Welding Inspector

TIG Welding

Section 12

TIG Welding

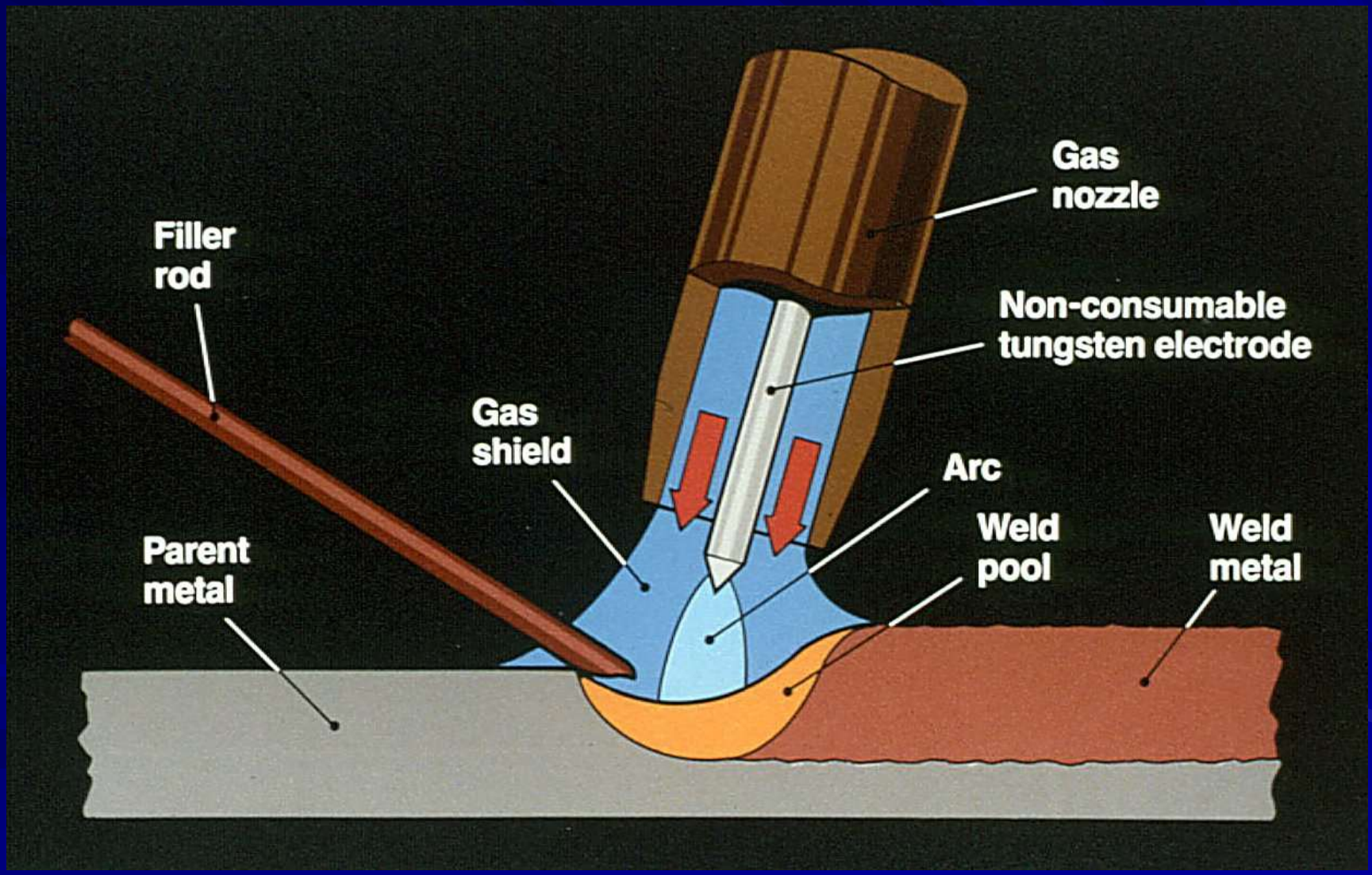
- Process characteristics
- Filler wires
- Tungsten inclusions
- Crater cracking
- Common applications
- Advantages
- Disadvantages

Tungsten Inert Gas Welding

The TIG welding process was first developed in the USA during the 2nd world war for the welding of aluminum alloys

- **The process uses a non-consumable tungsten electrode**
- **The process requires a high level of welder skill**
- **The process produces very high quality welds.**
- **The TIG process is considered as a slow process compared to other arc welding processes**
- **The arc may be initiated by a high frequency to avoid scratch starting, which could cause contamination of the tungsten and weld**

TIG - Principle of operation



TIG Welding Variables

- Voltage
- Current type & Polarity
- Travel speed
- Shape of tungsten electrode tip and vertex angle
- Shielding gas flow rate
- Electrode extension

TIG Welding Variables

Voltage

The Arc voltage of the TIG welding process is variable only by the type of gas being used, any changes in the arc length and The soundness of the connections. (typically > 14.7 V with Argon gas used)

Current

The current is adjusted proportionally to the tungsten electrodes diameter being used. The higher the current the deeper the penetration and fusion

Polarity

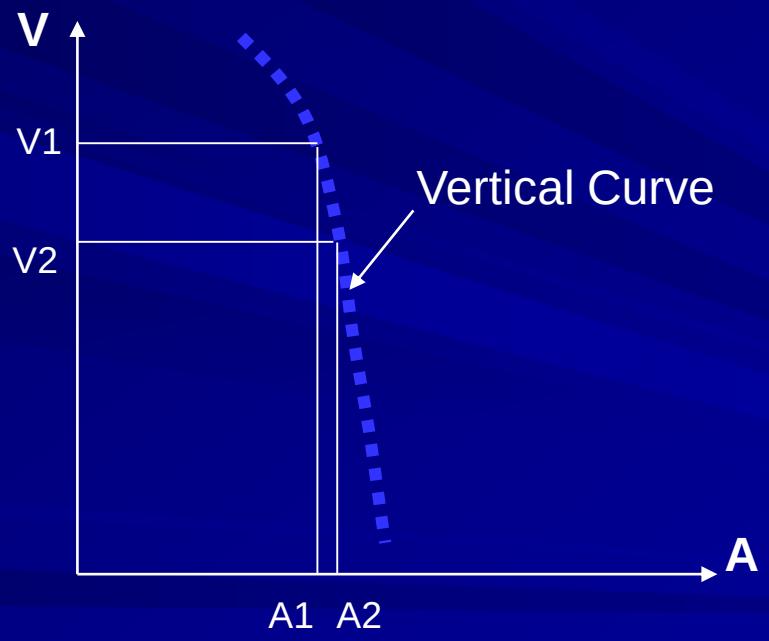
The polarity used for steels is always DC –ve as most of the heat is concentrated at the +ve pole, this is required to keep the tungsten electrode at the cool end of the arc. When welding aluminium and its alloys AC current is used

Types Of GTAW Power Source

- Provides Electric Energy – Arc – Heat
- Drooping Characteristic
- Inverter- DC
- Thyrester – DC
- Motor Generator – DC
- Rectifier – DC
- Transformer – AC (For Aluminum Welding Only)

Characteristic Of GTAW Power Source

Drooping – Constant Current



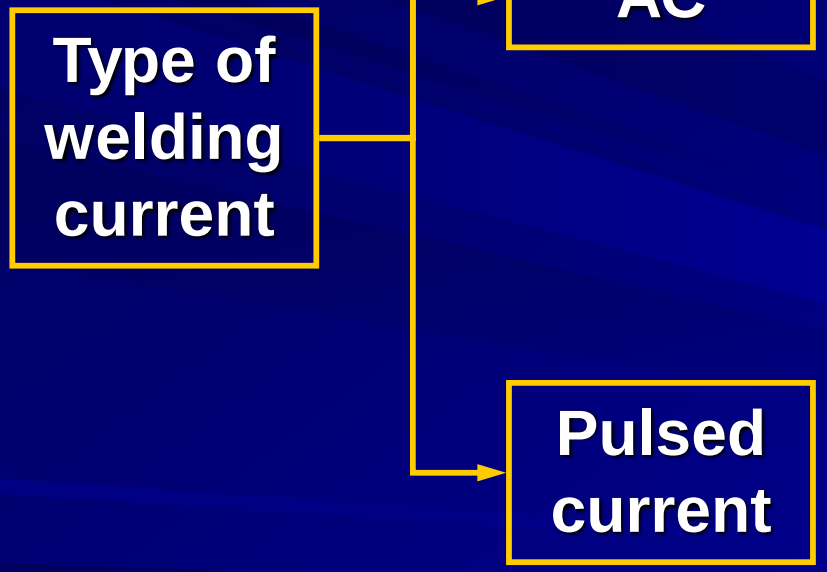
High Frequency Unit

- Provides High Voltage Electric Energy With Very high Frequency – 10000 Cycles / Sec.
- Initiates low energy Arc / Spark & Ionize Air Gap.
- Electrically charges Air Gap For welding Current to Jump Across the Tungsten Tip & BM to Form An Arc.
- HF Gets Cut Off, Once Welding Arc Struck.

Water Cooling System

- Provides Cooling Water To Welding Torch.
- Cools Tungsten Rod, Torch handle & Welding Cable.
- Cooling Water Returns through Flexible Tube Which Carries welding cable within.

Types of current



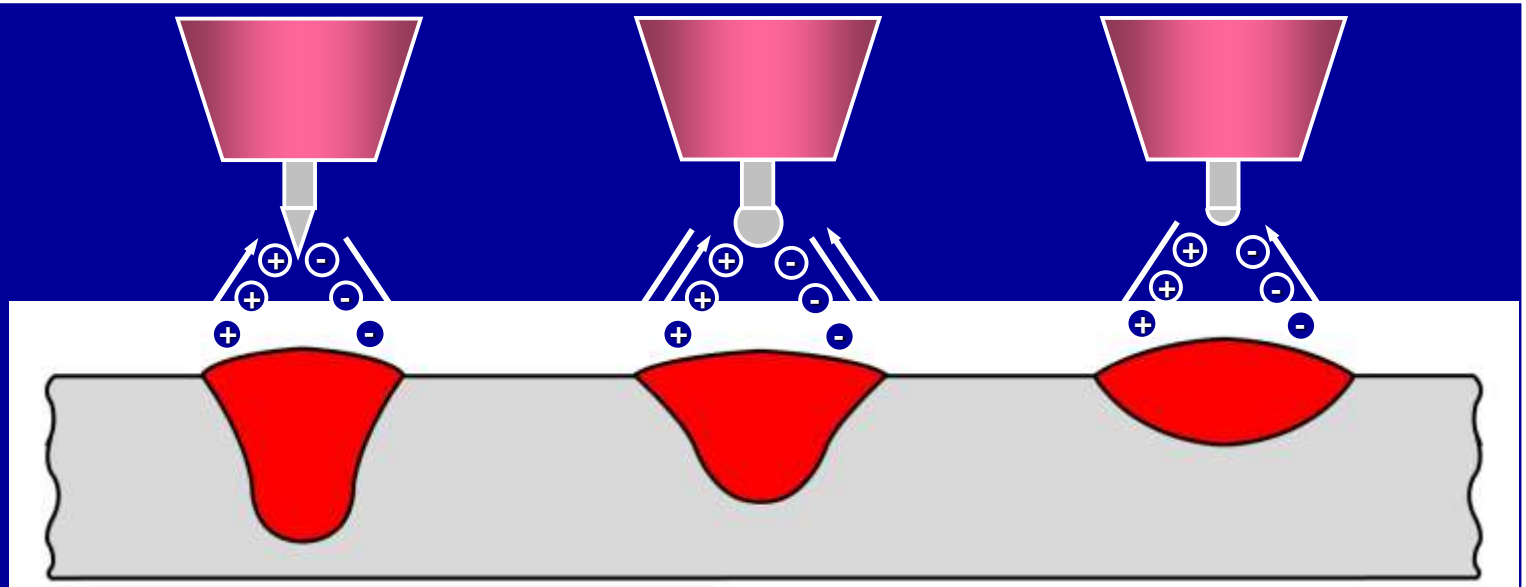
- can be DCEN or DCEP
- DCEN gives deep penetration

- can be sine or square wave
- requires a HF current (continuos or periodical)
- provide cleaning action

- requires special power source
- low frequency - up to 20 pulses/sec (thermal pulsing)
- better weld pool control
- weld pool partially solidifies

Choosing the proper electrode

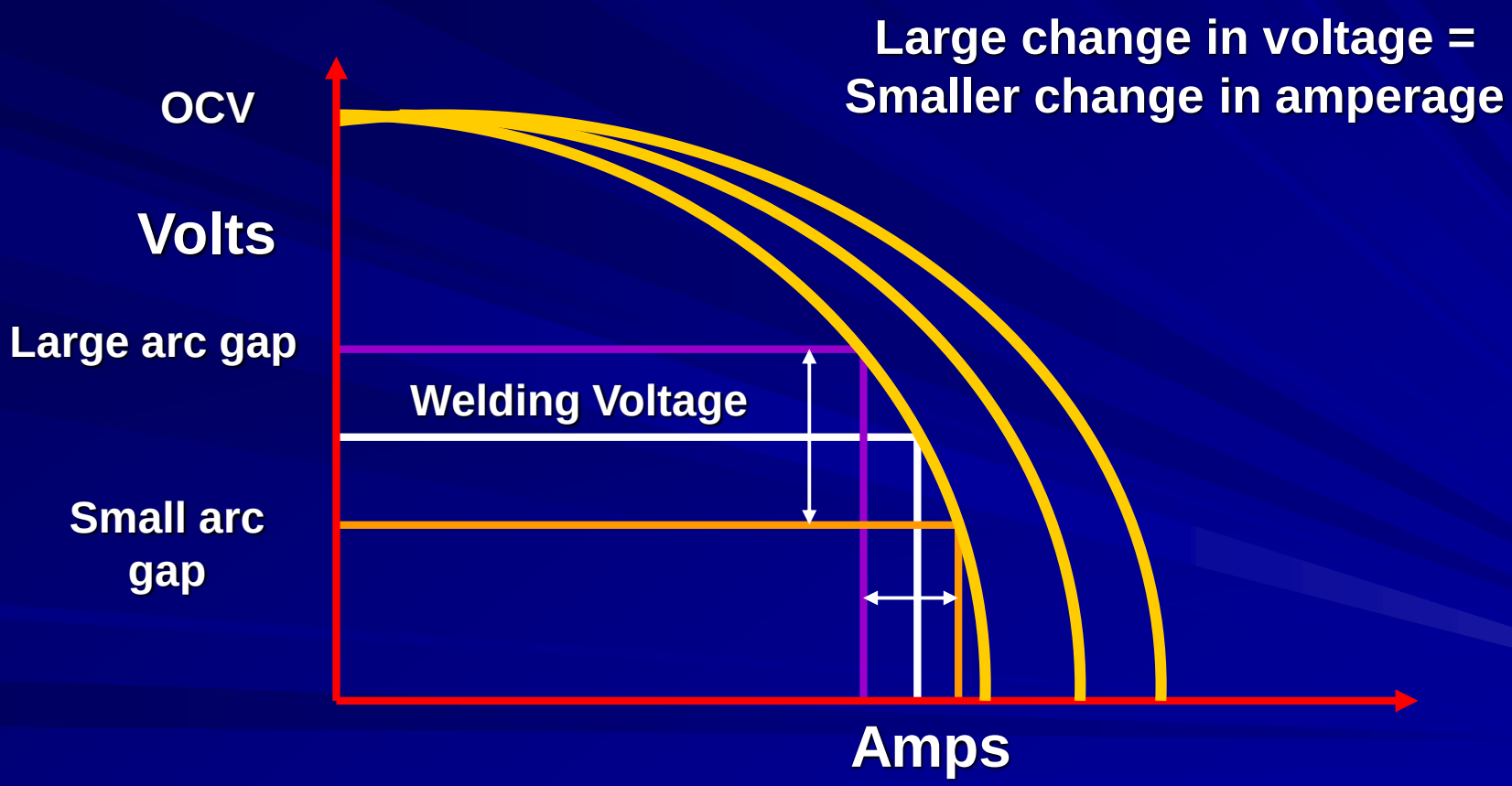
Current type influence



Current type & polarity	DCEN	AC (balanced)	DCEP
Heat balance	70% at work 30% at electrode	50% at work 50% at electrode	35% at work 65% at electrode
Penetration	Deep, narrow	Medium	Shallow, wide
Oxide cleaning action	No	Yes - every half cycle	Yes
Electrode capacity	Excellent (e.g. 3,2 mm/400A)	Good (e.g. 3,2 mm/225A)	Poor (e.g. 6,4 mm/120A)

ARC CHARACTERISTICS

Constant Current/Amperage Characteristic

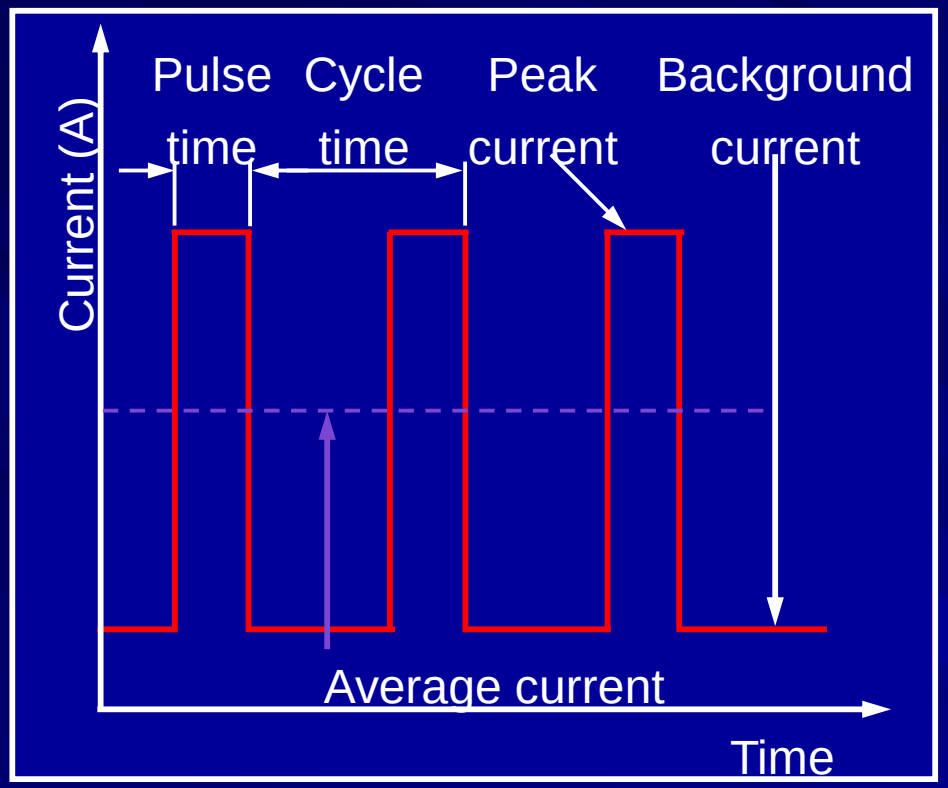


TIG - arc initiation methods

- simple method
- tungsten electrode is in contact with the workpiece!
- high initial arc current due to the short circuit
- impractical to set arc length in advance
- electrode should tap the workpiece - no scratch!
- ineffective in case of AC
- used when a high quality is not essential

- need a HF generator (spark-gap oscillator) that generates a high voltage AC output (radio frequency) costly
- reliable method required on both DC (for start) and AC (to re-ignite the arc)
- can be used remotely
- HF produce interference
- requires superior insulation

Pulsed current

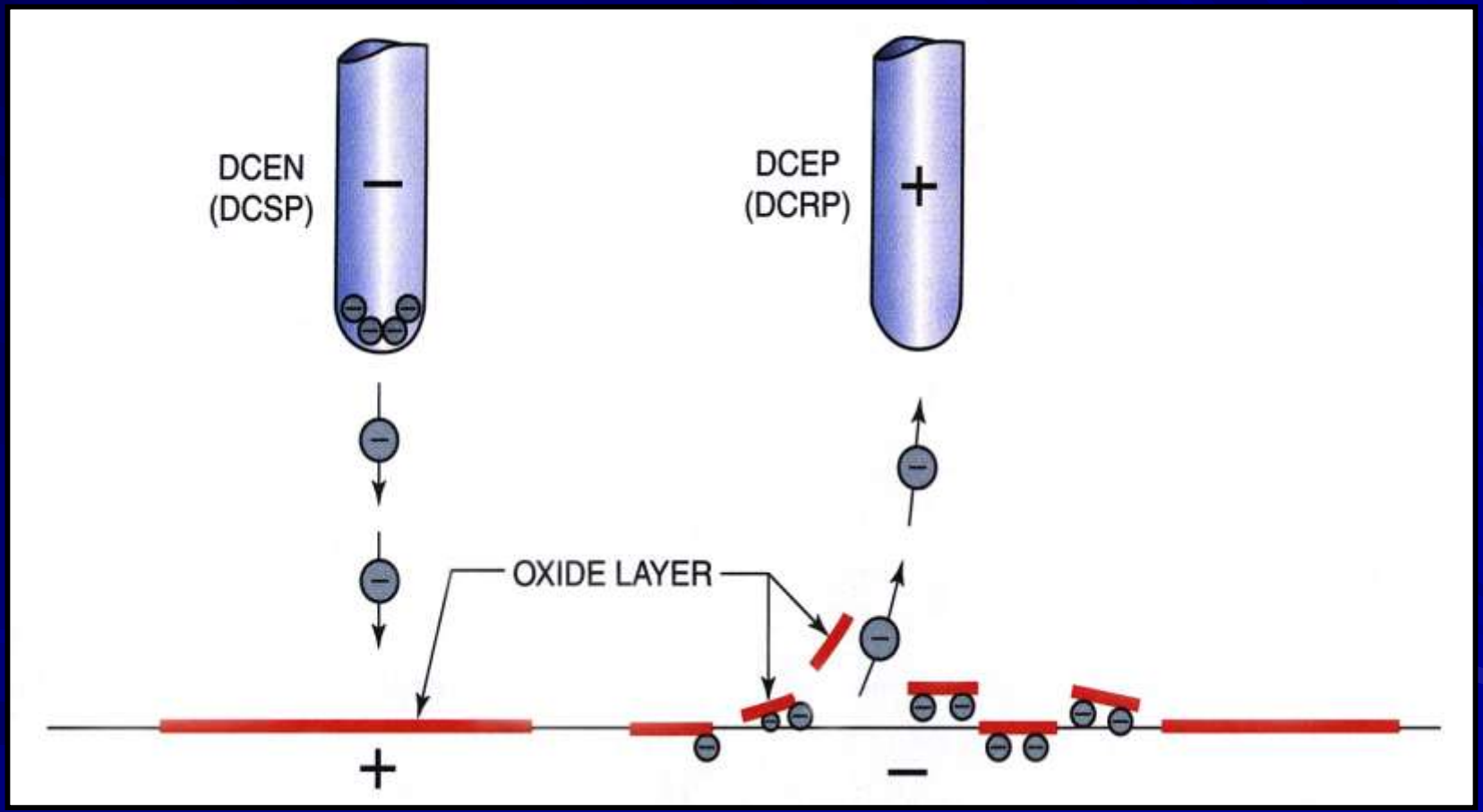


- usually peak current is 2-10 times background current
- useful on metals sensitive to high heat input
- reduced distortions
- in case of dissimilar thicknesses equal penetration can be achieved

- one set of variables can be used in all positions
- used for bridging gaps in open root joints
- require special power source

Choosing the proper electrode

Polarity Influence – cathodic cleaning effect



Tungsten Electrodes

Old types: (Slightly Radioactive)

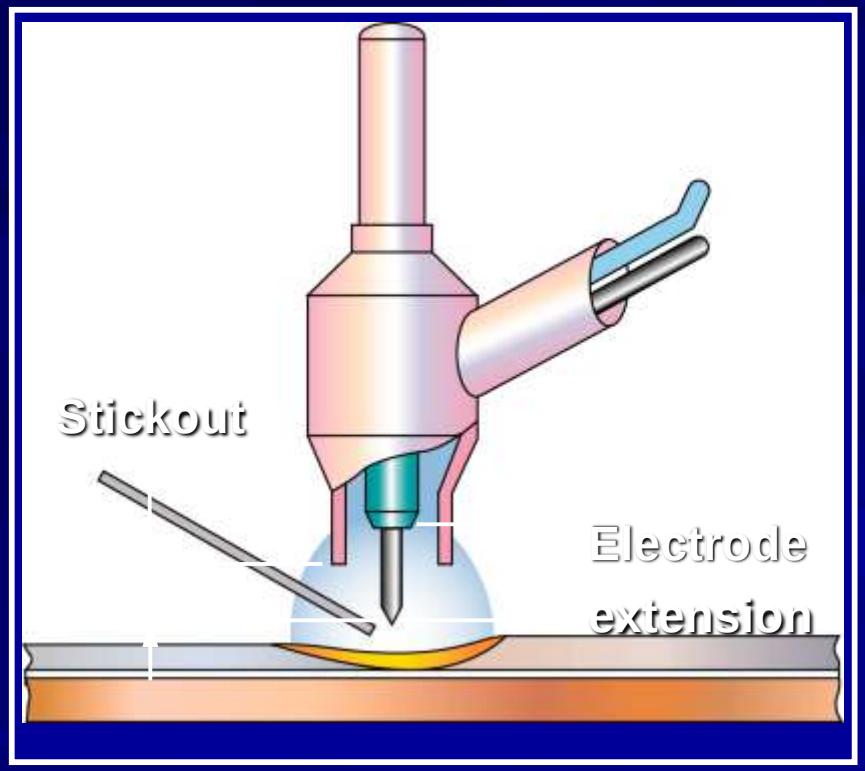
- Thoriated: DC electrode -ve - steels and most metals
- 1% thoriated + tungsten for higher current values
- 2% thoriated for lower current values
- Zirconiated: AC - aluminum alloys and magnesium

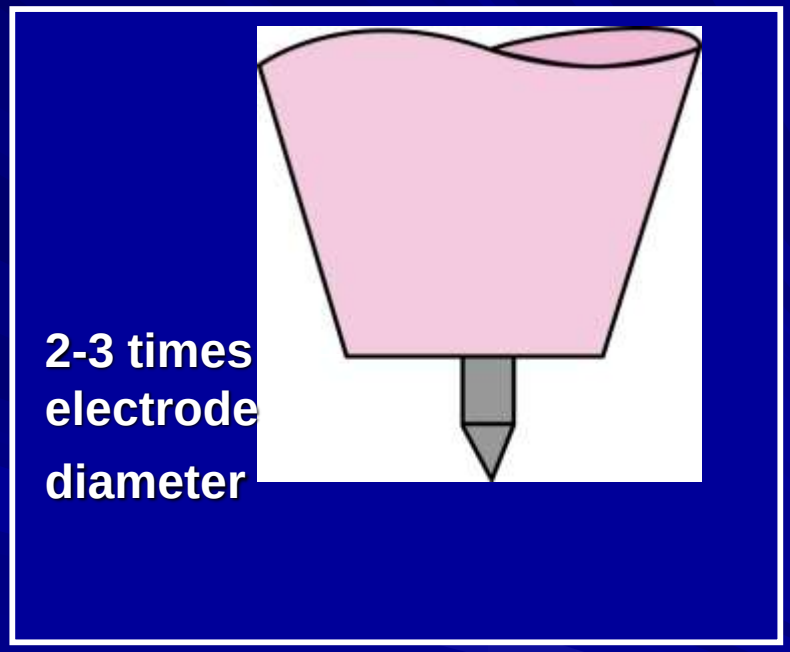
New types: (Not Radioactive)

- Cerium: DC electrode -ve - steels and most metals
- Lanthanum: AC - Aluminum alloys and magnesium

TIG torch set-up

- Electrode extension

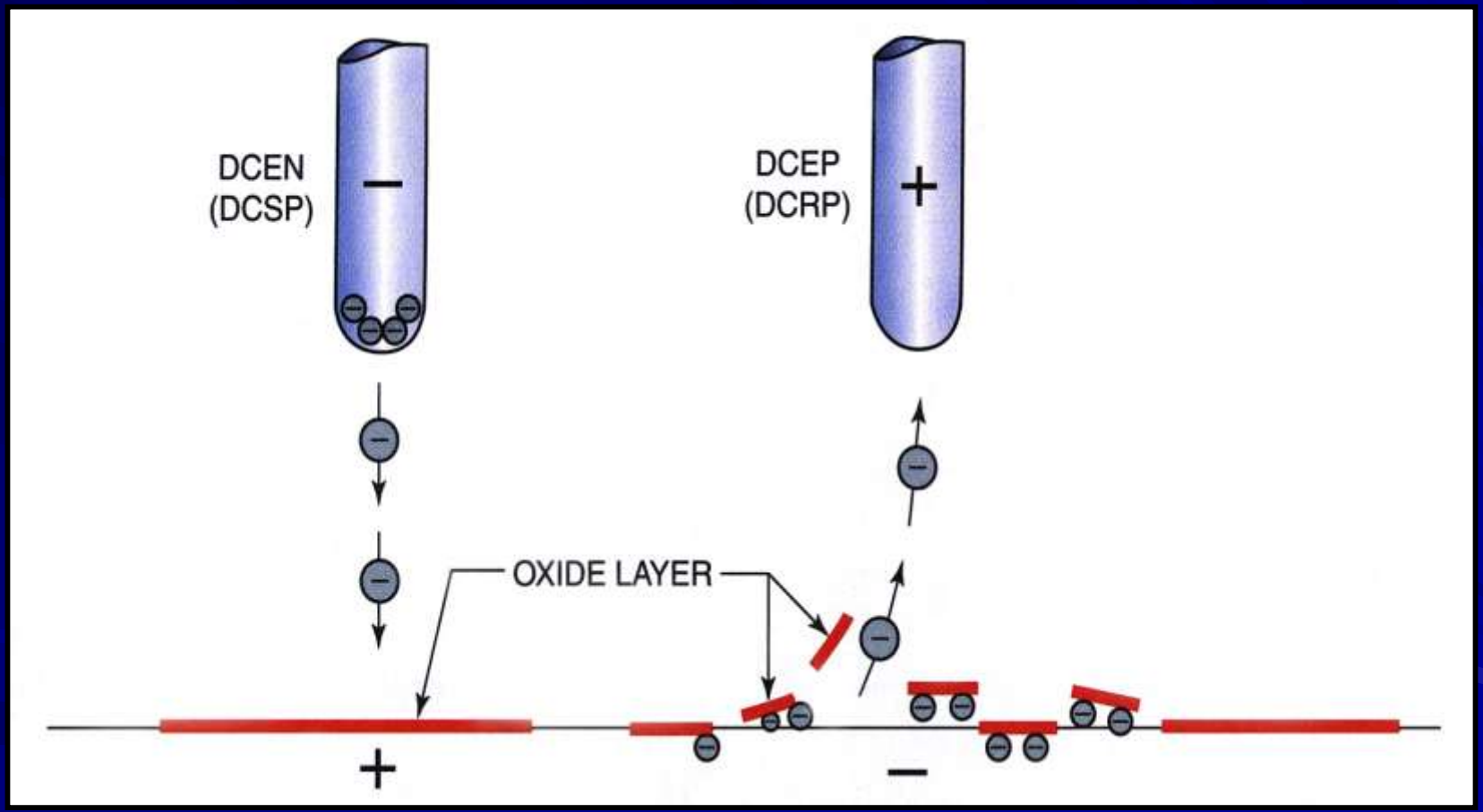




Low electron emission Unstable arc ← **Too small** | **Electrode extension** | **Too large** → **Overheating Tungsten inclusions**

Choosing the correct electrode

Polarity Influence – cathodic cleaning effect



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New types: (Not Radioactive)

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Tungsten electrode types

Pure tungsten electrodes:

- colour code - green
- no alloy additions
- low current carrying capacity
- maintains a clean balled end
- can be used for AC welding of Al and Mg alloys
- poor arc initiation and arc stability with AC compared with other electrode types
- used on less critical applications
- low cost

Tungsten electrode types

Thoriated tungsten electrodes:

- colour code - yellow/red/violet
- 20% higher current carrying capacity compared to pure tungsten electrodes
- longer life - greater resistance to contamination
- thermionic - easy arc initiation, more stable arc
- maintain a sharpened tip
- recommended for DCEN, seldom used on AC (difficult to maintain a balled tip)
- This slightly radioactive

Tungsten electrode types

Ceriated tungsten electrodes:

- colour code - grey (orange acc. AWS A-5.12)
- operate successfully with AC or DC
- Ce not radioactive - replacement for thoriated types

Lanthaniated tungsten electrodes:

- colour code - black/gold/blue
- operating characteristics similar with ceriated electrode

Tungsten electrode types

Zirconiated tungsten electrodes:

- colour code - brown/white
- operating characteristics fall between those of pure and thoriated electrodes
- retains a balled end during welding - good for AC welding
- high resistance to contamination
- preferred for radiographic quality welds

Electrode tip for DCEN

Electrode tip prepared for low current welding

Penetration increase

Increase

Vertex angle

Decrease

Bead width increase

Electrode tip prepared for high current welding

Electrode tip for AC

Electrode tip ground

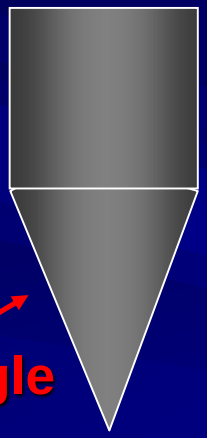
Electrode tip ground and then conditioned

TIG Welding Variables

Tungsten electrodes

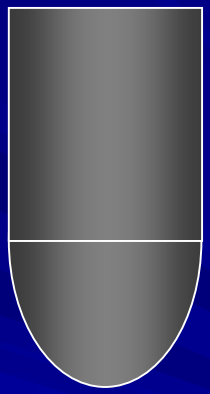
The electrode diameter, type and vertex angle are all critical factors considered as essential variables. The vertex angle is as shown

DC -ve



Note: too fine an angle will promote melting of the electrodes tip

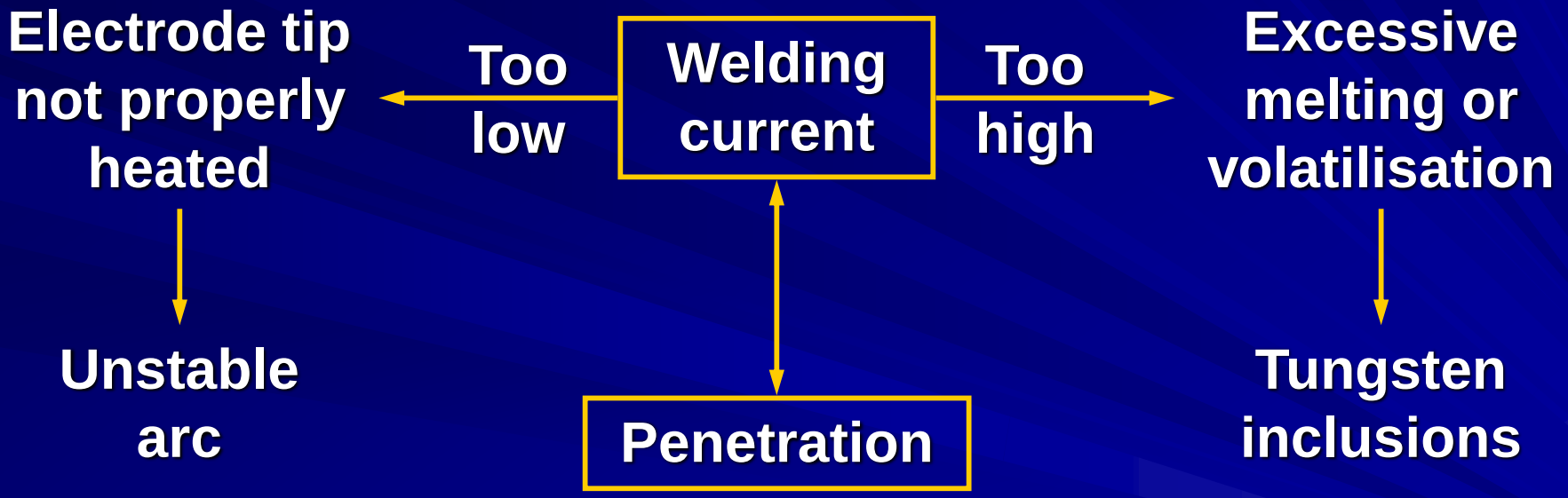
AC



Note: when welding aluminium with AC current, the tungsten end is chamfered and forms a ball end when welding

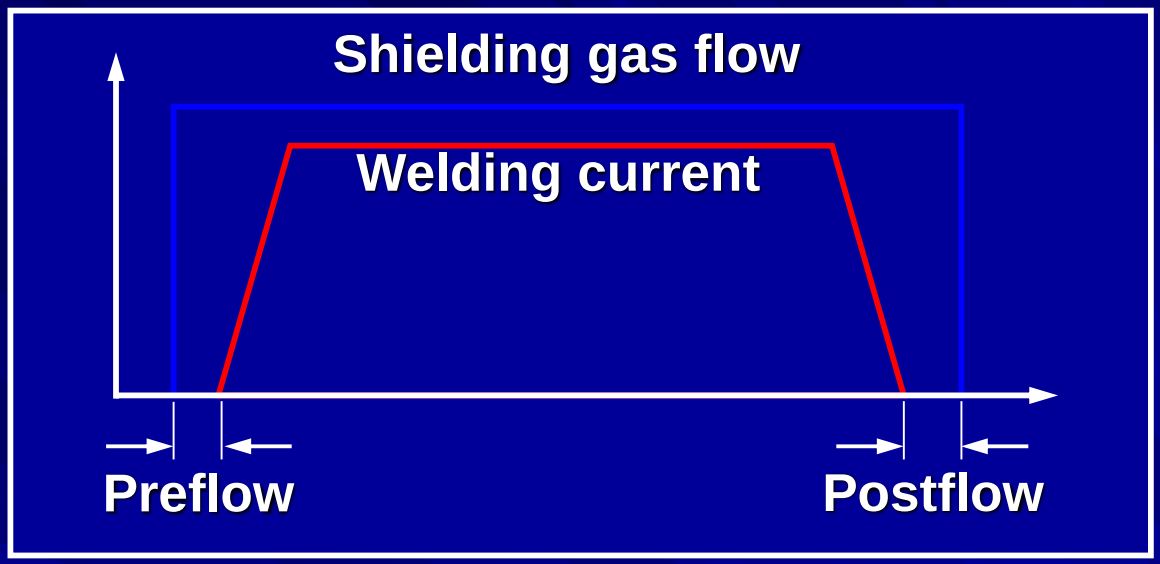
Choosing the proper electrode

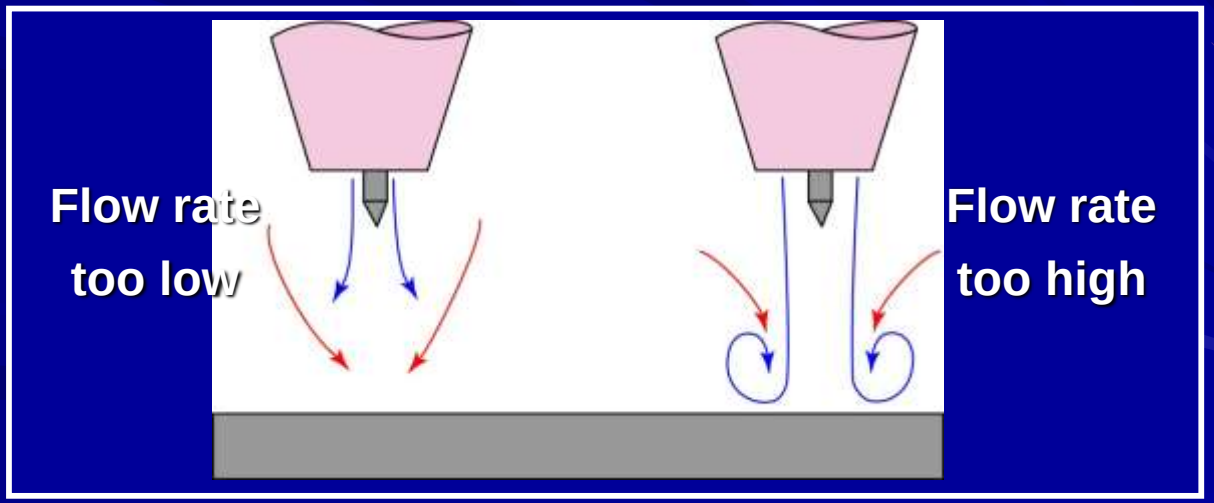
Factors to be considered:



Shielding gas requirements

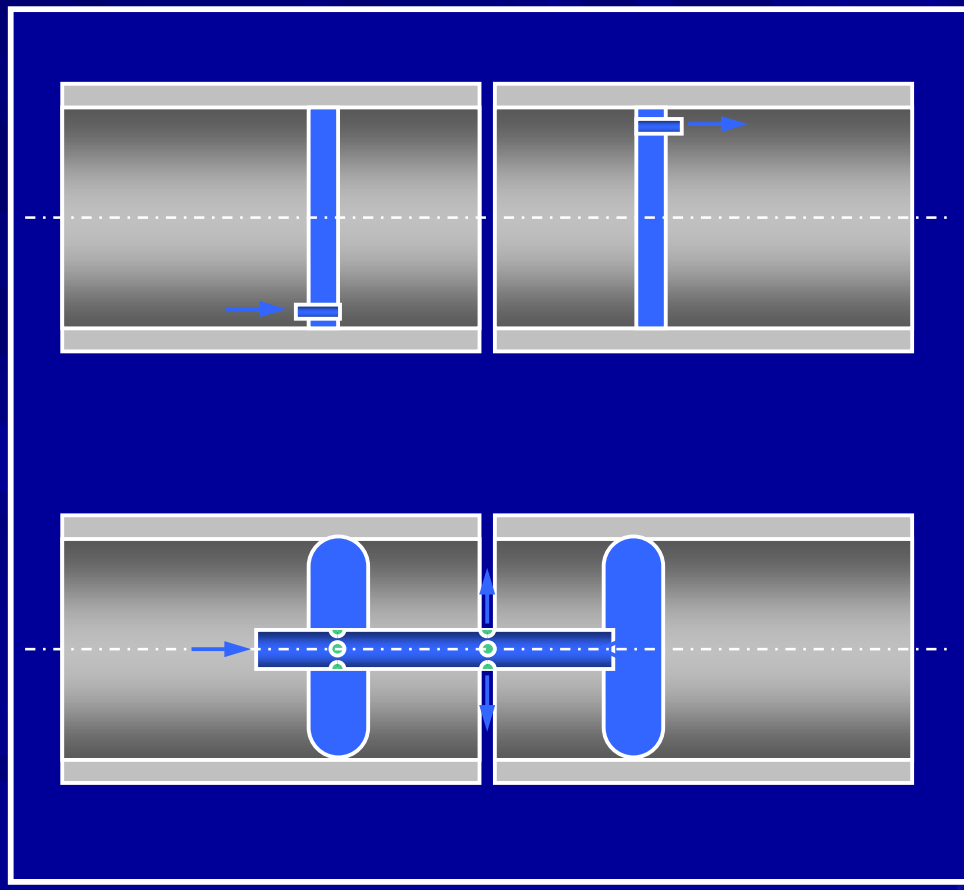
- Preflow and postflow





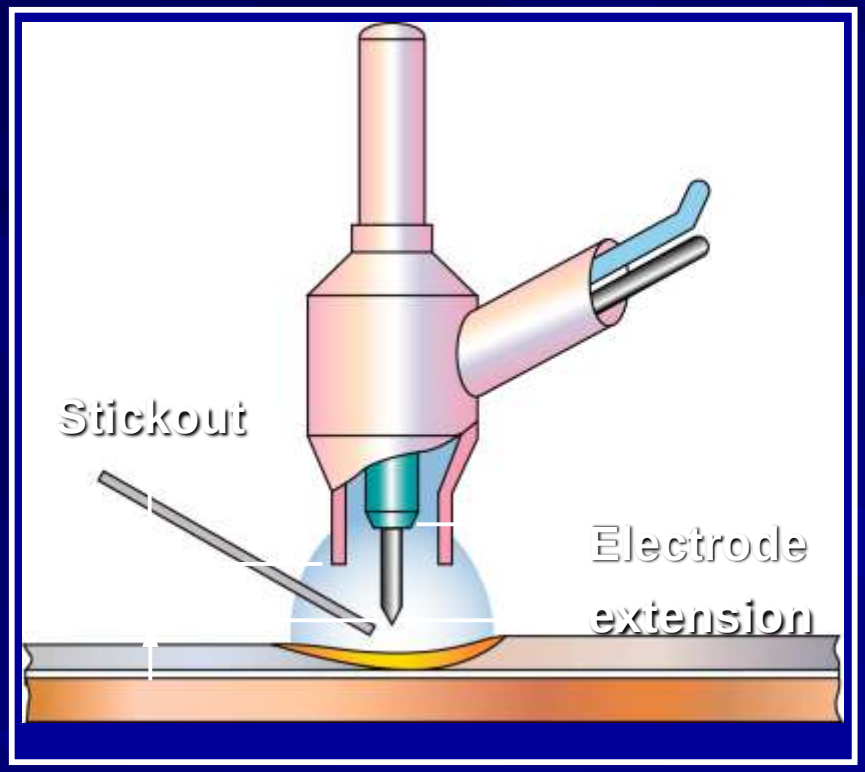
Special shielding methods

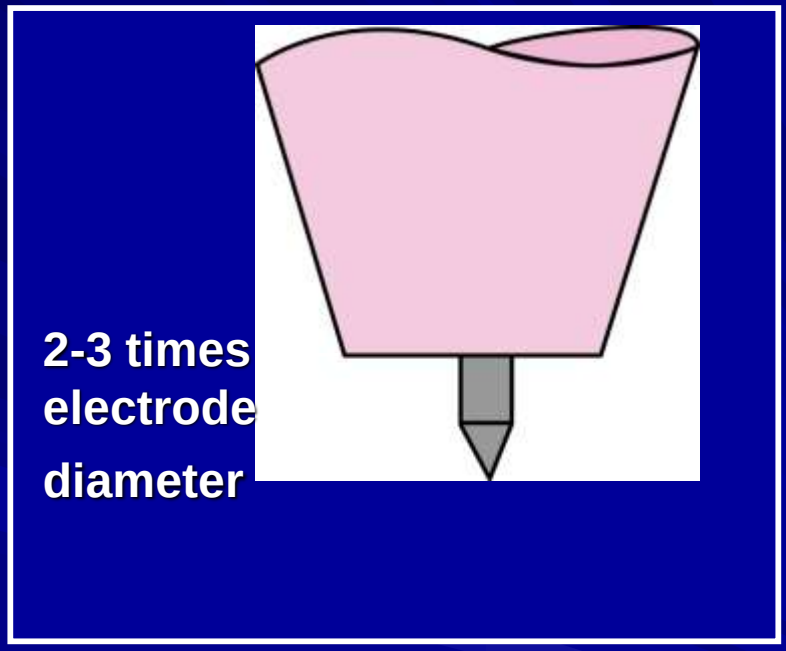
Pipe root run shielding – Back Purging to prevent excessive oxidation during welding, normally argon.



TIG torch set-up

Electrode extension





Low electron emission
⇒ Unstable arc

← **Too small**

Electrode extension

Too large →

Overheating
⇒ Tungsten inclusions

TIG Welding Consumables

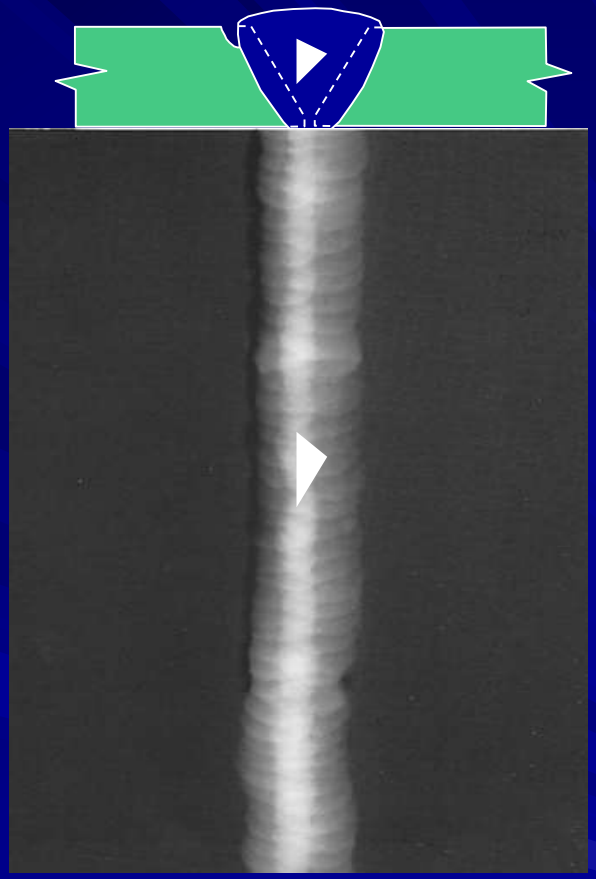
Welding consumables for TIG:

- Filler wires, Shielding gases, tungsten electrodes (non-consumable).
- Filler wires of different materials composition and variable diameters available in standard lengths, with applicable code stamped for identification
- Steel Filler wires of very high quality, with copper coating to resist corrosion.
- shielding gases mainly Argon and Helium, usually of highest purity (99.9%).

Tungsten Inclusion

May be caused by Thermal Shock of heating to fast and small fragments break off and enter the weld pool, so a “slope up” device is normally fitted to prevent this could be caused by touch down also.

Most TIG sets these days have slope-up devices that brings the current to the set level over a short period of time so the tungsten is heated more slowly and gently



A Tungsten Inclusion always shows up as bright white on a radiograph

TIG typical defects

Most welding defects with TIG are caused by a lack of welder skill, or incorrect setting of the equipment. i.e. current, torch manipulation, welding speed, gas flow rate, etc.

- **Tungsten inclusions (low skill or wrong vertex angle)**
- **Surface porosity (loss of gas shield mainly on site)**
- **Crater pipes (bad weld finish technique i.e. slope out)**
- **Oxidation of S/S weld bead, or root by poor gas cover**
- **Root concavity (excess purge pressure in pipe)**
- **Lack of penetration/fusion (widely on root runs)**

Tungsten Inert Gas Welding

Advantages

- High quality
- Good control
- All positions
- Lowest H_2 process
- Minimal cleaning
- Autogenous welding

  (No filler material)
- Can be automated

Disadvantages

- High skill factor required
- Low deposition rate
- Small consumable range
- High protection required
- Complex equipment
- Low productivity
- High ozone levels +HF