WELDING BASICS SERIES

MAKE SOMETHING BETTER

MIG BASICS

MIG Basics

Also known as:

Metal Inert Gas Welding

MAG Welding

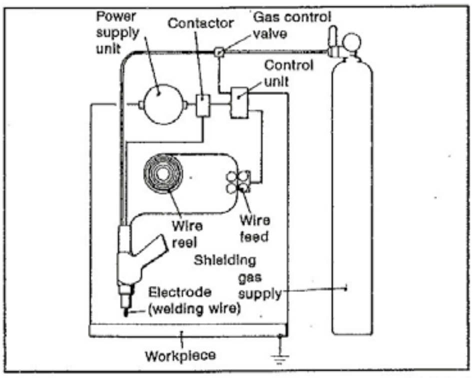
Please note:

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

MIG Basics

MIG welding

This type of welding is a refinement of the TIG process and uses a consumable wire electrode which replaces the fixed tungsten electrode of the TIG process.
The consumable electrode initiates the arc column and provides a supply of filler material. The MIG system can deposit filler metal at a much higher rate than the TIG process.



The component parts of a metal-arc gas shielded system are:
- Power supply unit.
- Wire feeder unit.
- Flexible lead (tube) assembly, and return cable.
- Welding gun or torch.
- Gas supply system.

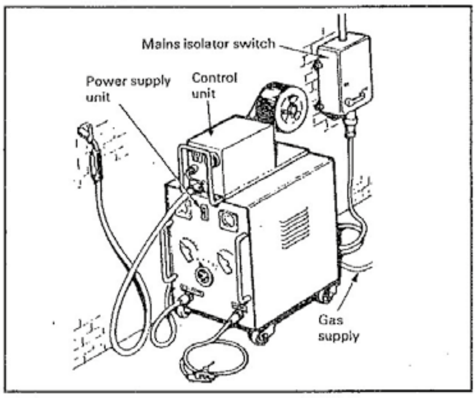
Note: Standard flowmeters are fitted, in the same way as for TIG welding, calibrated to suit the gas in use.
- A water cooling system (dependent upon amperage).

Welding processes

The basic MIG processes employed are:
- Bare wire electrode (standard consumable electrode) process.
- Flux-cored electrode process.

The standard bare wire electrode is suitable for fusion welding low alloy steels, carbon steel, aluminium, magnesium, copper base metals, nickel base metals and titanium. Using bare wire electrodes eliminates the need for post-weld cleaning.

Power supply units



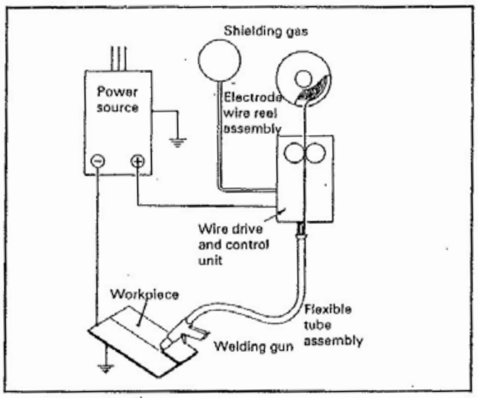
The power supply unit must be of the constant-arc voltage (CAV) or rising-arc voltage (RAV) and should be selected to suit the operating range. Units normally comprise a DC generator or AC rectified transformer.
The constant-arc voltage (CAV) allows latitude in arc length without appreciable change in voltage. The RAV machines are capable of handling the larger sizes of wires and have a greater voltage range than CAV machines.
It is usual, with both types of power supply units, to provide a voltmeter and ammeter for voltage and amperage adjustment purposes, and voltage and wire feed controllers.

Operating ranges:
- For free flight transfer, the unit should be capable of delivering up to 400A (for 1.2mm wire) or 600A (for 1.6mm wire or flux-cored electrodes). The open-voltage circuit should be high enough to provide a satisfactory arc length and voltage at the maximum operating current.
- For dip transfer, the unit used should be capable of delivering up to 200A at an operating voltage of 21V. The unit should be fitted with a tapped or variable inductance control to govern the rate of rise of current during short-circuit.
- For pulse transfer, special power supply units should be used. Seek the advice of the manufacturer.

Note: Equipment for pulse transfer will have a pulse height control which regulates the maximum voltage of each pulse. Some power units may be fitted with a pulse frequency control.

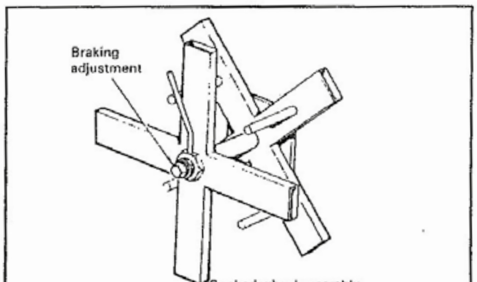
MIG Basics

The remaining equipment in a typical system is described in subsequent pages.



Wire feeder unit

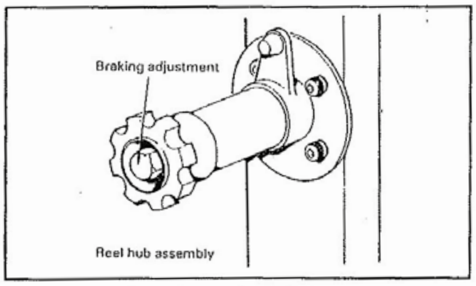
Electrode wire reel assembly



Spoked wheel assembly

The electrode wire reel or coil is mounted onto a spindle or spider hub, either horizontally or vertically as required.
The hub is free to rotate as the wire is drawn off by the wire drive unit.

An adjustable braking device is incorporated in the assembly to prevent overrun of the electrode wire when the motor of the wire drive unit is switched off.



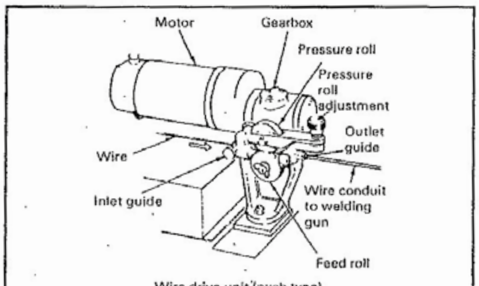
Reel hub assembly

To protect the electrode wire from dust and contamination, the reel assembly is usually enclosed by a cover or placed within the control unit cabinet. A cover is essential when using aluminium alloy wires.

Wire feeder

This may either be a push or a pull type or combined.

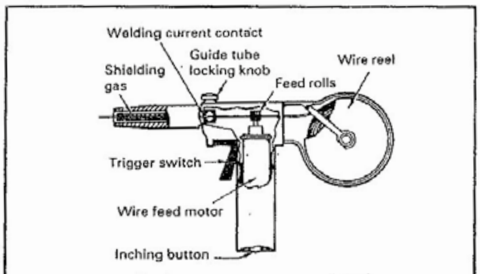
– Push type



Wire drive unit (push type)

In the push type the mechanism consists of two or more feed rolls where the grip or pressure can be adjusted.
This method of feeding is used for bare soft wire of a diameter not less than 1.2mm and of not less than 0.6mm in the case of hard wires.

– Pull type



Reel-on-gun arrangement (pull type)

The pull type consists of a drive usually built into the handle of the welding gun. Feed rolls pull wire off a small reel attached to the gun. In the combined method, push and pull feed units are used; one is mounted near the electrode wire reel assembly and the other in the welding gun.

– Control unit

This unit:

- Permits setting of the electrode wire feed rate.
- Starts and stops the feed motor instantaneously.
- Incorporates gas flow control and water flow control (if used).

Some control units incorporate a slow start facility to allow time for a molten pool to be established when starting a bead.

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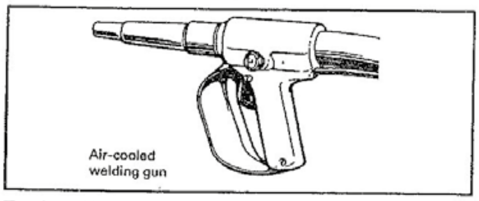
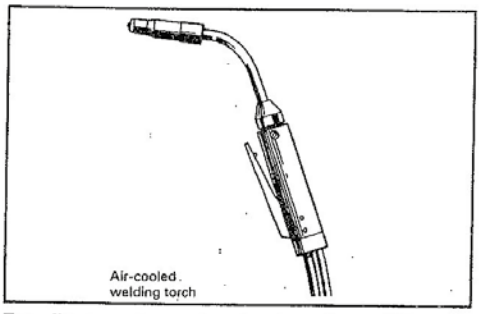
Flexible lead assembly
This will depend upon the type of equipment used. It normally contains:
- Cable for the welding current.
- Control cable to link the switch on the torch gun with the control unit.
- Hose to convey shielding gas.
- Conduit to convey electrode wire (except in the case of the reel-on-gun arrangement).
- Hoses to convey cooling water (if used).
- Hose to convey air to drive wire feed turbine (if used).

Welding gun or torch



For free flight transfer welding, with flux-cored wires 1.2mm diameter or larger, or where a pull feed unit is incorporated, the equipment is generally pistol-shaped, has a trigger-type switch, and is referred to as a welding gun. It can be water-cooled when required for use with currents in excess of 300/400A.



For dip transfer and pulse transfer welding the electrode holder normally has a curved neck. It is known as a welding torch since it resembles the shape of an oxy-actylene welding nozzle and incorporates a button or lever-operated switch.
Where a water-cooled gun or torch is required, there is usually a mechanism which cuts off electrical power should the water flow cease.

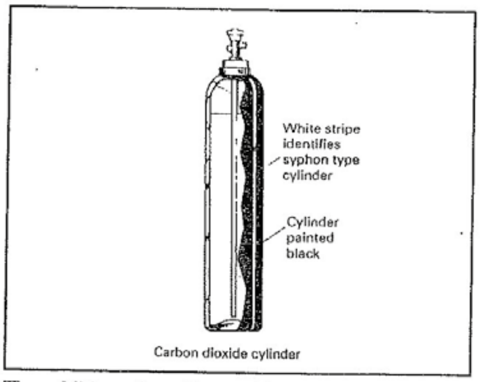
Gas supply system

! *IMPORTANT – Cylinder recognition*
Argon – Blue.
Argon-oxygen – Blue with black band.
Argon-carbon dioxide – Blue with green band.
Alternatively cylinders containing mixed gases may be painted with aluminium paint and the name of the mixture stencilled in black.
In addition gas identification labels are attached to the cylinders.

Inert gas
Argon of welding grade purity is used as the shielding gas when welding non-ferrous metals.

Gas mixtures
These mixtures are supplied in steel cylinders. Alternatively, separate gases may be mixed in the proportions required by the use of a gas mixer.

Argon-oxygen mixtures

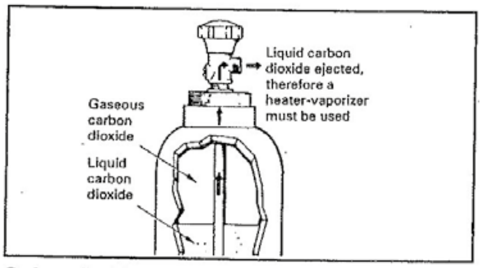


Carbon dioxide cylinder

The addition of small quantities of oxygen to argon makes it more suitable for use when welding steels. About 1–2 per cent of oxygen is added when used for welding stainless steels and 2–5 per cent when used for welding low carbon steel by free flight transfer technique.
For pulse transfer technique, argon mixed with up to 2 per cent of oxygen and up to 5 per cent of carbon dioxide, is used for welding steels.

Argon-carbon dioxide mixtures
Dip and free flight transfer welding techniques are possible with a mixed shielding gas of argon and from 5–25 per cent of carbon dioxide.

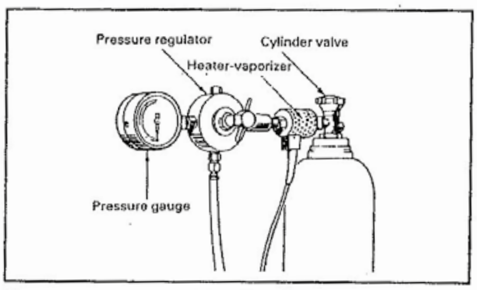
Carbon dioxide



Carbon dioxide can be used as a shielding gas for the welding of steel.
It is suitable for dip transfer at low currents and can be used at high currents for free flight transfer. There are two types of internal fittings to the cylinders; one which allows gas, which might contain moisture, to be ejected on opening the valve, and the other called the syphon type which only allows liquid carbon dioxide to be ejected.
Syphon type cylinders should be used, in which the liquid is drawn from the bottom of the cylinder.

MIG Basics

Heater-vaporizer unit



To prevent the regulator freezing as liquid carbon dioxide expands into gas, it is necessary to fit an electric heater-vaporizer unit between the cylinder valve and the regulator when using syphon type cylinders.

Shielding gases in general use

Of the two main inert gases helium is a less dense gas than argon resulting in a greater consumption in cubic feet per hour. As lower voltages can be used with argon than helium, it is most suitable for welding together thin metals with little danger of burn-through. It is particularly suitable for welding aluminium, magnesium and their alloys by the MIG process.

Helium can be operated at higher voltages and is most often used in the MIG process to provide greater weld speeds.

Argon and helium can be used to combine the advantages of the individual gases: high speed of helium and penetration of argon, resulting in good welding contours.

A mixture of argon and 1–3 per cent oxygen provides good arcing, improved metal transfer and weld pool coalescence when welding stainless steel by the MIG spray transfer process.

Carbon dioxide is mainly used for the welding of ferrous metals and provides similar penetration characteristics to that of helium.

! *IMPORTANT – Carbon dioxide must always be free of moisture as the hydrogen released may cause porosity of the weld bead.*

One disadvantage of carbon dioxide is that, due to its resistance, the arc length is sensitive. Too great an arc length will result in arc blow more readily than with argon or helium.

Other gases which are used for shielding are oxygen, nitrogen and hydrogen. These gases are usually mixed with inert gases. For example: mixtures of oxygen, as CO_2,or mixtures of oxygen, CO_2 and argon as used when welding low carbon steel. Mixtures of hydrogen and argon and nitrogen and argon, are used for welding stainless steels.

Frequently, mixtures that contain hydrogen or nitrogen are used for gas backing.

The following table, applicable to MIG welding, provides an example of gas and gas mixture applications and advantages:

Metal	Gas	Gas effects
Aluminium	Argon	Helps to remove surface oxides
Aluminium	Argon, 25 per cent in helium	Removes oxides and controls porosity
Magnesium	Argon	Helps to remove surface oxides
Titanium	Argon	Improves metal transfer
Nickel	Argon; or argon 50-25 per cent, helium 50–75 per cent.	Helps to control fluidity and provides good melting
Copper	Argon	Reduces sensitivity to surface cracks
Steel, low-alloy	Argon 98 per cent, oxygen 2 per cent	Eliminates undercutting
Steel, low-alloy	Argon 75 per cent, oxygen 25 per cent	Reduces undercutting
Steel, low carbon	Carbon dioxide	Low splatter
Steel, stainless	Argon 99-95 per cent, oxygen 1-5 per cent	Good arc stability with a reduction of undercutting

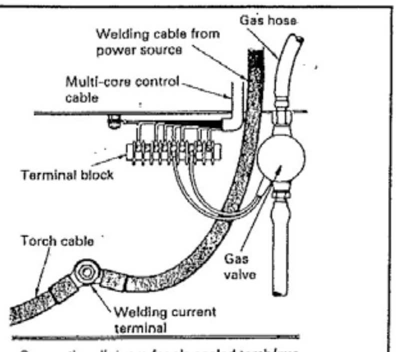
MIG Basics

Assembly of equipment

The initial installation and connection of the power source to the appropriate mains supply should be carried out by a competent person. Ensure that the equipment is adequately earthed.

! *IMPORTANT – Equipment varies considerably in the manner of making connections. The examples chosen illustrate the principles. Always consult the manufacturer's instruction book!*

Electrical connections



Connection diagram for air-cooled torch/gun

Use secondary cables of a suitable size for the maximum welding current, then:

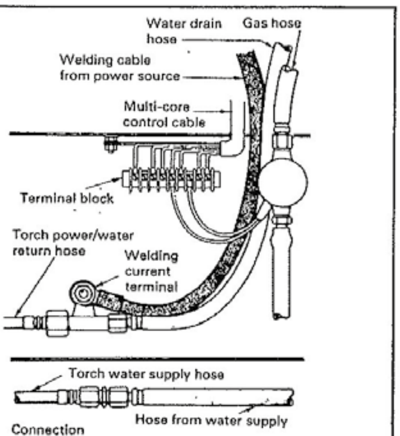
- Connect one end of the return lead (using a clamp or terminal) to the workpiece.
- Connect the other end to the negative terminal of the power source.
- Connect one end of the welding lead to the welding current input terminal on the wire feed and/or control unit.
- Connect the other end to the positive terminal of the power source.
- Connect one end of the multi-core control cable to the appropriate terminals on the wire feeder control unit.
- Connect the other end to the appropriate terminals or socket on the power source.
- Connect the welding cable and the control cable of the flexible tube assembly to the appropriate outlets on the wire feed and/or control unit.
- If using a heater-vaporizer, connect the lead from the heater to the terminal or socket on the power source or to a separate single-phase supply of the correct voltage.

Gas connections

! *IMPORTANT – Equipment varies considerably in the control arrangements. Take care to ensure that water-flow valves are correctly connected. Always consult the manufacturer's instruction book!*

- Ensure that cylinders being used are in an upright position and are securely fastened to a trolley or rigid object to prevent them falling or being knocked over, and, the valve socket is clean, dry and free from dust. This can be done by 'cracking open' the cylinder valve to pass gas to the atmosphere momentarily.
- If using carbon dioxide from a syphon type cylinder, fit the heater-vaporizer to the cylinder valve before fitting the pressure regulator.
- Fit the gas pressure regulator (and flowmeter if used) to the heater-vaporizer.
- Connect the hose to the regulator/flowmeter outlet and to the gas inlet on the control unit.

Water connections



Connection diagram for water-cooled torch/gun

When water-cooled torches are used, water may be taken from the mains or from an independent re-circulating unit.

- Connect the water supply hose from mains or re-circulating unit to water inlet connection of control unit.
- Connect water outlet of control unit to water hose in flexible assembly.
- Connect welding cable/return water hose to power/water connection of control unit.
- Connect return water outlet to drain or re-circulating unit.

Electrode wire

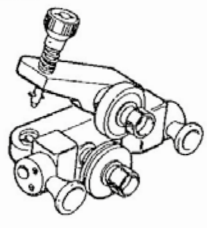
The electrode wire is usually supplied layer-wound on 300mm diameter reels. Larger coils are available.
Low carbon steel and low alloy steel electrode wires are usually coated with a thin layer of copper. This gives a measure of corrosion resistance and improves the electrical contact.
Aluminium and aluminium alloy electrode wires have to be specially processed to reduce the gas content of the material and to give a clean surface to the wire. Two methods are in general use: one in which the oxidized wire surface is mechanically skimmed, and the other, in which the wire is pickled and chemically cleaned.

MIG Basics

It is important that electrode wire should be stored carefully in dry, dust-free conditions. During use it should be protected by a plastic cover or other means. Contaminated wire will cause defective welds.

Wire feed mechanism

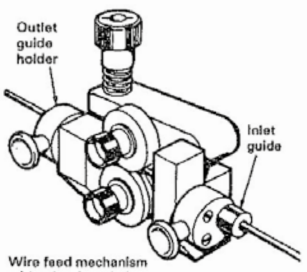
Fitting electrode wire



Wire feed mechanism opened

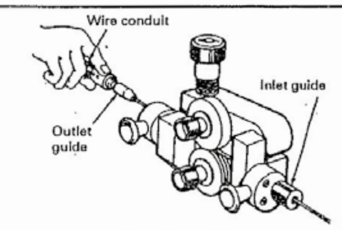
> ❗ *IMPORTANT – Equipment varies considerably in the manner of fitting and feeding electrode wire.*
> *The examples chosen illustrate the principles. Always consult the manufacturer's instruction book!*

- Locate the reel of wire on hub or spindle so that wire will be drawn off in the correct direction. Do not release the reel binding at this stage.
- Loosen braking mechanism so that reel runs freely. Then tighten just sufficiently to prevent overrun of spool when wire is drawn off.
- Fit correct size inlet guide to wire feed mechanism.
- Release the end of the wire from the reel binding but do not allow wire to become loose on the reel.
- Cut off the kinked end of the wire cleanly, making sure that the cut end is not jagged or burred.



Wire feed mechanism with wire threaded

- Thread the wire through the opened wire feed mechanism.
- Close the wire feed rolls so that the wire is gripped and adjust pressure in accordance with manufacturer's instructions.
  With the reel-on-gun assembly, the wire can now be 'inched' through the gun nozzle when the current is switched on.



Fitting wire conduit

- After making sure that all hose assembly connections other than the wire conduit connection have been made, fit the correct size outlet guide to the wire conduit.
- Thread the outlet guide over the electrode wire protruding from the wire feed mechanism and lock the guide in position.
- The wire can now be 'inched' through the conduit to the gun/torch contact tube when the current is switched on.
- Adjust the position of contact tube end/tip and fit gas nozzle.

Operating the equipment

> ❗ *SAFETY – Do not touch the electrode wire when the current is switched on.*

> ❗ *IMPORTANT – The following applies to all the remaining sections of this booklet:*
> - *The Examples are written for right-handed persons. Unless otherwise stated, adaptations of the procedure for left-handed persons simply involve reversal of direction.*
> - *Torch angles (ie, slope and tilt) have either been indicated in the related diagrams or are obvious as described in the text.*
> - *Two tack lengths are given in the text of the Examples for thin and thick materials respectively. Alternatively, tack lengths can be based on thickness, using the relationship: tack length = 2 to 3 x thickness of material (2–3t).*

Controls

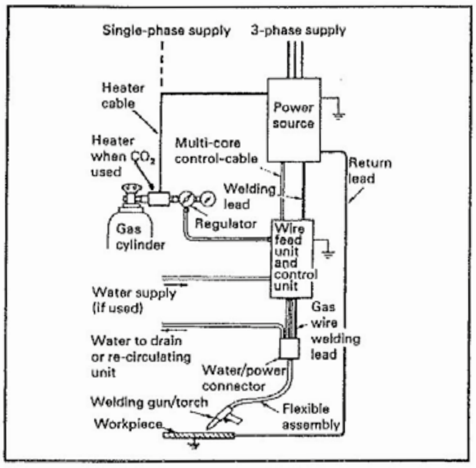
All equipment will have the following controls:

- Voltage control – governs arc length.
- Wire feed control – governs welding current.
- Equipment designed specifically for dip transfer welding will have an inductance control. This governs the rate of rise of current during short circuit and therefore it controls the frequency of short-circuiting and the weld profile. It is also used to regulate the amount of spatter.
- Equipment designed for pulse transfer will have a pulse height control. This regulates the maximum voltage of each pulse.
- Some power sources may be fitted with a pulse frequency control.

MIG Basics

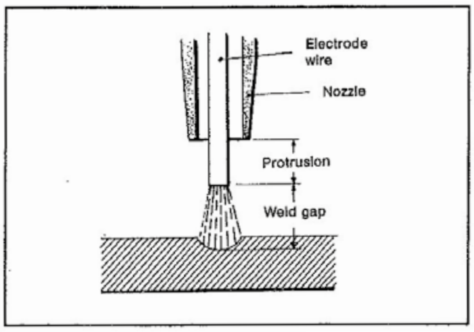
General procedure

The following general instructions, which are not repeated in the text, apply to metal-arc gas shielded welding.



Always:

- Comply with the prescribed safety precautions and fire prevention procedure.
- Check that the return lead is firmly connected to workpiece and power source.
- Check that all connections to wire feed and/or control unit are in good order.
- Check that gas and water hoses are not 'kinked' or otherwise obstructed.
- Check that the power source is switched on.
- Check that the gas cylinder valve is open and when using carbon dioxide from a syphon cylinder, that the heater-vaporizer is switched on five minutes before commencing welding.
- Check that the regulator pressure is set to 2.1 bar.
- Check that the correct size of contact tube/tip is fitted to gun/torch.
- Check that the correct size of gas nozzle is fitted.



- Check that the electrode wire protrusion and the relative positions of the exit ends of the contact tube and gas nozzle are correct.

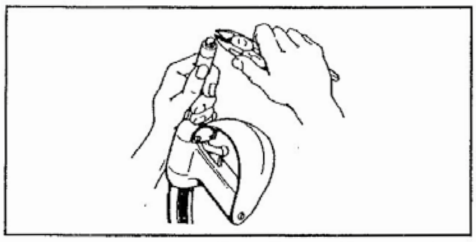
Note: The length of wire protrusion is governed by the setting of the wire feed control mechanism. The protrusion determines the penetration of the arc column and controls the current density of the electrode.

- Check that the 'burn-off' control (if fitted) is adjusted so that the electrode wire extension is correct after breaking the arc.
- Check that the gas flow is correctly set (while purging the air from the flexible tube assembly).
- Check that the water supply is turned on if using a water-cooled gun.

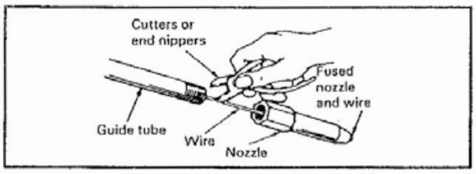
Clearing a 'burn-back'

A 'burn-back' is the result of an electrode wire fusing against the contact tube end. Do not attempt to clear the burn-back by repeated operation of the control switch on the gun/torch as the feed roll will 'chew' and deform the wire. This situation may result in another burn-back.

- Release the switch on the welding gun/torch immediately the burn-back occurs.

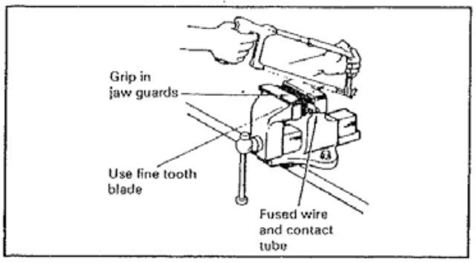


- Remove the gas nozzle and try to free wire from end of contact tube/tip with wire cutters.
- If wire is fused tight, release the pressure on the electrode wire feed rolls and unscrew contact tube/tip.



- Cut the wire and remove the fused portion from the contact tube/tip by gripping the wire in a vice. It may be necessary to file the end of the contact tube/tip, to remove the fused portion of wire, and clean and de-burr it.
- Where the contact tube does not have a screwed tip and the wire is fused tight, release the pressure on the electrode wire feed rolls and remove the contact tube from the torch/gun.

MIG Basics



- Cut the wire and remove the fused portion from the contact tube by gripping the wire in a vice. In severe cases, it may be necessary to cut off the end of the contact tube with a hacksaw to clear the fused wire.
- Replace seriously damaged contact tube/tips, and contact tubes that have been shortened to below the specified minimum length.
- Before refitting the contact tube or tip, feed sufficient wire through the gun/torch to make sure that the wire scored by the feed roll when the burn-back occurred is discarded.

Closing-down procedure

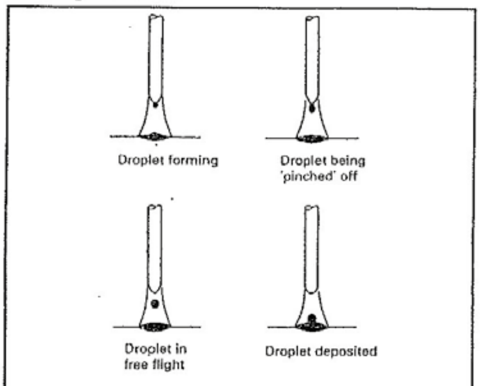
- Switch off power source supply current.
- Close gas cylinder valve.
- Switch off heater-vaporizer (if used).
- Turn off water supply (if used).
- Place torch/gun in a safe place.
- Cover wire feed and/or control unit to protect from damp and dust.

Metal transfer processes

The three main processes for depositing metal are:

- Free flight transfer.
- Dip transfer.
- Pulse transfer.

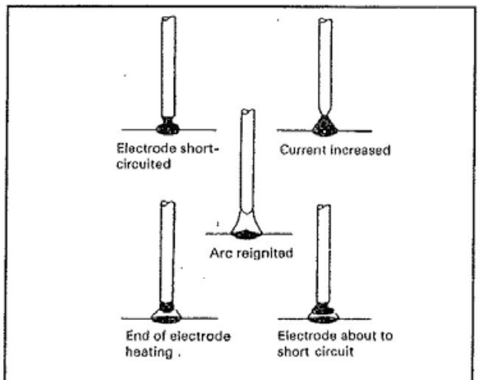
Free flight transfer



Schematic diagram, free flight transfer

In this transfer mode the molten electrode is projected across the arc gap in droplets which usually are smaller than the wire diameter. The arc is capable of carrying high current (200 to 600 amps). Deposition rate is high with deep penetration.
Free flight transfer can be used for welding aluminium in any position but can only be used satisfactorily on other metals in the flat position.

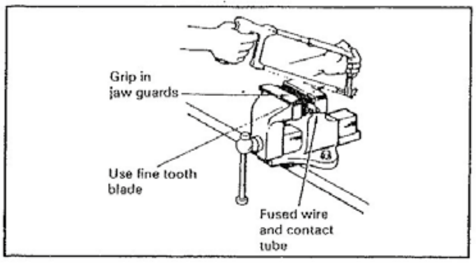
Dip transfer



Schematic diagram, dip transfer

In the dip transfer method, the electrode wire is caused to dip into the weld pool at rates in the region of 50 to 250 cycles per second.
The dipping phase reduces heat input by switching the arc on and off thus enabling both positional welding and the welding of thin materials to be carried out. Inductance control reduces spatter loss and gives improved weld appearance.

MIG Basics



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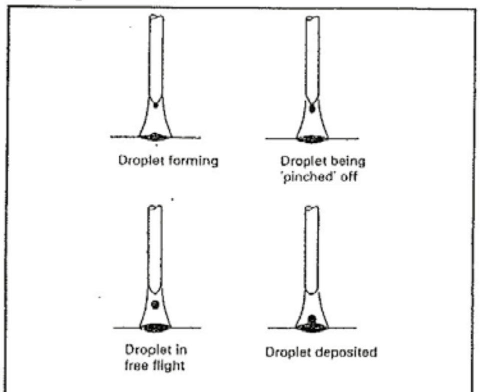
Free flight transfer



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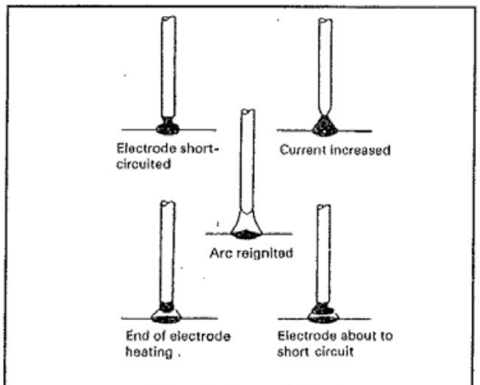
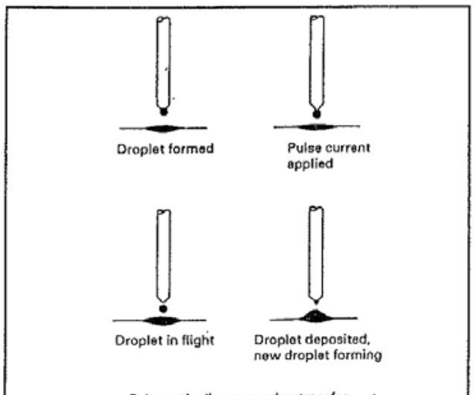


Schematic diagram, dip transfer

In the dip transfer method, the electrode wire is caused to dip into the weld pool at rates in the region of 50 to 250 cycles per second.
The dipping phase reduces heat input by switching the arc on and off thus enabling both positional welding and the welding of thin materials to be carried out. Inductance control reduces spatter loss and gives improved weld appearance.

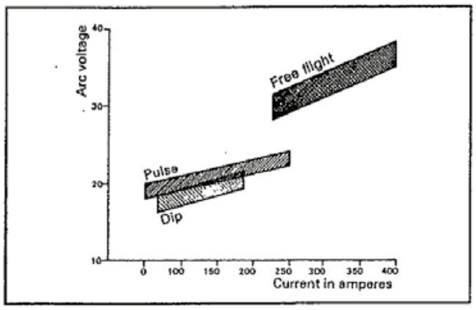
MIG Basics

Pulse transfer



Schematic diagram, pulse transfer

Pulsed current is delivered to the arc in the form of background low energy pulses which keep the arc alight, followed by a high energy pulse. This high energy pulse produces and projects droplets of molten electrode in a controlled manner. The pulsed arc enables arc energy to be accurately controlled. The pulse transfer process may be applied to most metals.

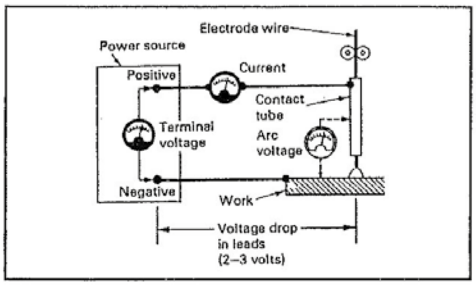


The graphical illustration shows typical operating ranges for free flight, dip and pulse transfer using a 1.2mm diameter wire.

Welding conditions

In the examples which follow, the electrical conditions quoted are intended as a guide. They are not precise because the actual settings will depend on the composition of the wire, the amount of electrode extension and so on.

Voltage

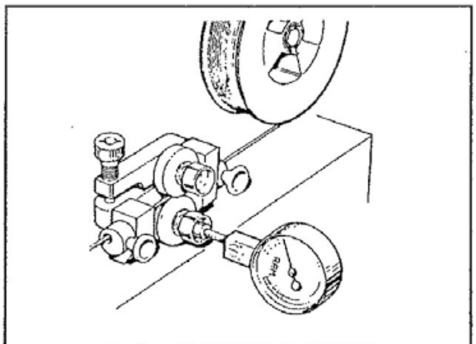


Usually indicated by a voltmeter incorporated in the power source. The meter indicates terminal voltage. The actual arc voltage will be lower because there is a voltage drop as the welding current flows through the leads. With the correct size of cable and with good connections, the voltage drop in the leads is usually about 2 to 3 volts for nominal 3m lengths.

Current

Indicated by an ammeter positioned in the power source.
With free flight conditions the meter gives the actual welding current.
With dip and pulse transfer the indicated reading is a mean value between the highest and the lowest currents experienced in the welding cycle.

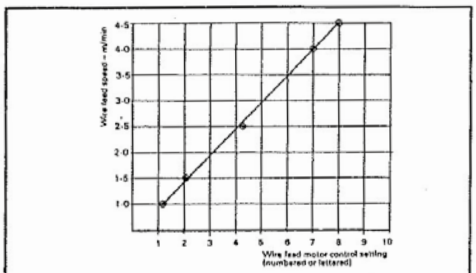
Wire feed speed



Checking wire feed speed with tachometer

Not normally metered on commercial equipments. It can be measured by using a tachometer attached to the drive rolls. This will indicate the speed of rotation of the rolls. The wire feed speed can then be calculated.
Wire feed speed = (revolutions per minute) x (circumference of the drive rolls). In the examples, wire feed speed is quoted in metres per minute (m/min).
Alternatively, the wire can be fed for a carefully determined period of time (say 10 or 20 secs) and the length of wire measured.
Data collected from these measurements can be used to calibrate the wire feed control of the machine on which the measurements were made.

MIG Basics



Typical calibration chart for wire feed unit

! *IMPORTANT – When measuring wire feed speed, disconnect the welding return lead to prevent stray arcing. Reconnect before welding. Always have the wire feeding and use the correct pressure on the rolls when measuring wire feed.*

Inductance

Cannot be measured easily. Variable inductances are calibrated with an arbitrary scale, usually marked from 0–10. These numerical settings cannot be transferred from one make of equipment to another.

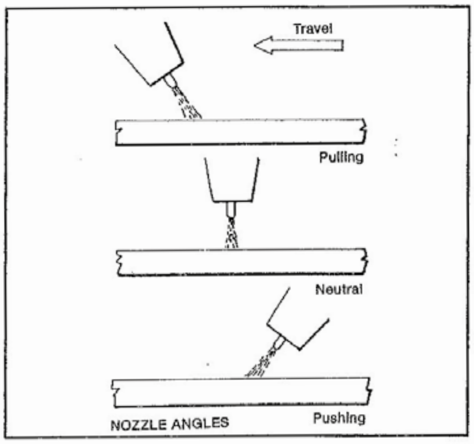
Welding methods and techniques

The main difference between MIG and TIG welding (other than that consumable electrode wire is used instead of fixed electrodes) is that a wider range of shielding gases is available with MIG.

The three main variables (applicable to most welding techniques) are:

- Welder/manipulator controlled variables.
- Machine-controlled variables (arc voltage, welding current, bead travel, speed etc).
- Workpiece variables.

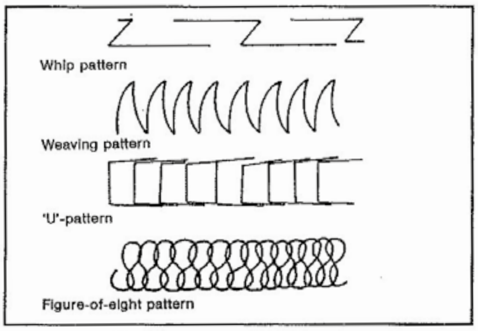
Welder/manipulator-controlled variables



These include protrusion of electrode wire, nozzle angle, gun/torch angles and wire speed feed. The welder can adjust all of these variables but, in doing so, the need for machine-controlled variables adjustment occurs.

The three main gun angles which determine the penetration of the arc column are illustrated. If significant change needs to be made in penetration characteristics, machine variables of amperage or voltage control should be used, or the original selection of electrode size should be reviewed.

Improvements cannot be made by changing the angle of inclination unless it was wrong in the first place.



The last significant welder control that can be applied is the manipulation pattern.

In the drag pattern, which is the standard movement, the gun/torch is moved in a straight line without oscillation, and without touching the workpiece.

Note: This pattern is mainly applicable to workpieces in the flat position.

For out-of-position work the whip pattern, weaving pattern, or 'U'-pattern may be preferred.

The whip and 'U'-patterns are particularly suitable for weld pool manipulation.

To make a cover pass, the figure-of-eight pattern is used.This pattern is not suitable for tack welding.

Workpiece variables

These are dictated by the composition of the parent metal which determines the type and amount of shielding gas, the electrode wire type and size, the welding position and the mechanical properties of the finished weld.

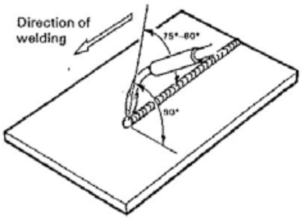
MIG Basics

Examples of MIG welding

Ensure familiarity with the effect each control has on the characteristics of the weld deposit.

Control of arc length – Free flight transfer

Material	One piece of low carbon steel 9mm thick. Minimum size 150mm x 75mm
Preparation	Clean surface
Electrode	1.2mm
Shielding gas	Argon-20 per cent CO_2 or carbon dioxide at 0.9 to 1.0m³/hr
Arc type	Free flight transfer



Standard torch angles

- Set wire feed speed to 8m/min.
- Set open circuit voltage to 38V and deposit a weld run in the flat position, keeping the contact tube-to-plate distance at 20mm. Note the voltage reading during welding.
- Reduce open circuit voltage by 2V and deposit further weld bead, maintaining the same contact tube-to-plate distance. Note the change in arc length and compare the surface profile of the weld beads.
- Reduce the voltage by steps of 2V until the electrode just starts to short-circuit regularly. Observe the appearance of the weld bead. This voltage represents the lower operating limit for welding with argon – 20 per cent CO_2 shielding gas.

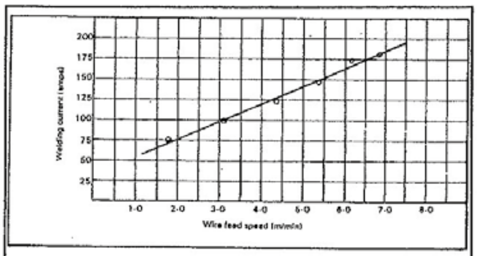
Note: In practice, the lower voltage limit is determined by the level at which there is inadequate fusion at the edges of the weld bead.

- Repeat the procedure using carbon dioxide shielding.

Control of current – Free flight transfer

Material	One piece of low carbon steel or aluminium 9mm thick. Minimum size 150mm x 75mm
Preparation	Clean surface
Electrode	1.2mm for low carbon steel 1.6mm for aluminium
Shielding gas	Low carbon steel: Carbon dioxide or argon-20 per cent CO_2 Aluminium: argon 0.9–1.0m³/hr gas flow
Arc type	Free flight transfer

- Set open circuit (OC) voltage to 35V for low carbon steel (28V for aluminium).
- Set wire feed speed to 8m/min for steel (7m/min for aluminium) and deposit a weld run, noting the current during welding.
- Reduce the wire feed speed by steps of 0.75m/min for steel (0.25m/min for aluminium). Keep contact tube-to-plate distance and travel speed constant. Deposit weld runs noting the current and the appearance of the weld bead.
- Note the wire feed speed at which the metal transfer becomes unsatisfactory (globular). This is the lowest possible operating limit for free flight transfer. Normally, welding currents should be at least 25-50A higher than this level.
- Record the results in the form of a burn-off curve.



Typical burn-off curve for mild steel electrode

Setting-up for dip transfer welding

The choice of wire diameter will depend on a number of factors related to the type of work, plate thickness and joint configuration.

In this example, the use of either 1mm or 1.2mm diameter wire is suggested since these sizes are frequently employed in practice.

MIG Basics

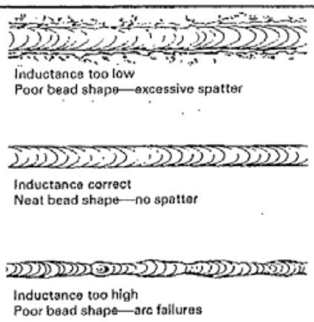
Examples of MIG welding

Material	One piece of low carbon steel 6.5mm thick. Minimum size 150mm x 75mm
Preparation	Clean surface
Electrode	1.0mm or 1.2mm
Shielding gas	Carbon dioxide 0.5–0.6m^3/hr
Wire feed speed	4.25 m/min
Arc type	Dip transfer

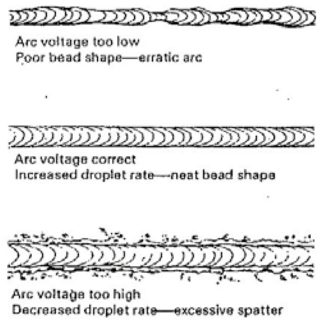
- Set open-circuit voltage to 22–24V.
- Set inductance at midpoint.
- Set wire feed speed to 4.25m/min.
- Deposit weld bead. Adjust voltage to give good fusion at the edges and a smooth weld profile, especially at the toes of the weld.
- Adjust inductance to give minimum spatter.

! *IMPORTANT – On some equipments the welding current must be switched off before adjusting voltage and/or inductance. Check with the manufacturer's handbook.*
Some equipments designed for dip transfer welding are not fitted with external inductance control. In these cases consult manufacturer's handbook.

- If electrode stubs into weld pool, increase voltage.
- Examine weld bead:
  If weld bead is too small increase wire feed speed.
  If weld bead is too large decrease wire feed speed.
  If weld bead is 'peaky' increase voltage.
  If there is inadequate fusion at the edges increase voltage and/or increase inductance.



Effect of inductance on weld bead



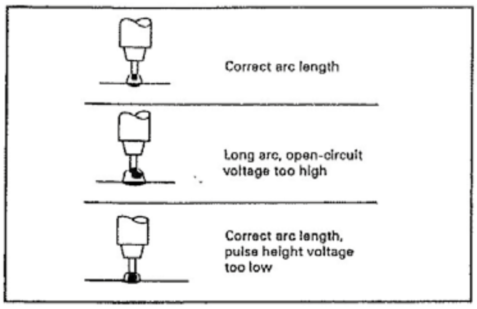
Effect of arc voltage on weld bead

Setting-up for pulsed arc welding

Material	One piece of low carbon steel or aluminium 6mm thick. Minimum size 200mm x 100mm
Preparation	Clean surface
Electrode	Low carbon steel: 1.2mm Aluminium: 1.6mm
Shielding gas	Low carbon steel: Argon-5 per cent CO_2 at 0.6–0.7m^3/hr Aluminium: Argon at 1.0m^3/hr
Wire feed speed	Low carbon steel: 3.75 m/min Aluminium: 2.5 m/min

- Set wire feed speed.
- Set pulse amplitude and background voltage controls to a low level.
- Deposit weld run and increase background voltage until short-circuiting ceases and globular transfer is obtained.
- Progressively increase pulse height until globular transfer just disappears. Each change in pulse height should be accompanied by a reduction in background voltage to maintain the arc length constant.
- Increase pulse amplitude by 1 volt (use meter on power source as a guide).

MIG Basics



- Finally, adjust background voltage to give correct arc length.
- Examine weld bead, paying particular attention to the shape and size of the deposit, the degree of fusion at the edges and the profile at the toes.

If the heat input is too high, ie, weld pool is too large, deposit is too heavy, or weld pool cannot be controlled in positional welding, reduce wire feed speed and reduce background voltage to give correct arc length.
If the heat input is too low, ie, deposit is too small, weld profile is unsatisfactory, or fusion at edges is poor, increase wire feed speed and increase background voltage to give correct arc length.

Pulse transfer – Vertical position

Material	One piece of aluminium 6mm thick. Minimum size 200mm x 100mm
Preparation	Clean surface
Electrode	1.6mm
Feed rate	3.25–3.65 m/min
Shielding gas	Argon at 1.0m³/hr
Current	110-120A
Peak voltage	33–34V
Background voltage	19-21V

- Hold the plate vertically in a clamp at about chest level.
- Establish an arc 25mm from the lower edge.
- Direct the electrode wire upwards at an angle of 65°–75°.
- Travel upwards in a straight line. Adjust the speed of travel to give good fusion at the leading edge of the weld pool but without allowing the molten metal to flow downwards.

Visual examination
Examine the completed weld bead.
Excessive convexity and undercut indicate slow travel speed.
Overlap at edges of weld bead indicates fast travel speed or inadequate current.

Dip transfer – Vertical position

Material	One piece of low carbon steel 3.2mm thick. Minimum size 200mm x 100mm
Preparation	Clean surface
Electrode	1.0mm
Feed rate	3.2–3.6 m/min
Shielding gas	Carbon dioxide or argon-20 per cent CO_2 at 0.5–0.6 m³/hr
Current	125–135A
DC voltage	24–25V
Arc voltage	21–22V

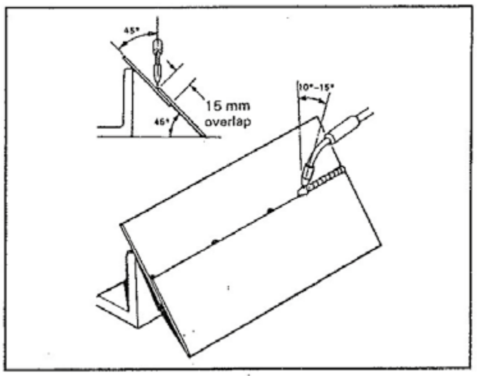
- Support the plate as in the previous example and establish a weld pool 25mm from the top edge.
- Hold the gun with the electrode pointing upwards at an angle of 55°–65°.
- Travel down the plate in a straight line, ensuring that the parent material is fused. Adjust travel speed to avoid molten metal running ahead of the arc.

Visual examination
Examine the completed weld as in the previous example.

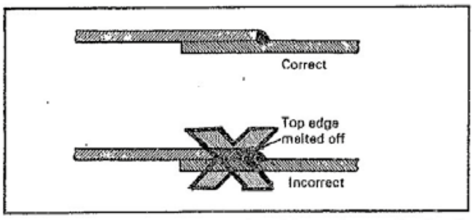
MIG Basics

Lap joint single fillet (low carbon steel)
Dip Transfer
Flat position

Material	Two pieces of low carbon steel 2mm thick. Minimum size 200mm x 100mm
Preparation	Square edge
Electrode	1.0mm
Feed rate	3.0-3.1 m/min
Shielding gas	Argon-20 per cent CO_2 at 0.8-0.9m³/hr
Current	100-110A
Arc voltage	18-19V
OC voltage	21-22V



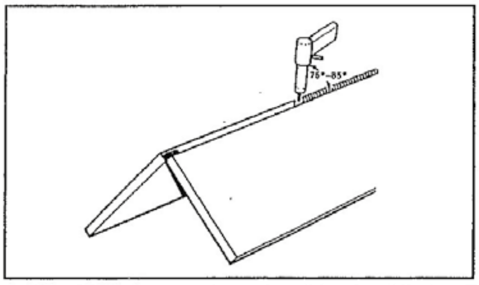
- Assemble joint with an overlap of 15mm.
- Tack weld at ends and at 65mm intervals on both sides of sheet.
- Support the assembly so that the weld is deposited in the flat position.
- Strike arc on tack weld at one end of joint and deposit weld along joint line.
- Adjust travel speed to prevent burn-through of lower sheet.
- Arc should be directed slightly away from edge of top sheet.



- Complete weld on opposite side and examine both welds for correct profile.

Close outside corner joint (aluminium)
Free flight transfer
Flat position

Material	Two pieces of aluminium 5mm thick. Minimum size 200mm x 100mm
Preparation	Square edge
Assembly	Tack weld both ends to give included angle of 90° no gap. Place on bench with joint preparation uppermost and line of joint parallel with front of bench
Electrode	1.6mm
Feed rate	5.6-6.1 m/min
Shielding gas	Argon at 1.0-1.1m³/hr
Current	190-215A
Arc voltage	24V



- Establish the arc on the tack weld at the right-hand end of the joint.
- As soon as the pool of molten metal is formed to full depth of joint preparation move the gun progressively leftwards.
- Point the electrode at the root of the joint at an angle of 75°–85°.
- Adjust the rate of travel so that the deposit fills the joint.
- Complete the weld by fusing into the tack weld at the left-hand edge of the joint.

Visual examination

A satisfactory weld will show that the deposited metal has filled the joint without excessive melting away of the top edges of the fusion faces.

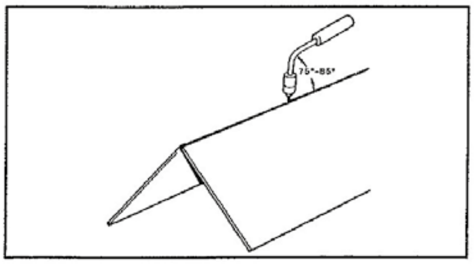
There should be signs of penetration to the root on the reverse side of the joint without burn-through.

The above also applies to the following two examples.

MIG Basics

Close outside corner joint (aluminium)
Pulse transfer
Flat position

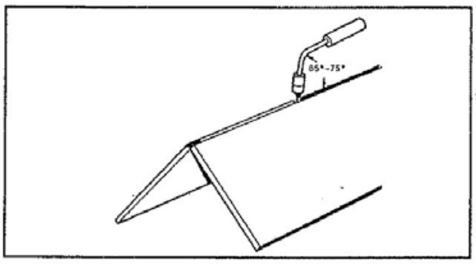
Material	Two pieces of aluminium 2mm thick. Minimum size 150mm x 100mm
Preparation	Square edge
Assembly	As for the previous example
Electrode	1.6mm
Feed rate	2.0-2.3 m/min
Shielding gas	Argon at 0.9-1.0m³/hr
Current	65-75A
Peak voltage	33-44V
Background voltage	17-18V



Proceed as for the previous example except for the amended welding conditions.

Close outside corner joint (low carbon steel)
Dip transfer
Flat position

Material	Two pieces of low carbon steel 3mm thick. Minimum size 150mm x 100mm
Preparation	Square edge
Assembly	As for the previous example
Electrode	1.2mm
Feed rate	3.0-3.3 m/min
Shielding gas	Carbon dioxide at 0.9-1.0m³/hr
Current	130-150A
OC voltage	19-21V
Arc voltage	19-20V



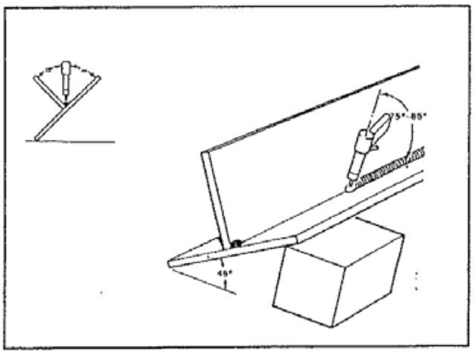
Proceed as for the previous example except for the amended welding conditions and with the electrode pointed at an angle of 65°–75°.

MIG Basics

Examples of MIG welding

Close square tee fillet joint (low carbon steel)
Free flight transfer
Flat position

Material	Two pieces of low carbon steel 10mm thick. Minimum size 200mm x 100mm
Preparation	Square edge
Assembly	Tack weld both ends to form an inverted T joint without gap between the two plates. Support the assembly so that the lower plate is inclined transversely at 45°
Electrode	1.6mm
Feed rate	5.6-6.4 m/min
Shielding gas	Argon-20 per cent CO_2 at 1.0-1.1m³/hr
Current	340-360A
Arc voltage	33-34V



- Establish the arc at the right-hand end of the joint.
- When an adequate weld pool is formed, start leftwards movement.
- Adjust the rate of travel so as to deposit a fillet weld having a leg length of about 5mm.
- The electrode should be pointed directly at the root of the joint and at an angle of 75°-85°.
- A very slight forward and backward reciprocating motion of the welding gun will help to smooth out the weld and give good fusion at the toes.

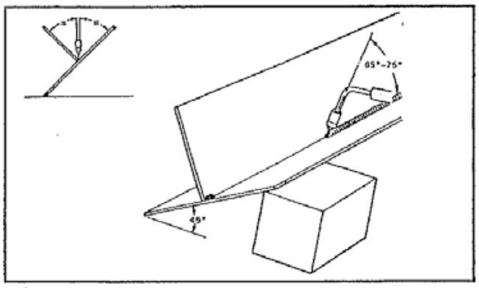
Visual examination

Examine the weld to check any operating faults. Repeat, welding the other side of the joint after making any necessary corrections to equipment settings, travel speed or electrode angle.

A satisfactory weld should be evenly disposed in the joint, be of uniform leg length and free from undercut at the toes.

Close square tee fillet joint (low carbon steel)
Dip transfer
Flat position

Material	Two pieces of low carbon steel either (a) 1.5mm or (b) 5mm thick. Minimum size 200mm x 100mm
Preparation	Square edge
Assembly	As for the previous example
Electrode	(a) 0.8mm; (b) 1.2mm
Feed rate	(a) 3.3-3.5 m/min (b) 2.5-2.8 m/min
Shielding gas	Carbon dioxide at 0.7-0.8m³/hr
Current	(a) 90-100A (b) 110-120A
Arc voltage	(a) 17-18V (b) 19-20V
OC voltage	(a) 19-20V (b) 21-22V



- Establish the arc at the right-hand end of the joint.
- As soon as fusion is established commence the leftwards movement.
- Adjust the rate of travel to deposit a fillet weld having a leg length of about 2.5mm, or 5mm.
- The electrode should be held without weaving at an angle of 65°-75° and pointed directly at the root.

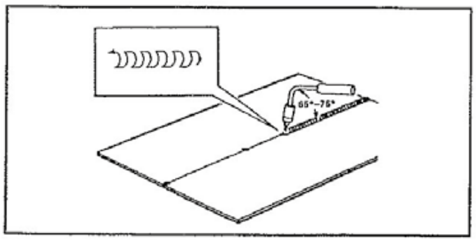
MIG Basics

Examples of MIG welding

Visual examination
Examine the weld to check any operating faults. Repeat, welding the other side of the joint after making any necessary corrections to equipment settings, travel speed or electrode angle.
A satisfactory weld should be evenly disposed in the joint, be of uniform leg length and free from undercut at the toes.

Open square butt joint (low carbon steel)
Dip transfer
Flat position

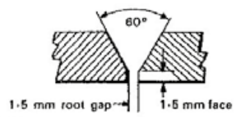
Material	Two pieces of low carbon steel 1.6mm thick. Minimum size 200mm x 100mm
Preparation	Square edge
Assembly	Tack with 1.5mm gap
Electrode	0.8mm
Feed rate	3.5-3.9 m/min
Shielding gas	Carbon dioxide at 0.7-0.8m³/hr
Current	110-130A
Arc voltage	18-19V
OC voltage	21-22V



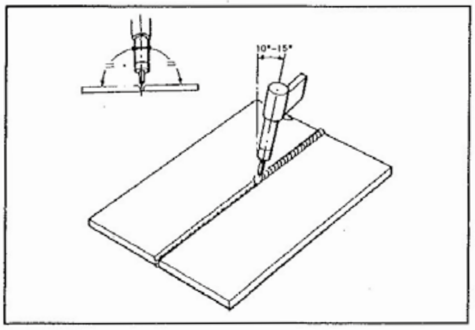
- Establish the arc at the right-hand end of the joint.
- Adjust the rate of leftwards travel to secure fusion of the spaced edges of the parent metal while avoiding burn-through.
- Use a small side-to-side movement to ensure fusion of sheet edges.

Visual examination
The weld face should be of even width, free from undercut at the toes. The profile should be slightly convex.
There should be full penetration with a slight penetration bead showing on the reverse side of the joint.

Single vee butt joint (low carbon steel) Free flight transfer – Flat position

Material	10mm thick low carbon steel 2 off	Minimum size 200mm x 100mm
Preparation and assembly	Single vee, tack with three tack welds in root	
Location of weld run	**Root**	**Filling passes**
Type of transfer	Dip	Free flight
Electrode	0.8mm	1.6mm
Feed rate	3.5–3.9 m/min	5.6–6.4 m/min
Shielding gas	Carbon dioxide or argon–20 per cent CO_2 at 0.7–0.8 m³/hr	Carbon dioxide or argon–20 per cent CO_2 at 1.0–1.1 m³/hr
Current	120–140A	340–360A
Arc voltage	18–19V	33–34V

MIG Basics

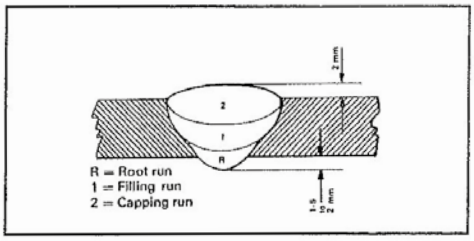


- Deposit the root run using the procedure given previously for 1.5mm sheet.

Note: Pulse transfer may be used for the root run as an alternative to dip transfer.

- Wire brush the surface of the root run, removing any silicate deposits.
- Deposit a weld run with free flight transfer. Adjust the travel speed so that the surface of the weld run is about 2mm below the surface of the plate. Ensure good fusion into the surface of the root run.
- Wire brush the surface of the first (filling) run and deposit the second (capping) run. Aim to just overfill the vee preparation so that the finished weld has an excess metal (reinforcement) height of 2mm.

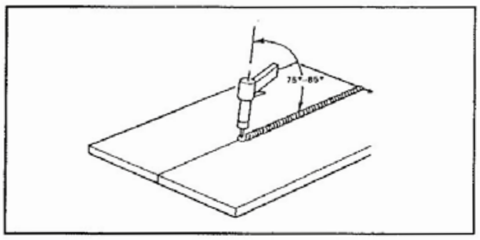
Visual examination



Examine the completed weld for uniform root penetration and absence of undercut at the toes of the weld on the top surface.

Close square butt joint (aluminium)
Free flight transfer
Flat position

Material	Two pieces of aluminium alloy 5mm thick. Minimum size 200mm x 100mm
Preparation	Square edge
Assembly	Tack weld with three tacks, no gap. The use of a stainless steel grooved backing bar is recommended
Electrode	1.6mm
Feed rate	6.1-7.3 m/min
Shielding gas	Argon at 1.0-1.1m³/hr
Current	200-235A
Arc voltage	25-26V



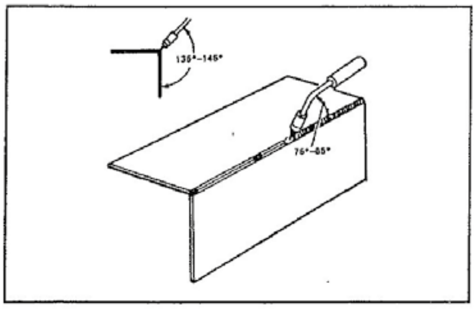
- Establish the arc on the tack weld at the right-hand end of the joint.
- When fusion has been obtained to the full depth of the plate, commence the leftwards progression.
- The electrode should be pointed at an angle of 75°–85° without weaving.
- Adjust the rate of travel so that the deposited metal is built up just proud of the plate surface and burn-through is avoided.

Visual examination
The weld face should be of even width and free from undercut at the toes. The profile should be slightly convex.
There should be full penetration with a slight penetration bead showing on the reverse side of the joint.

MIG Basics

Close outside corner joint (aluminium)
Pulse transfer
Horizontal/vertical position

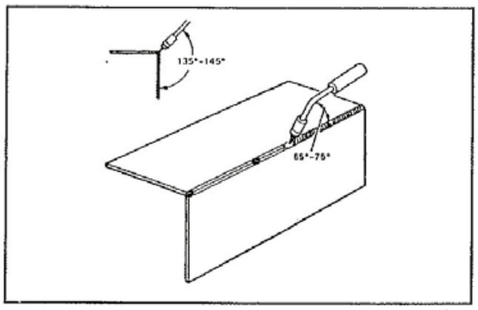
Material	Two pieces of aluminium 2mm thick. Minimum size 200mm x 100mm
Preparation	Square edge
Assembly	Tack weld with three tacks to give included angle of 90°, no gap. Support to form an inverted L with the horizontal sheet pointing away from the welder
Electrode	1.6mm
Feed rate	2.0–2.3 m/min
Shielding gas	Argon at 0.9–1.0 m^3/hr
Current	65–75A
Peak voltage	33–34V
Background voltage	18–20V



- Hold the welding torch body so that the electrode wire is pointing to the root of the joint at an angle of 75°–85° and at an angle of 135°–145° to the vertical plate.
- Establish the arc at the right-hand end of the joint.
- Adjust the rate of leftwards travel so that the weld metal just fills the joint preparation without excessive burning away at the top edge of the fusion face on the horizontal plate.

Close outside corner joint (low carbon steel)
Dip transfer
Horizontal/vertical position

Material	Two pieces of low carbon steel 1.6mm thick. Minimum size 200mm x 100mm
Preparation	Square edge and 0.8mm gap
Assembly	As for the previous example
Electrode	0.8mm
Feed rate	3.0–3.5m/hr
Shielding gas	Argon–20 per cent CO_2 at 0.7–0.8m^3/hr
Current	90–100A
Arc voltage	17–18V
OC voltage	19–20V

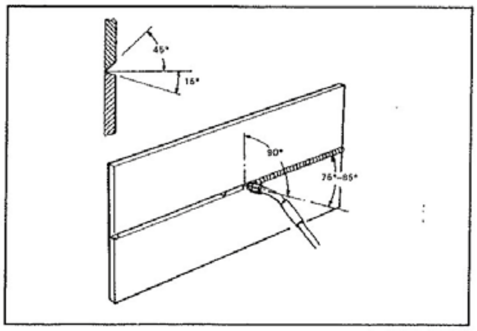


- Hold the welding torch body so that the electrode wire is pointing to the root of the joint at an angle of 65°–75° and at an angle of 135°–145° to the vertical plate.
- Establish the arc at the right-hand end of the joint.
- Adjust the rate of leftwards travel so that the weld metal just fills the joint preparation without excessive burning away of the top edge of the fusion face on the horizontal plate.

MIG Basics

Single vee butt joint (aluminium)
Pulse transfer
Horizontal/vertical position

Material	Two pieces of aluminium alloy 6mm thick. Minimum size 200mm x 100mm
Preparation	Lower sheet angle of bevel 15°, upper sheet angle of bevel 45°. No root face
Assembly	Tack weld with three tacks to give included angle of 60°–65°, no gap. Support in a vertical position with line of joint horizontal. Use of stainless steel backing bar optional
Electrode	1.6mm
Feed rate	3.4–3.7m/min
Shielding gas	Argon at 1.0–1.1m³/hr
Current	100-110A
Peak voltage	33–34V
Background voltage	18–20V

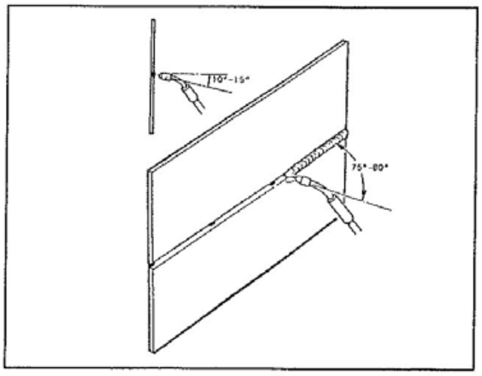


- Establish the arc at the right-hand end of the joint.
- The welding gun nozzle should be at right angles to the vertical plates with the electrode wire pointing at the root of the joint at an angle of 75°–85°.
- Adjust the rate of leftwards travel to secure neat fusion to the outer edges of both fusion faces and ensure that the weld face is not below the parent metal surface.

Visual examination
The weld face should be slightly proud of the parent metal surface and without any excessive sagging to the lower toe.
On the reverse side a uniform slight penetration bead should be present.

Open square butt joint (low carbon steel)
Dip transfer
Horizontal/vertical position

Material	Two pieces of low carbon steel 3mm thick. Minimum size 200mm x 100mm
Preparation	Square edge
Assembly	Tack weld with three tacks so that there is a uniform gap of 1.5–2mm. Support in vertical position with line of joint horizontal
Electrode	0.8mm
Feed rate	3.0–3.5m/hr
Shielding gas	Carbon dioxide at 0.7–0.8m³/hr
Current	90–100A
Arc voltage	17–18V
OC voltage	19–20V



- Establish the arc at the right-hand end of the joint.
- Hold the torch so that the electrode wire is at right angles to the sheets.

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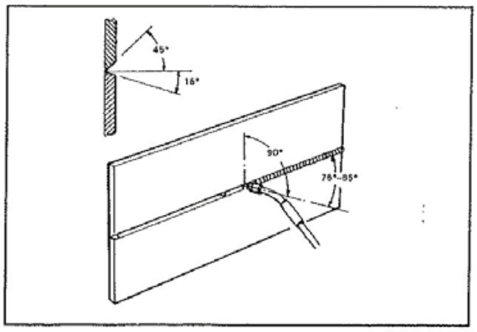
MIG Basics

Single vee butt joint (aluminium)
Pulse transfer
Horizontal/vertical position

Material	Two pieces of aluminium alloy 6mm thick. Minimum size 200mm x 100mm
Preparation	Lower sheet angle of bevel 15°, upper sheet angle of bevel 45°. No root face
Assembly	Tack weld with three tacks to give included angle of 60°–65°, no gap. Support in a vertical position with line of joint horizontal. Use of stainless steel backing bar optional
Electrode	1.6mm
Feed rate	3.4–3.7m/min
Shielding gas	Argon at 1.0–1.1m³/hr
Current	100-110A
Peak voltage	33–34V
Background voltage	18–20V

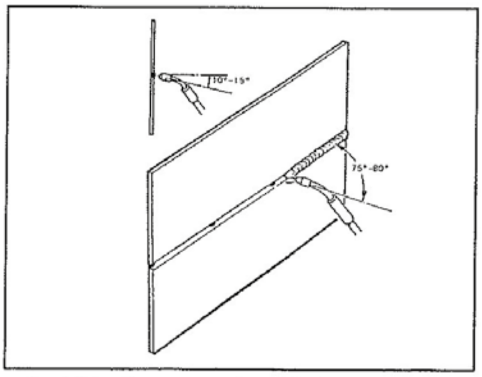


- Establish the arc at the right-hand end of the joint.
- The welding gun nozzle should be at right angles to the vertical plates with the electrode wire pointing at the root of the joint at an angle of 75°–85°.
- Adjust the rate of leftwards travel to secure neat fusion to the outer edges of both fusion faces and ensure that the weld face is not below the parent metal surface.

Visual examination
The weld face should be slightly proud of the parent metal surface and without any excessive sagging to the lower toe.
On the reverse side a uniform slight penetration bead should be present.

Open square butt joint (low carbon steel)
Dip transfer
Horizontal/vertical position

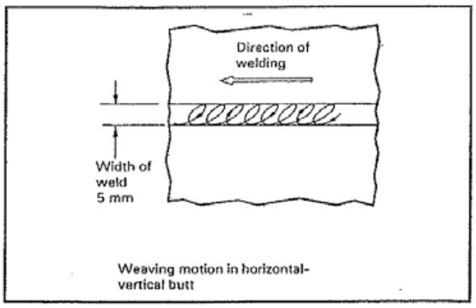
Material	Two pieces of low carbon steel 3mm thick. Minimum size 200mm x 100mm
Preparation	Square edge
Assembly	Tack weld with three tacks so that there is a uniform gap of 1.5–2mm. Support in vertical position with line of joint horizontal
Electrode	0.8mm
Feed rate	3.0–3.5m/hr
Shielding gas	Carbon dioxide at 0.7–0.8m³/hr
Current	90–100A
Arc voltage	17–18V
OC voltage	19–20V



- Establish the arc at the right-hand end of the joint.
- Hold the torch so that the electrode wire is at right angles to the sheets.

MIG Basics

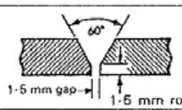
Examples of MIG welding

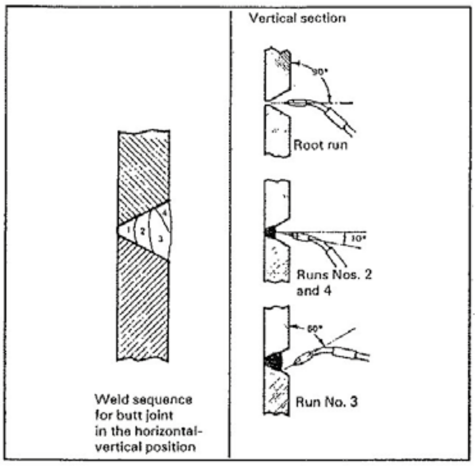


- Use a small weaving motion to ensure fusion of the sheet edges.
- Adjust rate of travel to secure fusion without over-penetration.
- Pay particular attention to torch angles.

Visual examination
Examine the completed weld for even penetration and uniform profile; the weld must not be offset towards the lower sheet.
The weld face should be slightly proud of the parent metal surface and without any excessive sagging to the lower toe. On the reverse side a uniform slight penetration bead should be present.

Single vee butt joint (low carbon steel)
Dip or pulse transfer
Horizontal/vertical position

Material	Two pieces of mild steel 10 mm thick Min. size 200 mm x 100 mm			
Preparation				
Type of transfer	Dip		Pulse	
Location of weld run	Root	Filling	Root	Filling
Shielding gas	Carbon dioxide	Carbon dioxide	Argon-5% CO_2	Argon-5% CO_2
Wire diameter, mm	0·8	1	1·2	1·2
Wire feed speed, m/min	4·0–4·5	4·0–4·5	2·5–2·9	3·5–3·9
Welding current	110–130 A	140–160 A	95–100 A	135–145 A
Arc voltage	17–18 V	19–20 V	—	—
Peak voltage	—	—	38–40 V	38–40 V
Background voltage	—	—	20–22 V	23–24 V



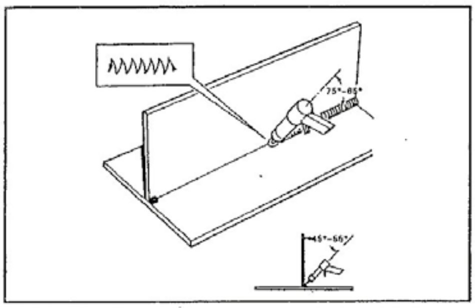
- Strike the arc at the right-hand end of the joint.
- Deposit the root run. Do not weave but concentrate on achieving penetration and fusion of the root faces.
- Deposit the second run using a circular weaving motion as in the previous example. Adjust travel speed to half fill the vee preparation.
- Keeping the torch at the angle shown, deposit the third run without weaving. Adjust travel speed to prevent the weld metal running out of the joint.
- Use a small weaving motion as necessary to fill the joint. If the weld shows a tendency to undercutting at the top edge, adjust the electrode angle.

Visual examination
Examine the weld as in the previous example. If possible, cut a macro test specimen to check for lack of side wall fusion.

Close square tee fillet joint (aluminium)
Free flight transfer
Horizontal/vertical position

Material	Two pieces of aluminium alloy 5mm thick. Minimum size 200mm x 100mm
Preparation	Square edge
Assembly	Tack weld with three tacks to form an inverted T joint without gap
Electrode	1.6mm
Feed rate	5.8–6.4 m/min
Shielding gas	Argon at 1.0–1.1 m³/hr
Current	210–230A
Arc voltage	23–25V

MIG Basics

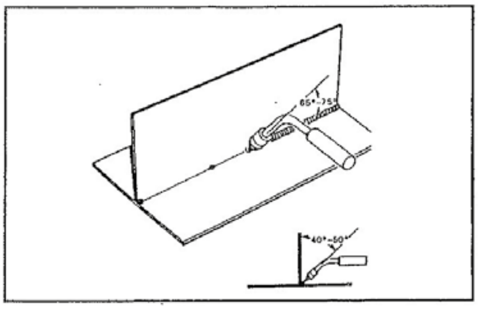


- Point the electrode wire at the root of the joint, at an angle of 75°–85° with the welding gun body inclined so that the electrode is at an angle of 45°–55° to the vertical plate.
- Establish the arc at the right-hand end of the joint.
- Adjust rate of leftwards progression so as to deposit a fillet weld having a leg length between 5mm and 6.5mm.
- A very slight quarter-circle weaving motion from the centre line of the weld, forwards and towards the vertical plate and back, will help to avoid undercut.

Visual examination
A satisfactory weld will have equal leg lengths uniform throughout the length of the weld.
The profile should be slightly convex and free from undercut at the toes.

Close square tee fillet joint (low carbon steel)
Dip transfer
Horizontal/vertical position

Material	Two pieces of low carbon steel 5mm thick. Minimum size 200mm x 100mm
Preparation	Square edge
Assembly	As for the previous example
Electrode	1.2mm
Feed rate	3.8–4.1 m/min
Shielding gas	Carbon dioxide at 0.7–0.8 m³/hr
Current	140–150A
Arc voltage	20–22V
OC voltage	25–26V



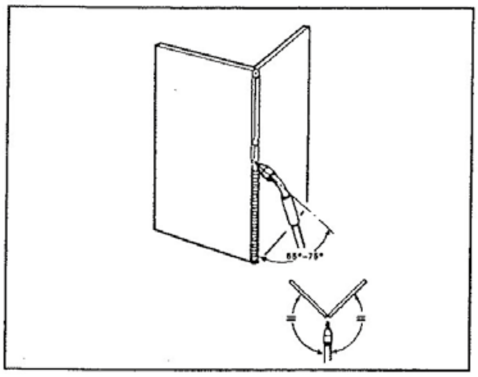
- Point the electrode wire at the root of the joint, at an angle of 65°–75° with the torch body inclined so that the electrode is at an angle of 40°–50° to the vertical plate.
- Establish the arc at the right-hand end of the joint.
- Adjust rate of leftwards movement to deposit a fillet weld having a leg length of about 4mm.
- A very slight weaving motion as for the previous example may be used.

Visual examination
A satisfactory weld will have equal leg lengths uniform throughout the length of the weld.
The profile should be slightly convex and free from undercut at the toes.

Close outside corner joint (aluminium)
Pulse transfer
Vertical position

Material	Two pieces of aluminium alloy 3mm thick. Minimum size 200mm x 100mm
Preparation	Square edge
Assembly	Tack weld with three tacks to give included angle of 90°, no gap. Support assembly with line of joint vertical, about 150mm above the bench top
Electrode	1.6mm
Feed rate	3.3–3.7 m/min
Shielding gas	Argon at 1.0–1.1 m³/hr
Current	100–110A
Peak voltage	33–34V
Background voltage	19–21V

Examples of MIG welding



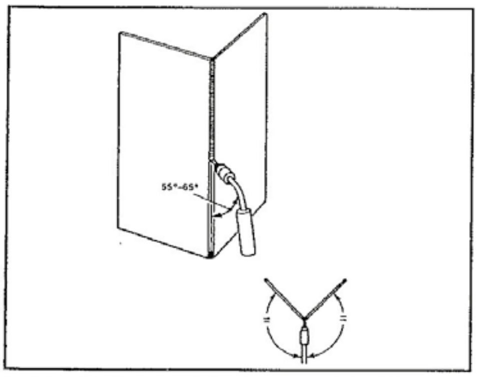
- Establish the arc at the bottom end of the joint.
- Direct the electrode wire at the root of the joint, pointing upwards at an angle of 65°–75°.
- Adjust the rate of upwards travel to secure fusion to the outer edges of the fusion faces and produce a slightly convex weld profile.

Visual examination

A satisfactory weld should have a neat even profile which is slightly convex. On the reverse side there should be a slight penetration bead along the full length of the joint.
Too fast a rate of travel may result in failure to secure full penetration.
Too slow a rate of travel may cause excessive penetration and/or excessive weld section.

Close outside corner joint (low carbon steel)
Dip transfer
Vertical position

Material	Two pieces of low carbon steel 1.5mm thick. Minimum size 200mm x 100mm
Preparation	Square edge
Assembly	As for the previous example
Electrode	0.8mm
Feed rate	3.0–3.3 m/min
Shielding gas	Carbon dioxide or argon-20 per cent CO_2 at 0.7–0.8 m^3/hr
Current	80–90A
Arc voltage	17–18V
OC voltage	19–20V



- Establish the arc at the top end of the joint.
- Direct the electrode wire at the root of the joint, pointing upwards at an angle of 55°–65°.
- Adjust the rate of downwards travel moving the torch at a fairly fast uniform speed co-ordinated with the rate of fusion of parent metal and deposition of filler metal.

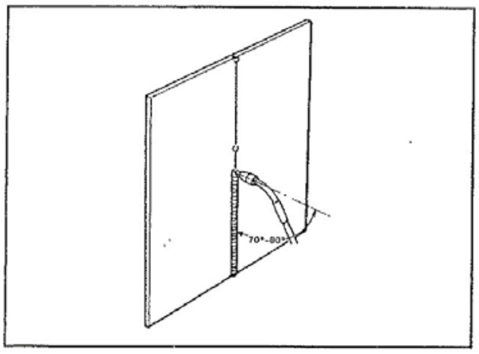
Visual examination

A satisfactory weld should show indications of penetration to the root of the joint without any concavity in the weld face profile.

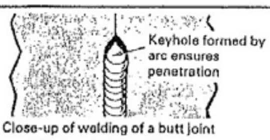
Open square butt joint (aluminium)
Pulse transfer
Vertical position

Material	Two pieces of aluminium 3mm thick. Minimum size 200mm x 100mm
Preparation	Square edge
Assembly	Tack weld with three tacks to give a uniform gap of 0.5mm. Support assembly with line of joint vertical, about 150mm above bench top
Electrode	1.6mm
Feed rate	3.6–3.9 m/min
Shielding gas	Argon at 1.0–1.1 m^3/hr
Current	105–115A
Peak voltage	33–34V
Background voltage	20–22V

MIG Basics



- Establish the arc at the bottom end of the joint.
- When fusion to the full thickness of the sheet has been obtained, commence the upwards travel.
- The electrode wire should be pointed upwards at an angle of 70°–80°.
- Direct the electrode wire at the gap between the plates to form a pear-shaped melted area (keyhole).



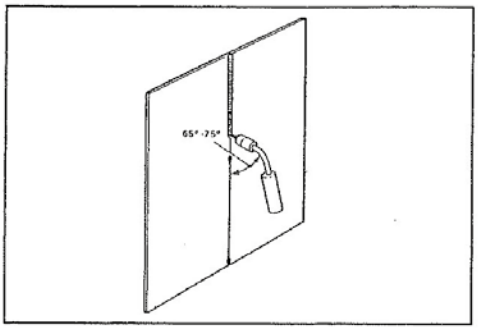
Close-up of welding of a butt joint

- Adjust the rate of upwards travel so as to maintain the 'keyhole' ahead of the weld pool with a weld run built up above the plate surfaces behind the weld pool.

Visual examination
A neat weld profile with a uniform (but not excessive) penetration bead should be achieved.

Open square butt joint (low carbon steel)
Dip transfer
Vertical position

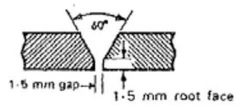
Material	Two pieces of low carbon steel 1.6mm thick. Minimum size 200mm x 100mm
Preparation	Square edge
Assembly	As for the previous example
Electrode	0.8mm
Feed rate	2.5–2.8 m/min
Shielding gas	Carbon dioxide or argon–20 per cent CO_2 at 0.7–0.8 m^3/hr
Current	90–100A
Arc voltage	17–18V
OC voltage	19–20V



- Establish the arc at the top end of the joint.
- The electrode wire should be pointed upwards at an angle of 65°–75°.
- Direct the electrode wire at the gap between the plates and adjust the rate of downwards travel to ensure even deposition and control of penetration.

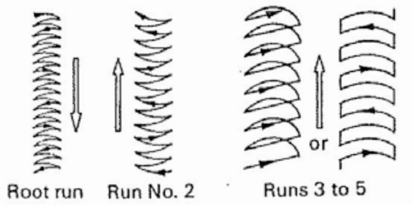
Visual examination
A neat weld profile with a uniform (but not excessive) penetration bead should be achieved.

Single vee butt joint (low carbon steel)
Dip transfer
Vertical position

Material	Two pieces of low carbon steel 10mm thick. Minimum size 250mm x 100mm
Preparation	
Electrode	1mm
Shielding gas	Carbon dioxide or argon–20 per cent CO_2 at 0.7–0.9 m^3/hr

- Assemble joint with a 2.5mm gap between the edges.
  Deposit a 25mm long tack at one end. Correct gap if necessary and tack at other end of joint.
- With the plate in the vertical position, deposit the root run vertically down on the first side, using a dip transfer technique (110–130A).
- Good fusion at the root faces must be achieved. A small weaving motion may be used to facilitate control of the weld pool.
- Visually examine the surface of the root run. There should be good fusion at the edges and the weld surface should be as near flat as possible. If the profile is peaky, voltage and/or inductance should be increased slightly.
- Wire brush the surface of the root run.

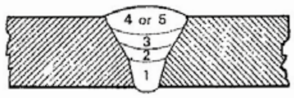
MIG Basics



Weaving patterns for vertical butt weld, showing direction of torch

- Increase the current to 140–160A readjusting voltage and inductance as required. Deposit the second run over the root run, using a weaving technique. Start at the bottom of the joint and travel vertically up.

Note: When weaving, the arc should be allowed to dwell at the edges, but should be traversed rapidly across the face of the weld.

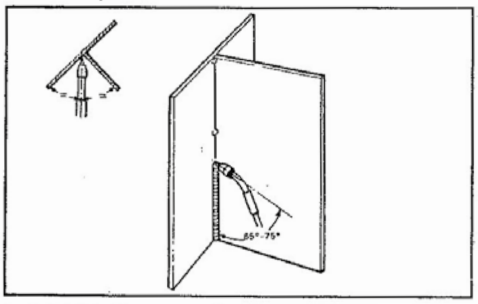


- Fill the joint using vertical – up to 4 or 5 runs according to the sequence illustrated.
- Particular care must be exercised when depositing the finishing capping passes to avoid undercut at the edges.

Visual examination
Section the completed weld. Use a side-bend test to locate any lack of side wall or inter-run fusion.

Close square tee fillet joint (aluminium)
Pulse transfer
Vertical position

Material	Two pieces of aluminium 5mm thick. Minimum size 200mm x 100mm
Preparation	Square edge
Assembly	Tack weld with three tacks to form a T joint, no gap. Support assembly with line of joint vertical, about 150mm above bench top
Electrode	1.6mm
Feed rate	3.7–4.1 m/min
Shielding gas	Argon at 1.0–1.1 m^3/hr
Current	110–120A
Peak voltage	33–34V
Background voltage	19–21V



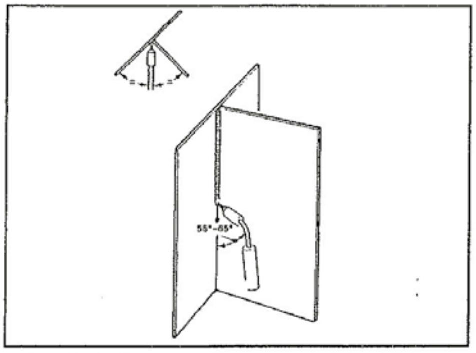
- Establish the arc at the bottom end of the joint.
- The electrode wire should bisect the angle between the plates and point directly at the root of the joint. The welding gun should be held so that the electrode wire points upwards at an angle of 65°–75°.
- Adjust the rate of upwards travel without any weaving motion so as to deposit a fillet weld of leg length between 5mm and 6.5mm.

Visual examination
Saw welded assembly transversely and examine the weld.
The weld profile should be slightly convex and have a uniform leg length without undercut at the toes.
There should be no cavity at the root of the joint. Lack of penetration may be caused by too fast a rate of travel while too slow travel may cause undercut.

MIG Basics

Close square tee fillet joint (low carbon steel)
Dip transfer
Vertical position

Material	Two pieces of low carbon steel 5mm thick. Minimum size 200mm x 100mm
Preparation	Square edge
Assembly	Tack weld with three tacks to form a T joint, no gap. Support assembly with line of joint vertical, about 150mm above bench top
Electrode	1.2mm
Feed rate	3.3–3.6 m/min
Shielding gas	Carbon dioxide at 0.7–0.8 m^3/hr
Current	125–135A
Arc voltage	21–22V
OC voltage	25–26V



- Establish the arc at the top end of the joint.
- The electrode wire should bisect the angle between the plates and point upwards at an angle of 55°–65°.
- Direct the electrode at the root of the joint and travel downwards without weaving motion.
- Adjust the rate of travel to secure a neat fillet weld.
- Repeat the procedure by welding from the bottom end of the joint, using the sequence as in paragraphs 1 and 2 of the previous example and adjusting the rate of upwards travel to obtain a neat fillet weld.

Visual examination
The weld should be uniform and not excessively concave. The leg lengths should be uniform and not less than 4mm.
Too fast a rate of travel will give inadequate weld section with excessive concavity.
Too slow a rate of travel may cause undercut at the toes and tendency for weld metal to 'sag'.

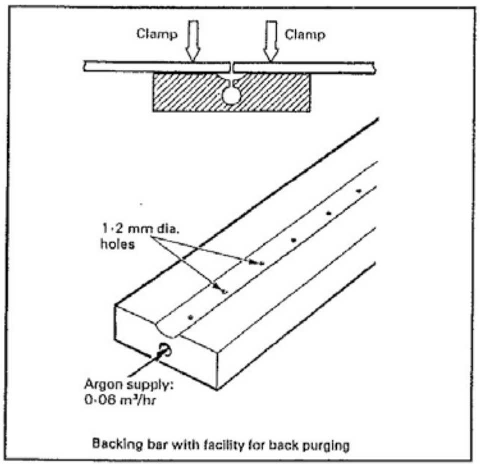
Welding stainless steel
The welding of stainless (corrosion resistant) and heat resistant steels containing chromium (17–25 per cent) and nickel (8–20 per cent) requires careful control to ensure that the finished weld will behave satisfactorily in service.
Before welding these steels, obtain the following information:

- Correct electrode wire composition.
  This will depend on tendency to cracking, and properties required.
- Maximum weld run size; large weld runs may crack.
- Sequence of welding, required to minimize distortion; it is more difficult to avoid distortion in austenitic steels by comparison with low carbon steel.
- Special precautions, eg, interpass grinding may be required to remove oxide on surface of deposit; correct grade and type of grinding wheel; slippage in fixtures.

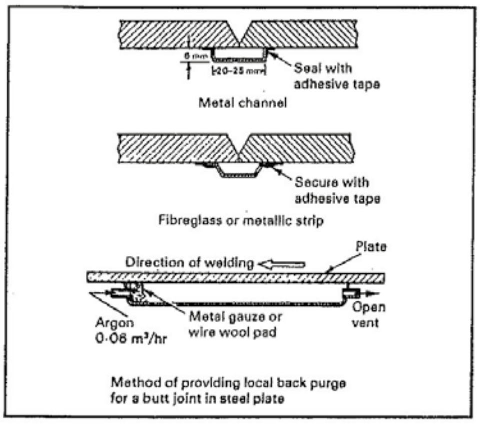
Notes:
- Electrode wires are available in standard sizes: 0.8, 1.0, 1.2 and 1.6mm diameter.
  Seek guidance from the electrode manufacturer on the most suitable composition for the steel being welded.
- The shielding gas for austenitic steels should generally be argon–2 per cent oxygen.
  Other gases may be used, but these are confined to specific applications where a particular requirement has to be satisfied. Do not use gases containing carbon dioxide without expert confirmation that they are suitable.
- Recommended flow rates:
  Free flight transfer: 1.0–1.2m^3/hr.
  Pulse transfer: 0.8–0.9m^3/hr.

Welding procedures (ie, assembly and tacking), torch angles and sequences are identical to those suggested in the examples for low carbon steel.
When welding austenitic steels:
- Keep electrode extension constant:
  for free flight transfer: 19mm extension.
  for pulse transfer: 13–16mm extension.
- Use large tacks.
- Do not use pre-heat in an attempt to avoid cracking.
- Do not deposit large weld runs; these may crack. Small stringer beads are preferred.
- Always use a stainless steel brush when cleaning the weld area. A low carbon steel brush will leave a layer of steel on the surface which will rust in service.

MIG Basics



Backing bar with facility for back purging



Method of providing local back purge for a butt joint in steel plate

Examples of MIG welding

- When depositing a butt weld from one side only, prevent oxidation of the underside of the root run by using a gas purge.
  The purging gas can be carried to the underside of the weld by means of a backing bar with holes or a section which will confine the gas to the joint area.
- Always fill the crater at the end of a run to avoid cracking.
- Free flight transfer can be used in the flat position for all joints; in the horizontal/vertical position for tee and lap only.
- Pulse transfer can be used for all joints in all positions.

Preparation for welding

Cleanliness and correct alignment of the joint edges are essential.

- Machine prepare or guillotine the edges wherever possible. Remove any burrs before welding.
- Degrease thoroughly after machining.
- Brush edges with stainless steel wire brush just prior to welding.
- On tee and lap joints, grind along the joint line if the surface is pitted or heavily oxidised.
- Avoid excessive handling of the electrode wire.

MIG Basics

Examples of MIG welding

Typical welding conditions
Flat position

Material thickness, mm	1.6	3.0	6.0–10.0	
Preparation for butt joint	Square edge	Square edge	Single vee, 70° included angle	
Transfer type	Pulse	Pulse	Pulse (Root)	Free flight (Filling)
Electrode dia., mm	1.2	1.2	1.2	1.6
Feed rate, m/min	2.3	3.1	3.8	3.5–4.2
Current, A	90	120	150	260–300
Arc voltage	—	—	—	26–28
Peak voltage	36–37	36–37	36–37	—
Background voltage	19	21	21–22	—

Vertical position

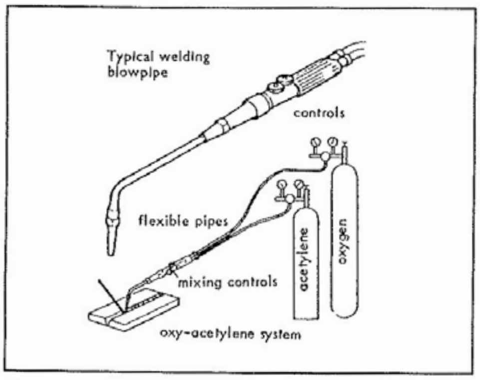
Material thickness, mm	up to 5	5 and above
Electrode dia., mm	1.2	1.2
Feed rate, m/min	2.0–2.5	3.1–3.8
Current, A	80–100	120–150
Peak voltage	37–38	37–38
Background voltage	19–21	22–24

Use pulse welding for all joints to be welded in the vertical positions.
Welding should be started at the bottom of the joint and traversed upwards.
Use only a very small weave to ensure fusion at the edges of the weld.

MIG Basics

Oxy-acetylene welding (GW1)

Safety

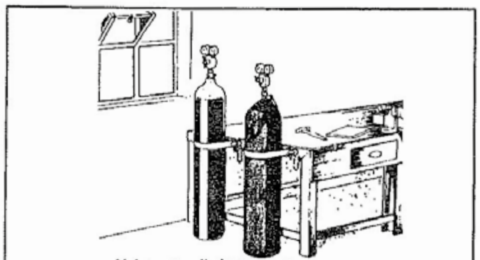


Oxygen and acetylene gases when mixed in suitable proportions burn at approximately 3300°C.
The gases are usually contained in high pressure storage cylinders and are fed to a welding torch through regulators and hoses.
The resultant process is known as oxy-acetylene welding and is used in the welding of a variety of metals.

Gas cylinders
These are recognised by a colour code.

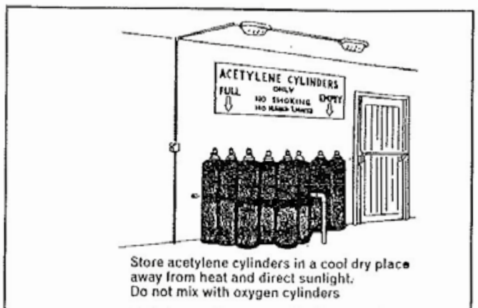
- Oxygen: black
- Acetylene: maroon

Store oxygen and fuel gas cylinders apart.
Handle cylinders carefully. Take care that they are not dropped or allowed to fall from a height.


Make sure cylinders are secure

Cylinders should be used in an upright position and fastened to prevent them falling or being knocked over.
Do not allow any flame near cylinder walls.
Do not allow any electric arc welding to be undertaken in the immediate vicinity.

Fuel gas cylinders



Close cylinder valve when not in use.
If gas leaks when valve is closed:

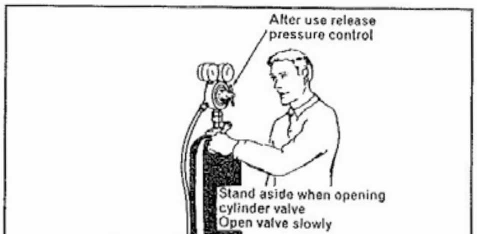
- Move the cylinder into the open, and away from electric motors, sources of sparks, heat or naked lights.
- Ensure that suppliers are advised immediately.

> ! *SAFETY – Acetylene and other fuel gases are highly flammable and form explosive mixtures with air and oxygen. Fuel gas leaks are a source of fire risk and explosion.*

Oxygen cylinders
Do not inhale oxygen from the cylinder.
Do not use it as a method of ventilation.
Do not allow it to leak.
Do not use oxygen as a substitute for compressed air.
In an oxygen-enriched atmosphere, clothing and any combustible material can be ignited easily by a spark and will burn fiercely.

> ! *SAFETY – Never allow oil or grease to come into contact with valves or cylinder fittings. Oxygen reacts explosively with oil or grease.*

Regulators



Do not use regulators with broken gauges.
Do not stand in front of gauge faces when opening cylinder valve.
Select the correct regulator for the gas being used.
Do not use:

- Low pressure regulator on dissolved acetylene cylinders.
- Dissolved acetylene regulator on hydrogen cylinders.
- Compressed air regulator on oxygen cylinders.

Maintenance of welding equipment

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 guns to clear spatter.
- Replacement of contact tip.
- Removal and replacement of wire conduit liner – to renew a worn part or to change to a different type– when changing from aluminium to steel wire for example.
- Changing wire drive rolls to accommodate different wire sizes.
- Changing guns/torches for work at different currents.

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

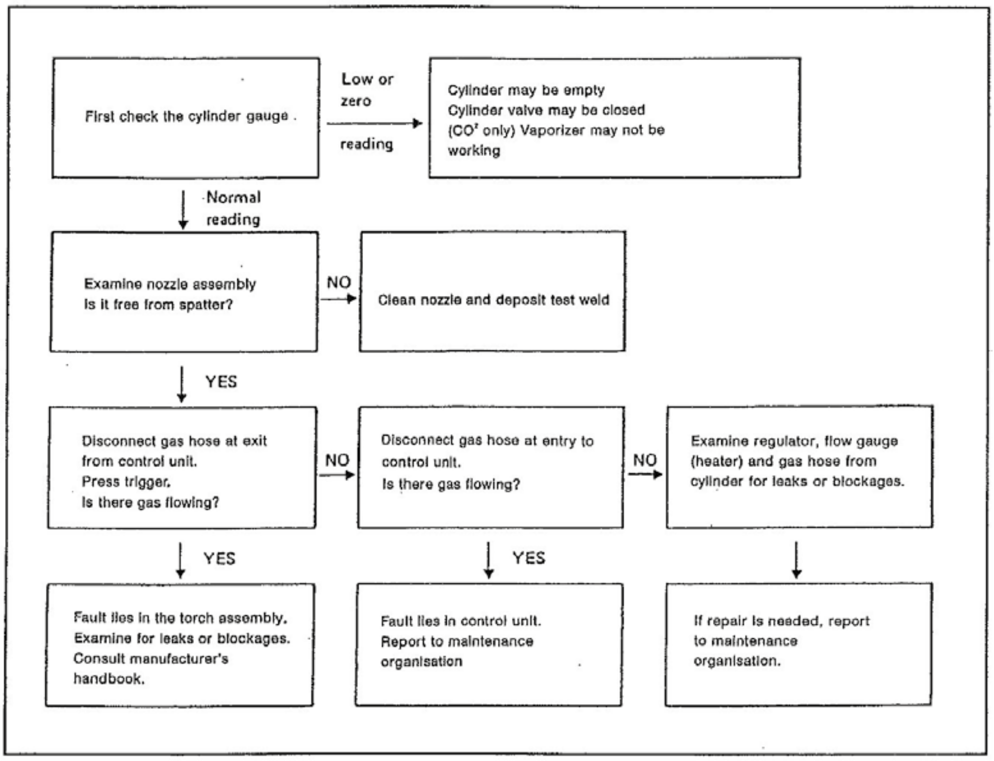
Locating faults on equipment

Well-maintained and correctly adjusted equipment should not normally break down in service.
If an equipment fault does arise, it is essential to use a logical fault-finding sequence to isolate the defect. Various methods of fault-finding may be used. The following suggested sequences cover the three most common faults which may be encountered when MIG welding.

Fault No.1 – Loss of gas shielding

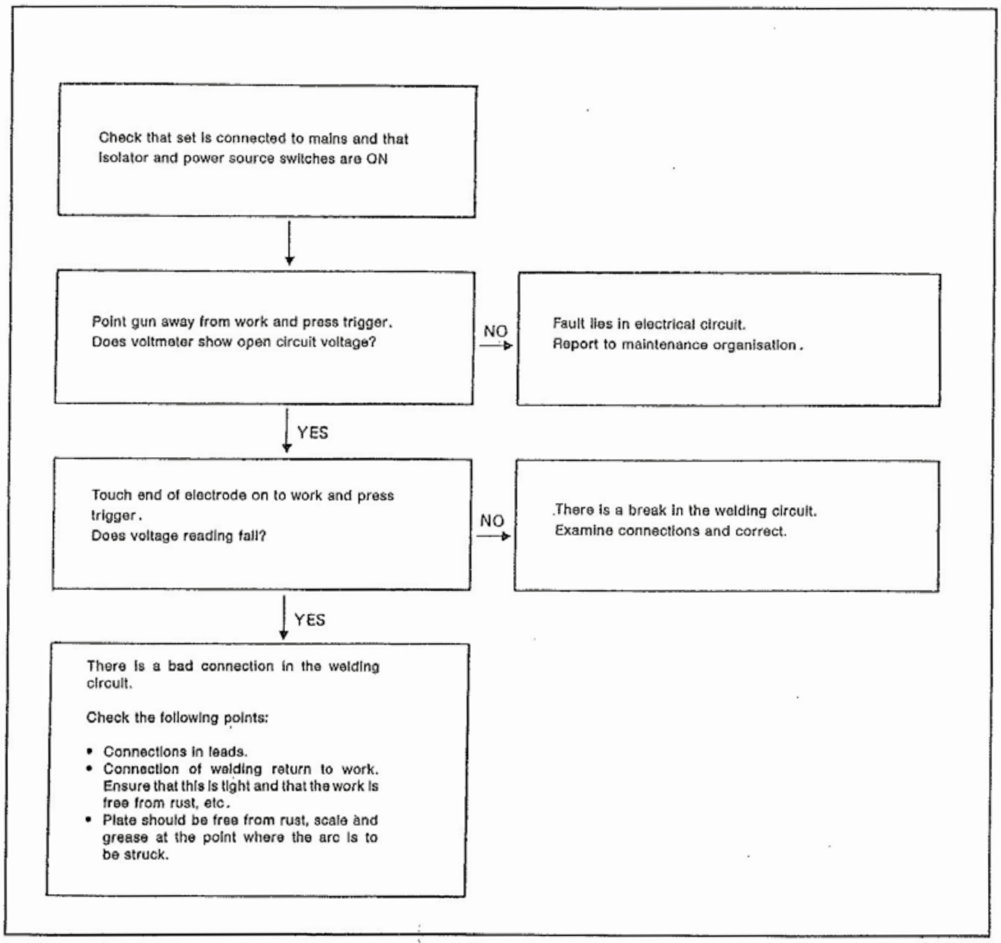
Symptoms:

- Porosity of or heavy oxidation on surface of weld.
- Poor metal transfer.



MIG Basics

Fault No.2 – Failure to strike an arc
Symptom:
Arc will not strike when the end of the electrode is touched to the plate after pressing the trigger.



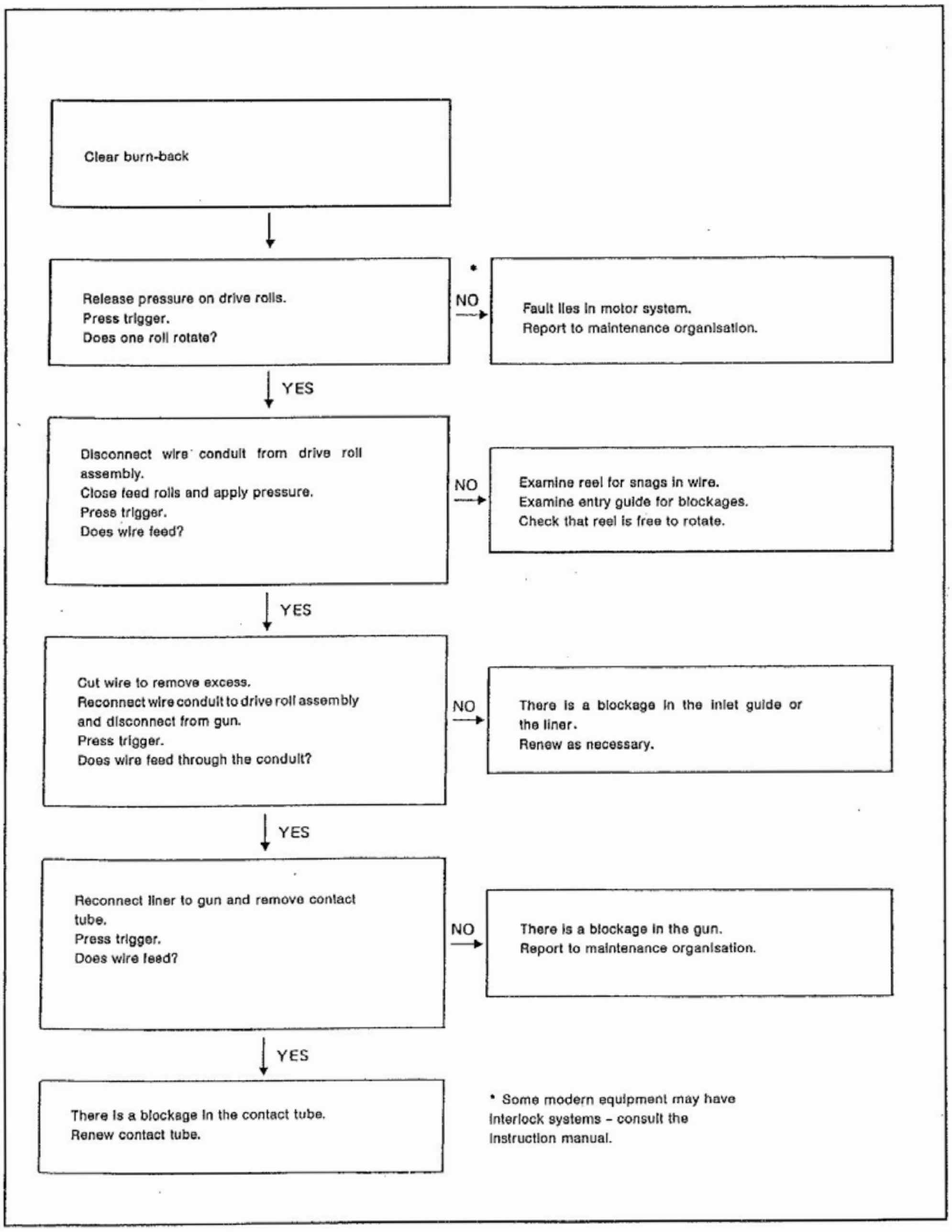
MIG Basics

Fault No.3 – No wire feed

Symptoms:

- Wire will not feed when trigger is depressed.
- Burn-back occurs.

Note: A burn-back may have resulted from using a short contact tube-to-plate distance.

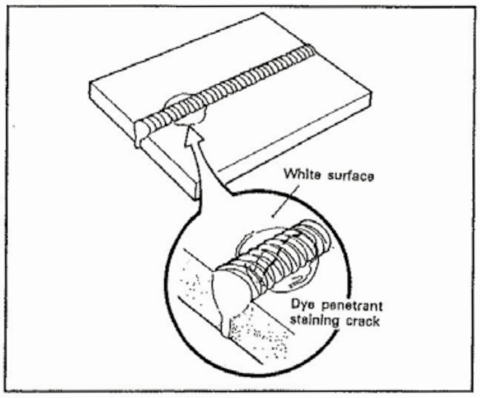


Welding inspection

Non-destructive weld testing
The welder should develop the habit of closely inspecting his own work before reporting it as complete.
A little time spent at this stage may save expensive non-destructive testing at a later stage.

Visual examination
Normally carried out before, during and after welding and prior to any other non-destructive or destructive testing methods being used, a visual check will usually determine:
- Weld size.
- Profile or weld face shape.
- Surface defects in weld face.
- Undercut and overlap.
- Root defects.
- Weld penetration.
- Surface slag inclusions.
- Lack of fusion.

Crack detection
Dye penetrant method



A solution of coloured dye is sprayed on the weld and parent metal and allowed to soak. The dye is then washed off with either a remover or water and the surface dried with a soft cloth.
A liquid developer is then sprayed on the weld to give a uniform dry powder coating which is white in colour. The coloured dye oozes out of any cracks in the weld into the white coating and can be seen in normal lighting conditions.

! *SAFETY – Care must be taken when using dye penetrant.*
If aerosol cans are used they should be directed at the weld and never pointed at other people.
Observe the manufacturer's instructions printed on the container.

Macro examination
Using a low power magnification, levelled, polished and etched sections of welds may be examined to detect:
- Lack of fusion.
- Lack of penetration.
- Porosity.
- Oxide inclusions.
- Internal cracks.

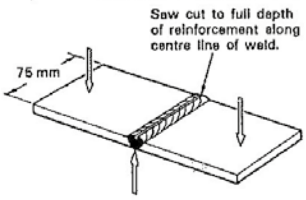
Preparation for etching specimens
Specimens should be prepared in accordance with BS 4872: Part 1: 1982 Appendices B1 and B2

! *SAFETY – Protect the eyes – wear eye protection or work behind a screen.*
Always have an eyewash available.
Do not allow etching solution to come into contact with the skin.
Do not inhale fumes produced during etching.

! *IMPORTANT – Etching solutions must only be mixed by a competent person.*

Destructive testing

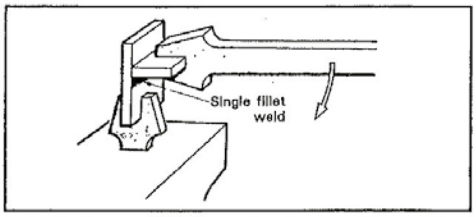
Nick-break test



Nick break test piece—butt weld

This is a quick and simple test to examine butt welds for inclusions, porosity, and lack of fusion. The specimen is scored around the weld bead so that it breaks through the middle of the weld when the specimen is subjected to leverage or hammer blows.

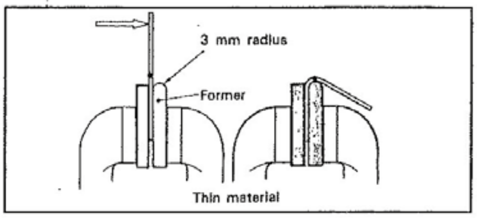
The length of test piece is usually approximately 75mm.



A similar form of test is used to inspect fillet welds in tee joints; the single fillet weld is broken open by causing initial fracture at the weld root.

! *SAFETY – Ensure that hands do not strike obstructions when the weld breaks.*
Beware of sharp edges on broken weld.

Bend tests (butt welds)



By bending the weld, surface defects (also some internal defects) become exposed.

The specimen is cut transverse to the weld and bent round a former so that either the face, or the root, or the side of the weld is in tension.

MAKE SOMETHING BETTER

ANY QUESTIONS? CONTACT US!

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