

TRADE OF  
**Pipefitting**

PHASE 2

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Module 2

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Thermal Processes

UNIT: 7

**Plasma Arc Cutting**

*Produced by*

**SOLAS**

**An tSeirbhís Oideachais Leanúnaigh agus Scileanna**  
Further Education and Training Authority

*In cooperation with subject matter expert:*

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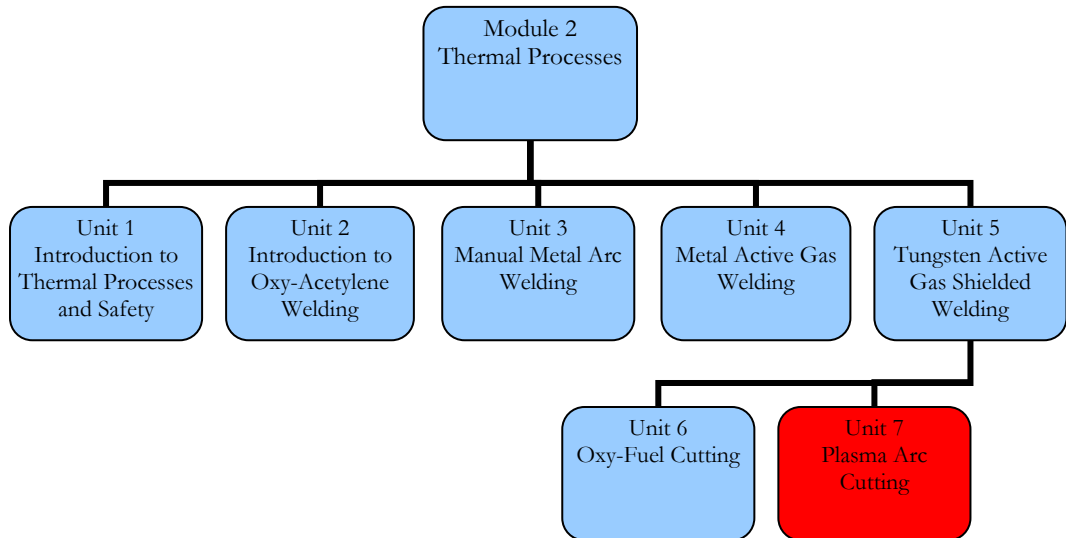
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## Unit Objective

There are seven Units in Module 2. Unit 1 focuses on Introduction to Thermal Process and safety, Unit 2; Introduction to Oxy-acetylene welding, Unit 3; Manual Metal Arc welding, Unit 4; Metal Active Gas welding, Unit 5; Tungsten Active Gas welding, Unit 6; Oxy-fuel cutting and Unit 7 Plasma arc cutting.

In this unit you will be introduced to Plasma Arc cutting and the safety precautions required when using Plasma Arc cutting equipment.



## Learning Outcome

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

- Describe the plasma arc cutting process and its applications in the pipefitting trade
- Identify the different components of Plasma Arc cutting equipment and PPE required for its use
- List the characteristics and hazards associated with plasma cutting
- Safely set up the equipment, adjust air pressure and current to correct settings

# 1.0 Plasma Arc Cutting Process and Applications for Pipefitting

## Key Learning Points

- Define what Plasma is
- Identify how Plasma Arc cutting works
- Identify component parts of a plasma cutting torch

## 1.1 Definition of Plasma

### The Fourth State of Matter

The first three states of matter are solid, liquid and gas. For the most commonly known substance, water, these states are ice, water and steam. If you add heat energy, the ice will change from a solid to a liquid, and if more heat is added, it will change to a gas (steam). When substantial heat is added to a gas, it will change from gas to plasma, the fourth state of matter.

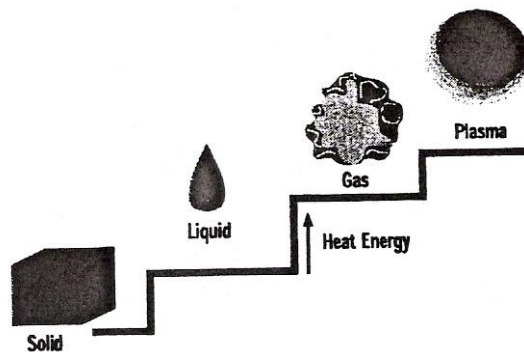


Figure 1 - Plasma - The Fourth State of Matter

### Definition of Plasma

Plasma is an electrically conductive gas. The ionisation of gases causes the creation of free electrons and positive ions among the gas atoms. When this occurs, the gas becomes electrically conductive with current carrying capabilities. Thus, it becomes a plasma.

### Plasma in Nature

One example of plasma, as seen in nature, is lightning. Just like a plasma torch, the lightning moves electricity from one place to another.

In lightning, gases in the air are the ionisation gases.

## 1.2 Plasma Arc Cutting

Accurate cuts can be made in stainless steel and non-ferrous metals such as aluminium by plasma arc cutting.

The cuts are made by a high temperature, high velocity gas jet generated by constricting an arc between a tungsten electrode and the component.

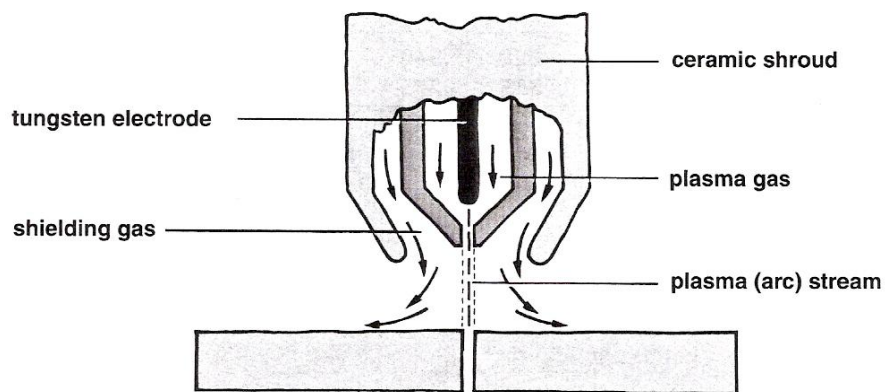
The heat from the arc melts the metal and the gas jet removes the molten metal from the cut.

The arc operates in an inert inner shield, whilst an outer shield provides protection for the cut surface.

Argon, helium, nitrogen and mixtures of these gases are used for both the inner and outer shields.

Plasma arc cutting is characterised by fast cutting speeds and is mainly used in mechanised systems.

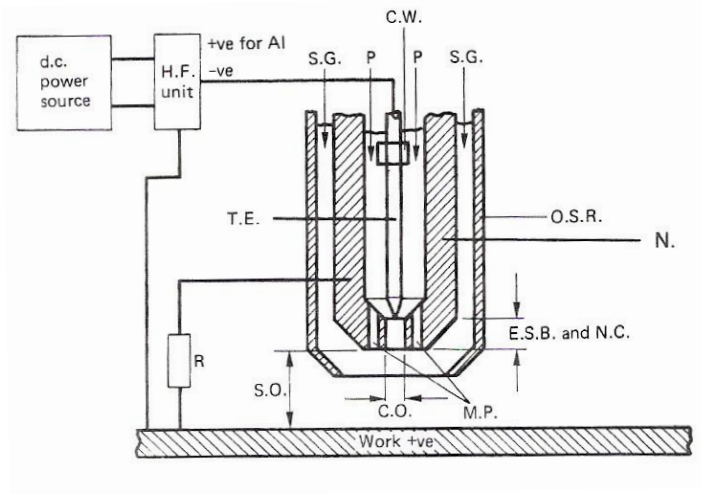
The cutting is accompanied by a high noise level which can be reduced by operating the torch under water.



*Plasma Arc Cutting*

As for other arc processes plus there is a danger of severe electric shock from the high open circuit voltage, up to 400 V for cutting. Dangerous fumes and noxious gases are formed when using nitrogen mixtures so it is important to have adequate fume extraction. The intense arc requires a darker shade of filter glass, at least 16 EW (BS 697). Intense high-frequency noise is possible when cutting, especially with non-transferred arcs, of levels 110 dB which requires ear muff protection.

### 1.3 Component Parts of a Plasma Arc Torch



*Component parts of a Plasma Arc Torch*

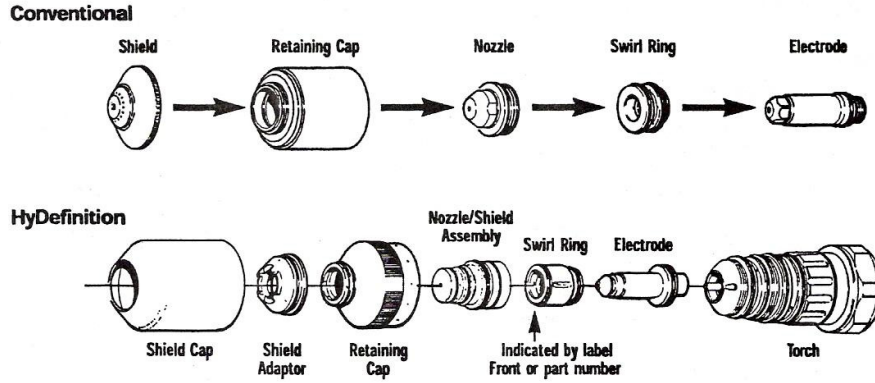
- C.W. = Cooling water, nozzle and electrode may be water cooled
- P = Plasma gas varies with different materials.
- S.G. = Auxiliary shielding gas, usually Argon + 1 to 15% H<sub>2</sub>
- T.E. = Tungsten electrode 60°
- O.S.R. = Outer shielding ceramic to prevent double arcing
- R = Resistance limiting pilot arc current (non-transferred)
- E.S.B. = Electrode set back distance
- N.C. = Nozzle constriction
- C.O. = Orifice constriction improves velocity  
2.5 mm dia., 250 amps max.,  
3.00 mm dia., 350 amps max.
- S.O. = Stand-off distance approx. 6mm
- M.P. = Multi-ports shape the arc plasma and allow increased welding speed
- H.F. = High-frequency discharge ignites the arc
- N. = Copper Nozzle

### 1.4 Changing Consumables

- Select consumable parts using the appropriate cut chart.
- Install consumables using the tools provided in your parts kit.  
DO NOT OVERTIGHTEN.
- Lubricate all consumable o-rings with silicone grease that is provided in the consumable parts kit. Do not over apply, only a thin film is needed. Apply the lubricant to your fingers (only enough to glisten) and then rub on o-rings.



- Electrodes and nozzles should be replaced as a set. Swirl rings should be replaced every five to ten electrode/nozzle changes. Shields, retaining caps etc. only need replacing when they are physically worn or when cut quality becomes poor.



- Installing Consumables
- Protect your equipment by using only genuine replacement spare parts.

### 1.5 Recording Consumable Life

- Recording consumable life is an important task that should be done each time consumables are changed.
- With records like this you will easily see when you are having a consumable life problem and will aid in effective troubleshooting.
- The table below provides a good example to record usage.

Consumable Usage Log							
Starts	Arc Time		Errors	Material Cut	Current/Process	Consumable Part	Notes
	Start	End					

*Consumable Usage Log*

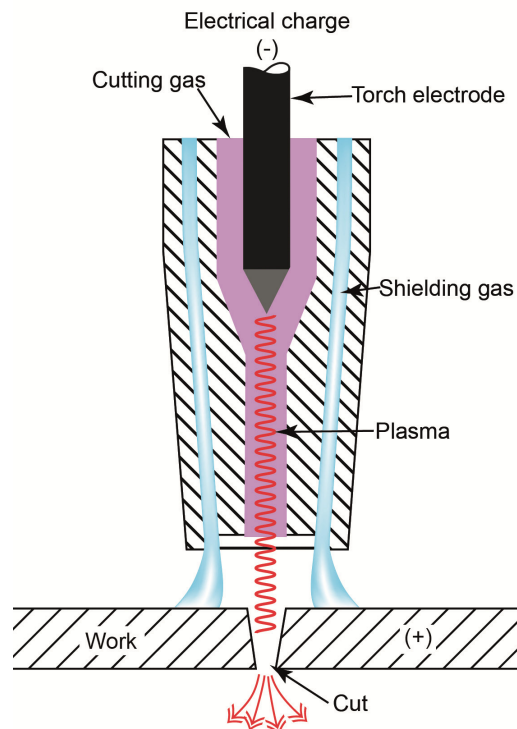
## 2.0 Gas Selection for Plasma Arc Cutting

### Key Learning Points

- Identify the function of the gases used in plasma cutting
- Identify the different types of gases used for plasma cutting
- Gas selection for different materials and thicknesses

### 2.1 Plasma (Cutting) Gas Selection

- Selecting the proper gas for the material you are cutting is critical to get a quality cut.



*Functions of gas in Plasma Arc cutting*

Plasma gas is also called the cutting gas. This is the gas that is ionised in the plasma process and exits through the nozzle orifice.

Examples of plasma gas are:

- Air
- Oxygen
- Nitrogen
- Argon-Hydrogen

## 2.2 Shield Gas Selection

The shield is the secondary gas in the plasma process. It surrounds the arc and is used to help constrict the arc and cool torch. It creates and protects the cutting environment which among other things affects the edge quality.

Examples of shielding gas are:

- Air
- CO<sub>2</sub>
- Oxygen-Nitrogen
- Air-Methane
- Nitrogen
- Methane

## 2.3 Selecting the Correct Gas

The cutting gas selected depends on the speeds and quality of cut desired. Several cutting gases can be used in a plasma system to improve cut quality and speed. Nitrogen is widely used because it is relatively inexpensive and can be used on many materials and thicknesses. Special mixtures of argon and hydrogen can improve cutting speed and quality on thicker metals and those other than carbon steels. Oxygen is used in combination with other gases to improve cut quality by increasing heat, improving cutting speed, and/or reducing power requirements. Compressed shop air is popular for many applications because it is inexpensive and provides good quality cuts on thicknesses under 25mm, especially on carbon steels.

Gas quality is critical for the proper operation of plasma arc cutting systems and optimal cut quality. Any contaminates can cause misfiring, poor cut quality or poor consumable life. Contaminates can be: gas impurities, moisture, dirt, piping system contaminates or improper gases (i.e. Air in O<sub>2</sub> systems-leaks, not following proper purge procedures when changing gas).

The table below gives a list of the typical gases used for Plasma Arc cutting and the application that they are suitable for:

Gas Selection Chart			
System	Material	Plasma Gas	Shield Gas
HyDefinition	Mild Steel	O <sub>2</sub>	O <sub>2</sub> & N <sub>2</sub>
	Stainless Steel- up to 1/4" above 1/4"	Air	Air
		Air	Air & Methane
	above 1/4"*	H35 & N <sub>2</sub>	N <sub>2</sub>
	Aluminium up to 3/8" up to 1/2"	Air	CH <sub>4</sub>
		H35 & N <sub>2</sub>	N <sub>2</sub>
Copper	O <sub>2</sub>	O <sub>2</sub> & N <sub>2</sub>	
MAX200 & HT2000	Mild Steel	O <sub>2</sub>	Air
	Stainless Steel up to 1/4" above 1/2"	Air	Air
		H35	N <sub>2</sub>
	Aluminium	Air	Air
	Copper	O <sub>2</sub>	Air
HT4001	Mild Steel **	O <sub>2</sub>	H <sub>2</sub> O
	Stainless Steel	N <sub>2</sub>	H <sub>2</sub> O
	Aluminium	N <sub>2</sub>	H <sub>2</sub> O
*Only valid if equipped with six channel gas console (p/n: 078059 & 078061).			
**O <sub>2</sub> cutting is only for 340 amps maximum. Must use N <sub>2</sub> for higher current.			

#### Gas Selection Chart

Aluminium and stainless steels require non-oxidising gases for good cutting results in both thin and thick sections. Argon/hydrogen mixtures permit good cuts and high cutting rates because the hydrogen increases the arc voltage and thermal conductivity of the mixture. Parallel kerfs, little dross, oxide-free cut faces and minimal fumes result from the use of A/H<sub>2</sub> mixtures. Argon/Hydrogen/Nitrogen or A/N<sub>2</sub> mixtures are used when machine cutting, but nitrogen is not recommended for hand cutting due to the formation of poisonous oxides of nitrogen. Higher cutting speeds are possible with this cheaper mixture with little loss of quality. The increase in cutting efficiency is probably derived from the greater anodic voltage drop associated with the nitrogen gas.

When inert gases such as argon are used, the heat is derived from the electrical energy of the arc. Carbon steels require an oxidising gas for the best results; the exothermic iron-oxygen reaction provides additional heat at the cutting point and so reduces the amount of electric power required. Air has proved to be a most efficient gas.

## 2.4 Cutting Speeds for Plasma Arc Cutting

This should be as high as possible for economic reasons provided a narrow kerf and a clean cut at top and bottom edges are produced. For a given electric power and gas mixture, there is an optimum speed range for each type and thickness of material. Excess speed causes a decreased kerf width with an increased bevel but current intensity is the main factor determining kerf width. For manual control and complicated machine cuts 1 m/min is a reasonable speed. In general speeds of several metres/min are used for straight line and trimming cuts.

Material	Thickness mm	Current amps	Cutting speed Mm/min	Gas
Aluminium	1.5	40	1200	A/H <sub>2</sub>
	5.0	50	1500	A/H <sub>2</sub>
	12.0	400	3750	A/H <sub>2</sub>
	25.0	400	1250	A/H <sub>2</sub>
Stainless steel 18/8	2	50	1600	A/H <sub>2</sub>
	5	100	2000	A/H <sub>2</sub>
	12	380	1500	A/H <sub>2</sub>
	25	500	625	A/H <sub>2</sub>

*Variation of Cutting Speed with Typical Gas-type and Current*

## 2.5 Depth of Cut for Plasma Arc Cutting

Plasma cutting power sources are rated on their cutting ability and amperage. Therefore, for cut depths up to 6mm thick material, a low amperage plasma cutter will suffice. For cut depths up to 12mm thick a higher amperage machine will be required. Even though a smaller machine may be able to cut through a given thickness of metal, it may not produce a quality cut. Instead, you may get a sever cut which barely makes it through the plate and leaves behind dross or slag. Every unit has an optimal range of thickness -- make sure it matches up with what you need. In general, a 6mm machine has approximately 25 amps of output, a 12mm machine has a 50-60 amp output while a 18mm to 25mm machine has 80 amps output. The table below gives typical piercing and cutting depths for different materials

System	Material Type	Max Cut Capacity	Max Pierce Capacity
HD3070	Mild Steel	6mm	6mm
	Stainless Steel	6mm	6mm
	Aluminium	6mm	6mm
MAX200	Mild Steel	50mm	25mm
	Stainless Steel	50mm	22mm
	Aluminium	50mm	22mm
HT2000	Mild Steel	50mm	25mm
	Stainless Steel	50mm	22mm
	Aluminium	50mm	22mm
HT4001	Mild Steel w/O <sub>2</sub>	30mm	25mm
	Mild Steel w/N <sub>2</sub>	75mm	25mm
	Stainless Steel	75mm	25mm

*Cutting depths with Plasma*

## 3.0 Safety Precautions for Plasma Arc Cutting

### Key Learning Points

- Identify specific hazards pertinent to Plasma Arc cutting
- Identify how these hazards are eliminated or minimised

### 3.1 Safety Precautions

The safety precautions to be observed for Plasma Arc cutting are similar for other thermal processes with following clarifications:

#### Fire Prevention

- Be sure the area is safe before doing any cutting.
- Keep a fire extinguisher nearby.
- Remove all flammables within 35 feet (10 m) of the cutting area.
- Quench hot metal or allow it to cool before handling or before letting it touch combustible materials.
- Never cut containers with potentially flammable materials inside - they must be emptied and properly cleaned first.
- Ventilate potentially flammable atmospheres before cutting.
- When cutting with oxygen as the plasma gas, an exhaust ventilation system is required.

#### Explosion Prevention

- Do not use the plasma system if explosive dust or vapours may be present.
- Do not cut pressurised cylinders, pipes, or any closed container.
- Do not cut containers that have held combustible materials.

#### Explosion Hazard: Argon-Hydrogen and Methane

- Hydrogen and methane are flammable gases that present an explosion hazard. Keep flames away from cylinders and hoses that contain methane or hydrogen mixtures. Keep flames and sparks away from the torch when using methane or argon-hydrogen plasma.

## Hydrogen Detonation with Aluminium Cutting

- When cutting aluminium underwater, or with the water touching the underside of the aluminium, free hydrogen gas may collect under the workpiece and detonate during plasma cutting operations.
- Install an aeration manifold on the floor of the water table to eliminate the possibility of hydrogen detonation. Refer to the Appendix section of this manual for aeration manifold details.

## Electric Shock Can Kill

Touching live electrical parts can cause a fatal shock or severe burn.

- Operating the plasma system completes an electrical circuit between the torch and the workpiece. The workpiece and anything touching the workpiece are part of the electrical circuit.
- Never touch the torch body, workpiece or the water in a water table when the plasma system is operating.

## Electric Shock Prevention

Plasma systems use high voltage in the cutting process (200 to 400 VDC are common). Take the following precautions when operating these systems:

- Wear insulated gloves and boots, and keep your body and clothing dry.
- Do not stand sit or lie on - or touch - any wet surface when using the plasma system.
- Insulate yourself from work and ground using dry insulating mats or covers big enough to prevent any physical contact with the work or ground. If you must work in or near a damp area, use extreme caution.
- Provide a disconnect switch close to the power supply with property sized fuses. This switch allows the operator to turn off the power supply quickly in an emergency situation.
- When using a water table, be sure that it is correctly connected to earth ground.
- Install and ground this equipment according to the instruction manual and in accordance with national and local codes.
- Inspect the input power cord frequently for damage or cracking of the cover. Replace a damaged power cord immediately. Bare wiring can kill.
- Inspect and replace any worn or damaged torch leads.
- Do not pick up the workpiece, including the waste cut off, while you cut. Leave the workpiece in place or on the workbench with the work cable attached during the cutting process.
- Before checking, cleaning or changing torch parts, disconnect the main power or unplug the power supply.
- Never bypass or shortcut the safety interlocks
- Before removing any power supply or system enclosure cover, disconnect electrical input power. Wait 5 minutes after disconnecting the main power to allow capacitors to discharge.



- Never operate the plasma system unless the power supply covers are in place. Exposed power supply connections present a severe electrical hazard.
- When making input connections, attach proper grounding conductor first.
- Ensure that all equipment used is compatible and do not mix and match similar torches as they could overheat and present a safety hazard.

### Toxic Fumes Produced by Plasma Cutting

Cutting can produce toxic fumes and gases that deplete oxygen and cause injury or death.

- Keep the cutting area well ventilated or use an approved air-supplied respirator.
- Do not cut in locations near degreasing, cleaning or spraying operations. The vapours from certain chlorinated solvents decompose to form phosgene gas when exposed to ultraviolet radiation.
- Do not cut metal coated or containing toxic materials, such as zinc (galvanised), lead, cadmium or beryllium, unless the area is well ventilated and the operator wears an air-supplied respirator. The coatings and any metals containing these elements can produce toxic fumes when cut
- Never cut containers with potentially toxic materials inside - they must be emptied and properly cleaned first.
- This product, when used for welding or cutting, produces fumes or gases which contain chemicals known to the State of California to cause birth defects and, in some cases, cancer.

### Plasma Arc Can Cause Injury and Burns


Plasma arc comes on immediately when the torch switch is activated. The plasma arc will cut quickly through gloves and skin.

- Keep away from the torch tip.
- Do not hold metal near the cutting path.
- Never point the torch toward yourself or others.

### Arc Rays Can Burn the Eyes and Skin

Eye Protection Plasma arc rays produce intense visible and invisible (ultraviolet and infrared) rays that can burn eyes and skin.

- Use eye protection in accordance with applicable national or local codes.
- Wear eye protection (safety glasses or goggles with side shields, or a welding helmet) with appropriate lens shading to protect your eyes from the arc's ultraviolet and infrared rays.

<i>Arc Current</i>	<i>Lens Shade</i>		
	AWS (USA)	ISO 4850	
Up to 100 A	No. 8	No. 11	
100-200 A	No. 10	No. 11-12	
200-400 A	No. 12	No. 13	
Over 400 A	No. 14	No. 14	

- Skin Protection Wear protective clothing to protect against burns caused by ultraviolet light, sparks and hot metal.
- Gauntlet gloves, safety shoes and hat.
- Flame-retardant clothing to cover all exposed areas.
- Cuffless trousers to prevent entry of sparks and slag.
- Remove any combustibles, such as a butane lighter or matches, from your pockets before cutting.
- Prepare the cutting area to reduce reflection and transmission of ultraviolet light:
- Paint walls and other surfaces with dark colours to reduce reflection.
- Use protective screens or barriers to protect others from flash and glare.
- Warn others not to watch the arc. Use placards or signs.

### Grounding Safety

#### Work Cable

Attach the work cable securely to the workpiece or the work table with good metal-to-metal contact. Do not connect it to the piece that will fall away when the cut is complete.

#### Work Table

Connect the work table to an earth ground, in accordance with appropriate national or local electrical codes.

#### Input Power

- Be sure to connect the power cord ground wire to the ground in the disconnect box.
- If installation of the plasma system involves connecting the power cord to the power supply, be sure to connect the power cord ground wire properly.
- Place the power cord's ground wire on the stud first, then place any other ground wires on top of the power cord ground. Fasten the retaining nut tightly.
- Tighten all electrical connections to avoid excessive heating.

## Compressed Gas Equipment Safety

- Never lubricate cylinder valves or regulators with oil or grease.
- Use only correct gas cylinders, regulators, hoses and fittings designed for the specific application.
- Maintain all compressed gas equipment and associated parts in good condition.
- Label and colour-code all gas hoses to identify the type of gas in each hose. Consult applicable national or local codes.

## Gas Cylinders Can Explode If Damaged

Gas cylinders contain gas under high pressure. If damaged, a cylinder can explode.

- Handle and use compressed gas cylinders in accordance with applicable national or local codes.
- Never use a cylinder that is not upright and secured in place.
- Keep the protective cap in place over valve except when the cylinder is in use or connected for use.
- Never allow electrical contact between the plasma arc and a cylinder.
- Never expose cylinders to excessive heat, sparks, slag or open flame.
- Never use a hammer, wrench or other tool to open a stuck cylinder valve.

## Noise Can Damage Hearing

Prolonged exposure to noise from cutting or gouging can damage hearing.

- Use approved ear protection when using plasma system.
- Warn others nearby about the noise hazard.

## Pacemaker and Hearing Aid Operation

Pacemaker and hearing aid operation can be affected by magnetic fields from high currents. Pacemaker and hearing aid wearers should consult a doctor before going near any plasma arc cutting and gouging operations.

To reduce magnetic field hazards:

- Keep both the work cable and the torch lead to one side, away from your body.
- Route the torch leads as close as possible to the work cable.
- Do not wrap or drape the torch lead or work cable around your body.
- Keep as far away from the power supply as possible.

## 4.0 Assembling Plasma Arc Cutting Equipment and Performing Cuts

### Key Learning Points

- Identify how to set up Plasma Arc equipment for cutting
- Identify different Plasma Arc set-ups and complete plasma arc cutting process on different materials
- Location and use of electricity emergency stop button/s, gas shut off tap and fire extinguishers

### 4.1 Generic Set-Up Procedure for Plasma Arc Cutting

The following are generic instructions for the setting up of a Plasma Arc cutting equipment. As there are many different suppliers of Plasma Arc cutting equipment is not possible to provide a specific check list.

*Equipment, particularly composite power sources, varies considerably in their control arrangements and therefore it is important to verify that actual equipment used is set-up correctly.*

#### Always -

1. Comply with the prescribed safety precautions and fire-prevention procedure.
2. Check that all earthing leads are firmly connected to bench and power source.
3. Check that all connections to torch hose assembly are in good order.
4. Check that gas supply hoses are not 'kinked' or otherwise obstructed.
5. Check that power source is switched on.
6. Check that gas cylinder valves are open.
7. Check that the gas regulators are functioning properly.
8. Check that the torch is set-up correctly for the work to be undertaken.
9. Check that the consumables are correct and that they are in a clean and properly prepared condition.
10. Check that the gas flow is correctly set.
11. Check that the gas delay and gas purge times are correctly set when using composite power source.
12. Check that power supply unit is switched on.

## 4.2 Generic Settings for Plasma Arc Cutting

### Mode Switch



Use to cut expanded metal. Automatically reinitiates pilot.

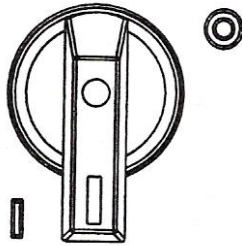


Use to cut plate/sheet metal. Optimum consumable life.



Use to gouge, or for non-transferred-arc operation.

### Power Switch



Position the power switch to ON (I) as shown.

### Check Indicator Lights



Check that the POWER ON lamp is illuminated.

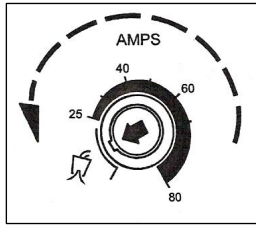


Check that the Gas Pressure LED is illuminated in Green.

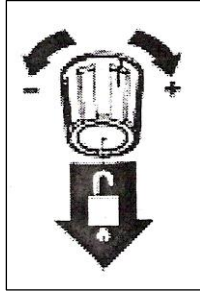


Check that the remaining indicator lamps are **NOT** illuminated.

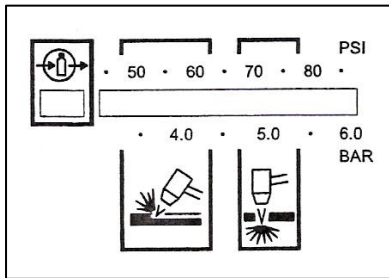
## Adjust Gas Pressure and Current Settings



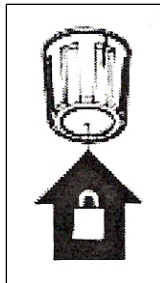
Set current knob to gas test



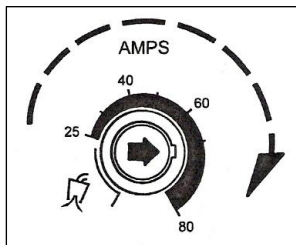
Pull regular knob to unlock



Set pressure: Cutting – 70-75 psig (4.8-5.2 bar), Gouging – 50-60 psig (3.4-4.1 bar)




Push regular knob to lock

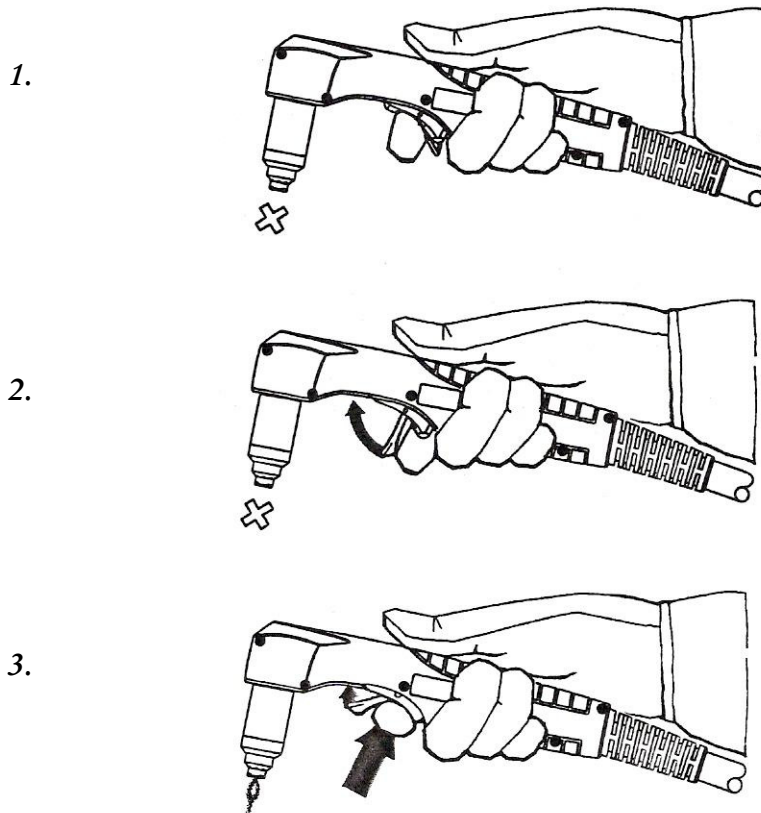



Turn current knob away from gas test to stop gas flow (25 amps minimum)

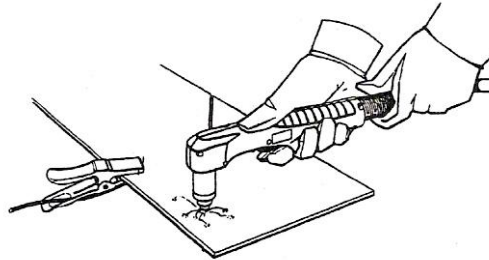
### 4.3 Operation of Hand Torch for Plasma Arc Cutting

	<p><b>WARNING</b>  <b>INSTANT-ON TORCHES</b>  <b>PLASMA ARC CAN CAUSE INJURY AND BURNS</b></p>
<p>Plasma arc comes on immediately when the torch switch is activated.          The plasma arc will quickly burn through gloves and skin.</p> <ul style="list-style-type: none"> <li>• Keep away from the torch tip.</li> <li>• Do not hold the workpiece, and keep your hands clear of the cutting path.</li> <li>• Never point the torch toward yourself or others.</li> <li>• Never use with Pendant Switch.</li> </ul>	

#### Safety Trigger Operation:



	<p><b>WARNING</b>                  SPARKS AND HOT METAL CAN INJURE                  EYES AND BURN SKIN</p>
<p>When firing the torch at an angle, sparks and hot metal will spray out from the nozzle. Point the torch away from yourself and others.</p>	

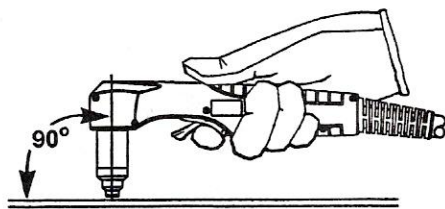


Attach the work clamp securely to the workpiece. Remove rust, paint or other coatings to ensure good electrical contact.

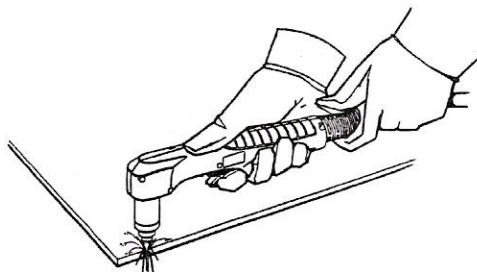
Attach the work clamp as close as possible to the area being cut, to reduce exposure to electromagnetic fields (EMF).

Do not attach the work clamp to the portion that will fall away.

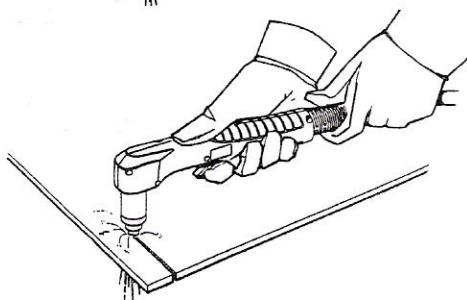
#### 4.4 Hand Torch Operation: Starting a Cut from the Edge of a Workpiece



Hold the torch nozzle vertical at the edge of the workpiece.



Start cutting from the edge of the workpiece. Pause at the edge until the arc has completely cut through the workpiece.



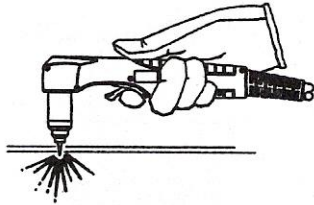
Then, proceed with the cut.



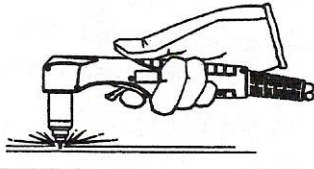
## 4.5 Hand Torch Operation: Manual Cutting Technique



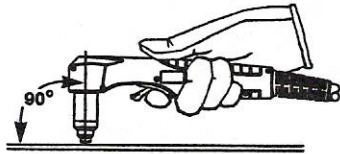
Firing the torch unnecessarily reduces nozzle and electrode life.



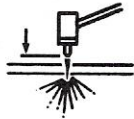
When cutting, make sure that sparks are exiting from the bottom of the workpiece.



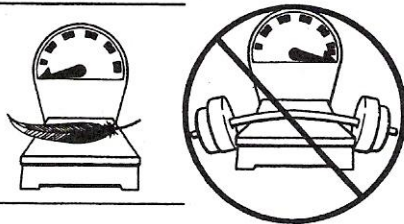
If the sparks are spraying up from the workpiece, you are moving the torch too fast, or without sufficient power.



Position the torch nozzle at a vertical position and watch the arc as it cuts along the line.



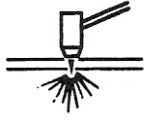
**Unshielded Consumables.** Maintain an approximate 1/8 inch (3 mm) torch-to-work distance.



**Shielded Consumables.** Do not push down on the torch when cutting. Lightly drag the torch across the workpiece to maintain a steady cut.

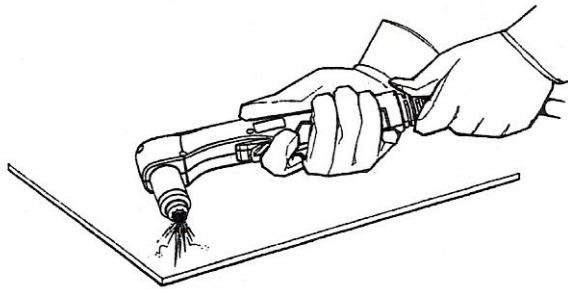
- Pulling the torch through the cut is easier than pushing it.
- To cut thin material, reduce the maps until you get the best quality cut.
- For straight-line cuts, use a straight edge as a guide. To cut circles, use a template or a Hypertherm circle cut guide, Part No. 027668.

## 4.6 Hand Torch Operation: Piercing Technique

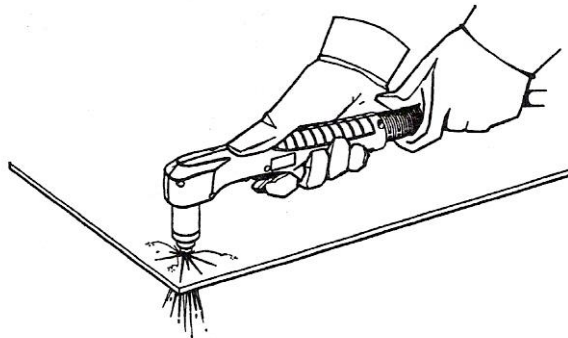


		<p><b>WARNING</b>                  SPARKS AND HOTMETAL CAN INJURE                  EYES AND BURN SKIN</p>
<p>When firing the torch at an angle, sparks and hot metal will spray out from the nozzle. Point the torch away from yourself and others.</p>		

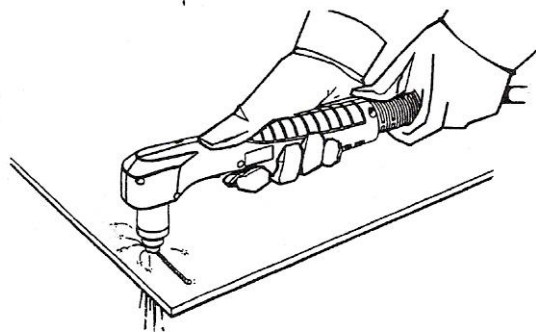
Hold the torch so that the nozzle is within 1/8 inch (3 mm) from the workpiece before firing the torch.



Fire the torch at an angle to the workpiece, and then slowly rotate it to an upright position.



When sparks are exiting from the bottom of the workpiece, the arc has pierced through the material.



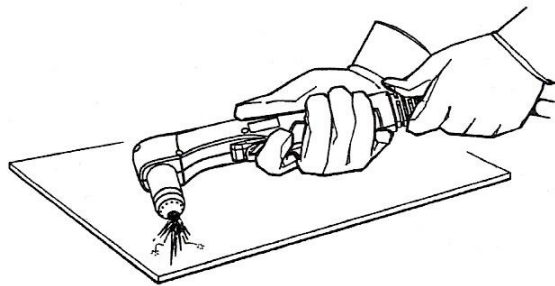
When the pierce is complete, proceed with the cut.

## 4.7 Hand Torch Operation: Gouging Technique

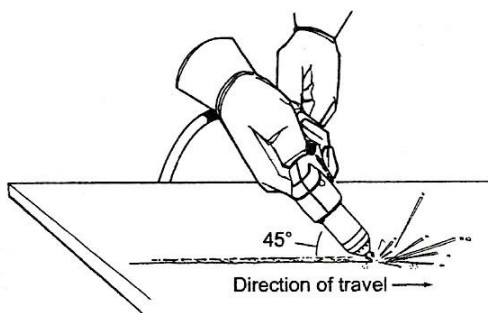


		<p><b>WARNING</b> SPARKS AND HOTMETAL CAN INJURE EYES AND BURN SKIN</p>
<p>When firing the torch at an angle, sparks and hot metal will spray out from the nozzle. Point the torch away from yourself and others.</p>		

Hold the torch so that the nozzle is within 1.5 mm from the workpiece before firing the torch.



Hold the torch at a 45 degree angle to the work piece. Pull the trigger to obtain a pilot arc. Transfer the arc to the work piece.



Maintain a 45° angle, approximately from the workpiece.

Feed into the gouge.

**Note:** A heat shield is available for added hand and torch protection.

## Exercises

- Assemble, adjust and operate Plasma arc cutting equipment to complete exercises listed below.
- Cut scrap mild steel, stainless steel and aluminium sheet freehand
- Cut mild steel, stainless steel and aluminium plate using cutting attachments – straight line and circular
- Read and interpret drawing related to Plasma arc cutting exercises
- Complete Plasma arc cutting exercises No. 2.2.7
- List the dangers/hazards and recommended safety precautions pertaining to Plasma arc cutting

## Additional Resources

Title	Author	Ref. Code
The Induction Book, “ <i>Code of Behaviour &amp; Health &amp; Safety Guidelines</i> ”	SOLAS	
Basic Welding and Fabrication	W Kenyon	ISBN 0-582-00536-L
Fundamentals of Fabrication and Welding Engineering	FJM Smith	ISBN 0-582-09799-1
<i>Workshop processes, practices and materials</i> , 3 <sup>rd</sup> edition, Elsevier Science & Technology	Black, Bruce J 2004	ISBN-13: 9780750660730
New Engineering Technology	Lawrence Smyth & Liam Hennessy	ISBN 086 1674480

### Videos:

- Understanding welding fumes
- Welder on Site...Be Aware (Vocam)
- Powered hand tool safety (Vocam)
- Industrial Ergonomics (Vocam)

Available from:

***Vocam Ireland***

***Circle Organisation Ltd***

***Friar Street, Thurles, Co Tipperary, Ireland***

***Tel: +353 504 24666***

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