WELDING BASICS SERIES

MAKE SOMETHING BETTER

TIG BASICS

TIG Basics

Also known as:

Tungsten Inert Gas Welding

WIG Welding

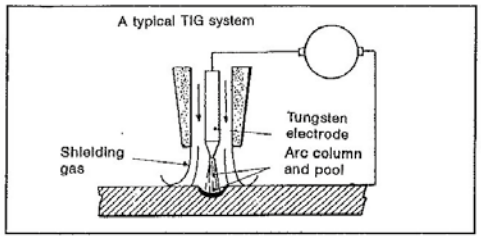
Please note:

The equipment shown in the following pages are not current models.

TIG Basics

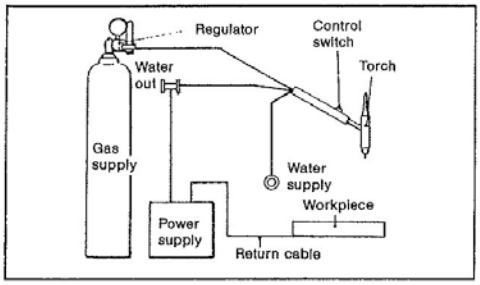
TIG welding

In this process the arc is carried by a tungsten electrode which is not consumed during welding. The electrode, arc and molten weld metal are protected from the atmosphere by an inert shielding gas such as argon. Filler rod addition is optional.



Equipment

A typical TIG system will comprise an inert gas supply, a gas supply regulator, a power supply unit, hose assemblies and a torch. Accessories may be incorporated in an installation to control amperage output or economise on gas usage.

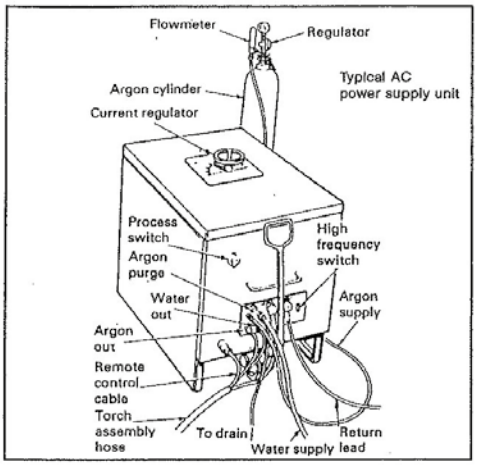


Installations may include a cooling water supply particularly for current over 200 amps.

Hose assemblies carry the shielded gas welding current cable from the composite power source to the welding torch. The hose assembly carries an additional cable from the torch control switch back to the power source which enables the gas, water flow, welding current and high frequency (HF) supply to be controlled from the torch.

A negative return cable is connected between the workpiece or the welding table and the power source.

Power supply units

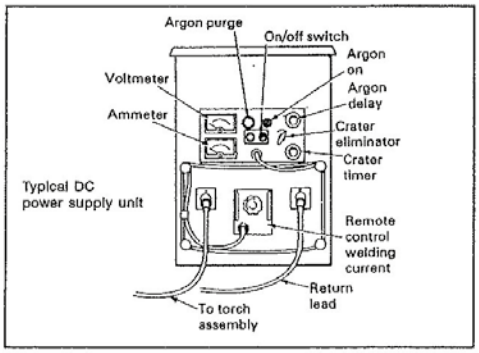


The major types of power units are the AC transformer and the combination of the AC transformer rectified to DC.

A drooping characteristic (constant current) power supply unit should be used and the open-circuit voltage should be between 50V and 100V.

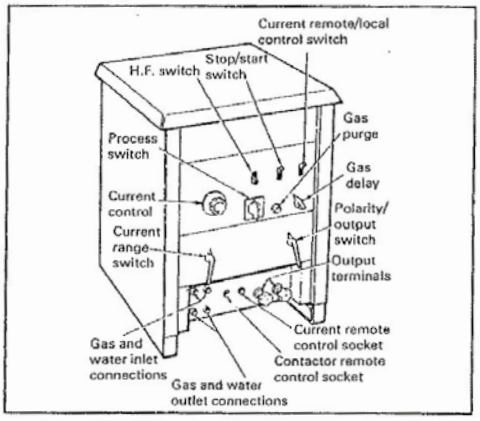
If possible, a power unit fitted with a remote control of current should be used.

An alternating current (AC) unit will be required for the welding of aluminium or aluminium alloys. A typical unit is illustrated.



A direct current (DC) unit will be needed for the welding of stainless steel, low carbon steel, copper, titanium and nickel alloys.

TIG Basics



Combined AC/DC units are also available.
Note: Power supply units used for manual metal-arc welding can be adapted for TIG welding if additional features are added to the circuit. In general it is better to use a power unit specifically designed for the latter process.

Control unit
The control unit should provide on/off switching for:
- Welding current.
- Shielding gas flow.
- Water flow (if appropriate).

Controls will normally be incorporated in the power supply unit. If possible, use a foot switch connected to the control unit; it is an advantage if this is fitted with a current control device.

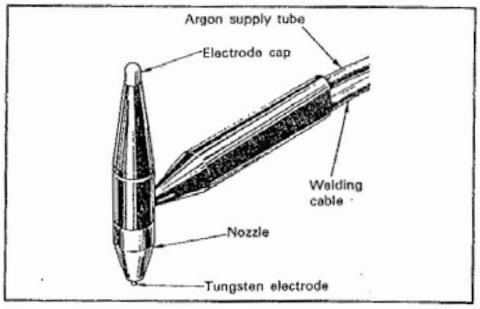
Arc initiation system
A peak starter or high frequency unit will initiate the arc without the need to touch the tungsten electrode onto the work.
This gives longer electrode life and better welds.
With most equipment, this is incorporated in the power supply unit.

Suppressor
A capacitor bank, often called a suppressor is needed when welding with AC to suppress the DC component which is produced in the welding circuit.

Crater eliminator
A crater eliminator is an automatic device which gradually reduces the welding current at the end of a run, preventing the formation of a crater.
The device is available only on a limited range of welding sets. In other cases the same effect can be obtained by use of the remote foot control.
The device, which is not suitable for AC, is usually fitted to DC or combined AC/DC units as an optional extra.

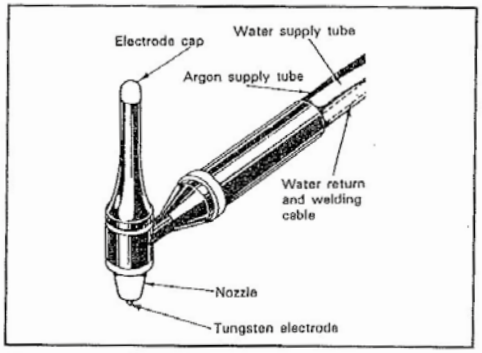
Welding torches
The welding torch can be air-cooled or water-cooled.

Air-cooled torches



These may vary from the pencil torches used for welding at currents of less than 50A to general purpose torches for use with currents up to 200A.
Torches are usually supplied with a hose assembly containing PVC tubing to convey the gas, and an insulated cable for the welding current.

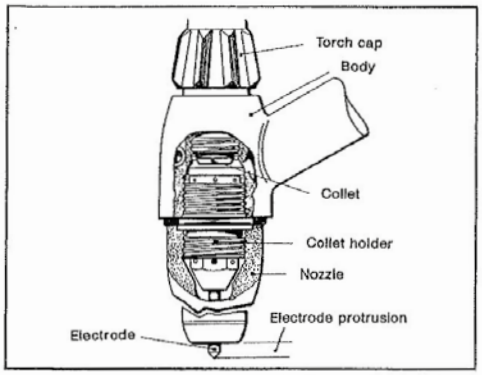
Water-cooled torches



These are made in various sizes depending upon the maximum welding current to be used, and are used where vast amounts of heat are generated. They are suitable for currents above 200A.
Torches are supplied with cable assemblies which contain:
- Gas supply hose.
- Water supply hose.
- Water return hose containing the welding cables.
- Usually a fuse unit or water flow switch to cut off current supply if water flow ceases.

In some types, a remote control cable is included with a switch in the torch handle.
The flow of water is controlled by a water control solenoid in the composite power unit.

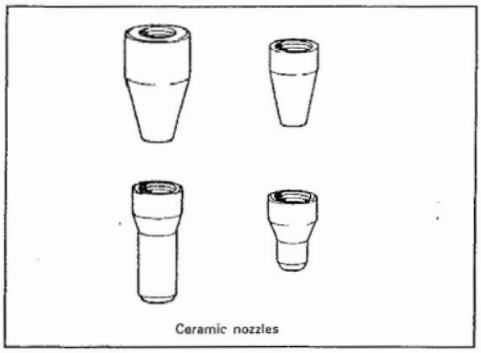
TIG Basics



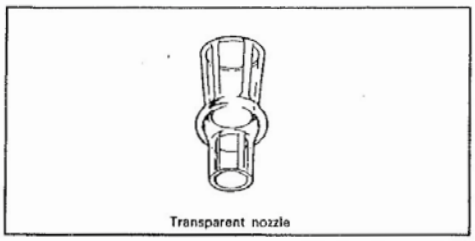
The tungsten electrode is held in the torch by collets which vary in size to suit its diameter.
The nozzle of the torch, which may be metal or ceramic, is the most vulnerable to damage, especially the ceramic type.
Metal gas nozzles are used when welding at low amperage. Ceramic nozzles are for high temperatures at which metal nozzles may melt.
Standard ceramic nozzles are 6.5mm bore for air-cooled torches and 10mm bore for water-cooled torches.
Both metal and ceramic nozzles are secured through threaded connections.

Nozzles

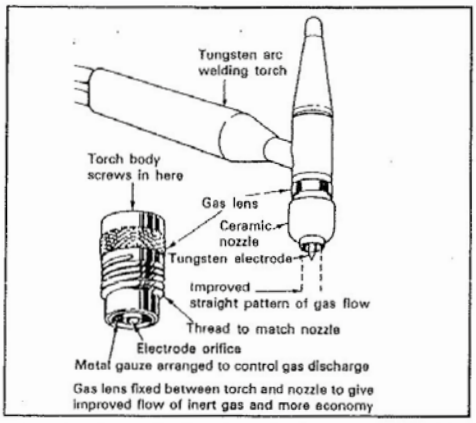
These units direct the flow of shielding gas around the electrode, the arc and the molten weld pool.
Large sizes and specially shaped nozzles are available for particular applications.
Water cooled metal nozzles are available for heavy work.


Ceramic nozzles

! *IMPORTANT – Ceramic nozzles are brittle and repeated heating and cooling renders them more fragile. The torch or nozzle should not be knocked against other objects.*


Transparent nozzle

Transparent nozzles may be fitted where it is important to have a good view of the arc.



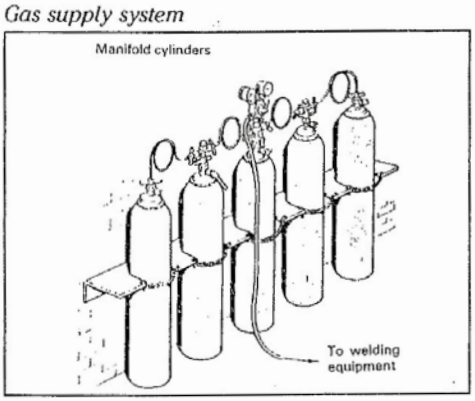
A 'gas lens' may be fitted to obtain access into tight corners, to improve the gas coverage and to allow the use of a longer electrode.
Where a standard nozzle prevents the ideal electrode-to-workpiece gap being acheived, a gas lens allows the electrode to be extended.

TIG Basics

Shielding gas

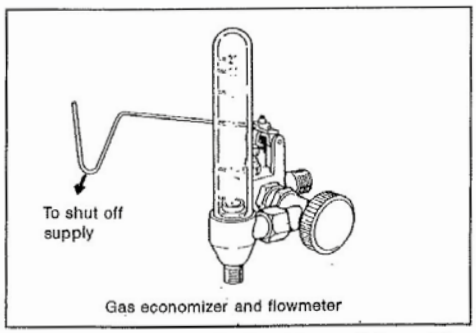
Welding grade argon is used as the shielding gas in practically all applications.
Argon is supplied in steel cylinders painted blue. The usual size is 8.5m³ charged at a pressure of 172 bars.

Gas supply system



Shielding gas can be supplied from an individual cylinder or manifold cylinders or bulk storage tank.
In all cases the gas supply pressure must be reduced to the working pressure by means of a regulator.
Gas flow is controlled by a valve and measured by a flowmeter.

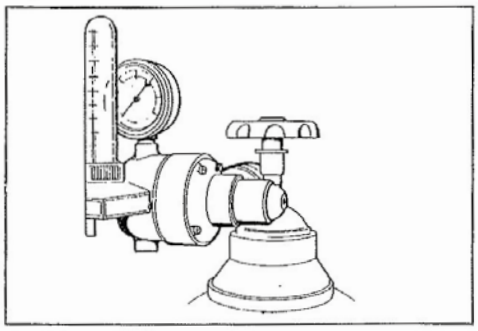
Economizers and flowmeters



A gas economizer may be fitted in association with a flowmeter. The economizer has a hook, which, when depressed as the torch is stowed, shuts off the gas supply.

! *CAUTION – Cylinder pressure should never be allowed to fall below 2 bars since atmospheric contamination may then occur.*
Make sure that valves on used cylinders are closed to avoid contamination of the small amount of gas remaining in the cylinders.

Regulators

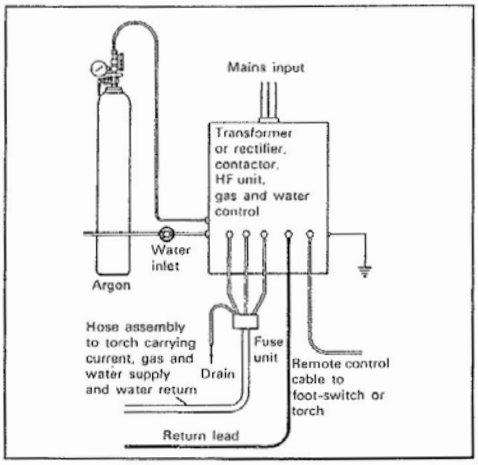


Special regulators consist of a standard single-stage regulator combined with a flowmeter. Gas supply from the cylinder is controlled by a valve and measured by the flowmeter.
In some installations the flowmeter may be of the bobbin type, in others a dial gauge may be used.

Assembly of equipment

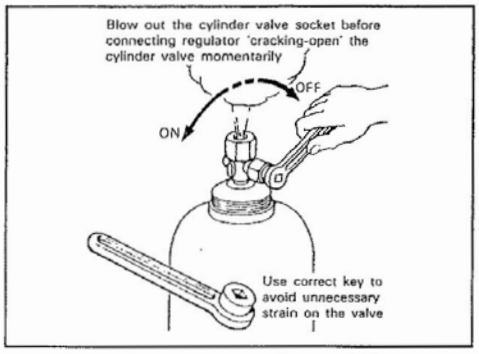
Equipments vary considerably in the manner of making connections. The examples chosen illustrate the principles. Always read the manufacturer's instruction book!

- Select secondary cables of a size suitable for the maximum welding current.
- Connect the bench (or work) to a convenient earthing point which would be capable of carrying the full welding current.



TIG Basics

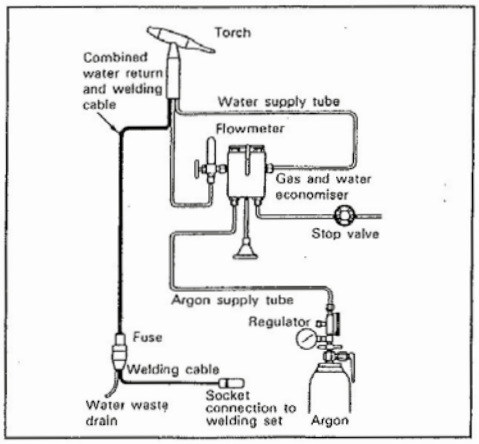
- Connect the bench (or work) to the welding return (or positive) socket of the power supply unit.
- Connect the torch lead to the electrode (or negative) outlet of the power supply unit.
- Connect the foot-switch (and remote current control if used) to the appropriate outlets on the power supply unit.



Make appropriate gas connections as follows:

- Make sure that cylinder valve socket is clean, dry and free from dust before fitting regulator.
- Screw regulator into valve socket (right-hand thread) until just home. Then give a sharp blow with one hand on the spanner shaft to ensure a gas-tight seal.
- Follow manufacturer's instructions for making hose connections between regulator, flow gauge and valve, on/off control and torch.

! *CAUTION – Use two spanners and take care when tightening male and female connectors. An uneven twist with a single spanner may cause strain, distortion or breakage of slender connectors.*



When water-cooled torches are used, water may be taken from the mains or from an independent re-circulating unit. If mains pressure is high, a water-pressure regulator must be used to reduce the pressure.

Make water connections as appropriate:

- Connect the water supply hose from mains or water re-circulating unit to water supply tube of the torch assembly, or to the water inlet on composite power source, and then to the torch assembly.
- Connect water return tube of the torch assembly to drain, or to water re-circulating unit.
- Check water flow

Selecting electrical conditions

– Type of current

Use AC for welding aluminium, magnesium, alloys based on these metals, and aluminium bronze.

Use DC for welding steels, stainless steels, copper, copper alloys, nickel, nickel alloys, titanium and other reactive metals.

– Current level

Select a welding current which will give:

- Good fusion of the parent metal.
- Adequate penetration.

The correct current level will depend on:

- Material being welded.
- Thickness to be welded.
- Type of joint.
- Position of welding.
- Electrode extension.
- Type of electrode holder.

Note: Current levels suggested are intended only as a guide. Small adjustments may be made to suit the above factors.

Electrodes

Electrode types

Plain electrodes can be used in TIG welding, but those containing a percentage of thorium or zirconium give better arc striking and improve the stability of the arc.

Tunsten electrodes are identified by a colour code:

- 1 per cent thoriated tungsten – Blue tip.
- 2 per cent thoriated tungsten – Red tip.
- 1 per cent zirconiated tungsten – Brown tip.

Thoriated tungsten electrodes should be used for DC welding. Zirconiated tungsten electrodes should be used for AC welding. They are particularly suitable for the welding of aluminium, magnesium, and alloys containing substantial amounts of either of these elements.

TIG Basics

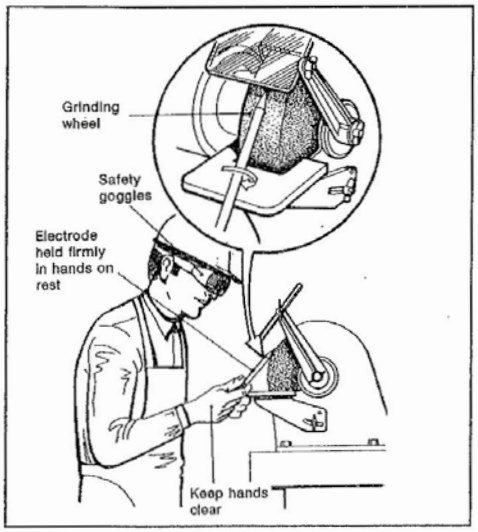
Electrodes are usually supplied in 150mm (6in) lengths in diameters ranging from 1.2mm to 5mm.
At high currents the electrode may become overheated and melt. If this happens the next larger size should be used.
At low currents, if the arc becomes unstable, change to the next smaller size of electrode.

Maximum recommended currents for electrodes

Electrode type	Thoriated tungsten	Zirconiated tungsten
Diameter mm	Amps (DC)	Amps (AC)
1.2	70	40
1.6	145	55
2.4	240	90
3.2	380	150
4	440	210
5	500	275

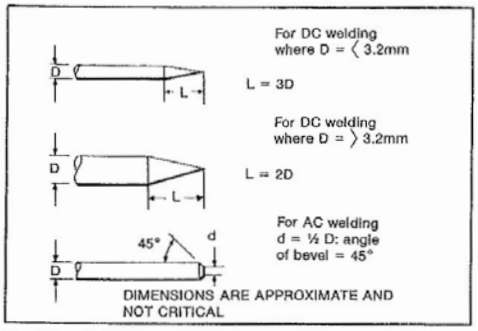
Preparation of electrode ends
The working tip of the electrode should be ground to a point to ensure an even gas flow when DC welding.

! *SAFETY – Always observe the safety regulations relating to the use of grinding wheels and the mounting of stones.*

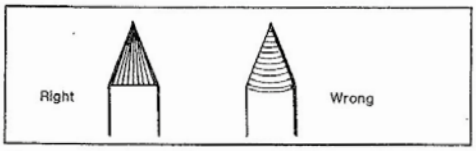


For the purpose of grinding electrodes, a silicon carbide wheel (grade 0 to M60) should be used.

! *IMPORTANT – The grinding wheel should not be used for any other purpose.*



For DC welding, a sharp point is required. The length of the taper for electrode sizes up to 3.2mm should be about three times the diameter. For electrode sizes over 3.2mm, the length of taper should be about twice the diameter.
For AC welding, a 'balled' point is required. The end of the electrode should be pre-chamfered at an angle of about 45° leaving a blunt point with a diameter about half that of the electrode diameter.
Before the electrode is used on a workpiece, an arc should be struck on a scrap piece of parent metal to 'ball' the end of the electrode.



Always ensure that the grinding marks run along the taper and not circumferentially round the tip.

Filler wires

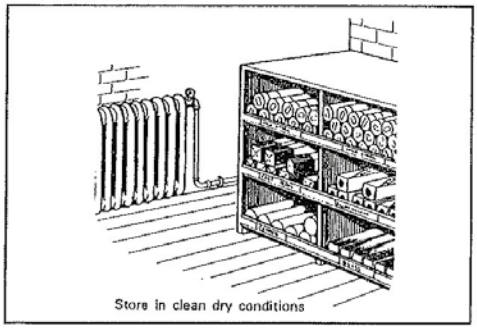
! *SAFETY – For important work, the cleaned filler rod should not be touched with the bare hands, as perspiration causes significant contamination.*
Wear clean, flexible, soft leather or fire proofed cotton gloves, as it is essential that one should have precise control of the manipulation of the filler rod.

Always use filler wires designed specifically for tungsten-arc gas shielded welding. The compositions of suitable filler materials are specified in BS 2901.
Recommended filler wires for metals referred to in the example procedures are given below.
Filler wire is supplied either in cut lengths (filler rods), or in coil form in the following diameters:
0.6; 0.8; 1.6; 2.4; 3.2; 4.8mm.

TIG Basics

Handling and storage (rod and wire)

- Handle filler rods with care.



Store in clean dry conditions

- Store under clean dry conditions to prevent deterioration.
- Do not mix different types of filler rod. Ensure that packages and their labels make for easy and correct selection.
- Where it is not practicable to store filler rods under heated conditions, an absorbent (such as silica-gel) for moisture may be used in the storage area.
- When welding, wear lightweight cotton gloves to prevent moisture from the hands being transferred to the filler rod or wire.

Preparing the filler rod for use

- Ensure that the rod is free from contamination such as rust, scale, oil, grease and moisture.
- Just prior to welding, clean the filler rod surface with wire wool. Use stainless steel wool on stainless steel and aluminium filler rods.
- Ensure that the rod is reasonably straight to assist manipulation during welding.

! *SAFETY – Always place a hot filler rod where it cannot accidentally be touched or handled. Always position the filler rod to avoid personal injury while welding – bend filler rod end to prevent injury to the eyes and to facilitate identification of the hot end. Take care to avoid fire hazards by keeping hot filler rods away from combustible materials.*

General procedures

The following general instructions, which are not always repeated later in the text, apply to TIG welding.

! *IMPORTANT – Equipment, especially composite power sources, varies considerably in design and control arrangement. Always consult the manufacturer's instruction handbook.*

Always:

- Comply with the prescribed safety precautions and fire prevention procedures.
- Ensure that effective protective equipment and all necessary protective clothing is used.
- Check that all connections to the torch hose assembly are in good order.
- Check that gas and water hoses are not kinked or otherwise obstructed.
- Check that the gas cylinder valve is open.
- Check that the gas cylinder regulator, if not of the preset type, is set to 2 bars pressure.
- Select the correct size tungsten electrode for the type and amount of current being used, and, at the same time, the appropriate nozzle.

Note: The choice of the nozzle will depend upon the amount of current being used and the length of electrode protrusion required. The shape and type of nozzle will depend on accessibility of the weld position and the visibility required at the arc.

TIG Basics

TIG welding

	Welding current amps	Electrode Dia.mm	Gas flow for electrode protrusions				Nozzle Dia.mm
			10mm	12.5mm	16mm	19mm	
AC	40-90	2.5	0.31m³/hr (11ft³/hr)	0.42m³/hr (15ft³/hr)	0.57m³/hr (20ft³/hr)	0.68m³/hr (24ft³/hr)	10
	80-140	3.25	0.34m³/hr (12ft³/hr)	0.45m³/hr (16ft³/hr)	0.57m³/hr (20ft³/hr)	0.68m³/hr (24ft³/hr)	10/12.5
	100-195	4.0	0.40m³/hr (14ft³/hr)	0.51m³/hr (18ft³/hr)	0.62m³/hr (22ft³/hr)	0.73m³/hr (26ft³/hr)	12.5/16
	180-275	4.8	0.45m³/hr (16ft³/hr)	0.57m³/hr (20ft³/hr)	0.71m³/hr (25ft³/hr)	—	16
DC	40-240	2.5	0.34m³/hr (12ft³/hr)	0.37m³/hr (13ft³/hr)	0.42m³/hr (15ft³/hr)	0.48m³/hr (17ft³/hr)	10
	200-300	3.25	0.37m³/hr (13ft³/hr)	0.42m³/hr (15ft³/hr)	0.51m³/hr (18ft³/hr)	0.57m³/hr (20ft³/hr)	12.5
	300-400	4.0	0.42m³/hr (15ft³/hr)	0.57m³/hr (20ft³/hr)	0.71m³/hr (25ft³/hr)	—	16
	250-350	6.25	0.57m³/hr (20ft³/hr)	0.71m³/hr (25ft³/hr)	0.79m³/hr (28ft³/hr)	—	16

- Grind tip of electrode to suit its application.
- Clean electrode thoroughly after grinding using stainless steel wool or aluminium oxide cloth.
- Select the collet to match the diameter of the electrode selected, and fit the electrode in the collet.
- Fit the electrode and collet into the head of the welding torch and position, approximately, the electrode protrusion by tightening the collet cap.
- Screw the selected nozzle into the torch.
- Slacken cap and adjust the position of the electrode so that it protrude to the length applicable to the application.
- Switch on the mains power supply.
- Switch on composite power source.
- Remove torch from hook on gas economiser, if it remains stowed, and set its switch to the 'on' position.
- Using the correct spindle key, open the valve on the gas cylinder slowly and adjust the flowmeter control valve to deliver about 0.34m³/hr (12ft³/hr).
- Switch off torch when the required flowrate has been established.
- Check that the water supply is turned on and that the flow to drain is correct (when using water-cooled torch).
- Check that the crater eliminator controls are correctly set.
- Acquire the habit of supporting and relaxing the body so as to be free from tension and able to concentrate on observing the welding operation.
- Hold the torch with just sufficient grip at the point of balance to give full control. Tight gripping or ill balance will cause muscle fatigue.
- Take up a position that will enable the weld run to be completed without having to stretch unduly, if possible with the shoulder line parallel with the longitudinal axis of the joint (except in vertical welding).
- Warn any persons in the vicinity when about to strike the arc.
- Ensure that any screens required are in position.
- Keep the welding screen in front of the eyes until the arc is broken.

Follow closing down procedure at the end of the work period or when there is a long interruption, namely:

- Switch off power source.
- Close argon cylinder valve.
- Turn off water supply (if used).
- Switch off power supply to power source and to separate high frequency unit (if used).
- Remove tungsten electrode from torch and store carefully.
- Place torch in a safe place.
- Collect any unused filler rods and store carefully.

TIG Basics

Maintenance and user adjustment of equipment

The equipment manufacturer's instruction manual should be consulted for details of any of the following operations which may be necessary, and the frequency with which routine maintenance checks should be made:

- Dismantling of torch
- Replacement of electrodes
- Changing torches – for work at different currents

Do not attempt unauthorised repairs or modifications to equipment.

Ensure that defective equipment is returned to the equipment manufacturer or authorised maintenance organisation for repairs or replacement.

Internal cleaning and adjustment of the power supply unit is normally the responsibility of the maintenance organisation.

TIG Basics

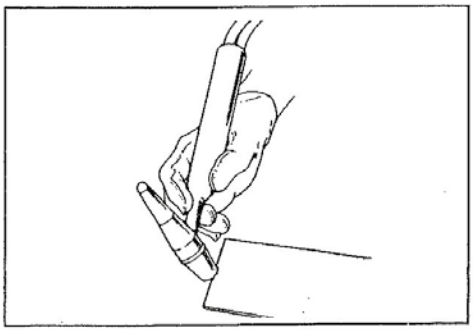
Examples of TIG welding

Striking the arc

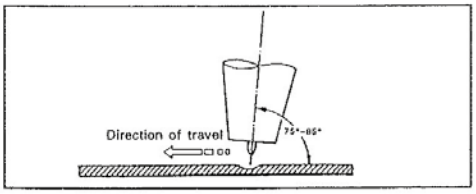
In TIG welding the electrode does not need to touch the workpiece when starting the arc. The arc is started by discharging HF across the arc gap to establish the working arc.
For DC welding the HF can be switched off during welding.
For aluminium welding the HF unit remains on during welding.

Fusion without filler metal (stainless steel) - Flat position

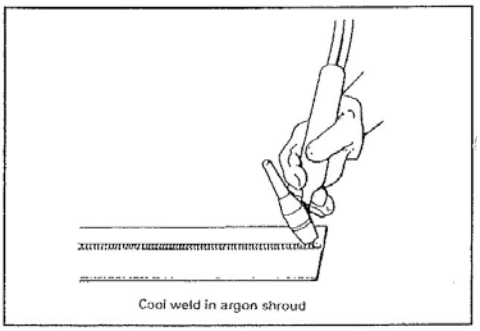
Material	One piece of stainless steel 1.5mm thick. Minimum size 100mm x 150mm
Preparation	Clean surface
Assembly	Support sheet in flat position, with air space below, long axis to be parallel to bench front
Electrode	1.6mm
Argon	0.11 to 0.22m³/hr
Current	50-70A



- Hold torch between the forefinger and thumb of the right hand with the torch handle lying on top of the hand and with the hose assembly supported by the forearm.



- With the torch body inclined backwards, so that the electrode is pointing at an angle of 75°–85°, lower the torch until the electrode end is about 25mm away from the sheet surface at the right-hand end.
- With welding current switched on, allow argon to flow (to purge the hose assembly of air) and switch on the high frequency starter.
- With welding screen in position, lower the torch until the electrode end is in close proximity to the sheet.
- A train of sparks will pass from the electrode, an arc will be established and the high frequency starter will cease to operate.
- Lower the torch until a short arc length of about 1.5mm is obtained.
- As soon as a small pool of molten metal is formed, where the arc is established, gently move the torch in a leftwards direction.
- Synchronize the rate of travel with the progressive formation of the molten metal pool.
- The molten pool should be perfectly clean and tranquil without trace of scum or oxide.
- Observe the width of the fused and resolidified metal. This will be uniform if the speed of leftwards travel is maintained correctly.
- As the torch approaches the left-hand edge of the sheet, switch off the welding current.


Cool weld in argon shroud

- Keep the torch in position over the crater with the argon flowing for 10–15 seconds. This allows weld and tungsten electrode to cool in the protective argon shroud.

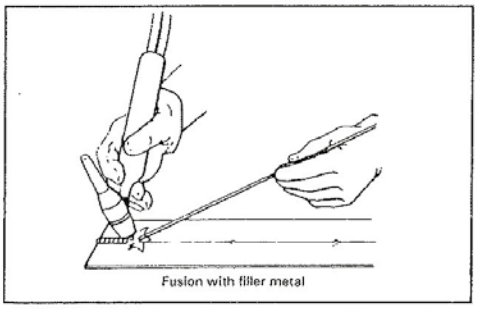
Repeat the procedure until the techniques of establishing, maintaining, and breaking the arc are mastered.

TIG Basics

Visual examination
The underside of the sheet should show that there has been near penetration of the sheet. If a burn-through has occurred it will be the result of excessive concentration of heat, either by the use of too high a welding current or too slow a rate of travel.
If the fused metal is not bright and clean after gentle wire brushing, or if the electrode end is discoloured, the argon flow should be checked for possible blockage or leakage or false flowmeter reading. Too long an arc length may be another possible cause.

Fusion with filler metal

When using the leftwards method and a filler rod, the arc is directed towards the unwelded portion of the joint, and the filler rod is directed towards the welded portion of the joint.

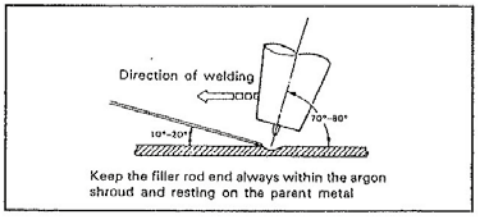


Fusion with filler metal

Sometimes in the handling of the filler rod, the tungsten electrode may become contaminated by accidental contact with the filler rod end. If so, the arc should be broken immediately, the electrode removed and replaced or ground to remove the contamination and the end reprepared.

Fusion with filler metal (stainless steel) – Flat position

Material	One piece of stainless steel 2mm thick. Minimum size 100mm x 150mm
Preparation	Clean surface
Assembly	Support sheet in flat position, long axis parallel to bench front
Electrode	2.4mm
Argon	0.22-0.33m³/hr
Current	110-125A
Filler rod	2.4mm



Keep the filler rod end always within the argon shroud and resting on the parent metal

- Establish small pool of molten metal near right-hand edge of sheet, holding torch vertical.
- Decrease the electrode angle to 70°–80°.
- Hold filler rod in left hand, between the fingers and thumb pointing at the front edge of the molten pool and at an angle of 10°–20°.
- Allow the arc heat to melt a little metal from the end of the filler rod and start the leftwards movement of the torch.
- Always keep the filler rod end within the argon shroud, making contact with the weld pool but not with the electrode when adding filler metal.
- Steady addition of filler metal gives even deposition. The rate of travel leftwards should be co-ordinated with melting of filler rod to control size of bead and extent of penetration. Repeat the procedure until separate straight runs of even shape and width can be produced at will with a consistent arc length of less than 3mm. Do not allow parent metal to become overheated.

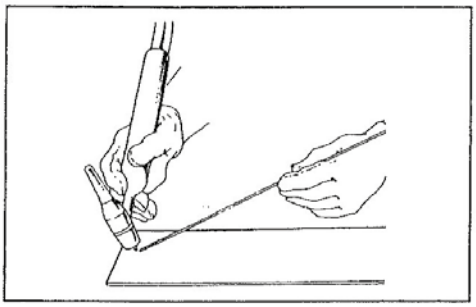
Fusion with filler metal (aluminium) – Flat position

Having mastered the basic skills using DC equipment for the welding of stainless steel (or low carbon steel), practice should be obtained using AC equipment for the welding of aluminium. It will be necessary to make adjustments to the rate of torch travel and the rate of filler metal feed. There will be observable differences in arc characteristics.

Material	One piece of aluminium 1.5mm thick. Minimum size 100mm x 150mm
Preparation	Surface cleaned immediately before welding
Assembly	Support the sheet in flat position, long axis parallel to bench front
Electrode	2.4mm
Argon	0.22-0.33m³/hr
Current	50-75A
Filler rod	2.4mm

TIG Basics

Examples of TIG welding



- Commence welding at the right-hand edge of the sheet.
- The torch and filler rod should be held in the same manner as in the previous example taking great care to ensure that the filler rod end is kept within the argon shroud.
- The weld pool will not be as clear as when welding corrosion-resistant steel but the slight oxide film will be disintegrated and removed so that it causes no difficulty in observing the weld pool.
- Co-ordinate the leftwards movement and the addition of filler metal to build up a reinforcement bead of even height and width.

Visual examination

Examine deposited beads and note any variations in width or height of run or depth of fusion into parent metal. These may be caused by variations in arc length, rate of travel, rate of addition of filler metal. Assess causes and take appropriate corrective action.

The reverse side of the sheet should indicate traces of penetration without any burn-through.

Re-starting a weld

- Establish the arc and direct the tip of the arc over the rear edge of the crater of the previously deposited weld.
- Hold the torch steady at the correct angle until a weld pool is formed.
- Move the torch slowly forward over the edge of the original weld until the leading edge of the molten pool reaches the leading edge of the crater.

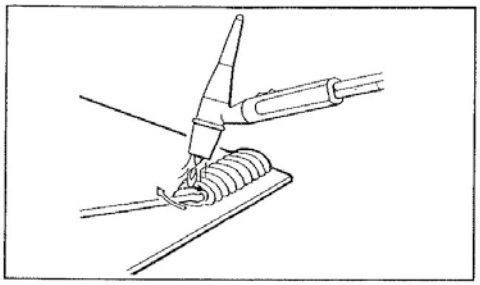
Note: If the pool appears to 'sink' filler metal must be added immediately.

- Progress the weld deposit by adding filler metal and continue welding in this manner.
- Build up crater and allow gas to flow to cool electrode.
- Switch off power source and place the torch on its hook.
- Clean the weld deposit with a stainless steel brush.
- Examine the weld for quality and appearance.

Note: The technique of building up crater assumes that a crater eliminator is incorporated in the welding power source. Where no such provision is made a crater eliminator may be added to the welding circuit in the form of a foot switch.

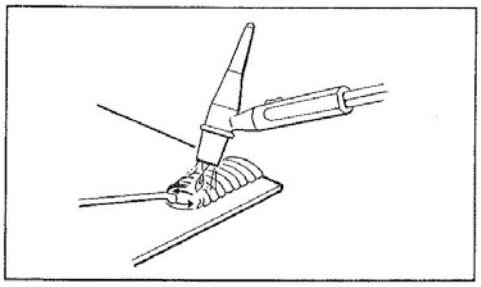
Depositing weld using a limited weaving action

- Check that the point of the electrode is correctly shaped.
- Strike an arc 12mm from the edge of the plate.
- Move the torch slowly sideways to enlarge the weld pool to about 12mm wide.
- When the pool appears to sink slightly start adding filler metal.



- Hold the arc at one side of the weld pool and dip the filler rod into the other side as shown above.
- When sufficient metal has been melted off the filler rod withdraw the rod from the weld pool.
- Move the arc slowly to the other side of the weld pool.

Note: The distance the arc is moved sideways across the weld will determine the final weld width.



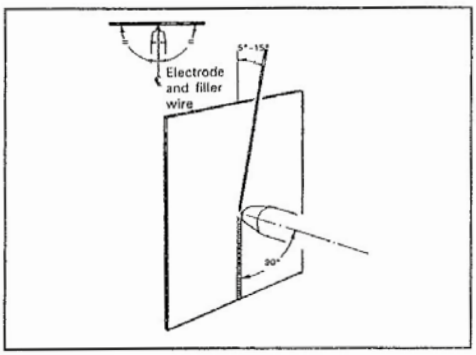
- Fuse the filler metal and parent metal in the new position shown then dip the filler rod into the weld pool at the side opposite the arc so that it melts and adds more filler metal.
- When sufficient metal has melted off the filler rod move the arc slowly across the weld at the same time withdrawing the filler rod.
- Continue welding in this manner.
- Press the torch switch and build up crater.

TIG Basics

Examples of TIG welding

Fusion with filler metal (stainless steel) - Vertical position

Material	One piece of stainless steel 1.5mm thick. Minimum size 100mm x 150mm
Preparation	Clean surface
Assembly	Support in a vertical position with bottom end 150mm above bench top
Electrode	1.6mm
Argon	0.16-0.22m³/hr
Current	55-70A
Filler rod	1.6mm



- Hold the torch body so that the axis of the electrode is at right-angles to the surface of the sheets.
- The filler rod is fed in from above the arc at an angle of 5°-15° to the sheet. The rod may be cranked to avoid heat discomfort.
- Establish the arc at the bottom end of the bead run.
- Move the torch gradually upwards, adding filler metal frequently but in small amounts to avoid contamination of the electrode end.

Visual examination

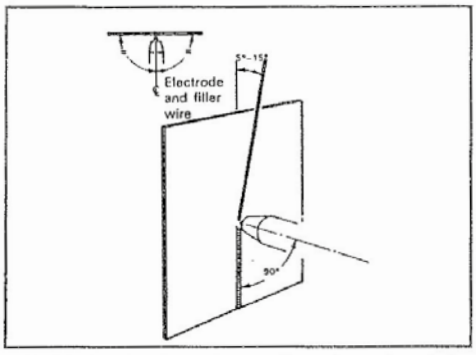
The deposited metal should be proud of the parent metal surface along the full length of the joint, without excessive convexity.

The weld metal should be free from tungsten inclusions.

The reverse side should have a reasonably uniform penetration bead and there should be freedom from burn-through.

Fusion with filler metal (aluminium) - Vertical position

Material	One piece of aluminium 3mm thick. Minimum size 100mm x 150mm
Preparation	Clean surface
Assembly	Support in a vertical position with bottom end 150mm above bench top
Electrode	5mm
Argon	0.22-0.33m³/hr
Current	120-150A
Filler rod	4.8mm



- Hold the torch body so that the axis of the electrode is at right angles to the surface of the sheets.
- The filler rod is fed in from above the arc at an angle of 5°-15° to the sheet. The rod may be cranked to avoid heat discomfort.
- Establish the arc at the bottom end of the bead run.
- Move the torch gradually upwards, adding filler metal frequently but in small amounts to avoid contamination of the electrode end.

Visual examination

The deposited metal should be proud of the parent metal surface along the full length of the joint, without excessive convexity.

The weld metal should be free from tungsten inclusions.

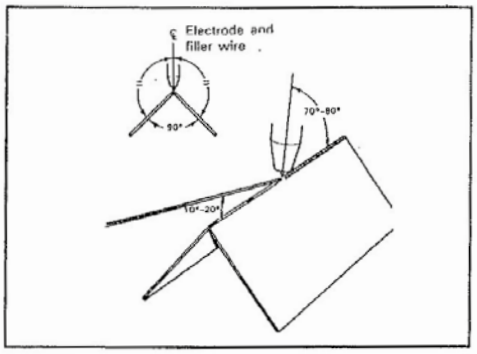
The reverse side should have a reasonably uniform penetration bead and there should be freedom from burn-through.

TIG Basics

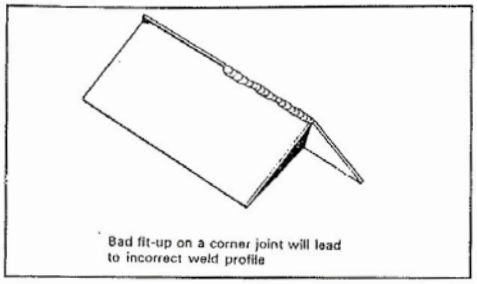
Examples of TIG welding

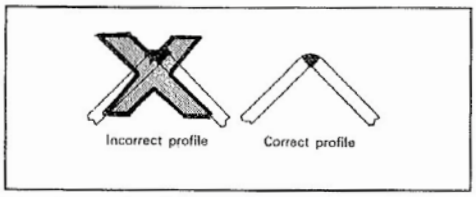
Close outside corner joint (stainless steel) - Flat position

Material	Two pieces of stainless steel 3mm thick. Minimum size 50mm x 200mm
Preparation	Square edge
Assembly	Tack weld with five tacks to give included angle of 90° without gap at the root
Electrode	2.4mm
Argon	0.22-0.33m³/hr
Current	110-125A
Filler rod	2.4mm



- Establish the arc on the tack weld at the right-hand end of the joint.
- As soon as a small pool of molten metal is formed add filler metal.
- Point the electrode at the root of the joint at an angle of 70°–80°.
- Move the torch progressively leftwards, co-ordinated with the melting of filler metal to just fill the joint.
- Keep arc length short.
- Adjust the rate of travel to avoid excessive melting away of the top edges of the fusion faces or excessive fusion through the root.
- When the tack weld at the left-hand end of the joint is reached, move the torch so that the electrode is perpendicular.
- After fusing the tack weld and building up the weld section, break the arc in the correct manner.


Bad fit-up on a corner joint will lead to incorrect weld profile

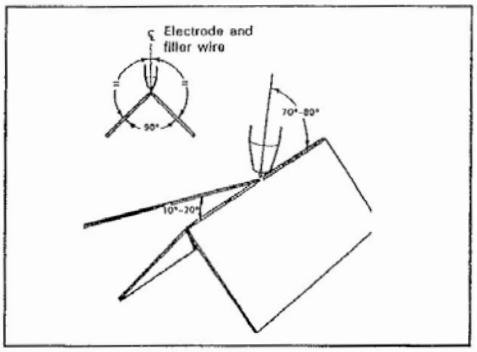


Visual examination
With correct speed of travel a full weld with a slightly convex profile will result.
The underside of the joint should show fusion to the root or even a slight penetration bead.

Close outside corner joint (aluminium) - Flat position

Material	Two pieces of aluminium 1.5mm thick. Minimum size 100mm x 150mm
Preparation	Square edge
Assembly	Tack weld with five tacks to give included angle of 90° without gap at the root
Electrode	2.4mm
Argon	0.33-0.44m³/hr
Current	65-85A
Filler rod	2.4mm

TIG Basics



- Establish the arc on the tack weld at the right-hand end of the joint.
- As soon as a small pool of molten metal is formed, add filler metal.
- Point the electrode at the root of the joint at an angle of 70°–80°.
- Move the torch progressively leftwards, co-ordinated with the melting of filler metal to just fill the joint.
- Keep arc length short.
- Adjust rate of travel to avoid excessive melting away of the top edges of the fusion faces or excessive fusion through the root.
- When the tack weld at the left-hand end of the joint is reached, move the torch so that the electrode is perpendicular.
- After fusing the tack weld and building up the weld section, break the arc in the correct manner.

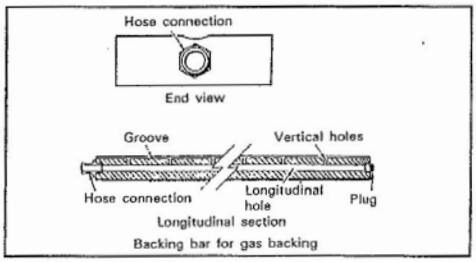
Visual examination

With correct speed of travel a full weld with a slightly convex profile will result.

The underside of the joint should show fusion to the root or even a slight penetration bead.

Backing bars

It will be found helpful to use a recessed backing bar when welding butt joints. This will control the penetration bead and enable higher welding currents to be used.

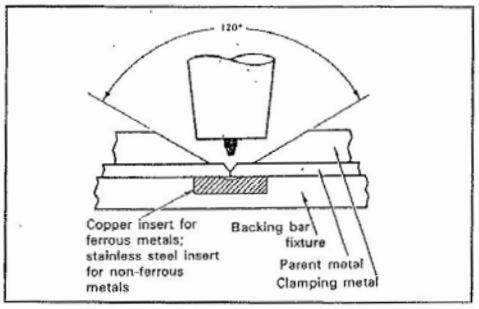


The backing bar should be made of copper when welding ferrous materials and preferably of stainless steel when welding non-ferrous materials. It should be provided with a longitudinal groove of suitable dimensions, eg, of a depth one-third of the thickness of the parent metal, semi-circular in form, having a radius of 6.5mm.

For many parent metals, including stainless steel but not aluminium, it is desirable to have an argon backing. Small vertical holes, communicating with a longitudinal supply hole, should be drilled at about 25mm intervals along the groove in the backing bar to permit an evenly distributed supply of argon to the underside of the joint at a flow rate of about 0.11 m^3/hr.

It is essential that adequate means should be provided for holding the underside of the parent metal in firm contact with the backing bar.

The backing bar may be incorporated as an insert in a jig, holding-down, or backing bar fixture.



Take care to ensure that the assembled joint does not lift away from the backing bar during welding, or burn-through may occur. Lack of such care makes welding more difficult.

The use of a backing bar with argon backing is advantageous when welding butt joints in stainless steel and other ferrous materials. It prevents oxidation of the penetration bead and gives the bead a neat and uniform appearance.

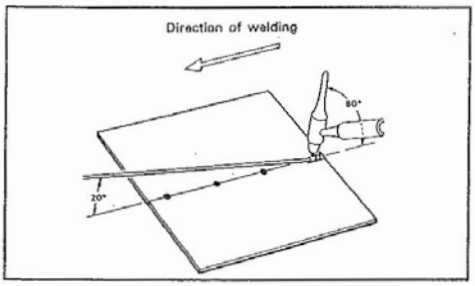
Provided the sheets are closely abutted, tacked in true alignment, and the correct welding technique is used, a backing bar is not necessary when welding aluminium or aluminium alloy sheet between 1.5mm and 3mm thickness.

TIG Basics

Examples of TIG welding

Close square butt joint (stainless steel) – Flat position

Material	Two pieces of stainless steel 1.5mm thick. Minimum size 100mm x 150mm
Preparation	Square edge
Assembly	Use grooved backing bar, preferably with argon backing
Electrode	1.6mm
Argon	0.22-0.33m³/hr
Current	50-70A
Filler rod	1.6mm

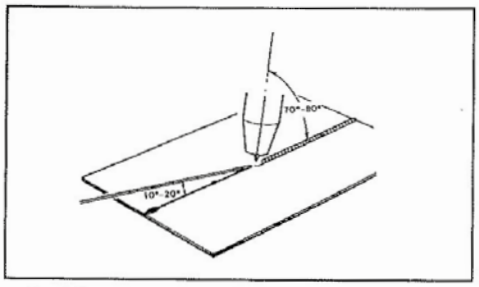


- Assemble and tack joint.
- Strike the arc on the first tack and move quickly to right-hand end of joint, maintaining the torch at an angle of 80° slope and 95° tilt from the line of the weld.
- Maintain the arc stationary until the joint is fused through the thickness of the plate.
- Move the filler rod towards the weld area at 10°–20° slope, 90° tilt. Introduce the tip of the filler rod into the leading edge of the weld pool and allow a short length of filler to melt into the pool.
- Withdraw the filler rod slightly. Do not allow the tip to come outside the gas shield.
- Move the torch slowly forward to the leading edge of the weld pool and move the filler rod out a similar distance.
- The pool will become elongated and the previous leading edge should form part of the main pool.
- Allow the leading edge to fuse and when a small depression appears in the base, add more filler rod.
- Maintain the small depression in the base by moving the torch forward and feeding the filler rod into the main pool. Continue this action along the joint, adjusting the additions of filler rod to allow the weld to be reinforced sufficiently.

Visual examination
Examine the completed weld for adequate penetration, freedom from undercut, cold lap, excessive reinforcement (and possible porosity).

Close square butt joint (aluminium) – Flat position

Material	Two pieces of aluminium 1.5mm thick. Minimum size 100mm x 150mm
Preparation	Square edge
Assembly	Tack weld with five tacks, no gap. Support in flat position with air space below.
Electrode	2.4mm
Argon	0.33-0.42m³/hr
Current	70-85A
Filler rod	2.4mm



- Establish the arc at the right-hand end of the joint, with the electrode held at an angle of 70°–80°.
- Immediately fusion to the root of the joint is obtained, add filler metal to prevent excessive fusion of parent metal.
- Commence leftwards movement without weaving of torch.
- Co-ordinate addition of filler metal and rate of travel so as to maintain fusion to the root and build up the weld to a slightly convex profile.
- Add filler metal immediately if excessive penetration seems imminent.

TIG Basics

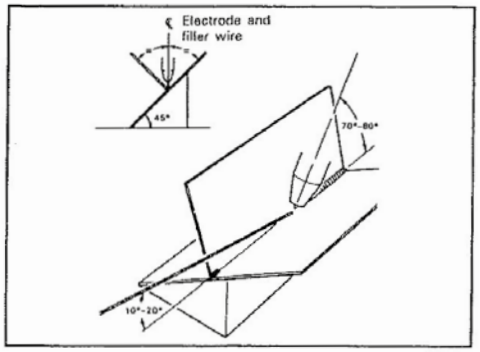
Examples of TIG welding

Faults in butt welds

Lack of penetration	Intermittent penetration	Excessive penetration	Undercut	Cold lap	Excessive reinforcement
Rate of travel too fast. Filler rod fed in too quickly. Current too low. Torch angle of slope incorrect.	Variations in speed of travel. Variations in torch angle of slope. Incorrect feed of filler rod.	Rate of travel too slow. Current too high.	Variations in angle of torch and/or filler rod. Current too high. Incorrect feed-in and/or deposition of filler rod.	Incorrect feed-in of filler rod. Excessive or fast deposit. Current too low.	Excessive deposition of filler rod. Current too low.

Close square tee fillet joint (aluminium) – Flat position

Material	Two pieces of aluminium 3mm thick. Minimum size 50mm x 200mm
Preparation	Square edge
Assembly	Tack weld both ends to form an inverted T joint, adding a spot tack centrally, no gap. Support the assembly so that the lower sheet is inclined at 45° transversely
Electrode	3.2mm
Argon	0.3-0.4m³/hr
Current	125-140A
Filler rod	3.2mm



- Establish the arc at the right-hand end of the joint.
- Point the electrode directly at the root of the joint at an angle of 70°–80°.
- Point the filler rod directly at the root of the joint at an angle of 10°–20° and in line with the joint.
- As soon as a small pool of molten metal is formed, add filler metal and commence the progressive leftward movement without weaving the torch.
- Adjust the rate of travel and addition of filler metal so as to produce a fillet weld of between 3mm and 5mm leg length.

Close square tee fillet joint (stainless steel) – Flat position

Material	Two pieces of stainless steel 1.5mm thick. Minimum size 150mm x 100mm
Preparation	As for the previous example
Assembly	As for the previous example
Electrode	1.6mm
Argon	0.1-0.2m³/hr
Current	50-70A
Filler rod	1.6mm

- As for the previous example except for the amended welding conditions.

Depositing straight runs in the horizontal/vertical position

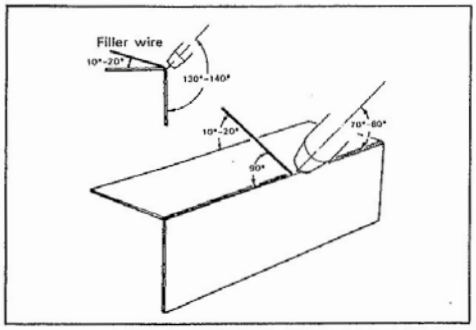
When welding joints that are in the horizontal/vertical position, the arm holding the torch should be placed below the hose assembly which is then looped so that the portion of the assembly near the torch handle is resting on the forearm. Supporting the hose assembly in this manner prevents drag on the torch handle.

TIG Basics

Examples of TIG welding

Close outside corner joint (aluminium) - Horizontal/vertical position

Material	Two pieces of aluminium 3mm thick. Minimum size 100mm x 200mm
Preparation	Square edge
Assembly	Tack weld with seven tacks to give included angle of 90°; no gap. Support to form an inverted L with the horizontal sheet pointing away from the welder.
Electrode	2.4mm
Argon	0.3-0.4m³/hr
Current	55-70A
Filler rod	2.4mm



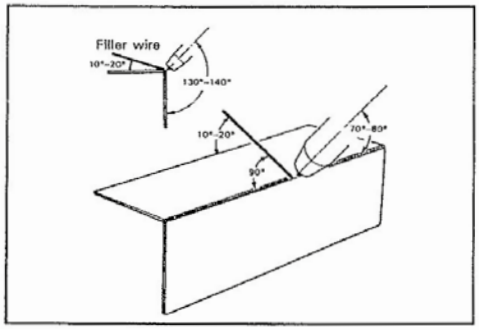
- Point the electrode at the root of the joint, at an angle of 70°–80° and with the torch tilted so that the electrode is at an angle of 130°–140° to the vertical plate.
- Hold the filler rod at right angles to the joint and at an angle of 10°–20° to the horizontal plate.
- Immediately fusion to the root of the joint at the right-hand end is obtained, commence leftwards movement adding filler metal to the top edge of the weld pool.
- Co-ordinate the addition of filler metal and the rate of travel so as to secure a full section weld without burn-through. Take care when welding material thinner than 1.5mm.

Visual examination

Good preparation of the edges and alignment of joint, also correct adjustment of welding current and rate of travel, should produce a neat uniform weld which on the reverse side has either a small uniform penetration bead or an indication that fusion to the root has been obtained consistently.

Close outside corner joint (stainless steel) - Horizontal/vertical position

Material	Two pieces of stainless steel 1.6mm thick. Minimum size 100mm x 200mm
Preparation	Square edge
Assembly	As for the previous example
Electrode	1.6mm
Argon	0.1-0.25m³/hr
Current	45-55A
Filler rod	1.6mm



- Point the electrode at the root of the joint at an angle of 70°–80° and with the torch tilted so that the electrode is at an angle of 130°–140° to the vertical plate.
- Hold the filler rod at right angles to the joint and at an angle of 10°–20° to the horizontal plate.
- Immediately fusion to the root of the joint at the right-hand end is obtained, commence leftwards movement adding filler metal to the top edge of the weld pool.
- Co-ordinate the addition of filler metal and the rate of travel so as to secure a full section weld without burn-through. Take care when welding material thinner than 1.5mm.

Visual examination

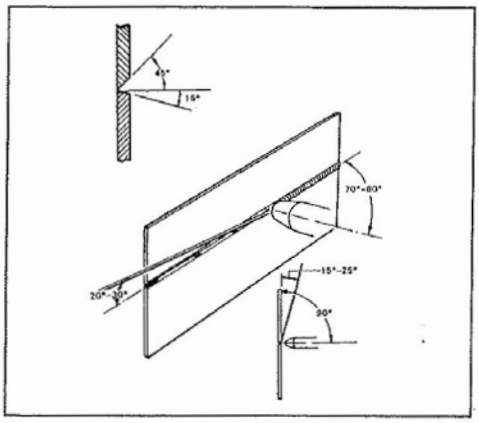
Good preparation of edges and alignment of joint, also correct adjustment of welding current and rate of travel, should produce a neat uniform weld which on the reverse side has either a small uniform penetration bead or an indication that fusion to the root has been obtained consistently.

TIG Basics

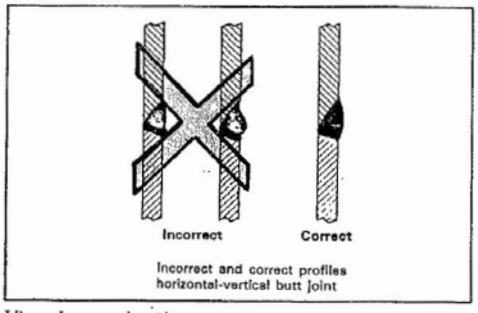
Examples of TIG welding

Single vee butt joint (stainless steel) – Horizontal/vertical position

Material	Two pieces of stainless steel 3mm thick. Minimum size 100mm x 200mm
Preparation	Lower sheet, angle of bevel 15°, upper sheet, angle of bevel 45°, no root face
Assembly	Tack weld with five tacks to give an included angle of 60°-65°; no gap. Support in a vertical position with line of joint horizontal. The use of a grooved backing bar with argon backing is recommended
Electrode	2.4mm
Argon	0.2-0.3m³/hr
Current	100-200A
Filler rod	2.4mm



- Establish the arc at the right-hand end of the joint.
- The torch body should be at right angles to the vertical plates with the electrode pointing at the root of the joint at an angle of 70°–80°.
- The filler rod should be held so that it is at an angle of 15°–25° to the vertical plates and at an angle of 20°–30° to the horizontal line of the joint.
- Add filler metal by inserting the filler rod end in the weld pool, in a fairly rapid reciprocating motion, fusing a small quantity at a time.
- Adjust rate of travel to secure neat fusion to outer edges of the fusion faces and ensure that face of weld is not below the level of the parent metal surface.



Incorrect and correct profiles horizontal-vertical butt joint

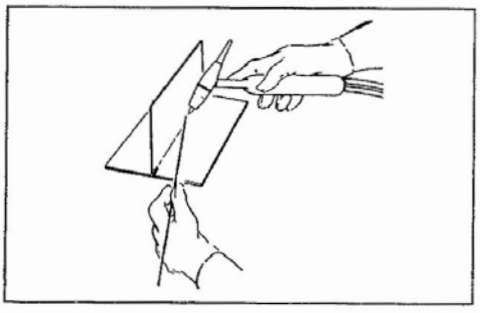
Visual examination

The weld face should be just proud of the parent metal surface and should be reasonably free from 'sagging' caused by molten metal falling.

A slight and uniform penetration bead should be visible on the reverse side with freedom from burn-through.

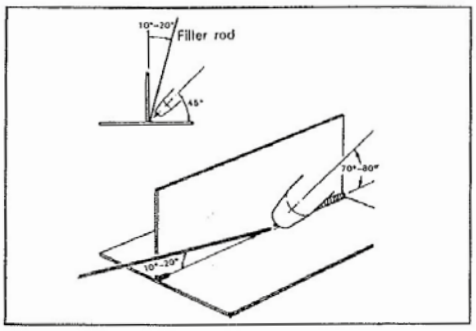
Close square tee fillet joint (stainless steel) - Horizontal/vertical position

Material	Two pieces of stainless steel 1.5mm thick. Minimum size 100mm x 150mm
Assembly	Tack weld both ends to form an inverted T joint, adding a spot tack centrally, no gap
Electrode	1.6mm
Argon	0.1-0.2m³/hr
Current	50-70A
Filler rod	1.6mm



TIG Basics

Examples of TIG welding

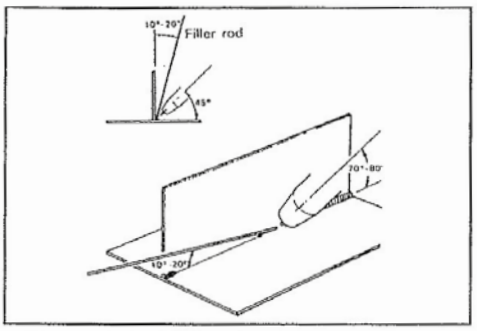


- The torch body should be inclined so that the electrode is at 45° to both the vertical and the horizontal plates.
- The filler rod should be held so that it is at an angle of 10°–20° to both the vertical and the horizontal plates.
- Establish the arc at the right-hand end of the joint and as soon as fusion starts bring the filler rod end into contact with the leading edge of the weld pool.
- Move torch slowly and uniformly leftwards without weaving.
- Regulate the rate of travel and the addition of filler metal to give a fillet weld of between 2.5mm and 3.5mm leg length.

Visual examination
The weld should be equally disposed between the vertical and horizontal plates and of uniform leg length, without undercut in the vertical plate. Undercut may be caused by too fast a rate of travel, too high a welding current or too shallow an angle of electrode to the horizontal plate.

Close square tee fillet joint (aluminium) – Horizontal/vertical position

Material	Two pieces of aluminium 5mm thick. Minimum size 50mm x 200mm
Preparation	As for the previous example
Assembly	As for the previous example
Electrode	3.2mm
Argon	0.3-0.4m³/hr
Current	140-160A
Filler rod	3.2mm



- The torch body should be inclined so that the electrode is at 45° to both the vertical and the horizontal plates.
- The filler rod should be held so that it is at an angle of 10°–20° to both the vertical and the horizontal plates.
- Establish the arc at the right-hand end of the joint, and as soon as fusion starts bring the filler rod end into contact with the leading edge of the weld pool.
- Move torch slowly and uniformly leftwards without weaving.
- Regulate the rate of travel and the addition of filler metal to give a fillet weld of between 4mm and 6mm leg length.

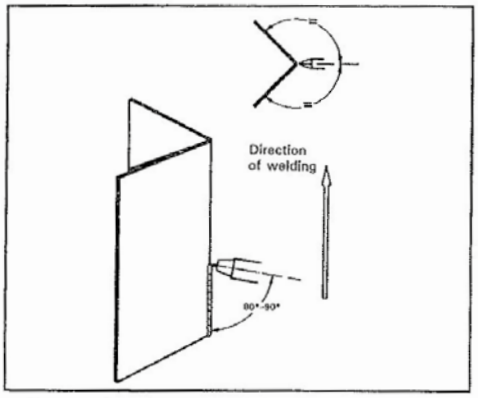
Visual examination
The weld should be equally disposed between the vertical and horizontal plates and of uniform leg length, without undercut in the vertical plate. Undercut may be caused by too fast a rate of travel, too high a welding current or too shallow an angle of electrode to the horizontal plate.

Close outside corner joint without filler (stainless steel) – Vertical position

Material	Two pieces of stainless steel 1.5mm thick. Minimum size 50mm x 100mm
Assembly	Tack the joint. Stand the plate on end with the corner towards the welder supporting the plates so that they will not fall or move during welding
Electrode	1.6mm
Argon	0.15-0.2m³/hr
Current	60-70A

TIG Basics

Examples of TIG welding

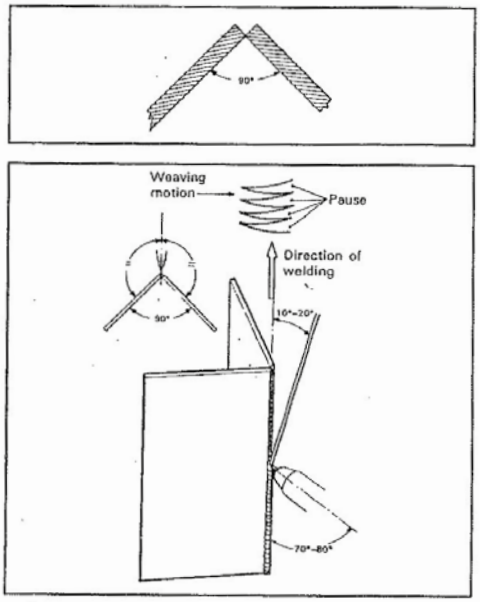


- Ensure that the welding operation can be carried out free from restriction and that heat is not being conducted away from the base.
- Strike the arc at the point of the tack weld.
- Establish the arc and move to the lower end of the joint.
- With the torch pointed directly at the centre of the joint, hold it at an angle of 80°–90° slope with equal angles of tilt as illustrated.
- Proceed to melt the edges of the plate.
- Manipulate the torch slightly to flow the molten edges together.
- As soon as a weld pool has been established hold the torch steady and advance up the joint ensuring that the edges are fusing in advance of the molten pool. When approximately 6.5mm from the top of the weld change the torch angle until it is 90° (slope) and reduce current to fill the crater at the end of the run. Allow the termination of the weld to cool off in the argon shield after the arc has been extinguished.

Visual examination
Weld should be of uniform profile and correct width with adequate root penetration and absence of overlap along the toes of the weld.

Close outside corner joint with filler (aluminium) - Vertical position

Material	Two pieces of aluminium 5mm thick. Minimum size 50mm x 200mm
Assembly	Tack the joint with the edges touching. Stand plate on end and support
Electrode	3.2mm
Argon	0.3-0.4m³/hr
Current	140-150A
Filler rod	3.2mm



- Ensure that the welding operation can be carried out free from restriction and that heat is not being conducted away from the base.
- Strike the arc at the point of the lowest tack weld and melt a weld pool.
- Add filler and commence to move up the joint, ensuring that the edges of the plates at the root are fused and that penetration is achieved.
- Deposit a root run which has a thickness of 2 to 3mm.
- Establish a weld pool at the base of the joint by melting the surface of the root.
- Point the torch to the right-hand edge and melt the joint face. As soon as fusion is achieved point the torch at the other edge; melt and add filler metal to the weld pool.
- Move up the joint weaving the electrode from side-to-side and adding filler metal to give a flat surface. Pause momentarily at the end of each weaving motion to ensure edge melting.

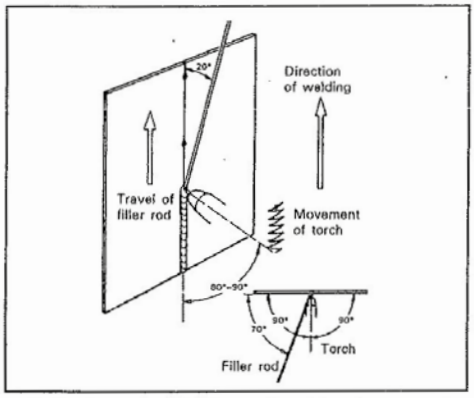
Visual examination
Weld should be of uniform profile and correct width with adequate root penetration and absence of overlap along the toes of the weld.

TIG Basics

Examples of TIG welding

Close square butt joint (stainless steel) – Vertical position

Material	Two pieces of stainless steel 2.4mm thick. Minimum size 150mm x 150mm
Assembly	Cut with square edges. Tack weld leaving no gap. Secure in vertical position
Electrode	3.2mm
Argon	0.2-0.25m³/hr
Current	90-125A
Filler rod	2.4mm

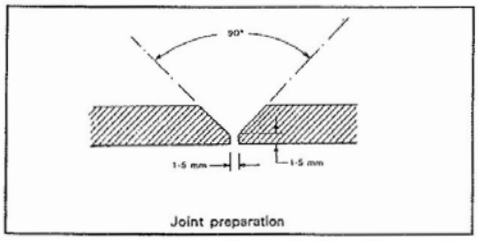


- Strike the arc on the first tack weld and move to the lower end of the joint.
- Establish a weld pool, holding the torch at an angle of 90° (slope) and 90° (tilt) from the line of the weld.
- Alter the torch angle to 80°–90° (slope) and move the torch slowly up the joint to a point where the leading edge of the pool was previously established. Manipulate the torch to ensure fusion through the material.
- Introduce the filler rod into the top edge of the weld pool at an angle of 20°–30° (slope) and 70° (tilt).
- Repeat the upwards movement of the torch fusing the side walls into the main pool and ensure full penetration.
- At approximately 6.5mm from the end manipulate the torch at an angle of 90° (slope) and ensure that the crater is filled at the termination of the weld. Allow this area to cool off in the argon shield after the arc has been extinguished.

Visual examination
Weld should be of uniform profile and correct width with adequate root penetration and absence of undercutting along the toes of the weld.

Single vee butt joint (aluminium) – Vertical position

Material	Two pieces of aluminium 5mm thick. Minimum size 100mm x 200mm
Assembly	Prepare one long edge of each plate with a 45° bevel leaving a 1.5mm root face. Tack weld the plates to give a 1.5mm root gap. Wire brush thoroughly
Electrode	3.2mm
Argon	0.3-0.4m³/hr
Current	(a) Root run 120-120A (b) Capping run 140-150A
Filler rod	3.2mm



- Support the plates in the vertical position so that there is complete freedom of movement.
- Strike the arc at the point of the lowest tack weld.
- Establish a weld pool and move up the joint, ensuring that the root faces are fused into the weld. Add filler metal as needed; the weld run should fill half the thickness of the joint.
- When the root run has been deposited, wire brush the joint and start the capping run by establishing a weld pool at the base of the joint.
- Fill the joint, using a side-to-side weaving motion. Pause momentarily at the edges of the joint to achieve fusion of the parent metal. Ensure that the surface of the root run is fused. Add sufficient filler metal to fill the joint.

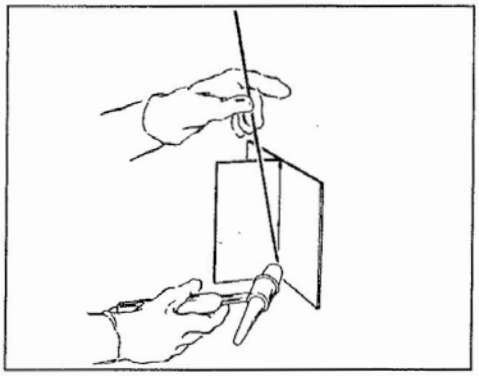
Visual examination
The penetration bead should be uniform in size along the length of the joint and should be free from oxide inclusion.
The surface of the weld should be uniform and free of undercut.

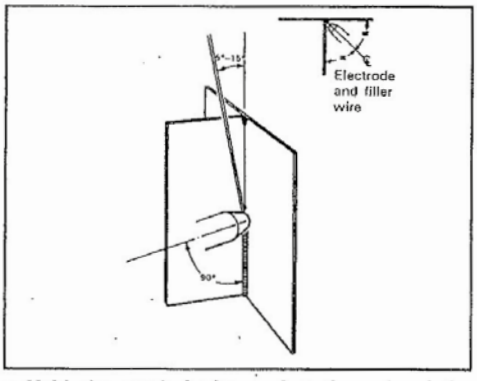
TIG Basics

Examples of TIG welding

Close square tee fillet joint (stainless steel) –Vertical position

Material	Two pieces of stainless steel 3mm thick. Minimum size 100mm x 200mm
Preparation	Square edge
Assembly	Tack weld both ends to form a T joint, adding spot tack centrally; no gap. Support assembly with line of joint vertical, about 150mm above bench top
Electrode	2.4mm
Argon	0.2-0.3m³/hr
Current	100-200A
Filler rod	2.4mm





- Hold the torch body so that the axis of the electrode bisects the angle between the two plates and is at right angles to the joint.
- The filler rod is fed in from above the arc at an angle of 5°–15° to the line of the joint. The rod may be cranked to avoid heat discomfort.
- Establish the arc on the tack weld at the bottom end of the joint and form a small weld pool.
- Add a small quantity of filler metal to build up the weld section and start upwards movement.
- Only a small quantity of filler metal should be melted each time to avoid contamination of the electrode end.
- Adjust rate of travel to secure neat fusion without undercut at either toe of the weld.

Visual examination

The weld should be equally disposed between the two plates and reasonably uniform in leg length. The leg length should be between 3.5mm and 6.5mm.

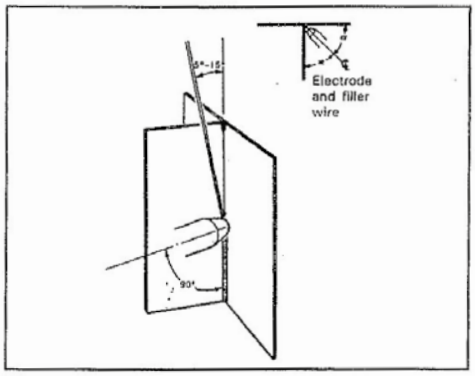
The weld metal should be free from tungsten inclusions and have a uniform profile without excessive 'sagging'.

There should be no undercut at the toes of the weld.

TIG Basics

Close square tee fillet joint (aluminium) - Vertical position

Material	Two pieces of aluminium 3mm thick. Minimum size 100mm x 200mm
Preparation	As for the previous example
Assembly	As for the previous example
Electrode	3.2mm
Argon	0.3-0.4m³/hr
Current	110-130A
Filler rod	3.2mm



- Hold the torch body so that the axis of the electrode bisects the angle between the two plates and is at right angles to the joint.
- The filler rod is fed in from above the arc at an angle of 5°–15° to the line of the joint. The rod may be cranked to avoid heat discomfort.
- Establish the arc on the tack weld at the bottom end of the joint and form a small weld pool.
- Add a small quantity of filler metal to build up the weld section and start upwards movement.
- Only a small quantity of filler metal should be melted each time to avoid contamination of the electrode end.
- Adjust rate of travel to secure neat fusion without undercut at either toe of the weld.

Visual examination

The weld should be equally disposed between the two plates and reasonably uniform in leg length.

The leg length should be between 3.5mm and 6.5mm.

The weld metal should be free from tungsten inclusions and have a uniform profile without excessive 'sagging'.

There should be no undercut at the toes of the weld.

TIG Basics

Examples of TIG welding

Welding defects

The following table relates to the cause and prevention of the more common defects encountered in welds made by the tungsten-arc gas shielded process.

DEFECT	APPEARANCE	CAUSE	PREVENTION
Porosity	Holes in the weld.	Insufficient shielding gas Bore of gas nozzle too small. Surplus degreasing agent. Arc too long.	Satisfactory supply of gas. Correct ceramic shield. Remove all degreasing agents and dry. Shorten arc.
Undercut	Irregular grooves or channels at the toes of the weld.	Incorrect welding technique. Current too high. Incorrect welding speed.	Correct rod manipulation. Correct current. Correct welding speed.
Lack of fusion (side, root or inter-run)	Surface onto which weld is deposited has not been melted. Not always visible Usually detected by bend test or by non-destructive techniques (eg. ultrasonic detection).	Incorrect current level. Incorrect filler rod manipulation. Unclean plate surfaces.	Correct current. Use correct rod manipulation. Clean plate surfaces.
Lack of penetration	Notch or gap at the root of a weld.	Incorrect preparation and set up. Incorrect current level. Welding speed too fast.	Use the correct preparation and set-up. Correct current. Correct welding speed.
Inclusions	Usually internal and only detected by suitable testing techniques. Normally oxide or tungsten inclusions.	*Oxide inclusions* Inadequate cleaning of parent material before welding. Contamination on surface of filler rod. Inadequate protection of underside of a weld. Loss of gas shield.	Clean all metal surfaces Back purge if necessary. Ensure a satisfactory supply of shielding gas. Exclude draughts.
Cracking	Cracks can occur in the weld metal and in the parent metal alongside the weld. They may not be visible on the surface and may only be detected by the use of suitable testing techniques.	The type of crack, and therefore its cause, will depend on the material being welded. The correct diagnosis of the cause of a crack frequently calls for expert knowledge. Contamination of parent metal or filler rod.	Use correct welding procedure, pre-heating and post-heat treatment. Use correct filler rod. Clean all metal surfaces. Always adhere strictly to the procedure specified when welding materials that are susceptible to cracking. Always ensure that the correct type of filler rod is used and that the correct amount of filler metal is added.

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