Gas Shielded Welding Processes

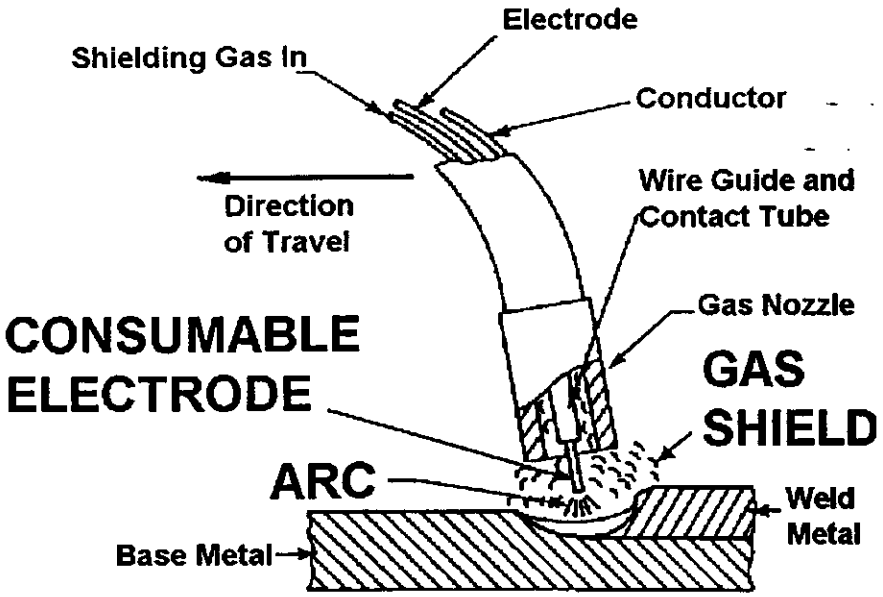
Gas Metal Arc Welding (GMAW)

Gas Metal Arc Welding

Process Fundamentals

- In GMAW the welding heat source is an arc maintained between a consumable wire electrode and the workpiece
- The weld is formed by melting and solidification of the joint edges together with filler material transferred from the electrode
- An flow of inert gas shields the high-temperature arc and weld pool from reactions with the surrounding atmosphere

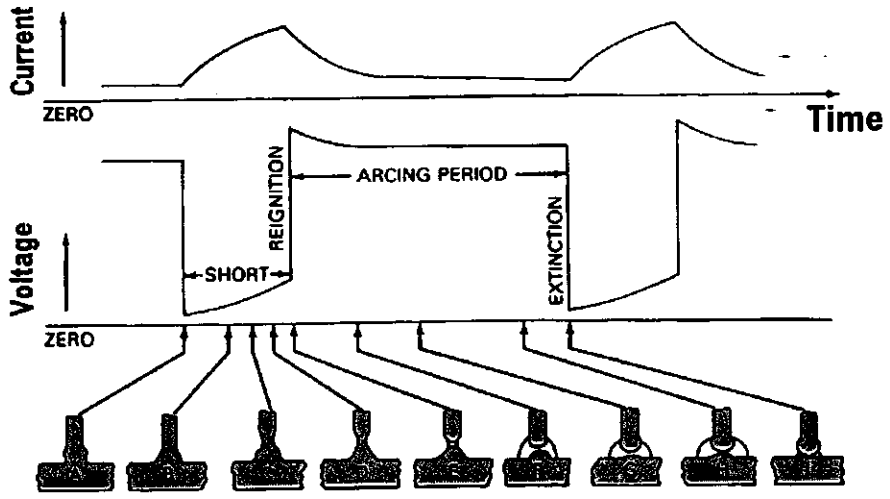
GMAW Process Fundamentals



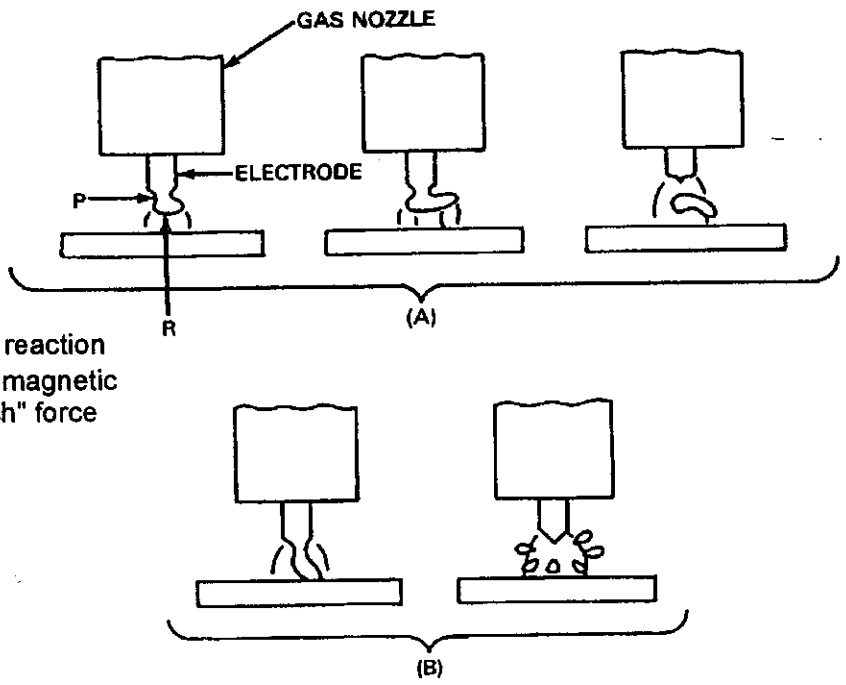
GMAW Metal Transfer Modes

- Short Circuiting or "Dip" Transfer
- Globular Transfer
- Spray Transfer
- Pulsed or Synergic Transfer

GMAW Short Circuiting Transfer



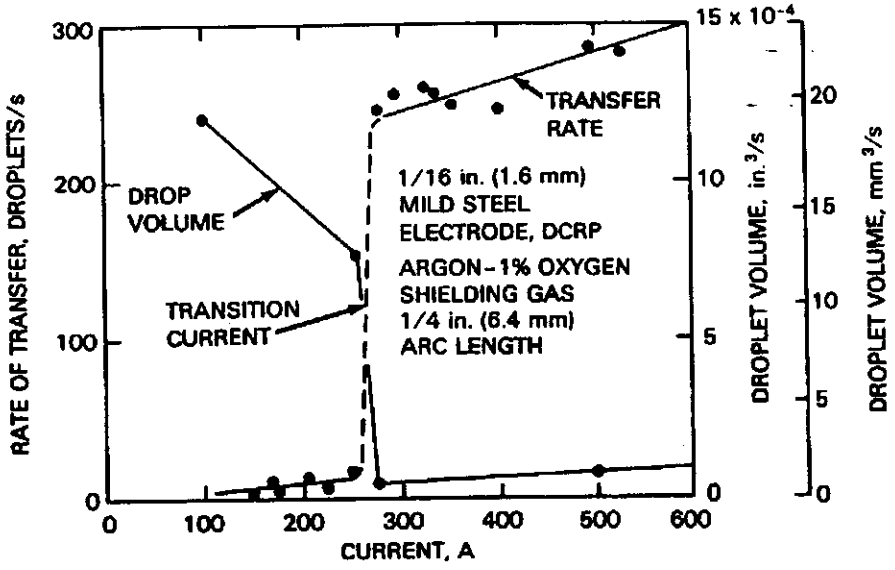
GMAW Globular Transfer Mode



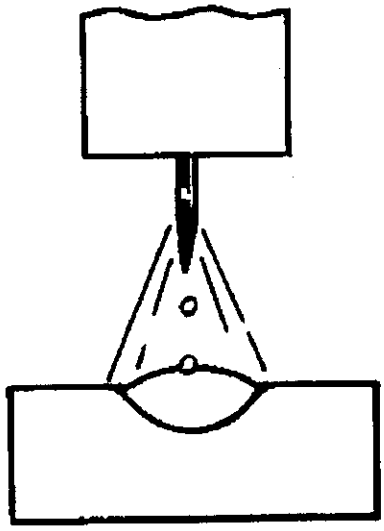
R-Anode reaction
P-Electromagnetic "pinch" force

GMAW Spray Transfer

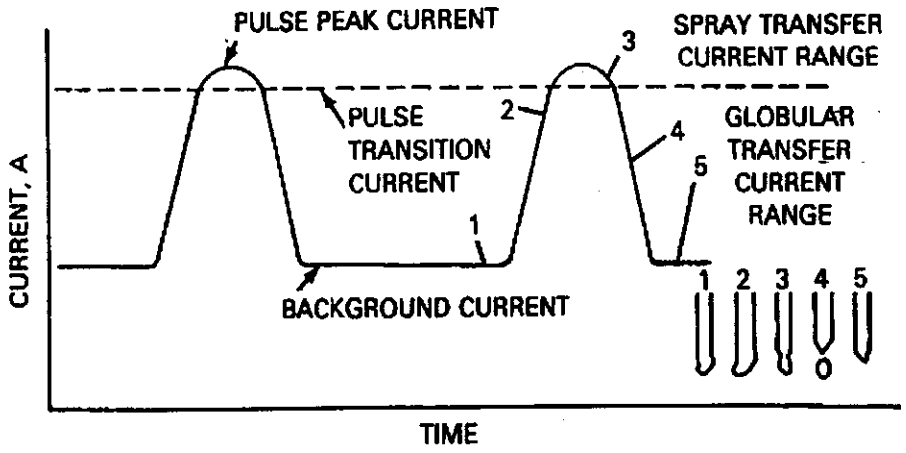
Variation in volume and rate of drop transfer with welding current



GMAW Spray Transfer



GMAW Pulsed Transfer

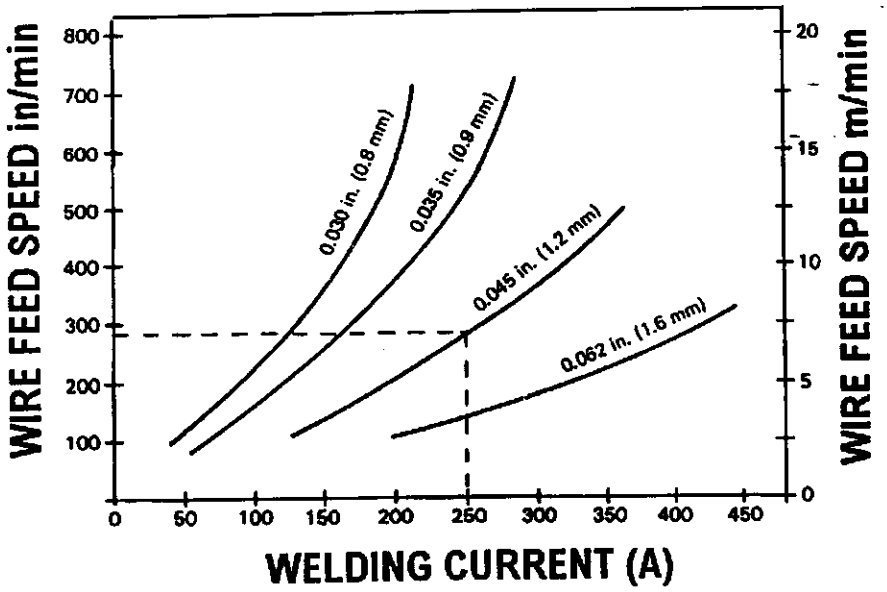


- Pulse frequency and amplitude determine wire melting rate
- "Synergic" control automatically gives the optimum pulse conditions for a given wire feed rate

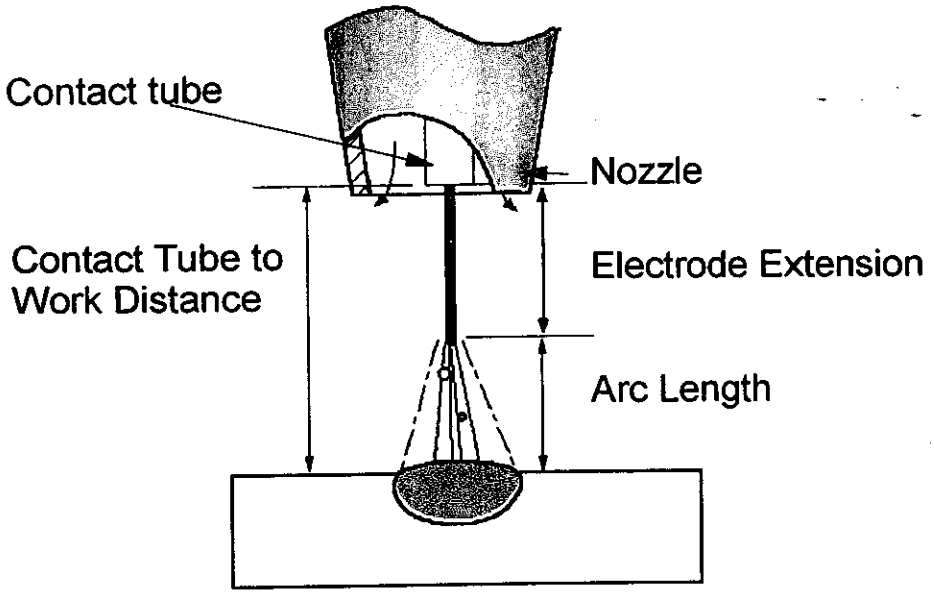
GMAW Welding Procedures

- Process Variables
  - Welding current (electrode melting rate)
  - Polarity
  - Arc voltage (length)
  - Travel speed
  - Electrode extension
  - Electrode size
  - Shielding gas composition

GMAW Electrode Melting Rate



GMAW Torch Geometry

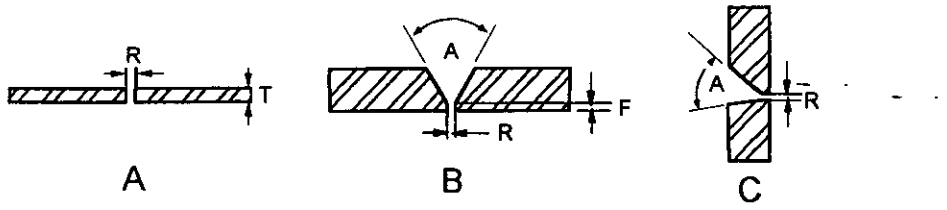


GMAW Consumables

- Electrode composition is usually similar to desired weld metal composition with additional deoxidizers e.g. Si, Al, Ti
- Electrodes are covered by AWS and other specifications
  - Carbon steel electrodes AWS A 5.18.
- Shielding Gases
  - Various shielding gases are used depending on metal being welded and desired transfer mode
  - Principally Ar, CO2 and mixtures of Ar-CO2, O2 or He
  - Several commercial "brand-name" compositions

GMAW Typical Welding Procedures

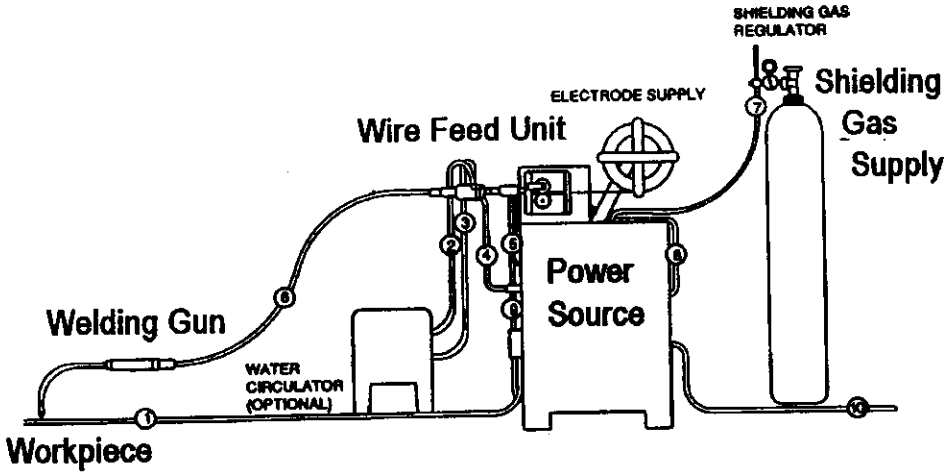
Carbon Steel



A B C

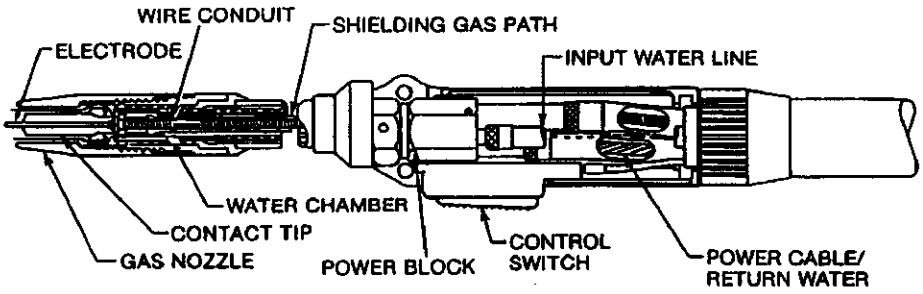
Joint	T mm	R mm	F mm	A Deg	Wire Dia mm	Current A	Voltage V	Wire Feed mm/s	Shielding Gas	Gas Flow Rate l/min
A	1.5	0	-	-	9	85	18	64	75%Ar 25%CO2	12
B	5-25	1.5-4	3	60	1.1	250	26	100	95%Ar 5%O2	12
C	5-25	1.5-4	3	60	1.1	250	26	100	95%A -5%02	12

GMAW Welding Equipment



1. WORK LEAD
2. WATER TO GUN
3. WATER FROM GUN
4. GUN SWITCH CIRCUT
5. SHIELDING GAS TO GUN
6. CABLE ASSEMBLY
7. SHIELDING GAS FROM CYLINDER
8. WELDING CONTACTOR CONTROL
9. POWER CABLE
10. PRIMARY INPUT POWER

GMAW Welding Gun

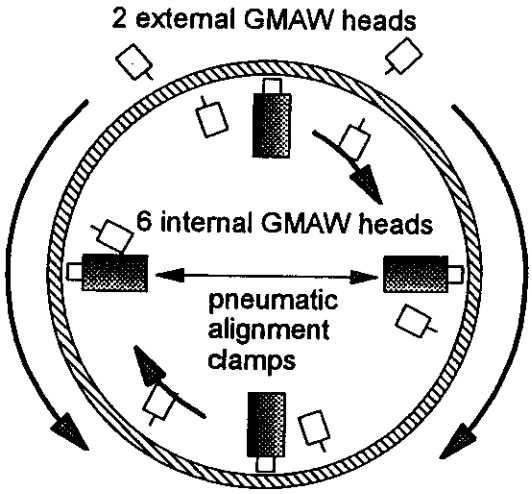


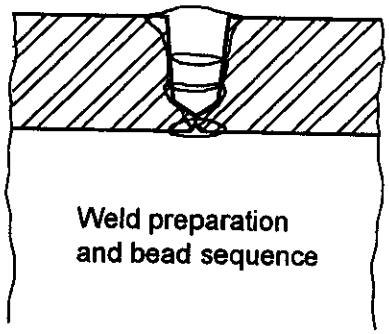
GMAW Applications

- Aluminum alloys, copper/bronze, magnesium. titanium, austenitic stainless steels, nickel alloys
- Sheet metal fabrication (short circuit mode)
  – eg automotive, appliance, light structures
- General structural fabrication (spray/pulsed mode)
- High production, mechanised and robotic welding

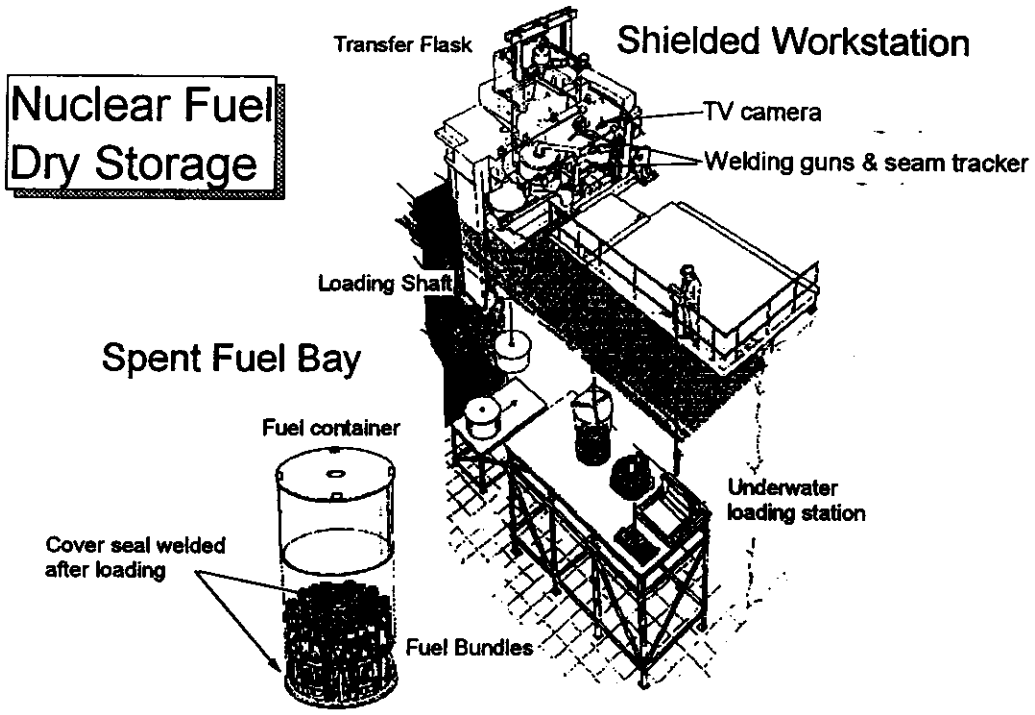
GMAW Mechanized Application

Field welds in oil/gas transmission pipelines

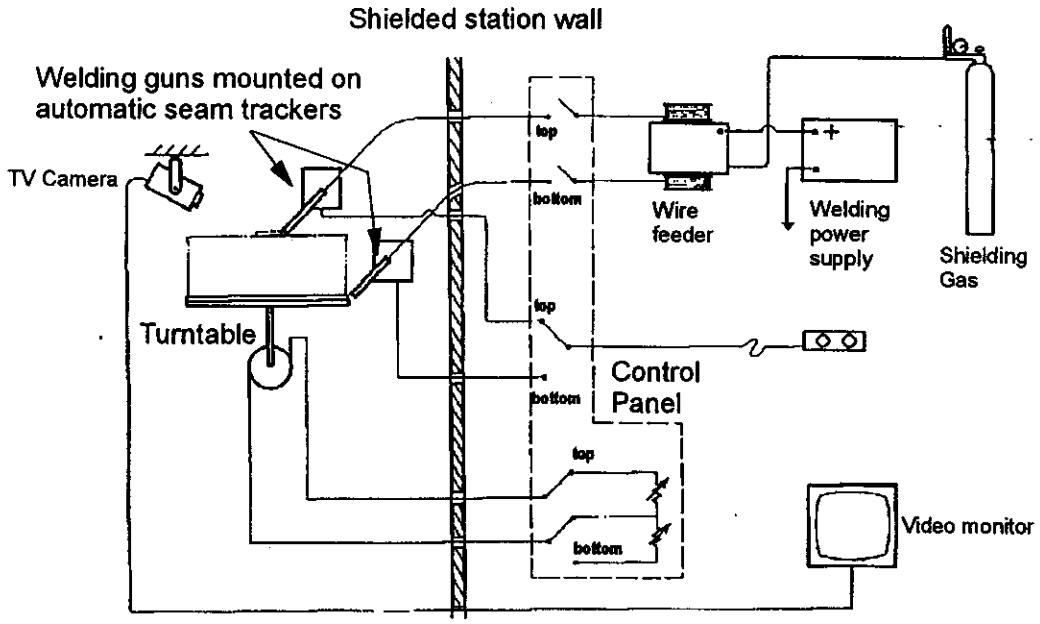




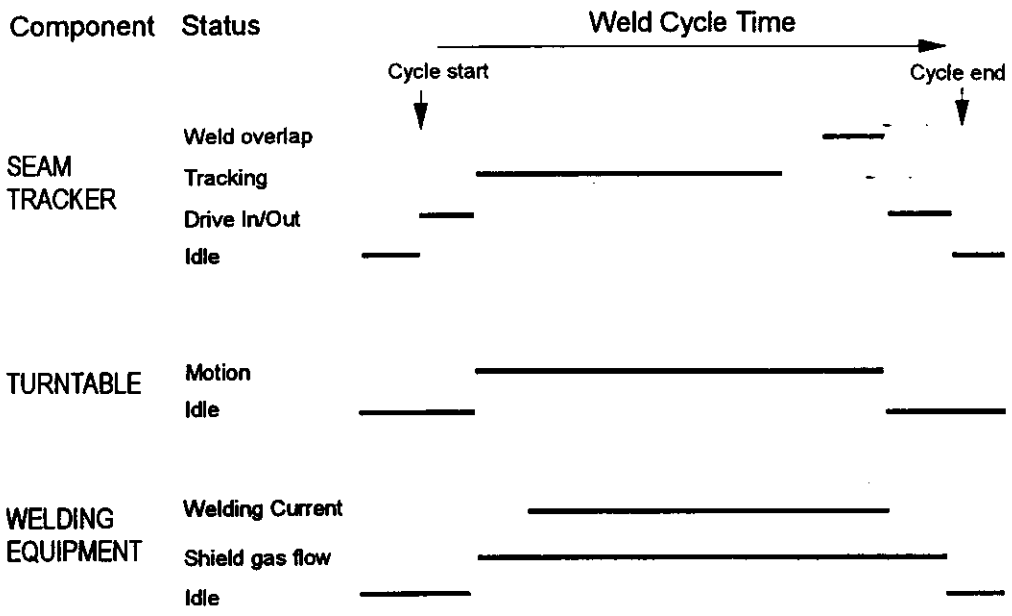
GMAW: Mechanized Applications



GMAW: Mechanized applications



Process Control



GMAW Capabilities & Limitations

+ Applicable to range of metals and thicknesses
+ Higher production rates than SMAW or GTAW
+ No flux or slag residues
+ Adaptable to manual or mechanized/robotic applications

– Complex equipment and set up
  - Wire feeding can be temperamental
– Less portable than SMAW
– Gas shield sensitive to air currents

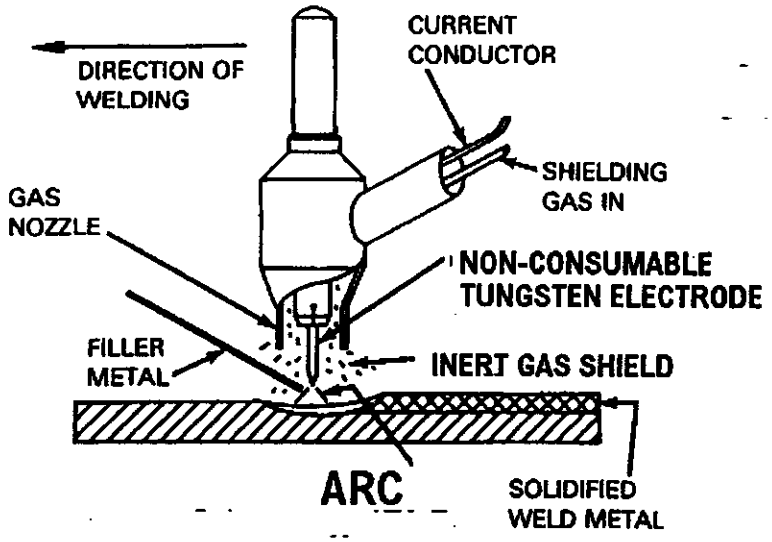
WELDING PROCESSES

GAS TUNGSTEN ARC WELDING (GTAW)

GTAW: Process Fundamentals

- In GTAW the welding heat source is an arc maintained between a non-consumable tungsten electrode and the workpiece
- Inert gas shields the arc and weld zone from atmospheric contamination
- Filler need not always be added (autogenous welding)
- Filler if required is added to the weld pool in the form of wire or rod.

GTAW: Process Fundamentals



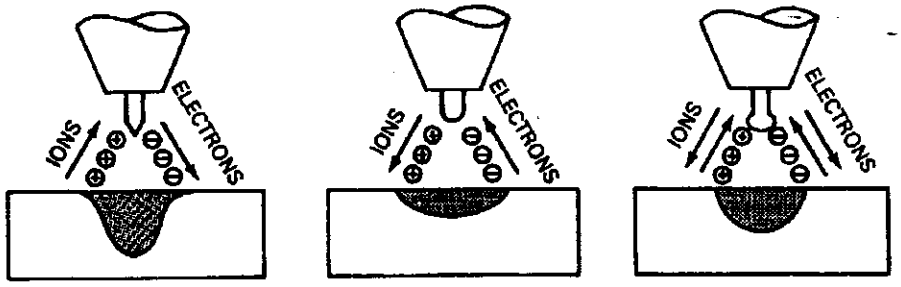
GTAW: Process Variables

- Welding current
  - DC, pulsed DC, high frequency pulsation, AC, variable polarity AC
- Arc length (Voltage)
- Weld travel speed
- Oscillation
- Filler addition
- Shielding gas composition & flow rate
  - generally Ar or He or mixtures.

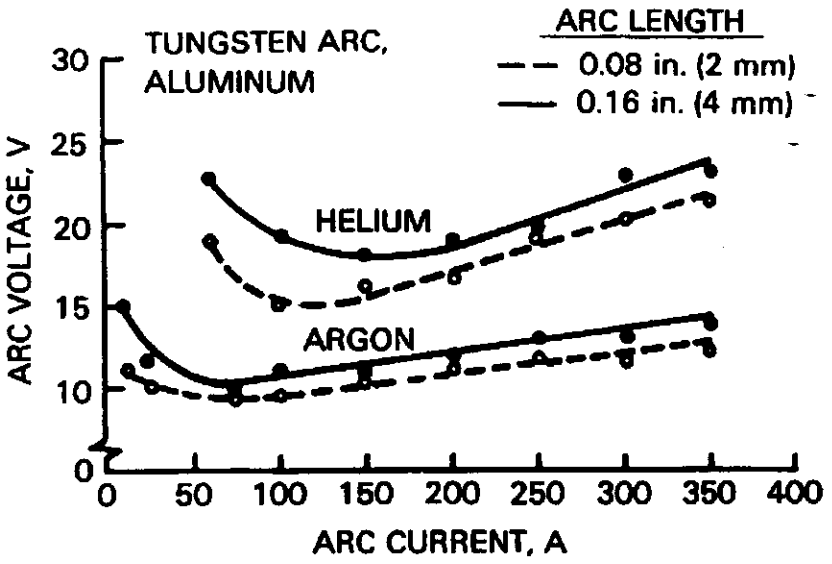
GTAW: Current Polarity

- DCEP is mostly used
  - approx 70% of heat produced at anode (workpiece)
- DCEN used to disperse tenacious surface oxides when welding Al, Mg
- AC also used in Al welding
  - variable polarity pulsed AC

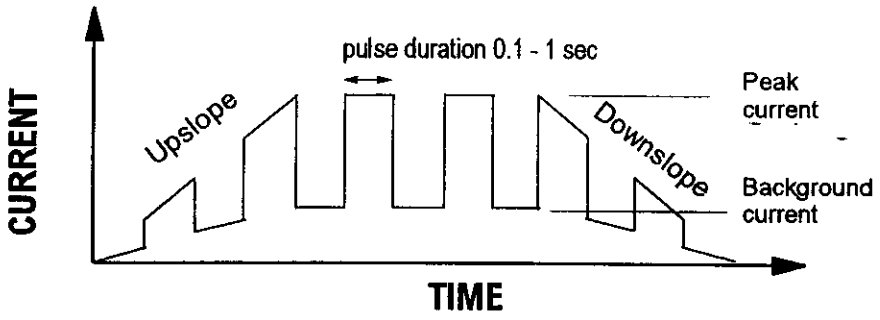
GTAW: Effect of Polarity



GTAW: Arc Voltage



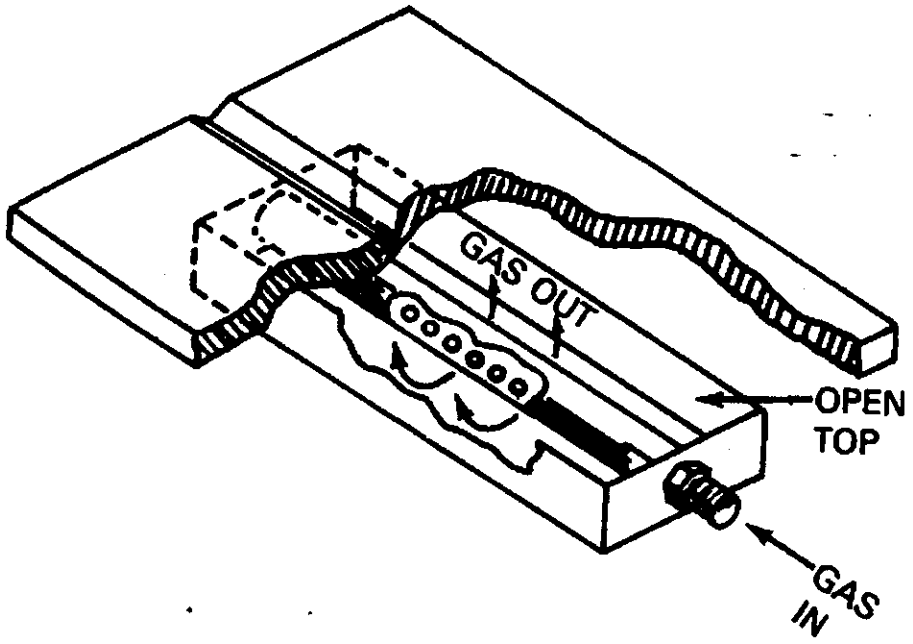
Pulsed GTAW (PGTAW)



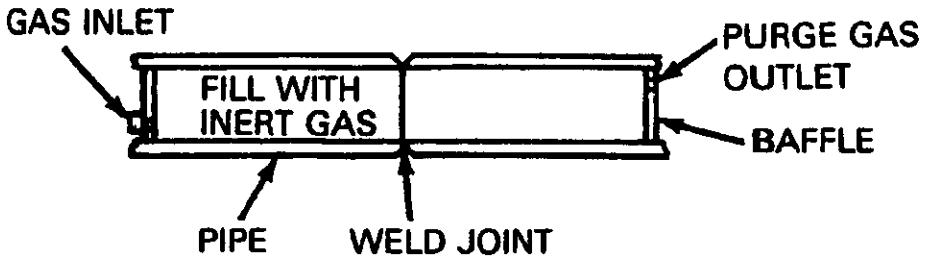
Pulsed DC advantages:

- ✓ Greater penetration for given average current
- ✓ Minimizes heat affected zone & distortion
- ✓ Improved capability to weld in all positions

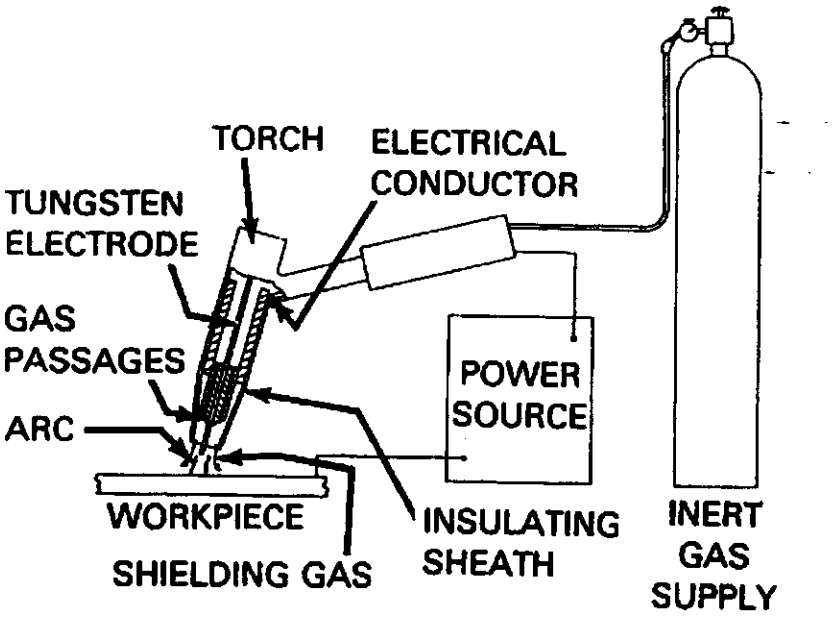
GTAW: Gas backing



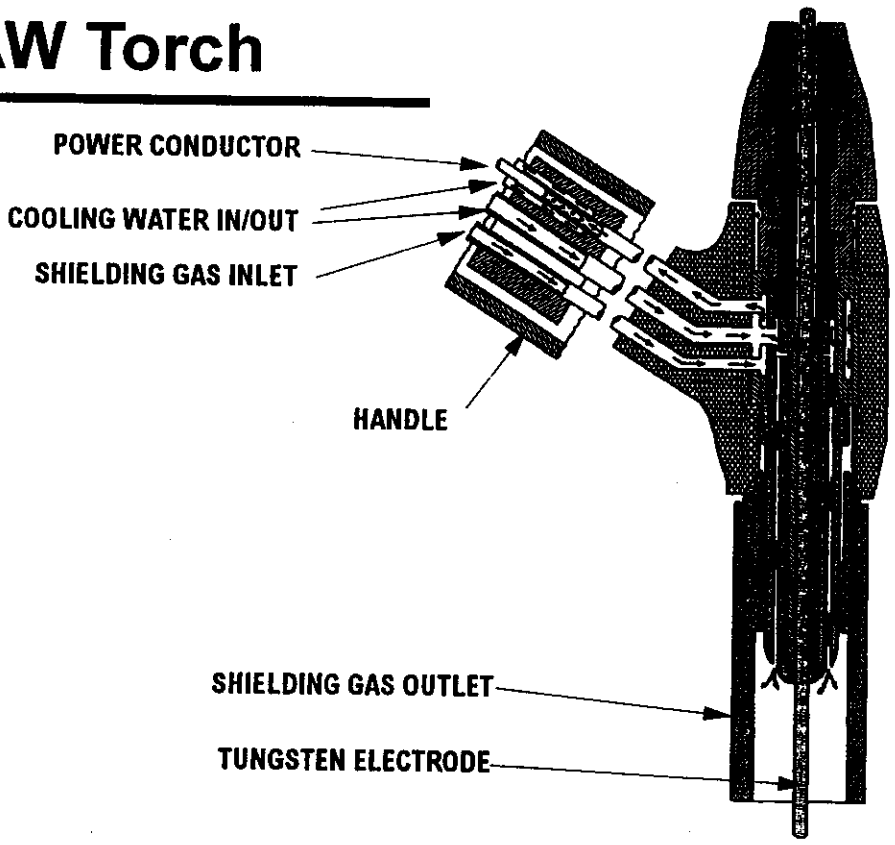
GTAW: Pipe internal purge



GTAW Equipment Schematic



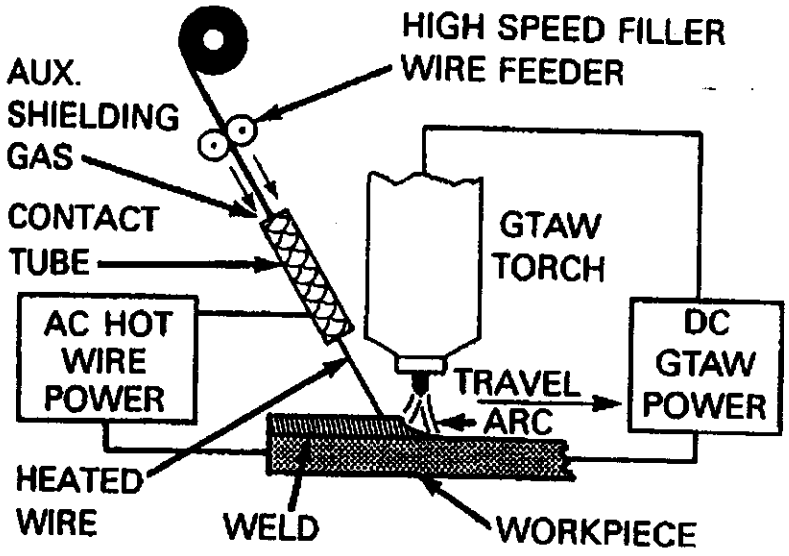
GTAW Torch


POWER CONDUCTOR
COOLING WATER IN/OUT
SHIELDING GAS INLET
HANDLE
SHIELDING GAS OUTLET
TUNGSTEN ELECTRODE

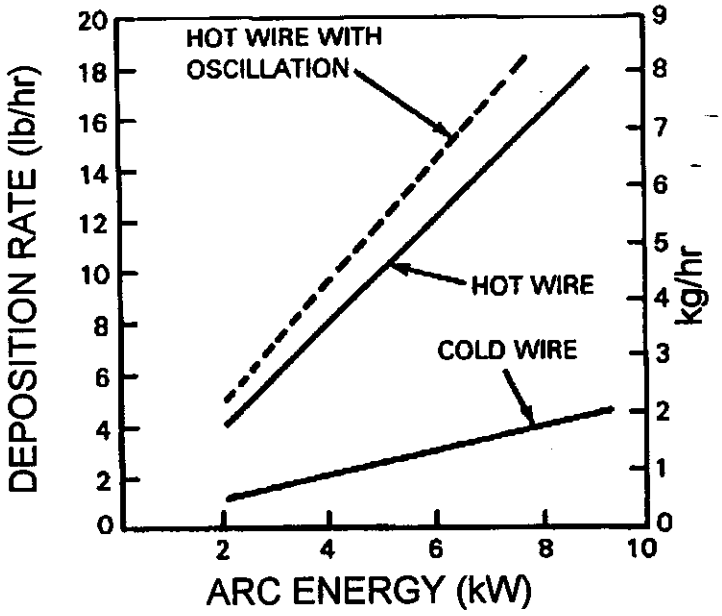
Mechanized GTAW Applications

- Mechanization of
  - weld head travel motions
  - wire feed (if required)
  - process controls: start/stop sequence, weld current profile, shielding gas flow, etc
- Typical applications: Pipe, tube, tube-tubesheet welding, longitudinal welds in formed tubes.
- Advantages of mechanization
  - Increased productivity
  - reduced weld defect rates
  - shorter joint completion times
  - reduced need for skilled labour

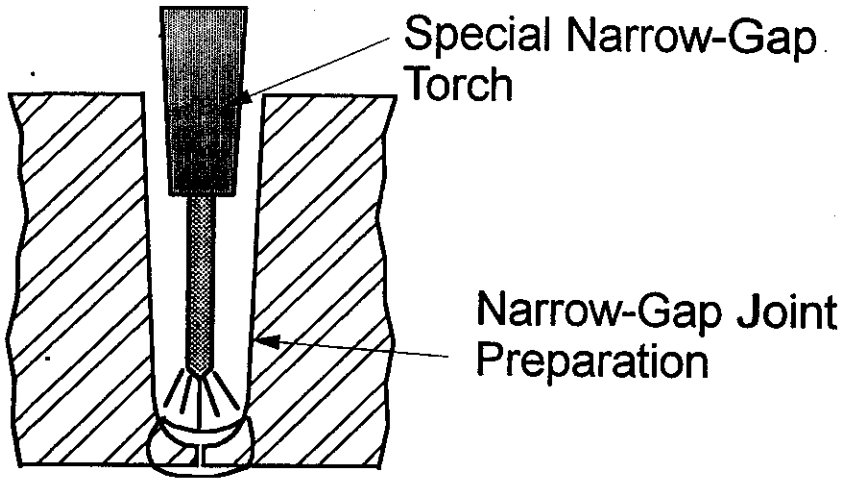
Hot Wire GTAW



GTAW Deposition Rates



Narrow-Gap GTAW



GTAW Capabilities & Limitations

+ Superior quality welds free from flux residues or spatter
+ Excellent control of penetration
+ Applicable to almost all metals
+ Adaptable to manual or precision mechanized applications

– Low deposition rates
– Higher welder skill required in manual processes
– Gas shielding sensitive to air currents