" lower). If I remove the rear stock springs the car still sits at stock height. I have gone to two dealers out here in Southern California and none of the Volvo mechanics are familiar with these shock units. Can I use these units with lowering springs or do I have to use different rear shocks.

A: Unless I miss my guess, your 850's automatic leveling shocks are actually Boge NIVOMATs. If so, then shame on your Volvo mechanic for not being familiar with them..... they were extensively fitted to 700-series cars and were often lamented for their short service life and HUGE replacement cost ($400.00 each).

If you wish to lower your Volvo, however, you may wish to switch to a much heavier-duty shock since a shorter spring will undoubtedly have a significantly higher spring rate. Subject to warranty considerations, a Bilstein high pressure gas shock
would likely be required to control the oscillations of a stiffer spring. Lowering your car by more than one inch would probably require you purchase a special shock which has been calibrated to effectively operate over a shorter stroke range.

If lowering is really your desire, go for it. I would recommend, however, that you complete all other mods (uprated tires, chassis, brakes, bushings, etc) *before* lowering. You may discover that you can achieve the handling you desire without getting the harder ride often associated with shorter springs.

A wealth of data on modifying or upgrading Volvo suspensions may be found in "The Volvo Performance Handbook".

Q: I have a 95 850 Turbo Sportwagon. I'd like to put chains on the front for snow conditions at Mammoth. One choice is to buy a whole set of 185-15 snow tires and steel wheels from Discount Tire for $500. I'd like to try borrowing the 15" alloy wheels from my friend's 850 wagon and put chains on them. Stock wheels for non-turbo are 195-15. Will the chains clear a 195 tire?

A: It depends purely on the length and width of the chains. Predicting the outcome is more difficult since you omitted the aspect ratio of the tire(s) in question. There are, of course, many variety of chains on the

market (steel link, wire, plastic) -
each with their own characteristics. Depending on where you live and how you drive, you may wish to consider steel wheels and *studded* tires (check local laws, some states/provinces do not allow studs). This may be better than chains which, if thrown, can cause a lot of damage to fenders, not to mention the wear and tear which they place on the tire itself.

Q: I wanted to ask you a question about replacing my snowtires on my 1992 944 Turbo: I have Nokia Hakka NR 10 that are about 5 years old and nobody seems to be able to tell me with certainty if the tread is still good. The side of the tire near the tread appears to have fine cracks. Do they need to be replaced? If I need to get new snowtires, what brand would you suggest. I live in Vancouver, and it stormed last year!

A: Cracks in the sidewall of a tire can be caused by two things, persistent under-inflation or age. I suspect that the cracks are more age-related and are the effect of the outer layers of rubber drying out from exposure to UV light and moisture. Very light cracks (those no wider than the width of a human hair) do not typically pose a hazard, whereas any crack which is wider than the thickness of a piece of white bond paper should be replaced immediately.

In addition to the thickness of the cracks, the following should be verified:

1. Tire holds pressure almost indefinitely;

2. There are no unusual bumps, bulges or humps in the sidewall or tread;

3. There are no visible cords, especially on the sidewall of the tire (would indicate that the tire has been "curbed" a few times);

4. To the best of your knowledge, the tire has not been subjected to abnormally large impacts, such as those which cause damage to a rim or wheel; and

5. The tread depth is sufficient. The tread bars have not yeet reached the outermost portion of the tread.

If you answer yes to those questions, your tires are probably still OK to use for the next (ski?) season.

The best snow tires (as rated by the automags entitled Tekniikan Maillma" from Finland, "Auto Motor & Sport" from Sweden and "Motor" from Norway) are:

Gislaved Nord Frost 2 - A tire readily available through your local Volvo dealer, the Nord Frost beat out the nearest two competitors in last year's shoot-out. Max Speed = 160 km/h.

Continental Viking Stop 4000 - Somewhat harder to find, the Conti's strength was in its consistent performance across the driving range (wet, snow, ice, cornering, braking). Max Speed = 160 km/h.

Michelin XM-S & Hakkapeliitta 10 - These two tires tied for third; somewhat of a fall from grace for Nokia, given that it had represented the state of the art in previous years' tests. The Hakkas scored top marks, however, in wet ice traction, probably the result of a softer compound and sidewall. Max Speed = Michelin 160 km/h, Nokia 190 km/h.

Bridgestone WT & Pirelli Winter S - Lack-luster performance for these two competitors, but still several notches above what one is likely to find in a true "four-season" tire. Max Speed = 160, 190, 210 km/h depending on the size and brand.

My choice would be either the Continental or the Hakka 10s, although I could be swayed enough by the good performance and tread life of the Hakkas to consider a repeat purchase. The Gislaved is, however, attractive due to its easy availability through the local Volvo dealer (the others tend to grace the shelves of performance-oriented shops only). Either way, the top three winter tires would be hard to beat.

Choose Another Category of Interest.....

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Type 1 Volvo Engine Designations -

For Model Years 1955 to 1985

by Paul Grimshaw,
Author, The Gothenburg Bible

Volvo used up to five characters to describe engines produced for passenger cars marketed during Model Years 1955 to 1985.

The first character used in the designation system referred to the fuel required by the engine. The second and third characters denoted the displacement in litres. The fourth character described the fuel delivery system. An optional fifth character was sometimes used to highlight special features.

First Character (Fuel Requirements):

B = benzine (gasoline) powered engine;
D = diesel powered engine;

Second and Third Characters (Engine Displacement):

14 = 1.4 litres
16 = 1.6 litres
17 = 1.7 litres
18 = 1.8 litres
20 = 2.0 litres
21 = 2.1 litres
23 = 2.3 litres
24 = 2.4 litres
27 = 2.7 litres

28 = 2.8 litres
30 = 3.0 litres

The only 2.4 litre engine that Volvo produced for passenger car use during this era was diesel powered.

Fourth Character (Fuel Delivery & Compression):

A = single carburetor, normal compression engine;
B = twin constant depression carburetors, normal compression engine;
D = twin carburetor, high compression engine;
E = fuel injection (usually continuous mechanical injection), high compression engine;
F = fuel injection (usually electronic sequential injection), normal compression engine; and
K = single carburetor, high compression engine.

The "E" engines were generally fitted with continuous injection and, in some markets, a high performance camshaft. Other features sometimes included a higher compression ratio made possible by a thinner head gasket, different pistons, or changes in valve timing. Exceptions to typical "E" designation was the US-specification B21F that was fitted with a high pressure (continuous) fuel injection system, moderate compression and a very mild camshaft.

More typical "E" engines were not marketed in the United States, whereas Canadian and European customers could specify the high output B23E engine in 200-series cars produced during the early 1980s.

Fifth Character (Optional - Special Features):

T = turbocharged engine.

Examples Using "TYPE 1" Engine Designation System:

B18B - Gasoline-powered, 1.8 litre, four cylinder engine with twin carbs (Skinner's Union HS 6)

B21A - Gasoline-powered, 2.1 litre, four cylinder engine with a single carb (Skinner's Union HIF 6 or Zenith Stromberg 175CD2SE).

B21F - Gasoline-powered, 2.1 litre, four cylinder engine with continuous fuel injection (Bosch K-Jetronic).

B23F - Gasoline-powered, 2.3 litre, four cylinder engine, with pulsed fuel injection (Bosch LH-Jetronic).

B23E - Gasoline-powered, 2.3 litre, four cylinder engine, with continuous fuel injection (Bosch K-Jetronic).

D24T - Diesel-powered, 2.4 litre, six cylinder engine, with turbocharger.

B21FT - Gasoline powered, 2.1 litre, four cylinder engine with continuous fuel injection. (Bosch K-Jetronic). Turbocharged.

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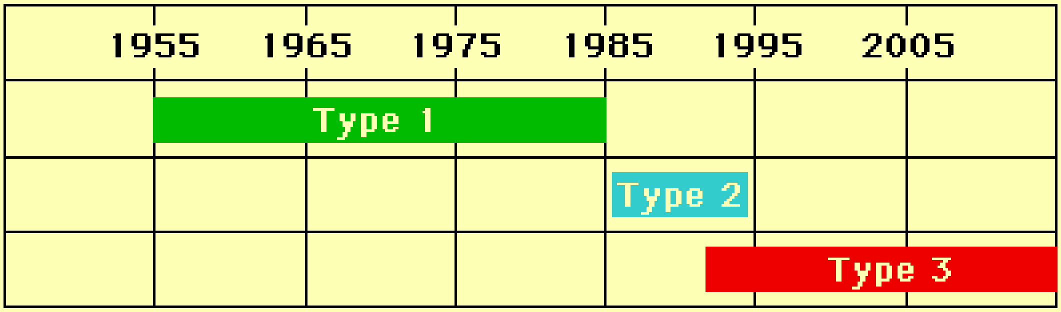
Or choose another engine designation:



Type 2 Volvo Engine Designations -

For Model Years 1985 to 1994

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by Paul Grimshaw,
Author, The Gothenburg Bible

Volvo made some significant engine changes to its engine designation system for the 1985 Model Year. This revised designation system, using up to six characters, was introduced to better describe Volvo's new low-friction engines.

First Character (Fuel Requirements):

B = benzine (gasoline) powered engine; and
D = diesel powered engine.

Second, Third and Fourth Characters (Engine Displacement):

200 = 2.0 litres, low friction engine;
230 = 2.3 litres, low friction engine; and
280 = 2.8 litres, low friction engine.

If the fourth character is "4", the engine is a low friction engine with dual overhead camshafts and four valves per cylinder. (Example: 234 = 2.3 litres, low friction engine with dual overhead camshafts and four valves per cylinder.)

Fifth Character (Fuel Delivery & Emission Controls):

E = high compression engine with fuel injection. No catalytic converter;
F = normal compression engine with fuel injection. With catalytic converter;

G = normal compression engine with fuel injection. No catalytic converter; and
K = high compression engine with single carburetor. No catalytic converter.

In Europe, "E" engines were more common due to relaxed emission control regulations and one may find B200 and B230E engines in Volvo 200- and 700- series cars with relative ease.

Sixth Character (Special Engine Features):

B = VX camshaft;
D = M camshaft;
G = VX camshaft;
K = low pressure turbocharged;
T = turbocharged; and
X = VX camshaft.

Examples Using "TYPE 2" Engine Designation System:

B230FD - Gasoline-powered, 2.3 litre, four cylinder engine, with fuel injection (Bosch LH-Jetronic) and an "M" camshaft.

B230FT - Gasoline-powered, 2.3 litre, four cylinder engine, with fuel injection (Bosch LH-Jetronic). Turbocharged.

B230FB, B230FG, B230FX - Gasoline-powered, 2.3 litre, four cylinder engine with fuel injection (Bosch LH-Jetronic) and a VX camshaft.

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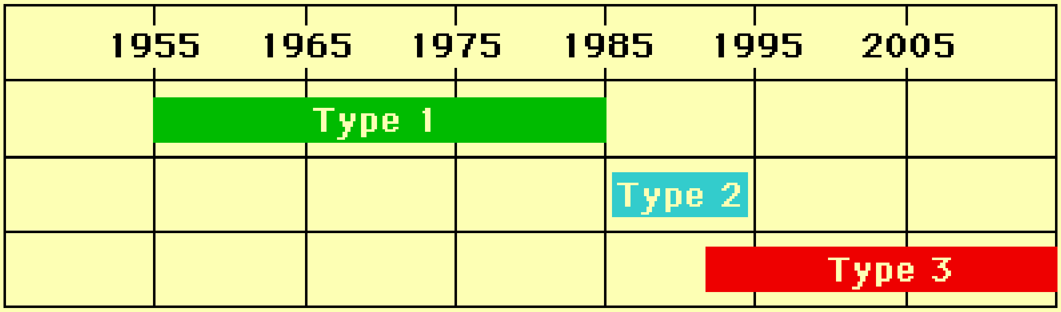
Or choose another engine designation:


1955
1965
1975
1985
1995
2005
Type 1
Type 2
Type 3

Type 3 Volvo Engine Designations -

For Model Years 1993 & Later

by Paul Grimshaw,
Author, The Gothenburg Bible

The introduction of Volvo's "RN" modular engine family for the 1993 Model Year required slightly revised nomenclature, with provision for up to eight characters. The resulting designation system could be used to describe the number of cylinders, displacement, number of valves per cylinder, and special features of a particular engine.

First Character (Fuel Requirements):

B = benzine (gasoline) powered engine; and
D = diesel powered engine.

Second Character (Number of Cylinders):

4 = four cylinder engine;
5 = five cylinder engine; and
6 = six cylinder engine.

Third and Fourth Characters (Engine Displacement):

16 = 1.6 litres
18 = 1.8 litres
20 = 2.0 litres
23 = 2.3 litres
24 = 2.4 litres

25 = 2.5 litres
30 = 3.0 litres

Fifth Character (Number of Valves per Cylinder):

2 = two valves per cylinder; and
4 = four valves per cylinder.

Sixth and Subsequent Characters (Engine Features):

F = fuel injection, normal compression, with catalytic converter;
G = low pressure fuel injection with catalytic converter;
S = low pressure fuel injection, catalytic converter;
FS = fuel injection, normal compression, with catalytic converter;
T4, T5 or T6 = high pressure turbocharged;
T = turbocharged;
LPT = turbocharged, low pressure; and
M = Gasoline Direct Injection. Note this feature was only fitted to one specific engine, only available in Europe due to the availability of low sulphur fuels in that market (0.5% versus 1-2% for North American fuels). For additional information on this engine, click here.

It is entirely possible that this designation system will be in place for some time. The only expected changes will be to streamline the designators for engine features as new technologies are introduced into the Volvo engine line.

Examples Using "TYPE 3" Engine Designation System:

B5254FS - Gasoline-powered, five cylinder, 2.5 litre, 4 valves-per-cylinder, sequential fuel injected engine with a catalytic converter.

B5254LPT - Gasoline-powered, five cylinder, 2.5 litre, 4 valves-per-cylinder, sequential fuel injected engine. Fitted with a low pressure turbocharger system and a catalytic converter.

B5234FT - Gasoline-powered, five cylinder, 2.3 litre, 4 valves-per-cylinder, fuel injected engine, with a turbocharger and a catalytic converter.

B5234 T-5 - Gasoline-powered, five cylinder, 2.3 litre, 4 valves-per-cylinder, fuel injected engine, with a high pressure turbocharger and a catalytic converter.

B6304G - Gasoline-powered, six cylinder, 3.0 litre, 4 valves-per-cylinder, fuel injected engine with a catalytic converter.

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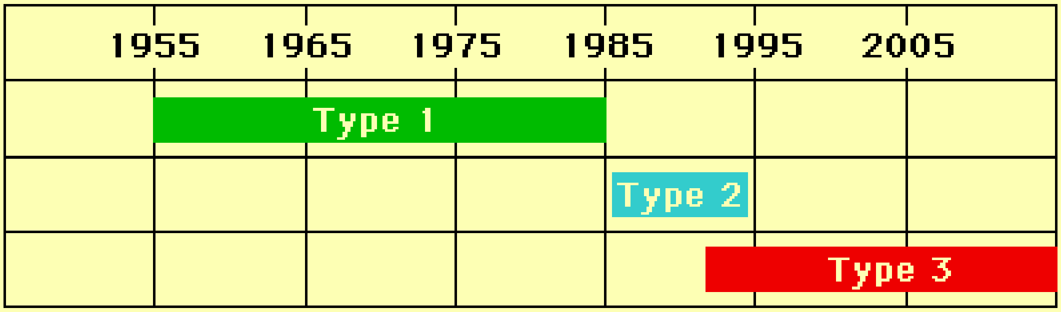
Or choose another engine designation:



Maintenance Charts (Part Two):

335,000 mile/532,000 km --> 405,000 mile/641,000 km

To help keep your maintenance records in one booklet, a series of supplemental service interval charts have been prepared. Print, clip and append to your maintenance records booklet as required.

335,000 mile 532,000 km Maintenance Service	340,000 mile 540,000 km Oil and Filter Change/Service	345,000 mile 548,000 km Maintenance Service
(Or at time interval*, whichever occurs first)	(Or at time interval*, whichever occurs first)	(Or at time interval*, whichever occurs first)
Dealer Stamp	Dealer Stamp	Dealer Stamp
Date Serviced	Date Serviced	Date Serviced
Odometer Reading	Odometer Reading	Odometer Reading
Serv. Mgr. Signature	Serv. Mgr. Signature	Serv. Mgr. Signature
Repair order no.	Repair order no.	Repair order no.
Additional Service Required:	Additional Service Required:	Additional Service Required:

*See Driving Conditions Chart

Service Intervals

350,000 mile **554,000** km Maintenance Service	**355,000** mile **564,000** km Oil and Filter Change/Service	**360,000** mile **572,000** km Maintenance Service
(Or at time interval*, whichever occurs first)	(Or at time interval*, whichever occurs first)	(Or at time interval*, whichever occurs first)
Dealer Stamp	Dealer Stamp	Dealer Stamp
Date Serviced	Date Serviced	Date Serviced
Odometer Reading	Odometer Reading	Odometer Reading
Serv. Mgr. Signature	Serv. Mgr. Signature	Serv. Mgr. Signature
Repair order no.	Repair order no.	Repair order no.
Additional Service Required:	Additional Service Required:	Additional Service Required:

*See Driving Conditions Chart

Service Intervals

365,000 mile 580,000 km Maintenance Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

370,000 mile 585,000 km Oil and Filter Change/Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

375,000 mile 593,000 km Maintenance Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

*See Driving Conditions Chart

Service Intervals

365,000 mile 580,000 km Maintenance Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

370,000 mile 585,000 km Oil and Filter Change/Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

375,000 mile 593,000 km Maintenance Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

*See Driving Conditions Chart

Service Intervals

380,000 mile 601,000 km Maintenance Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

385,000 mile 609,000 km Oil and Filter Change/Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

390,000 mile 617,000 km Maintenance Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

*See Driving Conditions Chart

Service Intervals

395,000 mile 625,000 km Maintenance Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

400,000 mile 633,000 km Oil and Filter Change/Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

405,000 mile 641,000 km Maintenance Service

(Or at time interval*, whichever occurs first)

Dealer Stamp

Date Serviced

Odometer Reading

Serv. Mgr. Signature

Repair order no.

Additional Service Required:

*See Driving Conditions Chart

Service Intervals

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