Phase 2

Trade of Motor Mechanic

Module 10

Unit 3

Welding & Registration Plate Fitting

Produced by

SOLAS

An tSeirbhís Oideachais Leanúnaigh agus Scileanna
Further Education and Training Authority

In cooperation with:

Subject Matter Experts

Martin McMahon

&

CDX Global

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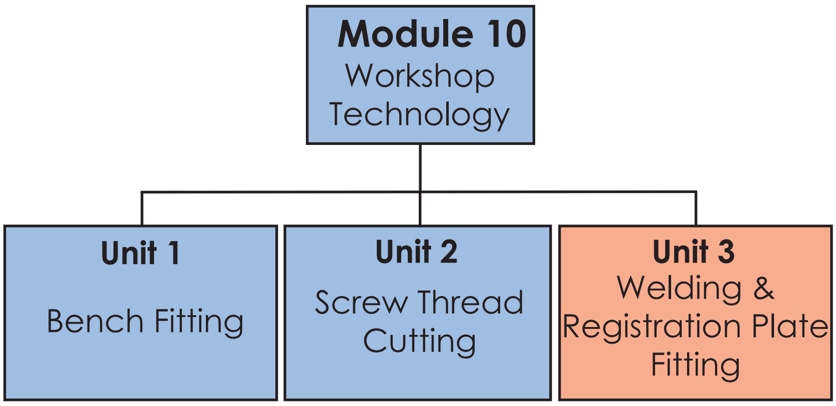
Introduction

There are three Units in Module 10. Units 1 focus on Bench fitting. Unit 2, screw thread cutting. Unit 3, welding and registration plate fitting.



Unit three covers the welding and registration plate fitting. You will receive information on Oxy-Acetylene gas welding, MIG welding and Fitting Registration Plates in accordance with NCT regulations. The health and safety issues related to this unit will be also covered.

Unit Objective

By the end of this unit each apprentice will be able to:

- Describe the procedures used to connect/disconnect the pressure gauges and torch assembly to oxy-acetylene gas cylinders
- Adjust the working pressure to given settings
- Light the torch and set to a neutral flame
- Tack/butt weld 2mm black mild steel sheet/plates
- Shut down the welding plant
- Describe the hazards associated with the use of oxy-acetylene welding equipment
- Define the principal terms used in MIG welding
- Assemble, adjust and operate safely a MIG welding plant
- Describe the hazards and appropriate safety procedures required when electric arc (MIG) welding
- Weld the components as shown in the activity diagram: *Exercise No. 2.10.3a*
- Assemble the components as shown in the activity diagram: *Exercise No. 2.10.3b*
- Describe the NCT/DoT VTM requirements for registration plates of new vehicles.
- Fit registration plates

1.0 Hazards in Using Oxy-Acetylene Welding Equipment

Key Learning Points

- Hazards; volatility, fire, explosion, accidental/careless use of the torch, flashback, gas leaks, dangers of working in confined spaces, poor ventilation, possibility of burns/ asphyxiation etc.

1.1 Welding Safety

When welding:

- Always wear protective clothing, i.e. flame retardant overalls.
- Always wear the correct eye goggles.
- Always have the spindle key in the acetylene cylinder valve.
- Always keep cylinders secured in an upright position.
- Always check for leaks with a soapy solution, NEVER with a naked flame.
- Never carry out makeshift repairs on welding equipment.
- Never allow oil or grease to come in contact with oxygen equipment.
- Never weld an enclosed vessel, i.e. petrol / oil drums until they have been thoroughly cleaned.
- Never work in an enclosed vessel on your own and always leave the cylinders outside. If working in an enclosure vessel, adequate ventilation should be provided and fire fighting equipment should be available.
- In the event of a serious flashback or backfire plunge the blowpipe in a bucket of cold water, leaving the oxygen running to prevent water entering the blowpipe.
- Should the hoses become damaged, turn off the supply of gas at the cylinder and inform your instructor.
- Don't forget, this equipment, if misused or damaged, can be dangerous. If in any doubt seek assistance and clarification from your instructor.

Lighting Up

When the equipment is initially set up and before lighting up it should be checked for leaks. Never use a naked flame to check for leaks. The correct method is to use soapy water.

Only when the equipment is in a sound working condition can you proceed to the pressure adjustment, lighting up and flame setting required.

Before opening the cylinder outlet valves check that the regulator control screw is in the slackened position, i.e. turned fully in an anti-clockwise direction.

Slowly open the cylinder valve until gas is registered on the contents gauge. Turn the regulator adjusting screw in a clockwise direction until the recommended working pressure is indicated. When this procedure is applied to both cylinders the system is fully charged and ready for lighting up.

Slowly open the acetylene valve on the blowpipe. This allows acetylene gas to flow through the nozzle where it is ignited by means of a spark lighter. The acetylene flame should be adjusted until it cases to smoke and there is no gap between the base flame and the welding tip. The oxygen valve is then opened and adjusted until a neutral flame is achieved. A neutral flame is a mixture of equal amounts of oxygen and acetylene gas and is used for all autogenous welding operations.

To extinguish the flame turn off the acetylene valve on the blowpipe. This will cause the flame to go out. The oxygen valve is then turned off. If the equipment is not to be used for a long period of time, i.e. lunch breaks etc., the valves on the cylinders should be closed. Both blowpipe valves should be opened fully until gas ceases to flow and then closed again.

The pressure adjusting screw on the regulators should be slackened by turning in an anti-clockwise direction.

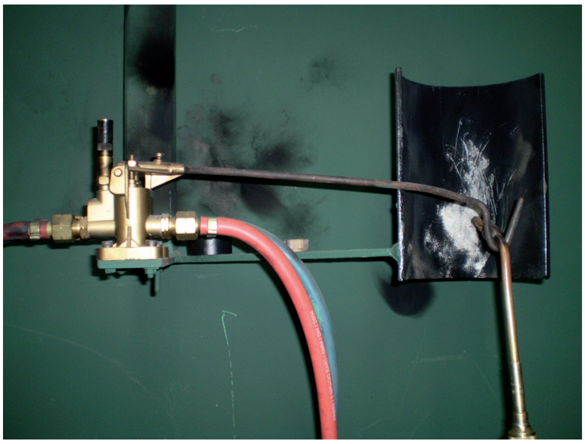
Hose and Hose Fittings

It is always recommended to buy and use fitted hoses. Factory fitted hose offers the customer the additional advantage of a 'gas system' which has been assembled and tested on a closely monitored production line to BS 1389.

Flashback Arrestors

When resetting Oxygen Arrestors where the pressure is above 1.5 bar (22 psi) it is recommended that the supply is closed and the connecting nut between the arrestor and the regulator loosened to vent the locked up gas prior to resetting. This will avoid the need to apply excessive force which could strain the reset mechanism.

Economiser



1. Remove the blowpipe from the hook.
2. Open both the fuel gas and the oxygen cylinder valves.
3. Adjust the regulators to the recommended operational pressures for the nozzle in use. Pressures must be obtained in gas flow conditions with the blowpipe gas control valves being opened and closed alternatively – commencing with the acetylene.
4. Ignite and adjust the pilot flame on the economiser to ½" to 1" flame length.
5. Open the blowpipe fuel gas control valve, light the blowpipe, adjust the fuel gas control valve until any smoke is lost in the flame, open the oxygen control valve, adjust and trim to neutral flame or normal size for nozzle being used.
6. Place the blowpipe on the hook.
7. If the economiser valves are properly adjusted the blowpipe flame should go out within a few seconds, with the fuel gas being shut off first.

Note: There should be no smoky flame on shut-off. Although a slight snap is normal, a loud bang indicates that the economiser valves need to be adjusted to ensure that the fuel gas stream is shut off before the Oxygen.

2.0 Oxy-Acetylene Gas Cylinders

Key Learning Points

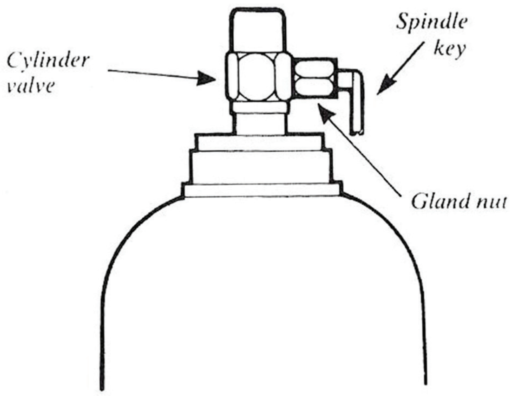
- Oxy-acetylene welding; cylinder identification/colour, valves/taps, pressure gauges, connector threads i.e. left and right hand

2.1 Gas Cylinders

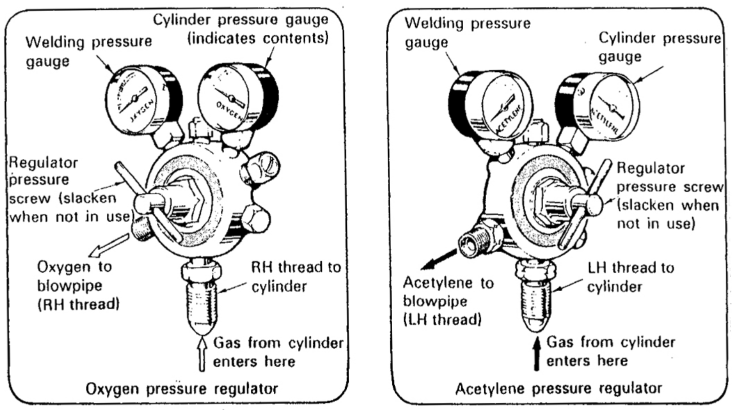
Leakage around the spindle of the cylinder valve will be revealed by hissing and in the case of fuel gases, by a smell. Tighten the gland nut on the cylinder valve slightly with a spanner (clockwise) and test with 1 % solution of Teepol® HB7 or equivalent solution, in water. If still leaking, do not use the cylinder but label and return it. *Never use a flame when testing for leaks.*

Oxygen bottle colour = black and has right hand thread.

Acetylene bottle colour = maroon and has left hand thread.



Gas Cylinder



Two Stage Regulators

3.0 Working Pressure

Key Learning Points

- Working pressure; adjustment of the gas flow to given levels

3.1 Flame Cleaning

Acetylene fuel gas

Nozzle Type	Fuel gas pressure bar	lbf/in²	Oxygen pressure bar	lbf/in²	Fuel gas pressure l/h	ft³/h	Oxygen consum. l/h	ft³/h
50mm flat	0.49	7	0.57	8	1050	37	1200	41
100mm flat	0.7	10	0.7	10	2000	70	2200	78
150mm flat	0.85	12	0.85	12	2700	94	3000	104

3.2 Super Heating with Propane

The flame size and heat output of these nozzles varies considerably with the pressure setting used.

Two typical alternatives are given for each size of nozzle.

Nozzle Type	Propane pres. bar	lb/in²	Oxygen pres. bar	lb/in²	Propane cons. l/h	ft³/h	Oxygen cons. l/h	ft³/h	Heat output (app.) W	Btu/h
1H	0.14	2	0.7	10	830	29	3500	121	244800	72,000
	0.49	7	2.1	30	1900	65	7300	255	554200	163,000
2H	0.21	3	1.1	15	1200	41	4800	168	346800	102,000
	0.56	8	2.5	35	2100	75	8700	304	639200	188,000
3H	0.28	4	1.8	25	2100	75	8300	290	622200	183,000
	1.1	15	5.0	70	4100	144	16500	575	1227400	361,000
4H	0.35	5	2.5	35	2700	94	10600	370	802400	236,000
	1.3	18	5.7	80	4600	162	18600	650	1380400	406,000
5H	0.85	12	3.5	50	3200	112	12700	444	955400	281,000
	2.1	30	8.7	125	7000	246	28000	985	2101200	618,000

3.3 Heating

Nozzle Size	Fuel gas pres. bar	lb/n²	Oxygen pres. bar	lb/n²	Fuel gas con. l/h	ft³/h	Oxygen con. l/h	ft³/h	Heat output (app.) W	Btu/h
A-LHT500L	0.49	7	0.7	10	380	13.3	420	14.7	62000	20,000
A-HT 25	0.35	4	0.35	4	1100	36	1100	40	176800	57,000
A-HT 50	0.43	6	0.43	6	1800	63	2000	70	309400	91,000
A-HT 100	0.49	7	0.7	10	2700	96	3000	106	472600	139,000

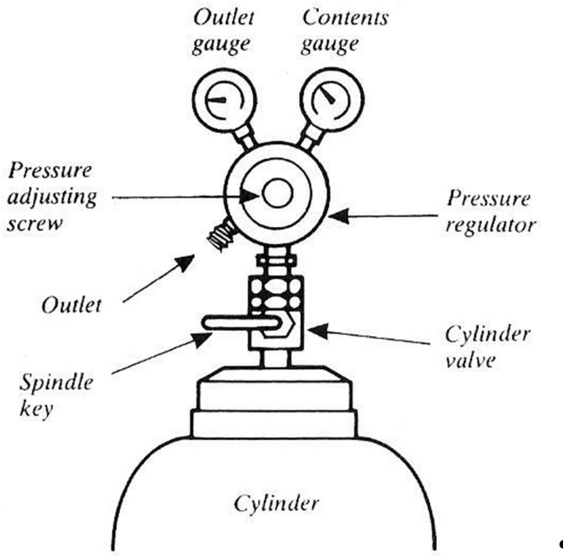
Nozzle data for Acetylene fuel gas.

1. Data is for guidance only and may vary with operating conditions, materials, etc.

2. Gas pressures are shown in *bar*-1 bar = 1kg/cm², lbf/in² = 0.069 bar.

3. Gas consumption is *litres per hour* (l/h).

3.4 Pressure Regulators



Always treat a pressure regulator as a precision instrument. Do not expose it to knocks, jars or sudden pressure surges caused by the rapid opening of the cylinder valve. Always open the cylinder valve slowly and smoothly using the special Spindle Key. Periodically check the bullnose seating on the pressure regulator. If the seating is damaged, it will leak gas. The pressure regulator should be replaced immediately.

Never use a pressure regulator with other than the gas for which it was designed. Release pressure using the pressure adjustment screw when shutting down, after cylinder valves have been closed and pressure in the hose has been released.

If gauge pointers do not return to zero when the pressure is released, the mechanism is faulty and the regulator should be replaced.

If the regulator "creeps" (passes gas when the pressure adjustment screw is released, or builds up on the low pressure side when the blowpipe valve is shut) it should be replaced.

Do not attempt to repair regulators.

3.5 Hoses

Use hose which is in good condition and manufactured to the correct specification. Hoses should be fitted with the correct end connections attached by permanent clips.

Do not expose hoses to heat, traffic, slag, sparks, oil, grease, or sharp edges of metal. Test for leakage at working pressure by immersing in water; leaks may be repaired by cutting out a faulty section of hose and inserting an approved coupling. Never use copper couplings with acetylene. Doing so could permit the formation of copper acetylide. Worn ends should be cut back and re-fitted with hose connectors using permanent clips.

In general, do not fit more than two or three couplings in a length of hose. Consider replacing the hose entirely as parts are likely to be perished or damaged.

Ensure hoses are not wrapped around cylinders when stored or in use.

The hose check valve is an automatic safeguard, incorporating a spring-loaded non-return valve. Its purpose is to inhibit oxygen and fuel gases mixing in the hoses. The hose check valve has reduced the incidence of backfeeding in which oxygen contaminates fuel gas hose or vice versa. It is essential to ensure that your welding and cutting equipment is protected, as far as possible, against backfeeding which may cause extensive damage to hoses and regulators in the event of a flashback.

3.6 Flame Traps

Flame traps are designed to give automatic protection to personnel and equipment against the hazard of mixed gas explosions in gas welding or cutting equipment. The explosion (flashback) can occur when backfeeding of gases has taken place. A mixture of gases is then present in either the oxygen or fuel gas hose and if the operator fails to purge the hoses sufficiently, a flashback can occur when the blowpipe is ignited.

Flashback can be avoided by adhering to recommended operating procedures and the use of flame traps does not enable the operator to ignore good operating practices.

It is recommended that approved flame traps are installed in both the oxygen and the fuel gas lines immediately downstream of the pressure regulator

3.7 Blowpipes

Gas leaks can be detected by 1% Teepol® or proprietary leak detection solutions or hissing and, in the case of fuel gases, also by smell. Leaks at the head nut or welding nozzle should be cured by cleaning the seat with a soft cloth. If the leak continues, the blowpipe should be replaced. Do not carry out blowpipe repairs.

3.8 Backfire

For a variety of reasons e.g. incorrect operating conditions, nozzle blockage etc. the flame may backfire into the blowpipe. Usually the flame can be re-lit immediately.

In a small number of instances the flame may continue to burn inside the blowpipe, a condition called sustained backfire. This can be recognised by a roaring, rushing sound and the body of the blowpipe will become very hot. Rapid action is necessary to prevent permanent damage to the blowpipe, Close the blowpipe oxygen valve, then the blowpipe acetylene valve and allow the blowpipe to cool - it can be plunged into a bucket of water. Check the nozzle for tightness, check gas pressures on the pressure regulators, purge the hoses and if everything looks correct, begin the lighting up procedure,

If sustained backfire recurs, the nozzle or blowpipe or both require replacement.

3.9 Fluxes

Fluxes must only be used in a well ventilated area.

3.10 Protective Clothing

Goggles should be worn at all times whilst welding and cutting and should conform to the Protection of Eyes Regulations. Leather or suitable protective clothing should be worn for heavy cutting or welding. The feet should be protected from sparks, slag or falling off-cuts.

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3.11 Welding, Cutting Drums and Containers

Welding or cutting drums, containers or tanks which have held flammable liquids or gases can be dangerous, even though they are supposed to be clean and free from explosive vapour or liquids. BOC will advise you on suitable precautions.

Do not weld hollow vessels before establishing that confined air is properly vented; hollow metal parts should be drilled to prevent explosions caused by heat.

3.12 Ventilation

In a confined space, ensure that there is a suction fan to give adequate ventilation (a fume hood, at the source of fumes, is the best method); *DO NOT USE OXYGEN OR AN AIR BLOWER* and always post a trained helper outside for emergencies. Test all equipment for leaks before entering and remove the equipment outside during periods when it is not in use and on completion of daily work. The welding of brass or galvanised materials should be carried out in well ventilated areas and if the work is likely to be prolonged suitable breathing apparatus should be worn.

When cutting painted or galvanised steel, unless ventilation is very good, fume extraction should be installed at the point of cutting. In some cases it may be necessary to wear a respirator as well.

3.13 Fire

Take care that there is no combustible material within reach of sparks. Sparks from cutting may travel as far as 10 metres (35 feet) along a floor. Ensure that sparks and falling slag do not fall over the cylinder or hoses. If necessary protect anything in the neighbourhood of the work with sheet metal guards or fibreglass sheets down to the floor - tarpaulins do not give sufficient protection. Where it is necessary to work close to combustible material, keep fire fighting apparatus handy and post a man at the scene of the work for at least half-an-hour after the work has finished. In dusty or gassy atmospheres consult the responsible official in charge before starting work.

Clothing should be free from grease and preferably made of wool which is not so readily flammable. Goggles, collars, combs, buttons, etc., of flammable material should not be worn.

3.14 Nozzle Size

For a given welding torch, the *NOZZLE OUTLET SIZE* has a much greater influence on governing the flame size than changing the gas pressures on adjusting the control valves.

The manufacturers of gas welding equipment have adopted various methods of indicating nozzle sizes, such as:

1. By the approximate consumption of each gas per hour.
2. By the nozzle outlet bore size (orifice diameter).
3. By a reference number corresponding to a metal thickness range which may be welded with a specific nozzle.

Whatever the method employed for indicating nozzle sizes there is a definite relationship between the sizes of welding nozzles and the metal thicknesses.

Manufacturer's recommendations should always be followed with regard to nozzle sizes and gas pressures for a particular application.

4.0 Lighting the Torch and Set to a Neutral Flame

Key Learning Points

- Lighting; lighting up procedure i.e. acetylene first, emergency shutdown procedures, setting/adjusting gas flow to a neutral flame

4.1 Setting up an Oxy-Acetylene Torch

Preparation and Safety

Objective

Set up an oxyacetylene torch for heating.

Safety Check

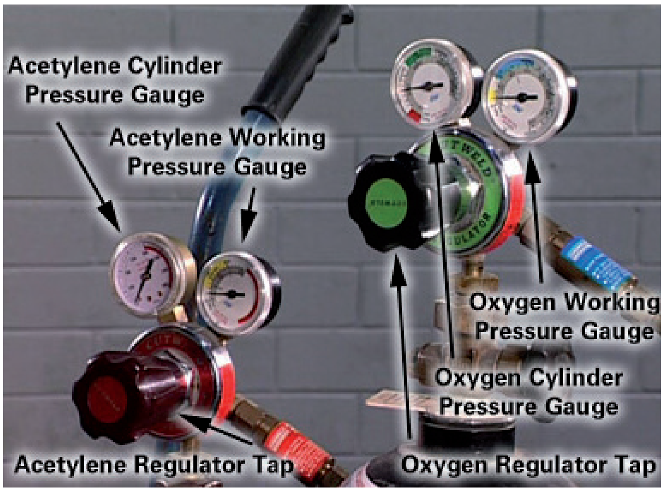
- Oxygen and acetylene cylinders must be securely stored in an upright position.
- An oxyacetylene torch can produce a large amount of heat. Be aware that any objects you direct the flame towards will become hot.
- Always have a suitable fire extinguisher near your work area.
- Do not use an oxyacetylene torch near any flammable materials.
- Make sure that you understand and observe all legislative and personal safety procedures when carrying out the following tasks. If you are unsure of what these are, ask your instructor.

Points to Note

- If a cylinder falls over and breaks the main valve off, the cylinder will become a missile and cause extreme damage.
- Wear a leather apron or similar protective clothing and welding gloves when using an oxyacetylene torch. T-shirts, nylon and polyester blend clothing will not provide enough protection. Ultraviolet light and sparks of hot metal will pass through them.
- Always use proper welding goggles. Do not use sunglasses because they do not filter the extreme ultraviolet light as effectively. The plastic used in sunglass lenses will not protect your eyes from sparks.

- Never point the lighted flame toward another person or any flammable material.
- Always light the oxyacetylene torch with the striker. A cigarette lighter or match would put your hand too close to the igniting tip.
- Wherever possible, use a heat shield behind the component you are heating. This will prevent nearby objects from becoming hot.
- After heating a piece of metal, label it as "HOT" with a piece of chalk so that others will not attempt to pick it up.

Component Identification



Some parts of this illustration are labelled. It is important to learn the names of these equipment components.

Step-by-Step Instruction

1. *Check equipment:* First, make sure that the gas flow from both the oxygen and the acetylene cylinders is turned off tightly. The two cylinders are secured in an upright position. This is usually on a wheeled trolley. Look at the hose pressure and cylinder pressure gauges on top of each cylinder. Both gauges on each cylinder should read zero. If both gauges do not read zero, turn the main cylinder valve on the top of the cylinder clockwise, to close it completely. Then you must purge the system of any gas.

2. *Purge the system:* To purge the system, make sure the main cylinder valve is closed tightly. Pick up the torch handle and note that it has two hoses attached. One hose supplies acetylene, the other oxygen. Turn the oxygen regulator under the gauges clockwise and open the oxygen valve on the handle. This will purge any gas that may still be in the system and the gauges should both drop back to zero. Repeat this procedure with the acetylene cylinder.

3. *Install the torch handle:* The torch handle is the connection between the hoses and the working tips. It consists of a body and two taps. It's used for both welding and heating. Different attachments are connected to the handle to enable welding, heating or cutting. Examine the connections. One connection is marked "OX" and is for the oxygen hose. The other is marked "AC" and is for the acetylene hose.

4. *Connect the hoses:* As a further safety precaution, you'll find the oxygen connector is right hand thread and the acetylene connector is a left hand thread.

5. *Install the correct tip:* Welding tips come in sizes that are stamped with a number. Number one is the smallest tip. The larger the number, the larger the tip and the greater the heat that it will provide. Select the tip size suitable for the heating task and screw it onto the end of the torch handle. Hold the torch handle in your hand, so that you can comfortably adjust the oxygen and acetylene taps. Position the tip so that it faces away from you. Gently tighten the tip-securing fitting.

6. *Adjust the pressure of the gas flow:* You are now ready to adjust the gas pressure for heating. Look at the two valves on the torch handle. The valve next to the oxygen hose controls the flow of oxygen to the tip. Close it tightly clockwise. The valve next to the acetylene hose controls the flow of acetylene to the tip. Also, close it tightly clockwise.

7. *Turn on the gases:* Now that you're ready to use the torch, turn the main valve on the top of each cylinder counter-clockwise half a turn to open the valve. The needle on the cylinder pressure gauge will rise to show you the pressure in the cylinder. Turn the oxygen regulator handle clockwise until the needle in the gauge registers 10 PSI. Turn the acetylene regulator handle clockwise until the needle in the gauge registers 5 PSI. This is your working pressure for heating.

8. *Check the area:* Before you light the torch, check the area you're working in to make sure there are no flammable materials or fluids nearby. Workmates should also be clear of the area. The welding flame is not only extremely hot; it also produces dangerous ultra violet rays, which will damage your eyes. It is absolutely vital that you are wearing the right safety gear: gloves and tinted goggles or face mask. So put them on and adjust them comfortably.

9. *Ignite the torch:* Now you are ready to ignite the torch with the striker. The tip of the torch must be pointing downwards away from your body and away from the gas cylinders. Turn the acetylene valve on the torch handle slightly towards the 'ON' position. You should hear the gas hissing. Hold the striker against the tip of the torch with the lighter cup between the torch and you. Flick the striker to create the spark that will ignite the gas at the tip of the torch. Open the acetylene valve slowly until the sooty smoke produced by the torch disappears. Then slowly open the oxygen valve on the torch handle.

10. *Adjust the flame:* As you open the oxygen valve, you will see the colour of the flame change. The pure acetylene flame is yellow and it will change to blue as you add the oxygen. Continue to open the oxygen valve until you can observe a small, sharp blue cone in the centre of the torch flame. This is the "neutral" flame you need for general heating.

4.2 Using an Oxy-Acetylene Torch

Preparation and Safety

Objective

Use an oxyacetylene torch for heating.

Safety Check

- Oxygen and acetylene cylinders must be securely stored in an upright position.
- An oxyacetylene torch can produce a large amount of heat. Be aware that any objects you direct the flame towards will become hot.
- Always have a suitable fire extinguisher near your work area.
- Do not use an oxyacetylene torch near any flammable materials.
- Make sure that you understand and observe all legislative and personal safety procedures when carrying out the following tasks. If you are unsure of what these are, ask your instructor.

Points to Note

- If a cylinder falls over and breaks the main valve off, the cylinder will become a missile and cause extreme damage.
- Wear a leather apron or similar protective clothing and welding gloves when using an oxyacetylene torch. T-shirts, nylon and polyester blend clothing will not provide enough protection. Ultraviolet light and sparks of hot metal will pass through them.
- Always use proper welding goggles. Do not use sunglasses because they do not filter the extreme ultraviolet light as effectively. The plastic used in sunglass lenses will not protect your eyes from sparks.
- Never point the lighted flame toward another person or any flammable material.
- Always light the oxyacetylene torch with the striker. A cigarette lighter or match would put your hand too close to the igniting tip.
- Wherever possible, use a heat shield behind the component you are heating. This will prevent nearby objects from becoming hot.
- After heating a piece of metal, label it as "HOT" with a piece of chalk so that others will not attempt to pick it up.

Step-by-Step Instruction

1. *Light the torch and adjust neutral flame:* Light the torch and adjust the gas flow so that you have a neutral flame.

2. *Heat for 'Removal':* Place a flywheel and ring gear assembly on a set of insulating spacers, to elevate it from the working surface. Direct the flame onto the ring gear and apply the heat until smoke starts to appear. Stop applying the heat. At this stage, the ring gear is hot enough to remove by gently tapping with a hammer and drift. DO NOT TOUCH the metal with your hands. Use welding Gloves and tools that are designed for use in a hot environment.

3. *Heat to 'Red Hot':* Direct the flame to the component you wish to heat. If the component is made from thin metal it will heat quicker than one that is thicker. Apply the heat evenly, until you notice the object begin to glow red. Once the glow is uniform, the metal will now be hot enough to manipulate. Once again *Do Not Touch* the metal with your hands. Use welding gloves and tools that are designed for use in a hot environment.

4. *Shut down:* When you have finished the job, you will need to shut down the equipment. Turn off the acetylene valve on the torch handle. This will extinguish the flame. Turn off the oxygen valve on the torch handle. Next, remove your safety goggles or mask and your welding gloves. Turn the main cylinder valve clockwise on the top of both gas cylinders. Now open the two valves on the torch handle to "bleed" the system. Turn both the oxygen and acetylene regulator handles counter-clockwise until they are loose. Close both valves on the torch handle. Put the handle and tips away and return the gas cylinders and their hoses to their proper storage area.

5.0 Shutting Down a Welding Plant

5.1 Shut Down

When you have finished the job, you will need to shut down the equipment. Turn off the acetylene valve on the torch handle. This will extinguish the flame. Turn off the oxygen valve on the torch handle. Next, remove your safety goggles or mask and your welding gloves. Turn the main cylinder valve clockwise on the top of both gas cylinders. Now open the two valves on the torch handle to "bleed" the system. Turn both the oxygen and acetylene regulator handles counter-clockwise until they are loose. Close both valves on the torch handle. Put the handle and tips away and return the gas cylinders and their hoses to their proper storage area.

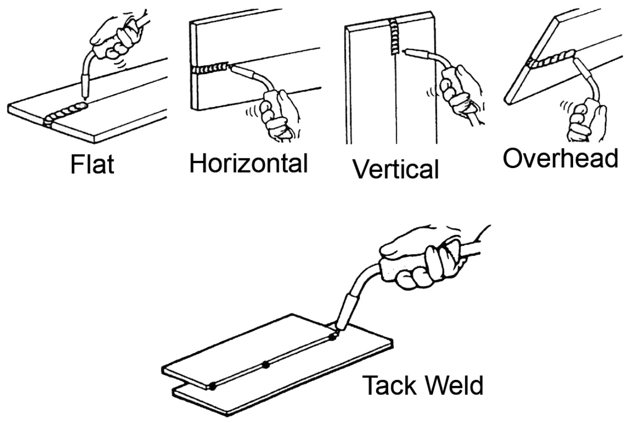
6.0 Tack/Butt Welding

Key Learning Points

- Welding procedures; basic tack/butt weld

6.1 Tack Weld

A tack is a relatively small temporary MIG/MAG weld that is used instead of a clamp or a self-tapping screw, to tack and hold the panel in place while proceeding to make a permanent weld .Like the clamp or self-tapping screw, the tack weld is always and only a temporary device. The length of the tack weld is determined by the thickness of the metal panel to be welded and is approximately a length of 15 to 30 times the thickness of the metal panel. Tack welds must be done accurately, as they are very important in maintaining proper alignment.



Typical MIG Welding Positions and Tack Weld

7.0 Principal Terms Used in MIG Welding

Key Learning Points

- Weld; joining by fusion, melting, melting temperature, heat by electric arc
- Arc; flow of current, release of heat energy

7.1 Metal Inert Gas (MIG) or Gas Shielded Metal Arc Welding

MIG belongs to the category of consumable electrode electric arc welding techniques.

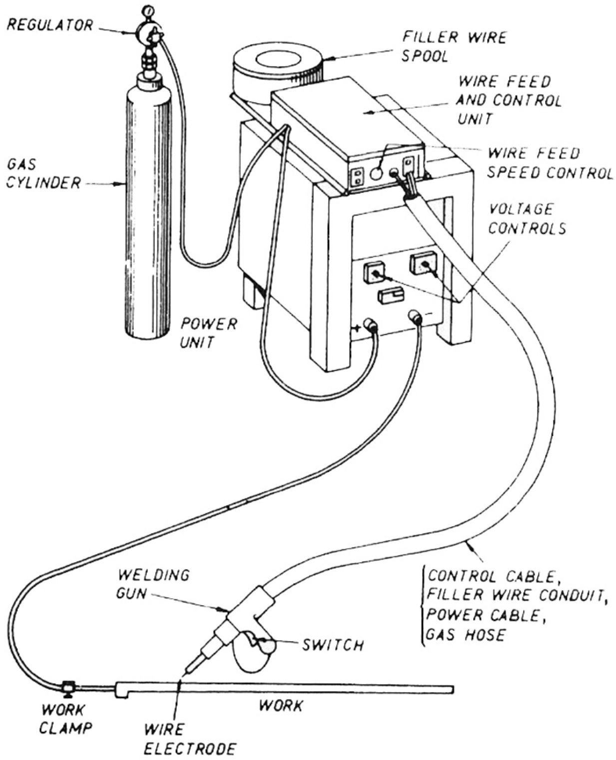
This term is a common name for all the welding processes, which involve shielding the arc with inert gas, CO_2 and various gas mixtures provided by external source and uses a consumable wire as one of the electrodes.

7.2 Description of the Process

The consumable electrode wire is carried on a spool and fed automatically to a manually operated or automatic gun and through a nozzle into the weld arc. In addition to the electrode wire, a shielding gas is fed to the gun together with welding current supply and cooling water. MIG requires a DC power supply of reverse polarity.

In addition to the use of inert gas, deoxidisers are usually present in the electrode itself, which prevents oxidation of the weld pool. The process thus results in welds free of slag, which can be deposited in multiple layers.

In manual MIG welding, metal is transferred in globules or droplets from electrode to the workpiece. If the current is increased the rate of transfer of the droplets across the arc increases and they become smaller in volume. The transfer occurs in the form of a fine spray.



7.3 Components of Gas Shielded Metal Arc Welding Process

Gases

The title MIG is not true as not inert gases are used in the process, such as CO_2 and oxygen. The title metal Active Gas (MAG) is used in these cases.

Argon

Although argon is very suitable for non-ferrous metals and alloys, if it is used for welding steel the process becomes unstable and the weld profile uneven. Mixtures of argon and oxygen result in more stable process and gives optimum welding conditions for various metals.

Helium

If helium is used as the shielding gas, it requires significantly greater gas flow than argon. It is usually used mixed with argon e.g. argon – 15% helium for certain high nickel alloys, argon – 50% helium for copper welding.

Carbon Dioxide

Pure CO_2 is the cheapest of the shielding gases and can be used for welding steel up to 0.4% C and low alloy steel. CO_2 is not suitable for stainless steel because the corrosive resistance of the weld is reduced.

Argon + CO_2 (5% and "20%)

The addition of CO2 to argon for the welding of steels improves the 'wetting' action, reduces surface tension and makes the molten pool more fluid. The mixture is more expensive than pure CO2 but gives a smoother, less critical arc with reduced spatter and a flatter weld profile.

Argon + Nitrogen (15-20%)

The mixture can be used instead of pure argon for copper welding. Arc voltages are higher, giving greater heat output for a given current value thus reducing the pre-heating requirements. If pure nitrogen is used the droplets are of coarse size and there is more spatter and porosity with poor weld appearance.

Spray Transfer

In MIG metal is transferred to the workpiece by two basic mechanisms: Short circuit (or dip transfer) and by Spray transfer.

Short circuit transfer occurs when low arc voltages and currents are deployed. Under these conditions the metal from the electrode is transferred to the workpiece in individual droplets when the electrode tip touches the molten weld arc and causes short circuit. In manual metal arc, welding metal is transferred in globules from electrode to the workpiece. If the current is increased to the continuously fed gas shielded wire, the transfer rate increases and become smaller in volume. The transfer occurs in the form of a fine spray and is called Spray transfer.

Applications

The process is suitable for a great variety of ferrous and non-ferrous metals. The temperatures involved are relatively low and hence the process is suitable for thin sheet sections (less than 6 mm).

MIG and TIG are competing more or less for similar welding applications. However, TIG welding becomes troublesome when currents increase above 300 A. The MIG welding process does not suffer from these disadvantages. Thus larger welding currents can be used with bigger deposition rates.

The process is particularly suitable for aluminium, magnesium alloys, plain and low-alloy steels, stainless and heat resistance steels, copper and bronze.

It is versatile process and relatively easy to train operators. It lends itself to automation and it is used in conjunction with robotics.

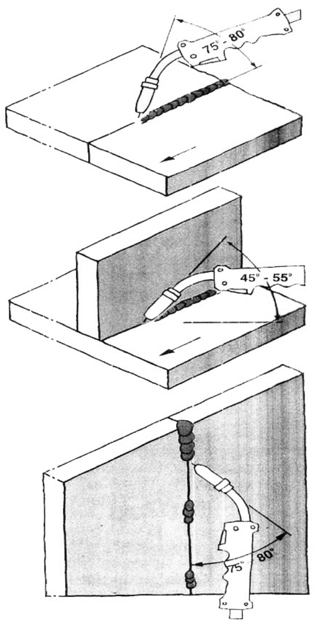
8.0 Using a MIG Welding Plant

Key Learning Points

- MIG; metal-inert-gas welding, gas-shielded metal arc welding
- Inert gas; non reactive, function as atmosphere shield, possibilities of weld pollution by oxygen
- Weld penetration; depth of fusion
- Wire feed; rate of supply of filler wire
- Gas supply; rate of supply of shield gas
- Current; quantity of electric current required for particular weld/material/material thickness
- Welding plant set correctly, (3mm black mild steel), MIG wire 0.6-0.8, current quantity 75-80 amps, Argon mix shield gas 12-14 litres/min., appropriate earth connection
- Location and use of electricity emergency stop button/s, gas shut off tap and fire extinguishers

8.1 MIG Welding

Control of the angle between the gun and the surface of the sheet is critical in MIG welding.



8.2 Introduction

These semi-automatic and automatic processes have found increasing use in recent years. They have replaced the use of oxyacetylene and manual metal arc processes on certain types of fabrication.

The process is known by different names, such as MIG (metallic inert gas), CO_2 welding (when a carbon dioxide gas shield is employed).

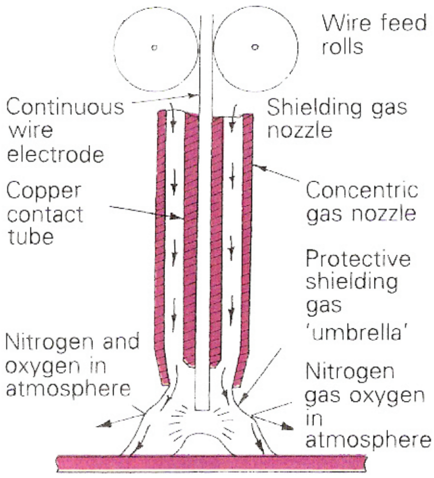
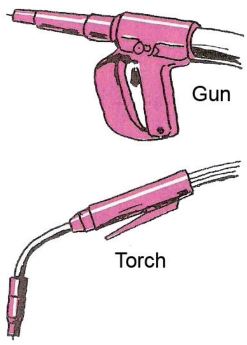


Diagram of Welding Nozzle and Gas Shield for Metal Arc Gas-Shielded Welding

The Process

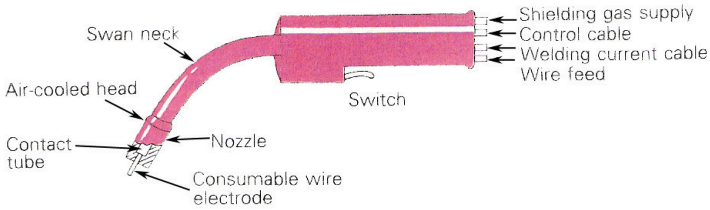
A continuous consumable wire electrode is fed through a welding gun fitted with a concentric gas nozzle. The arc is struck between the workpiece and the wire, which acts as both electrode and filler. The arc and the weld pool are shielded from atmospheric contamination by passing a suitable gas through the nozzle to form a protective shield around the welding area.



MiG Welding Gun and Welding Torch

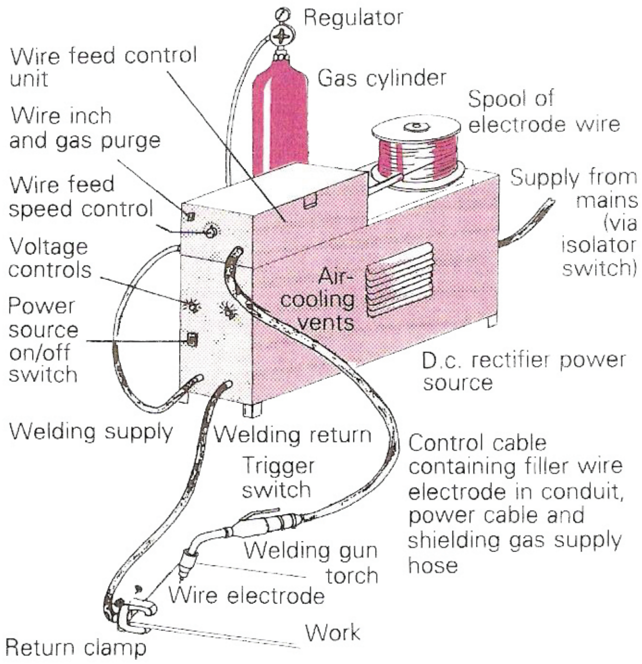
Some guns can have an outer nozzle attachment for fume extraction. This has to be carefully set so as not to disturb the gas shield.

For non-ferrous metals, pure argon is usually used as the gas shield. Other gases can be used, such as helium or (for copper) nitrogen. For ferrous metals, the gases used include carbon dioxide, argon and oxygen, argon and CO_2.

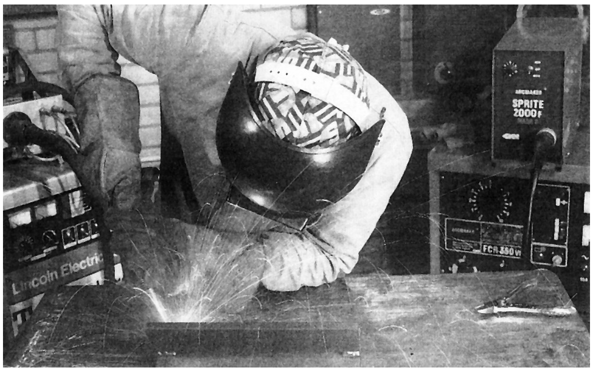


Air-Cooled Welding Torch

The arc is self-adjusting, which means that any variation in the arc length made by the welder produces a change in the burn-off rate of the electrode and the arc rapidly returns to its original length.



Basic Set-Up for MiG Welding



MiG Welding a T-Fillet Test Piece

Metal Transfer in MiG Welding

There are three main types of metal transfer: spray transfer, pulsed transfer and dip transfer.

In spray transfer, droplets of metal are transferred from the end of the electrode in the form of a fine spray. It is usually used for welding thicker plate in the flat and horizontal/vertical positions.

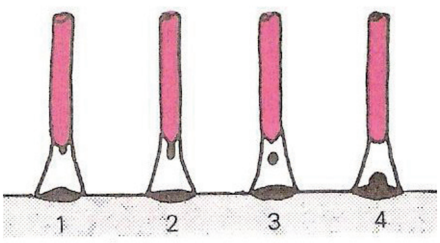
Spray transfer requires the use of higher welding current and arc voltages. The resulting fluid state of the molten pool prevents it from being used for welding steels in positions other than flat or horizontal/vertical. Aluminium, however, can be welded in all positions using spray transfer.

There are two types of spray transfer. The true spray is obtained when the shielding gas is argon or argon/oxygen mixture. With these gas shields, the droplets in the spray are very fine and never short-circuit the arc. When carbon dioxide or an argon/carbon dioxide mixture is used, a molten ball tends to form at the end of the electrode. This can grow in size until it is bigger than the diameter of the electrode. These large droplets can cause short circuits to occur. This mode is known as globular transfer. With conditions that cause the short circuits to occur very rapidly, the mode becomes short-circuiting or dip transfer.

The Three Types of Metal Transfer used in MiG Welding

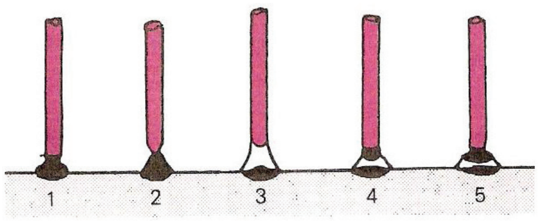
Spray Transfer

1. Droplet forming
2. Droplet being 'pinched' off
3. Droplet in free flight
4. Droplet deposited in molten pool



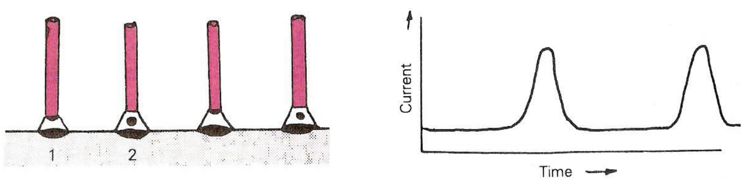
Dip or Short-Circuiting Transfer

1. Electrode short-circuits
2. Current increases
3. Arc re-ignited
4. End of electrode heating up
5. Electrode about to short circuit. Cycle repeats.



Pulsed Arc Transfer

1. Background current maintaining arc
2. Pulsed current projects metal droplet across the arc gap



Electrode Wire Size

Generally speaking, the smaller-diameter wires will give greater current density, resulting in a fast burn-off rate and a tendency to give deeper-penetration welds.

Modern MiG welding machines have an automatic inductance, but older machines may need a manual setting. The inductance is used for dip transfer welding. Increasing the inductance for a given open-circuit voltage produces a hotter arc, which results in quieter welding conditions with less spatter and a smoother weld finish. Decreasing the inductance produces a cooler arc that gives out a distinctive 'crackling' sound and a weld surface with a more pronounced ripple.

On machines that require manual adjustment, high inductance will be needed for thicker materials and low inductance for thin sheet.

Contact Tips and Nozzles

On some torches and guns, the positions of contact tip and nozzle can be adjusted to allow greater visibility of the welding area or accessibility to the particular joint and/or to improve gas shielding.

Always use the correct size of contact tip. A brief spray with silicon 'anti-spatter' solution before use and at regular intervals during use will make it easier to remove spatter from the nozzle and tip. Clean the nozzle and tip regularly.

Mode of Metal Transfer	*Recommended Position of Control Tip*
Dip	3-9 mm beyond the end of the nozzle to allow greater visibility / accessibility
Spray (on steels)	6-9 mm within the nozzle to give improved gas shielding
Spray (on aluminium)	9-12 mm within the nozzle to give improved gas shielding
Spray (using flux-cored wire)	9-18 mm within the nozzle to give improved gas shielding and contact tube protection

Contact Tip Positions for MiG Welding

Welding Speed

Perfection with MIG welding, as with the other processes discussed in this book, will only come with adequate practice under guidance.

When you are learning MIG welding, you must pay special attention to obtaining the correct welding speed. Too fast a welding speed can cause excessive spatter and undercut. Shielding gas can get trapped in the quickly solidifying weld metal, causing porosity. Too slow a welding speed may cause excessive penetration.

Wire Extension

The length that the electrode wire extends beyond the contact tip can also affect weld quality. With more wire protruding, the arc current will be reduced and this will result in less penetration. Wire extension from the contact tip should be approximately:

1. For dip transfer: 3-6 mm
2. For spray transfer: 18-30 mm
3. For flux-cored wire: 30-45 mm

9.0 Hazards and Safety Procedures When Electric Arc Welding

Key Learning Points

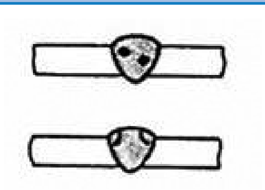
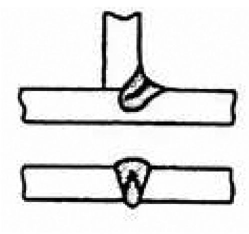
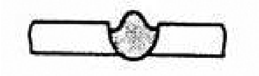
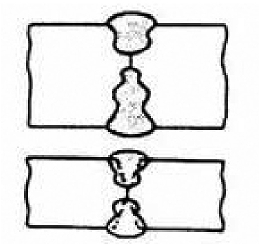
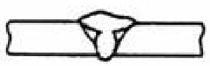
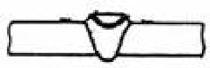
- Danger of arc eye/stray arc eye injury to other operators in surrounding area, inhalation of toxic fumes due to lack of proper ventilation/welding in confined spaces, fire due to presence of combustible materials, burns/electrocution due to misuse of heat/electrical insulation materials/gloves etc.
- MIG welding of 2mm mild steel butt joint
- Arc eye; damage to eye, ultraviolet radiation
- Filter glass; suitable weld shield glass e.g. 11 EW
- Electrical insulation; open-bare voltage supply
- Faults in the weld-identification and causes

9.1 Safety Precautions

Safety Precautions

- Check that there is good ventilation of the working area to prevent the build-up of harmful concentration of gases. Remember that carbon dioxide is heavier than air.
- The protective clothing and protective equipment as used for manual metal-arc welding are applicable. The amounts of ultra-violet and infra-red radiation, as well as the visible light radiation, are however more intense and full precautions must be exercised.
- Ensure that proper precautions are applied when hot material is left un-attended.
- Be aware of electrical leads and the fatal consequences of contact with any sharp or hot objects.

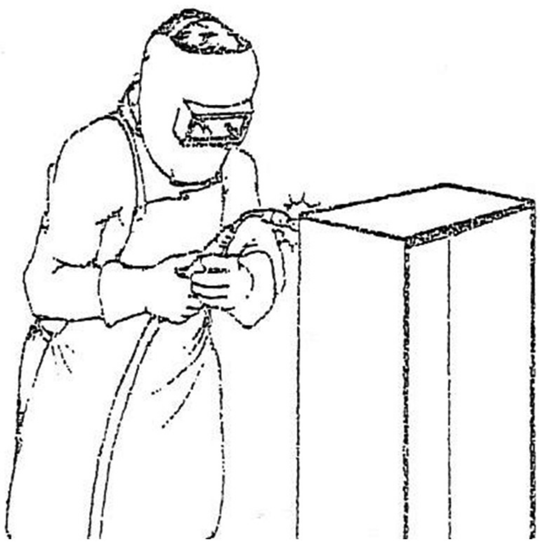
Faults in MIG Welding (Identification and Causes)

Fault		*Cause*
Porosity		Insufficient CO2 shielding because of flow rate, frozen value, clogged nozzle, draughts. Torch angle too low.
Cracking		Dirty work – grease, paint, scale, rust Weld bead too small
Undercutting		Travel speed too high Backing bar groove too deep Current too low for speed
Lack of penetration		Current too low – setting wrong Wire feed fluctuating Joint preparation too narrow Angle too small, Gap too small Torch angle too low
Lack of fusion		Uneven torch manipulation Insufficient indulgence (short circuiting arc) Voltage too low
Slag inclusions		Incorrect technique Current too low Irregular weld shape
Spatter - on work, on nozzle, in weld		Voltage too high Insufficient inductance

Other Safety Precautions

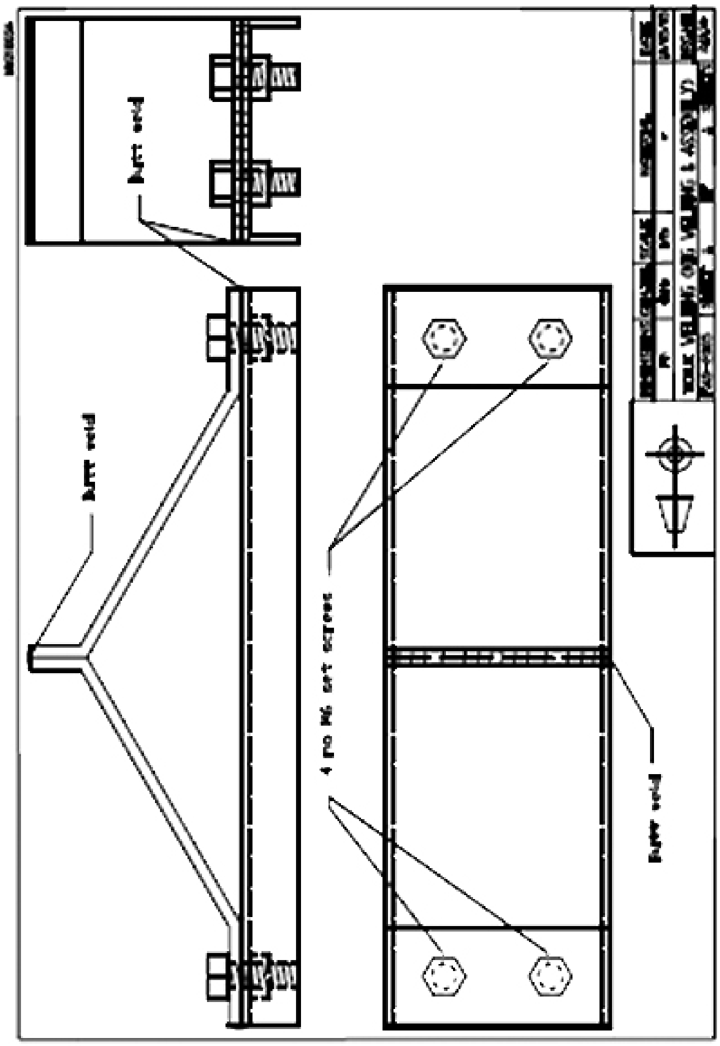
1. Use effective protective equipment and any necessary protective clothing.
2. Have full control of the torch/gun and hold it steady. Concentrate on watching the welding operation.
3. Support the flexible hose assembly so that drag on the torch/gun is reduced.
4. Hold the torch/gun with just sufficient grip at the point of balance to give control. Otherwise it will cause muscle fatigue. Position yourself to avoid over-balancing.
5. Warn any bystanders when about to strike the arc.
6. Ensure that any portable screens required are in position.
7. Ensure protection from radiation reflected from bright surfaces. Screen or temporarily cover polished surfaces in the vicinity.
8. Keep the welding screen in front of the eyes until the arc is broken.
9. Follow closing down procedure at the end of the work period or when there is a long interruption.

Please refer to your instructor for additional information, which is available from the automotive technical manuals.



Safety Precautions

10.0 Welding Components as Shown in the Activity Diagram



Exercise No. 2.10.3a

Instructions

Assemble components of Exercise No. 2.10 2a using set screws and nuts.

MIG weld butt joints as per drawing

Tools and Materials

Components of Exercise No. 2.10.2a inclusive

4 x M6 x 16mm set screws and nuts

MIG welding plant

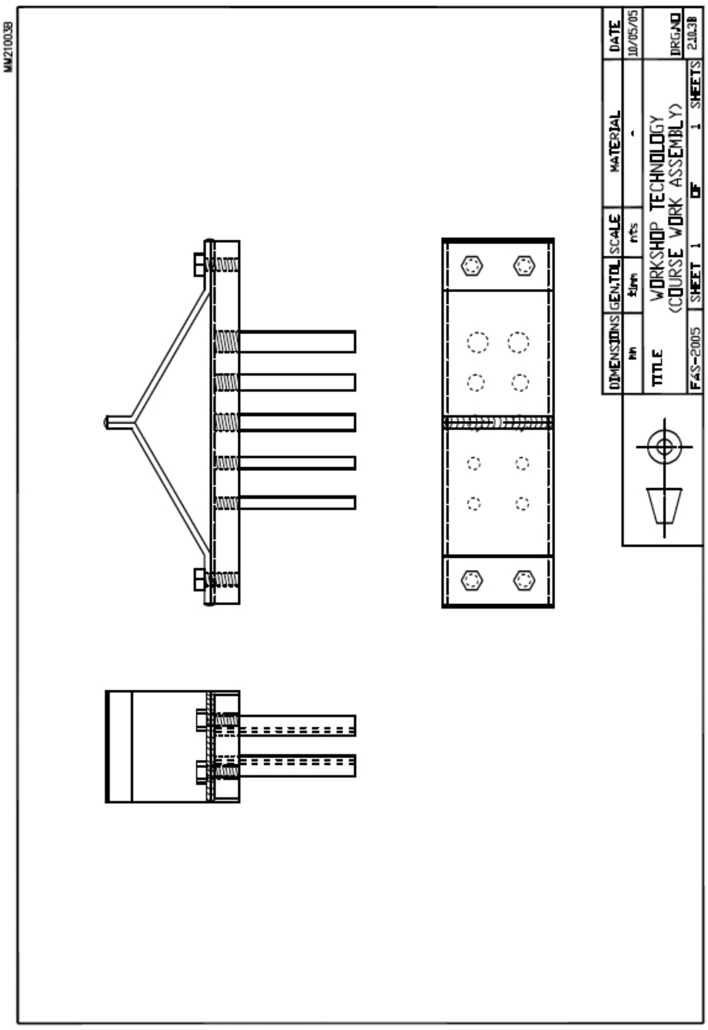
Appropriate personal protection, equipment and ventilation

Standards Uniform butt weld, strong joint, no oxygen/air contamination

Time 1 hour

Please refer to your instructor for additional information.

11.0 Assembling Components as Shown in the Activity Diagram



Exercise No. 2.10.3b

Instructions

Assemble Exercise Nos. 2.10.1a, b, c, 2.10.2a, b, c and 2.10.3a inclusive

Tools and Materials

Completed components of Exercise Nos. 2.10.1a, b, c, 2.10.2a, b, c and 2.10.3 a inclusive

Standards Components assembled fully to General tolerance and finished smooth and square

Time 0.5 hours

Please refer to your instructor for additional information.

12.0 NCT/DoT VTM Requirements

Key Learning Points

- Description of NCT/DoT VTM requirements for registration plates

Please refer to Section 1 of the 2004 NCT manual for specific information.

13.0 Fitting Registration Plates

Key Learning Points

- Registration plates fitted, secure, level, correct location and retainer screws located/capped appropriately

Practical Task

Please refer to your instructor for additional information

Self Assessment

Q1: An oxyacetylene gauge set has: (Tick one box only)

❑ 1. Right hand thread

❑ 2. A cylinder pressure gauge

❑ 3. A cylinder pressure and working pressure gauge

❑ 4. A gas flow gauge

Q2: Hacksaw blades come in a variety of sizes, material and teeth for different cutting situations. They are graded according to teeth per inch. Which one of the following is correct? (Tick one box only)

❑ 1. A blade with many teeth per inch has a coarse pitch; one with few teeth per inch has a fine pitch

❑ 2. A blade with many teeth per inch has a fine pitch; one with few teeth per inch has a coarse pitch

❑ 3. All blades can be used on all jobs

Q3: A self-locking nut is locked against the thread by means of: (Tick one box only)

❑ 1. A built-in lock washer

❑ 2. Two nuts that lock together

❑ 3. A nylon or soft metal insert

❑ 4. Small holes that let in thread sealant

Q4: It is difficult to tension a castellated nut to an accurate torque setting because: (Tick one box only)

❑ 1. The slots cause it to work loose

❑ 2. It is easily damaged with a socket spanner

❑ 3. It can be pinned only in certain positions

❑ 4. It is always made of a soft metal

Q5: What is the purpose of a flat washer used under a nut? (Tick one box only)

❑ 1. To protect the underside of the nut

❑ 2. To protect the metal underneath the nut

❑ 3. To prevent the nut from working loose

❑ 4. To seal the thread to prevent oil leaks

Q6: Which of the following threads would be cut in a 9mm hole drilled through a 20mm thick steel plate? (Tick one box only)

- ❑ 1. M 9 X 1.0
- ❑ 2. M 10 X 1.0
- ❑ 3. M 12 x 1.0
- ❑ 4. M 20 X 9.0

Q7: Which die would be used to cut a thread on a 12mm diameter steel rod? (Tick one box only)

- ❑ 1. M 10 x 2.0
- ❑ 2. M 12 x 2.0
- ❑ 3. M 14 x 2.0
- ❑ 4. M 20 x 2.0

Q8: What is the purpose of a safe edge on a file? (Tick one box only)

- ❑ 1. A file handle is no longer required
- ❑ 2. It removes metal on the forward stroke
- ❑ 3. It reduces the risk of injury to the user
- ❑ 4. It prevents damage when filing into a corner

Q9: The recommended method for cleaning metal from file teeth is to: (Tick one box only)

- ❑ 1. Wipe across the teeth with a file card
- ❑ 2. Rub the teeth with the palm of the hand
- ❑ 3. Wash the file in a chemical cleaner
- ❑ 4. Drag the file backwards over soft metal

Q10: What punch is designed to mark metal immediately prior to drilling? (Tick one box only)

- ❑ 1. A prick punch
- ❑ 2. A centre punch
- ❑ 3. A drill point punch
- ❑ 4. A starter drift pin punch

Q11: A fine-toothed blade should be used for: (Tick one box only)

- ❑ 1. Cutting thin material
- ❑ 2. Cutting thick material
- ❑ 3. Very hard material
- ❑ 4. Material coated with rust

Q12: How is a feeler gauge identified? (Tick one box only)

- ❑ 1. It has small indentations on the blade
- ❑ 2. It has radiating lines on the case
- ❑ 3. It has radiating lines on the blade
- ❑ 4. It has the numbers marked on the blade

Q13: The purpose of the drill chuck on a drilling machine is to allow: (Tick one box only)

- ❑ 1. The machine to be held with both hands
- ❑ 2. A range of drill sizes to be fitted
- ❑ 3. The drills to be thrown into a tool box
- ❑ 4. Morse taper drills to be removed easily

Q14: Name the material you place on the cutting thread of a thread tap to keep the tool sharp. (Tick one box only)

- ❑ 1. Thread cutting grease
- ❑ 2. Thread cutting cement
- ❑ 3. Thread cutting compound
- ❑ 4. Thread chassis grease

Q15: Why is one end of a chisel made softer than the other? (Tick one box only)

- ❑ 1. It won't chip when hit with a hammer
- ❑ 2. It won't damage the bench or vice
- ❑ 3. It makes the chisel as cheap as possible
- ❑ 4. It makes the chisel easier to sharpen

Suggested Exercises

1. 1. Assemble, adjust and operate a MIG welding plant as in exercises Nos. 2.10.3a and
2. 2.10.1b
3. 2. Weld butt, lap and tee joints on 2mm mild steel
4. 3. List the dangers/hazards and recommended safety precautions pertaining to electric arc (MIG) welding
5. 4. Fit registration plates to bench unit bumpers/rear lids etc..

Training Resources

- Technical information in book/electronic form on electric arc welding, the dangers and recommended safety procedures, MIG welding possibilities - techniques, advantages and disadvantages
- MIG welding plants, appropriate work area/bays - ventilation etc., personal protection equipment, supply of 2mm mild steel/welding materials
- Assorted registration plates, training vehicles bumpers/bench unit bumpers, retainer screws and drill and bits

Suggested Further Reading

- Advanced Automotive Diagnosis. Tom Denton. ISBN 0340741236
- Automobile Electrical and Electronic Systems (3rd Edition). Tom Denton. ISBN 0750662190
- Automotive Mechanics (10th Edition). William H. Crouse and Donald L. Anglin. ISBN 0028009436
- Bosch Automotive Electrics Automotive Electronics: Systems and Components (4th Edition). Robert Bosch. ISBN 0837610508
- Bosch Automotive Handbook (6th Edition). Robert Bosch. ISBN 1860584748
- Bosch Automotive Technology Technical Instruction booklet series (numerous titles)
- Hillier's Fundamentals of Motor Vehicle Technology: Book One (5th Edition). V.A.W. Hillier and Peter Coombes. ISBN 0748780823
- Hillier's Fundamentals of Motor Vehicle Technology: Book Two (5th Edition). V.A.W. Hillier and Peter Coombes. ISBN 0748780998
- Modern Automotive Technology. James E. Duffy. ISBN 1566376106
- Motor Vehicle Craft Studies - Principles. F.K. Sully. ISBN 040800133X
- National Car Test (NCT) Manual (Department of Transport, Vehicle Testers Manual - DoT VTM). Department of Transport
- Transmission, Chassis and Related Systems (Vehicle Maintenance and Repair Series: Level 3) (3rd Edition) John Whipp and Roy Brooks. ISBN 186152806X
- Vehicle and Engine Technology (2nd Edition). Heinz Heisler. ISBN 0340691867
- http://www.cdxglobal.com/
- http://auto.howstuffworks.com/
- http://www.autoshop101.com/
- http://www.cdxetextbook.com/
- Automotive Encyclopedia and Text Book Resource (CD version of e-textbook), Available from your instructor.

Notes

SOLAS

An tSeirbhís Oideachais Leanúnaigh agus Scileanna
Further Education and Training Authority

27-33 Upper Baggot Street
Dublin 4