MUREX

Saffire®

The Safe Use Of Oxy-Fuel Gas Equipment

Issue 4

GAS EQUIPMENT

The Safe Use of Oxy-Fuel Gas Equipment

ESAB Group (UK) Ltd

CONTENTS

INTRODUCTION

This booklet is published by ESAB Group (UK) Ltd as a companion to the Groups Gas Equipment Training Courses.

Written by Mike Williams and David Fell the booklet covers the course material used on the Sales Representatives Training Course, the Internal Sales Staff Training Course and forms the notes for the Accredited Gas Inspectors Scheme.

The content focuses on the Safe Use of Oxy-Fuel Gas Equipment but includes essential guidance on Legislation, Standards and Codes of Industrial Practice.

Although primarily aimed at ESAB Group Trainees it is believed the booklet will be an important reference document for managers and supervisors involved with Gas Equipment and provide good support material for welding students.

The references quoted are accurate at the date of printing but may change with legislative changes.

Published January 1998
Revised January 2000
Revised April 2004
Revised February 2006

CHAPTER ONE

LEGISLATION, STANDARDS AND CODES OF PRACTICE

LEGISLATION, STANDARDS & CODES OF PRACTICE

Those responsible for the purchase and use of Gas welding and cutting equipment should be aware of the current legislation and other forms of relevant information available, to ensure that items are purchased, maintained and used to an acceptable standard to ensure the safety of the operator and those in the vicinity of the work area.

Although all will recognise the need to abide by current legislation, the question often arises as to the need to purchase and use equipment that meets a recognised standard.

The law does not insist that gas welding and cutting equipment meets either European or British standards. They are recommendations only and not compulsory.

However, when there is an incident which requires that the Health and Safety Inspectorate, or some other authority to be notified, questions may well be asked during the course of any enquiry, as to the suitability and condition of the equipment being used, the adequacy of the training received and details of the process being employed.

At such times, equipment that can not be proved to have been manufactured to a recognised standard, operatives who cannot give evidence that they have received adequate training, and means of operating which are outside accepted codes of practice, may well make both owners and operatives liable to conviction under one of the relevant pieces of current legislation such as the Health and Safety at Work Act or The Pressure Systems Safety Regulations.

Manufacturers, importers and suppliers have requirements under the Consumer Protection Act which covers not only complete items but component parts and instruction leaflets, to ensure that items they supply are not defective. A defective product is defined as *"one where the safety of the product is not such as persons generally are entitled to expect."*

It is strongly recommended therefore that equipment is purchased to the current British, European or other recognised standard, and that operatives receive training, employ processes and maintain equipment in line with those laid down in Codes of Practice issued by the Industry.

Following guidance given in these Codes of Practice will normally ensure that the requirements of the law are being met and will satisfy the relevant authorities that good working practices are being maintained.

The following are the major pieces of legislation and the current British and European Standards relevant to this industry.

LEGISLATION

Below is a list of the important Acts and Regulations which are most relevant to Gas Equipment. The list is not exhaustive but is a general guide.

Legislation

The Pressure Systems Safety Regulation 2000.
The Health and Safety at Work Act 1974.
The Explosives Act 1875 Compressed Acetylene Order 1947 (Certificate of Exemption No 2 1989).
The Consumer Protection Act 1987.
The Factories Act 1961.
Personal Protective Equipment Regulations 1992.
Manual Handling Operations Regulations 1992.
Control of Substances Hazardous to Health Regulations 1999
The Management of Health and Safety at work Regulations 1999.

BRITISH AND EUROPEAN STANDARDS

When a European Standard (EN) is published the British Standards Institute is obliged to withdraw from sales the equivalent British Standard (BS) and offer the harmonised EN Standard in its place.

The objective of common European Standards is to harmonise the content throughout the EEC. EN Standards issued in UK are prefixed BS EN.

Many International Standards (ISO) are now also harmonised to provide a more Global approach. When this is the case and the Standard is published in UK the document is designated BS EN ISO.

Below are the titles of the most important Standards for Gas Equipment.

British and European Standards

BS EN 560 & BS EN 1256 Specification for Hose Connections and Hose Assemblies for Equipment for Gas Welding, Cutting and Related Processes.

BS EN 559 Specification for Rubber Hoses for Gas Welding and Allied Processes.

BS EN 13918 Specification for Integrated Flowmeter Regulator for Welding, Cutting and Allied Processes.

BS EN 730 Part 1 and 2 Specification for Safety Devices for Fuel Gases and Oxygen or Compressed Air for Welding, Cutting and Related Processes.

BS EN ISO 5172 Specification for Hand Held Blowpipes Mixers and Nozzles, Using Fuel Gas and Oxygen for Welding, Cutting and Related Processes.

BS EN 562 Specification for Bourdon Tube Gauges used in Welding Cutting and Related Processes.

BS EN ISO 2503 Pressure Regulators Used in Welding, Cutting and Related Processes with Compressed Gases up to 300 bar.

A British Standard (BS) still applies for small welding kits and cylinder identification as there is no equivalent in Europe.

BS 6942 Parts 1 & 2 Design and Construction of Small Kits for Oxy-Fuel Gas Welding and Allied Processes.

Pt 1 Kits using the one or more non-refillable gas containers for oxygen and fuel gases.

Pt 2 Kits using refillable gas containers for Oxygen and fuel gas up to 20 litres.

CODES OF PRACTICE

The British Compressed Gases Association issues a wide range of Codes of Practice (CP) which give valuable technical and safety guidance for the use of compressed gases and equipment. Below is a list of the most commonly applied Codes for Gas Equipment.

Codes of Practice

BCGA GN 2 Safe Practice for the Storage of Gases in Transportable Cylinders Intended for Industrial Use : Revision 3 : 2005.

BCGA GN 3 Application of the Manual Handling Operations Regulations to Gas Cylinders Revision 1 : 2005

BCGA CP 4 Industrial Gas Cylinder Manifolds and Distribution Pipework/Pipelines (Excluding Acetylene) Revision 3 : 2005.

BCGA CP 5 The Design and Construction of Manifolds Using Acetylene Gas to a Maximum Working Pressure of 25 bar (362 lbf/1n^2) : Revision 1 : 1998.

BCGA CP 6 The Safe Distribution of Acetylene in the Pressure Range 0 to 1.5 bar (0-22lbf/In^2) : Revision 1 : 1998.

BCGA CP 7 The Safe Use of Oxy-Fuel Gas Equipment (individual portable or mobile cylinder supply) Revision 4 : 2004.

BCGA GN 7 The Safe Use of Individual Portable or Mobile Gas Supply Equipment Revision 1 : 2004.

BCGA CP 17 The Repair of Hand Held Blowpipes and Gas Regulators Used with Compressed Gases for Welding Cutting and Related Processes. Revision 2 : 2004.

BCGA 23 Application of the Pressure Systems and Transportable Gas Containers Regulations 1989 to Industrial and Medical Pressure Systems Installed at Consumer Premises : Revision 1 : 2002.

Note: This is not a complete listing of BCGA publications. A complete list showing the cost of each item is available from:

British Compressed Gases Association
6 St. Mary's Street
Wallingford
OX10 0EL

Tel: 0044 (0)1491 825533
Fax: 0044 (0)1491 826689
Website: www.bcga.co.uk
E-mail: enquires@bcga.co.uk

One Code is very widely used in the welding industry.

CP 7 - The Safe Use of Oxy-Fuel Gas Equipment (individual portable or mobile cylinder supply) Revision 4 : 2004.

Covers the minimum safety requirements for the use, inspection and maintenance of Oxy-Fuel gas equipment, using portable cylinders, with emphasis being given to the correct assembly, operation and maintenance of equipment in line with the requirements of the Pressure Systems Regulations.

The function and purpose of each piece of equipment is given with a glossary of terms.

Details of the minimum recommended safety devices to be used are listed and re-usable hose clips and non-spring activated non-return valves are condemned.

Specific action to be taken in case of certain emergencies is given.

MAINTENANCE RECOMMENDATIONS

The correct maintenance of equipment is an essential requirement for the safe use of Oxy-Fuel gas systems. Employees are required under the provisions of The Pressure Systems Safety Regulations and the Health and Safety at Work Act to ensure that equipment is maintained in a safe manner. In order to assist users to determine a suitable maintenance schedule for their equipment, the following table has been compiled. It is recommended that procedures outlined are carefully followed.

It is important that only equipment complying with National Standards be used and that persons employed to carry out the recommended Annual equipment checks are competent and qualified.

EQUIPMENT	RECOMMENDATIONS			
	BEFORE USING THE EQUIPMENT (Operators show check the general condition of their equipment at initial start up to ensure it is undamaged and leak free). *	ANNUAL INSPECTION A annual detailed inspection should be conducted by a Murex/City & Guilds Accredited Gas Inspector with a current registration certificate. **	REPLACEMENT INTERVAL Replacement is influenced by the type and severity of use. Below are the officially recognised replacement intervals.	RECOMMENDATIONS Below are the recognised guidelines for the replacement of equipment found to be defective in service or by inspection.
PRESSURE REGULATORS	Check suitability for service, gas, pressure rating, any sign of damage, condition of threads and seals. Freedom from oil or grease. Leak check all joints at operational pressure using leak detection fluid.	Functional tests to ensure the correct function of the internal components and protective devices.	Elastomeric components deteriorate over time. Regulators should be replaced after 5 years in service or to a timescale issued by the manufacturer.	Replace with a new or Original Manufactures Service Exchange unit. Never replace with a repaired item.
FLASHBACK ARRESTORS	As above. Check for gas type, pressure rating. condition of threads and sealing faces. Check for freedom from oil contamination. Leak check all joints at operational pressure using leak detection fluid.	Test the units in reverse flow to ensure the cut off valves operate correctly. For pressure sensitive reset types flow in the normal direction with cut off valve tripped.	5 year or manufacturers instructions as above.	Replace with a new or Original Manufactures Service Exchange unit. Never replace with a repaired item.
HOME ASSEMBLIES	Visually examine to determine suitability for service. Check gas, pressure rating, condition of the cover ie freedom from cuts and abrasions. Check threads and sealing faces for damage. Leak check all joints at operational pressure using leak detection fluid.	Check the correct function of the hose check valves by reverse flowing the hose. Check the integrity of the hose cover to ensure no reinforcement is visible.	The replacement of hoses and assemblies can only be determined by local conditions. If the products are in aggressive working environments they could need replacement more frequently due to damage.	Replace with an Original Manufactures Hose Assembly tested in accordance with BS EN 1256 "Hose Assemblies".
BLOWPIPES & CUTTERS	Visually check the nozzle and head seats for damage. Check gas inlet threads for damage. Leak test all joints.	Test all valve functions. Blank off all exits and leak test for internal malfunction.	As above, the products should be replaced if they are physically damaged or worn.	Replace with a new or Original Manufactures Service Exchange unit. Never replace with a repaired item.

* These checks should be conducted daily

** Elastomeric components and seals will wear and deteriorate in service or when stored. Items stored for 1 year or more without use must be receive an annual inspection.
The annual inspection should be carried out by a qualified Inspector accredited to the Murex/City & Guilds Oxy-Fuel Gas Inspectors Register with current certification.

MUREX

CHAPTER TWO

CYLINDERS AND GASES

CYLINDERS AND GASES

Cylinders

All cylinders contain gas under pressure, and are sealed with a valve which must not be removed or tampered with in any way.

Gas is released from the cylinder by turning the spindle with an appropriate key, anti-clockwise, or if a handwheel operated valve by turning this wheel anti-clockwise. Never rotate the spindle to its fullest extent so that it can no longer be turned, as there is the danger that it will become jammed in this position, and could cause problems if it needed to be closed quickly in an emergency.

Cylinders must bear a label giving the gas they contain, the owner of the cylinder, who is responsible for it's maintenance, and the maximum pressure to which the cylinder may be filled.

These labels may also give an indication of the amount of gas contained and be colour coded to give identification at a distance of the maximum filling pressure.

Cylinders are colour coded to a recognised standard to identify their contents, and this is given on the back cover.

Individuals handling cylinder gases should be made aware of the properties of the gases they are handling and any associated hazards, safety precautions and action to be taken in case of emergency.

The moving of cylinders comes under the Manual Handling Operations Regulations, 1992, which require that an assessment is made of the operation, training given, and where possible mechanical aids employed. Careful consideration should be given as to the choice of a trolley employed to move cylinders, as it becomes very difficult to control a trolley where the cylinders are being transported at an angle over sloping or uneven ground.

Trollies are available which enable transportation with the cylinders remaining in an upright position and meet the requirements of the above regulations.

Many accidents occur due to falling cylinders, which may amount to loss of work due to strains etc, or far more seriously, the release of stored energy in an uncontrolled manner.

If a cylinder begins to fall, do not attempt to stop it - get out of the way. If it is thought that the valve may have been damaged in the fall, then contact the gas supplier.

Cylinders may be churned for short distances by staff who have received training in this operation. Clean gloves should be worn for this; in no way must oil or grease be allowed to come into contact with Oxygen or other oxidants. Feet should also be protected by use of approved footwear.

Unless specifically stated by the cylinder owner that it is suitable, valve guards or protection caps should not be employed for lifting cylinders.

Adequate supplies of water for extinguishing fire should be available in any area where cylinders are being handled or used.

Cylinders must not be subjected to excessive shock, ie. being kicked off the tailboard of a vehicle. This can cause damage to the valve or even cause decomposition in Acetylene cylinders with the possible disastrous consequence of a cylinder explosion.

Never transfer gas from cylinder to cylinder (decanting) or attempt to increase draw off rates by heating cylinders.

If gas flow is insufficient then cylinders should be coupled together using approved couplers and valves.

When transporting cylinders on a trolley, make sure they are upright, secure and the valves closed.

If it is found necessary to move cylinders without the aid of a trolley specifically designed for that purpose, all downstream equipment should be removed after first closing the cylinder valve and releasing the gas from the equipment by opening and closing all down stream valves.

When using cylinders, a means of shutting off the gas should be available for each cylinder. ie, if a key operated cylinder, a cylinder key should remain on the spindle during the time that it is open.

All cylinders open by turning the spindle or handwheel anti-clockwise.

Cylinders must never be left unsupported. When a cylinder trolley is not being employed, suitable stands complete with chains should be used. Note it is a requirement of the **Explosives Act 1875 (Exemptions) Regulations 1979 - Certificate of Exemption No. 2 1989**, that Acetylene cylinders are to be fully protected from impact or friction, and guards or barriers are to be provided to ensure this.

When cylinders are empty, the valves should be closed, and the cylinder removed to a location specifically marked only for that type of empty cylinder. Different gases must not be mixed, and full and empty cylinders must not be mixed. Cylinders should be marked in chalk “MT”.

The “Full” and “Empty” locations should be so marked.

Gases

Users of Industrial Gases should obtain from their supplies the relevant data sheets, which will give information about the gas and safety instructions on their use. A summary of the most commonly used gases is given overleaf.

Oxygen

A colourless gas which has no natural odour, (although in certain situations this is added). It is non-toxic.

Although non-flammable of itself, it is normally required for something to burn. It is essential for life.

Oxygen enrichment

The air we breath contains 21% Oxygen by volume and items will burn in a controlled manner at this level. However, if this percentage increases by say 5%, then the nature of the burning changes significantly. Instead of the burning taking place in only one area and advancing in a controlled manner, flames can break forth anywhere over the combustible material and the burning is fierce and uncontrolled.

Items which do not normally ignite in air can ignite where the percentage of Oxygen is greater than the 21%, and the greater the percentage of Oxygen the more fierce the burning and the more difficult it is to extinguish the flame.

At 50% Oxygen in air the combustion level is more than ten times normal and is almost impossible to extinguish.

The danger of Oxygen enrichment is greatest in enclosed areas or where there is no air circulating, but even in the open air it is possible for clothing to be “soaked” in Oxygen which will then burn fiercely, where under normal conditions it would only smoulder and go out.

If it is suspected that clothing has become impregnated with Oxygen, then it should be removed and taken into fresh air for approximately 5 minutes.

Oxygen must never be used for cleaning clothing, or sweetening the atmosphere. It must not be used in place of compressed air or nitrogen, say to power air tools or for purging purposes.

Smoking must be totally banned where Oxygen is being used.

Oils, greases and some tarry substances can explode if subjected to Oxygen at high pressure, while some plastics will self-ignite.

All equipment used in Oxygen must be compatible with it’s use.

Copper, brass, bronze, monel and stainless steel are generally accepted as safe to be used in Oxygen at pressure if “oxygen clean”.

Oxygen enrichment can be caused by using too high pressures while cutting, as the cutting oxygen stream is not fully consumed. This is not normally a problem with hand cutting, particularly if this is performed in a well ventilated area.

However, flame gouging or use of a six headed cutting machine in an area with poor ventilation can increase the Oxygen to dangerous levels.

Leakage of Oxygen from poorly maintained equipment or from valves which have not been fully shut, are the most common causes of enrichment.

Oxygen depletion

In certain conditions where welding or heating is being carried out it is possible to deplete the amount of Oxygen in the atmosphere to below the normal 21%.

However, the most common reason for Oxygen depletion is the feeding into the atmosphere of an inert gas. Nitrogen is commonly used for purging vessels, and if it is fed into a restricted area it will displace the oxygen.
If Oxygen levels fall to about 16% it will begin to effect the body and the normal warning systems will prove unreliable. Sometimes individuals have a positive sense of well-being in these conditions, but symptoms vary greatly. At levels of 12% there is the possibility of fainting without any other warning. Levels lower than this are likely to cause permanent brain damage or death.

It must be remembered that Oxygen depletion cannot be distinguished by our senses, and it will result in a loss of mental alertness and distortion of our capabilities to effectively judge the situation.

It is recommended that where personnel have to enter a vessel that has been purged with an inert gas, or where work is being performed which may cause Oxygen depletion, a second person with the means of obtaining help be stationed outside of the vessel, but always in view of the operator.

This second person should be equipped with the means of removing the operator without entering the danger area themselves. If the operator is working below the person watching, it will be necessary for some form of harness to be worn by the operator, and a method of lifting be available.

The gas supply must be outside of the vessel so that the second person can control it.

Acetylene

Is lighter than air, and has a distinctive garlic odour. It is colourless and not poisonous. In high concentrations it could be an asphyxiant by depleting the Oxygen level. It is highly flammable and ignites very easily in air, or when mixed with oxygen.

It is flammable with as little as 2.5% to 81% in air by volume. Contact with hot metal or a spark will ignite it.

It is held dissolved in acetone supported in a porous mass.

Cylinders must always be stored and used upright, as acetone will be drawn off cylinders that are horizontal or have been in a horizontal position. If cylinders have inadvertently been placed horizontally, they should be restored to an upright position and not used for at least 30 minutes.

Drawing acetone from an Acetylene cylinder will ruin weld quality as well as doing considerable damage to rubber components within the regulator such as valves, seals and diaphragms.

Acetylene should never be allowed to stand in vessels or pipes containing 70% or more of copper or 43% of silver as it will cause an explosive reaction with these materials.

Some processes may require the manifolding of cylinders if the draw off rates are high. ie cutting in excess of 150mm, welding above 10mm, and all gouging, flame cleaning or heating operations.

As an approximate guide the maximum draw off rates should be restricted to:

Work place temperature	Max draw off in Cu.Ft/hr.
20°C (68°f)	35
15°C (59°f)	25
0°C (32°f)	15
-10°C (14°f)	10

Although Acetylene has proved to be very safe in use, it is officially an explosive under the terms of The Explosives Act 1875. It is potentially unstable and may decompose violently in the absence of air or Oxygen if subjected to shock or high temperature.

Use of Acetylene at pressures from .62bar (8.82 lbf/in2) to 1.5 bar (21.23 lbf/in2) is subject to the requirements of the Certificate of Exemption No.2 1989. Details are available from your Gas supplier.

Although Acetylene is a more expensive fuel gas than propane it is only one element in the cost of cutting, cleaning or joining metals. Because of it's higher flame temperature, labour costs are normally lower using Acetylene as the fuel gas. Savings will also be made in cylinder handling and rental.

The reduction in the amount of Oxygen required for Oxy/Acetylene as against Oxy/Propane also needs to be taken into account when arriving at a cost for any specific application.

In some countries, where cylinder gas is difficult to obtain Acetylene may be generated from calcium carbide and water. However, the pressure of generated Acetylene is so low, that it can only be used at the generator, and it is not possible to install normal safety devices such as flashback arrestors or non-return valves into the system.

Propane

Is heavier than air, and has a sweet, fish like odour added for identification. It is colourless, flammable but non-toxic. In high concentrations it could be an asphyxiant by depleting the Oxygen level. It will ignite if in contact with hot plate or sparks. Because of it's density (1.55 at 20°C, where air = 1) it will drain into ducts, drains, trenches etc. This makes it a high fire and explosion hazard, as a spark or cigarette end falling into a pocket of as little as 2% Propane in air will readily ignite.

Cylinders contain both gas and liquid, and the conversion to gas depends on the temperature of the cylinder. Therefore the gas pressure obtainable from the cylinder will depend on the ambient temperature. For this reason, Propane regulators are not normally fitted with a contents pressure gauge, as the pressure of the gas does not indicate how much gas is in the cylinder. The only way to estimate contents is to weigh the cylinder. Nett and tare weights are indicated on each cylinder for this purpose.

If the ambient temperature is very low, it may not be possible to obtain gas from the cylinder as it will remain in liquid form. On no account should the cylinder be heated by means of flame or electrical source. It is acceptable to warm water and heat the cylinder valve with hot rags.

If gas is flowing, but freezes as the draw off rate increases it will be necessary to couple cylinders together. Connecting arms should be made of steel.

Propane cylinders are fitted with an over pressure release device. It is essential for this to function, that the cylinder is not laid down.

The normal vapour pressure of propane is 8.0 bar at 21°C.

Breathing pure propane is very dangerous, causing immediate loss of consciousness and will normally result in loss of life.

Liquid Propane can cause severe frost bite, and gloves should always be worn.

Hydrogen

Much lighter than air, non-toxic and has no colour or smell.

Highly flammable, and burns with a flame which is so clean it can be very difficult to detect. It is not uncommon for operatives to place their hands through a hydrogen flame not recognising its existence.

Because it is so light it will collect in roof spaces and care needs to be taken in provision of safe lighting where this is a possibility. High point ventilation should be available. Forced ventilation must be intrinsically safe and properly earthed.

Hydrogen should never be released to atmosphere to clean the valve outlet (snifting) as it can self ignite.

Because of its high flammability, it is very easily ignited by contact with hot metal, sparks, electrical discharge of static electricity or even two metals impacting.

Hydrogen flames, particularly from a high pressure source are very difficult to extinguish, and the only sure method is to terminate the supply.

The flammable range is 4% to 75% in air by volume.

Due to the thinness of the gas, particular care must be taken with fittings and seals. Hydrogen can seep through many porous materials which would be satisfactory for use with other fuel gases.

Pressure testing with air is not satisfactory to ensure the system is leak tight, and a gas with a similar density, such as Helium should be used.

Certain steels are subject to attack or embrittlement in Hydrogen, and regulators and down stream fittings should be checked with the manufacturer to ensure that they are safe for use with this gas.

Small users of Hydrogen, such as Goldsmiths, jewellers and dental repairers may generate Hydrogen electrolytically. Because of the hazards mentioned above, it is not normally used now for welding, cutting or heating processes. However, those requiring a carbon free clean flame, may still be obliged to use this fuel gas.

Hydrogen must never be used for filling balloons.

Other fuel gases

Methane, Natural Gas and other methyl-acetylene, propadiene mixtures are sometimes available. Apart from Natural Gas at low pressure, their use, however, is minimum.

Gas	Formula	Density (air = 1)	Cylinder colour	Outlet connection. 5/8”BSPCone recess
Oxygen	O_2	1.10	Black	Right Hand
Acetylene	C_2H_2	0.91	Maroon	Left Hand
Propane	C_3H_8	1.55	Red	Left Hand
Hydrogen	H_2	0.07	Red	Left Hand

CHAPTER THREE

PRESSURE REGULATORS

PRESSURE REGULATORS

A pressure regulator is a device which will accept gas at a higher pressure than required, (and can be variable) and reduces it to a lower, controllable outlet pressure, which is kept reasonably constant. It will also react to pressure build up down stream to ensure that hoses are not subject to over-pressurisation if valves are closed or there is any unplanned restriction of gas flow.

Outlet pressure may be adjustable or preset depending on the regulator.

There are two types of pressure regulator available:

1) Direct acting

The inlet pressure of gas forces the valve to open.

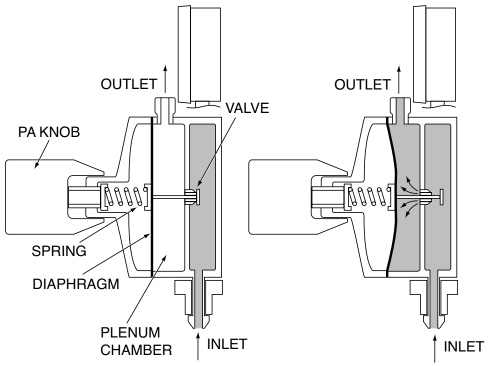
The regulator adjusting mechanism may be prefixed giving a reasonably constant gas flow, or may be adjustable by means of a knob, which sets the position of the valve relative to the inlet pressure and outlet pressure required. Direct acting regulators are only suitable for control of gas at very low pressures, and are used with natural gas or low pressure propane equipment. They are not suitable for welding, cutting or heating processes but are commonly used in caravan and camping applications.

2) Indirect acting

The inlet pressure forces the valve against the seat, and seals the gas passage. On better regulators this action is reinforced with a compensating spring.

INDIRECT ACTING REGULATOR

How does a regulator work?



Closed position **Gas flowing**

To allow gas to flow, the inlet gas pressure has to be overcome, and this is achieved by exerting pressure on the valve, via a pin, rubber membrane, spring and screw, by turning a pressure adjusting knob.

This allows gas to enter the plenum chamber past the control valve.

The smaller the gap between the valve seat and the valve, the less gas will feed into the plenum chamber, the more room it has to expand and the greater will be the pressure drop. The more pressure exerted on the valve (by turning the knob) the further the valve will move from the seat, and the greater the amount of gas that will feed into the chamber, the less room for expansion, and therefore the higher the outlet pressure.

In this way it will be seen that the outlet pressure from the regulator is fully controllable.

However, a regulator not only controls the pressure of gas flowing through it from the cylinder, it also controls the pressure of gas downstream of it. This is achieved by one wall of the plenum chamber being flexible and coupled to the valve by a pin.

This flexible membrane is known as the diaphragm.

If the pressure of gas down stream of the regulator increases to an amount in excess of that set by the operator via the pressure adjusting knob, (this would occur if the gas flow were restricted - say by a truck crushing the outlet hose), then the diaphragm would move away from the valve seat and against the adjusting spring.*

The inlet pressure of gas will force the valve against the seat and stop any further flow of gas into the plenum chamber. The movement of the diaphragm will also increase the size of the chamber allowing the gas in it to expand and reduce in pressure.

Once the down-stream pressure is at that set by the operator, the diaphragm will move and force the valve to open, restoring the flow of gas through the regulator.

A state of equilibrium between the pressure being exerted via the pressure adjusting knob on the valve, and the incoming gas from the cylinder, is controlled by the constant flexing of the diaphragm and the consequent adjusting of the valve.

The larger the flexible area of the diaphragm the more sensitive it will be to pressure changes and the more constant will be the outlet pressure.

Some older style regulators were fitted with removable adjusting knobs. These proved to be dangerous in that it was possible to change knobs between regulators thereby fitting them to regulators with which they had not been calibrated.

In extreme cases, it was possible to over-pressurise the adjusting spring so that they would go solid and allow no movement of the diaphragm when there was a build up of pressure down-stream of the regulator.

This, in effect, made the regulator inoperative.

Regulators, where there is a possibility of this occurring do not meet European or British standards.

Preset regulators (fixed pressure)

The above describes a regulator, where the outlet pressure is determined within a set range by the operator.

Regulators are also available, which have been preset at time of manufacture, which ensure that a reasonably constant pressure of gas is always being delivered with no ability for the operator to increase or reduce it. It is often a requirement with this type of regulator that an additional form of flow control is employed down stream of the regulator. This is the case with TIG regulators and a flowmeter.

Because the pressure adjusting screw is set to always deliver gas, the regulator cannot be turned off. Care, therefore needs to be taken when turning on the gas at the cylinder valve, that the gas is slowly and progressively fed to the regulator. If the valve were to be opened too quickly, it would be possible to obtain a blast of gas through to the plenum chamber which could damage the regulator.

Pipeline regulators

Although the method of gas control through a pipeline regulator is similar to that described above, there are certain differences.

These regulators are designed to receive gas at a much lower inlet pressure than those designed for connection to a cylinder. Some cylinder regulators will be designed to receive inlet pressures up to 300 bar (4350 lbf/in^2) where a pipeline regulator for the same gas may well be designed to receive gas at a maximum inlet pressure of 14 bar (200 lbf/in^2).

As the down-stream equipment is likely to be the same, and therefore the flow of gas through the regulator needs also to be the same, it will be obvious that the regulator designed for pipeline use at lower inlet pressures will need to have passages passing through it which are much larger than in a cylinder regulator.

It is essential that pipeline regulators are only used on pipelines, and not modified to be fitted to cylinders.

Regulators manufactured in the UK have special inlet fittings for pipelines to ensure that this cannot occur. However, items manufactured in other countries do not always have this safety feature.

It is also strongly recommended, that cylinder regulators are not fitted to pipelines as the flow obtainable through them at the lower inlet pressures will be greatly reduced.

Single-stage versus Multi-stage

Indirect regulators can be further sub-divided into single-stage and multi-stage.

A multi-stage regulator is, in effect, two single-stage regulators employing the same body and connected in series.

The first stage is preset at the factory, to a pressure somewhat higher than the required maximum outlet pressure from the regulator. ie, a regulator giving a maximum outlet pressure of 10 bar, may well have the first stage set at 16 bar. This is not critical, it simply takes the first major pressure reduction, therefore allowing the second reduction to be much smaller. This allows the use of seats that employ rubber elastomers which seal far better but which could not be used at current high inlet pressures.

The reduced outlet pressure from the first stage, therefore becomes the inlet pressure to the second stage.

Multi-stage regulators employ larger diaphragms on the second stage, which give them greater sensitivity to minor pressure changes. This makes them much more suitable for welding applications where flame control is all important.

As the second stage receives gas at a much lower pressure, the valve system is not only more sensitive, but also does not have to cope with the major pressure change necessary with a single-stage regulator. This ensures greater service life and less likelihood of freezing when flow rates are high.

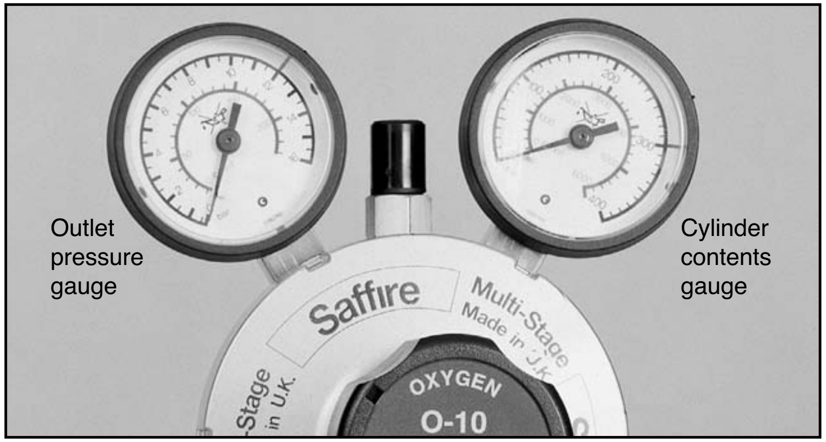
Pressure characteristics

We have already noted that the control of the outlet pressure from the regulator is determined by the operator turning the pressure adjusting knob to overcome the pressure being exerted by the incoming gas and, if fitted, the compensating spring.

We have also seen that gas expands to fill the space into which it is fed and in doing so reduces in pressure.

Therefore, as gas is used, the remaining gas expands within the cylinder and the pressure is lowered.

The way the operator gauges the amount of gas in a cylinder which contains only gas (not liquid and gas, as in a Propane cylinder) is to read the contents gauge which records inlet (cylinder) pressure.



Because the valve system has been set to overcome the inlet pressure, at the commencement of the operation as the gas in the cylinder is used and the pressure is therefore reduced, the valve has less pressure to overcome, and will progressively open further and further. This, in turn, allows a greater quantity of gas to feed through to the plenum chamber, and because it has less room to expand, will be at a higher pressure than originally set by the operator.

This process is known as a rising pressure characteristic.

In effect this means that a single-stage regulator is not a fully automatic device, as it will require constant adjustment by turning the adjusting knob anti-clockwise to give a constant outlet pressure.

If the interval between re-adjustment is small, then this will not be a problem to the operator. Some processes are not so pressure critical and these also will not be adversely effected by small increasing outlet pressure changes.

Multi-stage regulators have been designed to overcome this problem. Because they have two diaphragms and two valve systems working in series, both controlling the pressure of gas both up and down-stream of

them, the gas being fed to the second stage of the regulator is kept at a constant pressure and is not affected by the decrease in cylinder pressure, this having been ironed out by the first stage.

Multi-stage regulators are therefore a fully automatic device and will continue to deliver the outlet pressure set by the operator over the life of the cylinder, without any need for further adjustment.

To sum up then, the advantages of a multi-stage regulator over a single-stage are:

1) Fully automatic	a constant outlet pressure without need of adjustment over the life of the cylinder.
2) Sensitive control	Due to constant inlet pressure, and use of rubber sealing control valves and a large rubber diaphragm on the second stage.
3) Longer reliable service life	Valve system controls a much smaller pressure range.
4) Less tendency to freezing	At high flow rates, or where water vapour is entrapped in the gas stream.

All multi-stage regulators use rubber diaphragms on the second stage, and most use stainless steel on the first.

Choice of regulator

As a general rule, single-stage regulators will prove satisfactory for all cutting, and heating operations. Multi-stage is to be preferred for welding or laboratory work where sensitive control of the gas is a requirement.

In welding with injector equipment, where the injector controls the flow of gas to the flame, single-stage regulators will normally be found to be adequate.

Single-Stage Regulator

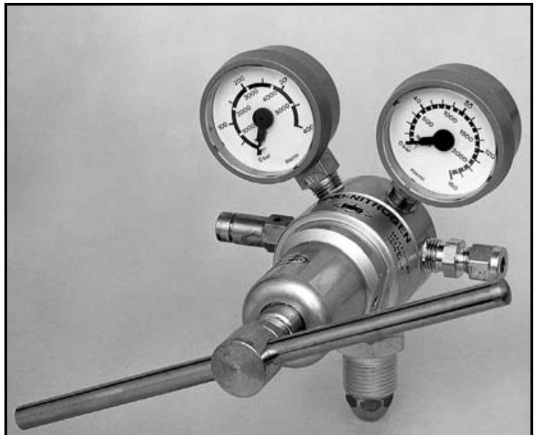
Multi-Stage Regulator

Both single-stage and multi-stage regulators are available for high pressure and high flow duties.

Flow rates of 175m $^3/h$ (6200 ft $^3/h$) are obtainable with special multi-stage regulators, while flows of 247m $^3/h$ (8739 ft $^3/h$) can be achieved with single-stage indirect acting regulators.

These regulators have standard 5/8" BSP inlet fittings, but the single-stage models are provided with adaptors for use with pipelines. Outlets are standard 3/8" BSP.

High pressure regulators are available to give 170 bar (2500 lbf/ in 2). These also have 5/8" BSP inlets but are fitted with special outlet fittings for connecting to pipework.



High Pressure 170bar Regulator

Before purchasing regulators, advice should be sought as to the correct type and pressure range that should be employed, consistent with the maximum inlet and outlet pressures and the gas to be used.

There is no difference in the inlet fittings for regulators designed for use at a maximum inlet pressure of 200 bar or those designed for 300 bar. It is also possible to fit a fuel gas regulator designed for an inlet pressure of 7.4 bar to a Hydrogen cylinder filled to 200 bar.

Therefore, great care needs to be taken to ensure that the pressure marked on the cylinder is equal to or lower than the inlet pressure (service pressure) marked on the regulator.

These situations could prove dangerous, so if in doubt ask your equipment supplier to advise you.

Although many regulators are fitted with over pressure release devices, they are there to protect the regulator and not equipment down-stream of it.

Where users have a need to ensure that pressure released from the regulator is not higher than that intended by the operator, they need to fit supplementary safety devices upstream of the critical apparatus they wish to protect.

Because of the reaction of certain gases with different materials, it is essential that regulators are only used with the specific gas for which they are designated.

Although they may look similar externally, and some would suggest are only different with regard to a label change, there are a number of different materials used in gauges, diaphragms, valves, filters, seals etc.

It is never worth taking the risk that a regulator is suitable if it is not specifically marked for use with the gas it is intended to be used with.

Regulators are sensitive devices controlling potentially, dangerous gases, some of which are at very high pressures.

It is well worth taking the effort to ensure that the best product available is purchased, to give not only long, but safe service life.

Many, inferior copies of UK style regulators are being made available, and it is not easy for the uninitiated to recognise the difference between a cheap copy and a quality product.

Some clues as to the standard of internal components and manufacturing quality can be gauged by looking at the following:

Marking and labelling	Are cheap paper labels being used? Do they bear the current European standard?
Inlet Filters	Do they have a conical, sintered filter? Flat, or wire filters may restrict flow or allow foreign matter into the regulator.
Sealing of Inlet threads	Tapered threads, sealed with PTFE tape will have a tendency to work loose in service, giving high pressure leaks.
Gauge bodies	Pressed steel bodies will not stand up to the wear and tear experienced in many rugged work areas and will go rusty if left in the open air.
Back bonnets	Some imported regulators (multi-stage only) have been designed for use in (multi-stage only) markets where the maximum inlet pressure is only 200 bar. At inlet pressures up to 300 bar, brass bonnets are much safer.
Size of Bonnet	Will often give an indication of the size of the diaphragm being used. The larger the diaphragm, the more sensitive the control obtainable.

Potential buyers would also be wise to study any instruction manuals and advertising literature issued with the product.

The Health and Safety at Work Act 1974 states that Manufactures, Importers and Suppliers are to **take such steps as are necessary to secure that persons supplied by that person with the article are provided with adequate information about the use for which the article is designed or has been tested and about any conditions necessary to ensure that it will be safe and without risk to health.**

It will not be difficult for the buyer, taking the trouble to read such information, to determine if it is adequate and thereby make a reasonable decision as to the manufactures ability to produce a product suitable for the purpose for which it has been sold.

By comparing different manufactures advertising literature, it can often be determined by what they have not said, (which is of equal importance as to what they have said) as to the real quality of their product. ie do they claim that their product meets any relevant standards? What features has one product over another? Is it likely to be a benefit to you?

Gauges and indicators

The number of gauges fitted to a regulator is no indication as to whether it is a single or multi-stage regulator.

Single-Stage Single Gauge | Single-Stage Indicator | Multi-Stage Two Gauge

Regulators fitted with only one gauge, normally record on that gauge the inlet (cylinder) pressure. The outlet pressure may be fixed at time of manufacture, or there may be a crude method of estimating outlet pressure

by aligning the end of the pressure adjusting knob with marks on the regulator bonnet. However, where a propane regulator is fitted with one gauge, it is likely to record the outlet pressure; as has already been indicated, propane cylinder pressures are dependent on the ambient temperature and not the contents of the cylinder.

Pipeline regulators will also be fitted with only one gauge which will record the outlet pressure, as the inlet pressure is likely to remain constant and will be recorded as an outlet pressure on the system master control regulator.

Most regulators are now fitted with two gauges; one indicating cylinder contents pressure and the other the outlet pressure set by the operator via the pressure adjusting knob. This is so whether they are single-stage or multi-stage.

Pressure indicated is above atmospheric pressure, and is normally indicated in bar and lbf/in^2.

(1 bar = 14.5 lbf/in^2)

Gaugeless Regulator

Pressure Indicator

Regulators employed in rugged situations where gauges are unlikely to withstand the type of knocks which are unavoidable in these environments, may be fitted with a crude piston indicator to identify approximate cylinder contents.

Gauges are manufactured to be employed with specific gases, and it can prove dangerous to fit a gauge to a regulator for a gas for which it was not manufactured.

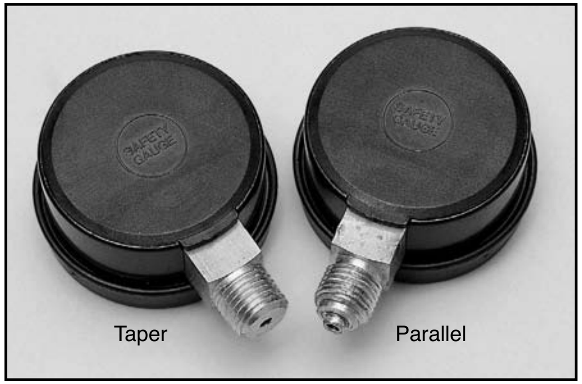
Gauges used on Oxygen or Acetylene regulators must indicate these gases.

Regulators are now being fitted with 1/4 g parallel threaded gauges to meet new European standards.

For many years UK manufactures have employed gauges with a 1/4 NPT tapered thread, and for a considerable period we are likely to see these in the market.

It is essential that these gauges are not incorrectly matched with the body when replacing a gauge.

All NPT gauges are marked on the square body of the gauge stem "NPT".



SPECIAL PURPOSE REGULATORS

Fluid loaded regulators

In an indirect acting regulator, the pressure decreases as the flow increases.

This is due to the inadequacy of the spring employed to continue to maintain a constant load on the non-gas side of the diaphragm.

With the comparatively small flows required through regulators used for welding and cutting processes this does not cause a problem.

However, if high flows are involved, where pressure increases are not acceptable, a fluid loaded regulator will be required.

Although they are, in effect, single-stage regulators, they employ two diaphragms and two valve systems.

When the gas is fed into the upper chamber of the regulator it exerts a force onto the other side of the main diaphragm which then opens the valve in the lower chamber. This allows gas to flow into this chamber and ensures the diaphragm has pressure subjected to both sides of it.

The gas between the diaphragm in the upper chamber and the diaphragm in the lower chamber remains at a constant pressure and ensures, even when there are large flows of gas, a constant outlet pressure is maintained.

Fluid loaded regulators are available which allow flow rates in excess of 450 m^3/h (16000 ft^3/h) with acceptable pressure variations.

CHAPTER FOUR

SAFETY DEVICES

SAFETY DEVICES

While the risks to personnel and property can be greatly reduced by the use of well manufactured and maintained equipment and the training and supervision of the operatives using it, it should be recognised that mishaps cannot be entirely avoided and the following information is given to reduce the risk of fire and explosion in hoses and equipment which could spread to the gas container.

The flame condition we need to achieve for both welding and cutting will be obtained when the quantity and velocity of the gas being fed through the system is equal to that required by the size and type of nozzle being employed. We will need to take into account :

1) Pressures set at the regulators
   Although manufactures give guidance figures, they can only be an approximation as working conditions, age and condition of equipment, length of hoses, etc will have a marked effect on the amount and velocity of gas fed to the nozzle.
2) Condition of the equipment
   Flashback arrestors which have heavily coated filters and hoses blocked with carbon or badly kinked will effect flow.
3) Length and diameter of hose
4) Condition of blowpipe and nozzle
5) The work being attempted
   For certain brazing operations a soft flame will be required, while heating or cutting will need far greater flows of gas.

Before reviewing the equipment and safety devices available, we should consider the four mishaps which can occur and how they can be minimised.

Snap-out

If the nozzle is inadvertently placed against the workpiece and the flame is inadvertently extinguished with a sharp crack, this condition is known as snap-out.

Although this is not dangerous in and of itself, we need to recognise that we will now be feeding mixed gases into the atmosphere and prompt action needs to be taken to turn off the flow of gas.

Where pressures are set too high and the flow of gas is too great for the size of nozzle being used, a gap will appear between the flame and the nozzle. If the flow is further increased, the pressure of the gas will similarly snap-out the flame.

Backfire

Where insufficient gas is being fed through to the flame it will seek more fuel by burning back into the nozzle. The official terminology is that the burning velocity of the flame is higher than the exit velocity of the gas.
A sharp crack will be heard and the flame will either extinguish or reignite at the tip.

A backfire is caused by an imbalance between the burning velocity of the nozzle used and the amount of gas being fed to it. There can be a number of reasons for this.

1) Regulator pressures incorrect.
2) Torch fine adjustment valves incorrectly adjusted.
3) Hoses kinked or crushed.
4) Cylinder contents low.
5) Blocked nozzle - spatter reducing the flow.
6) Too large a nozzle for the size of flame required.
7) Nozzle orifice bell ended.
8) Temperature of gases increased by working in restricted area.

Sustained backfire

When a backfire occurs, the explosion will normally go back to the point where the gases mix. If the explosion is very severe, enough heat can be generated to ignite the forward flowing gases. These are then likely to ignite, backfire and ignite again. This happens very rapidly, and can be detected by a sharp bang followed by a high pitched scream or whistle. Black smoke will often be emitted from the nozzle.

This is a very serious situation and must be stopped at once by starving the fire of Oxygen. Having turned the Oxygen valve on the torch off, followed by the fuel gas, the cylinders should also be closed. The torch should then be plunged into water, and then carefully inspected for damage. Enough heat may well have been generated to melt the nozzle, mixer or injector, and the “O” ring or plastic seals may have lost their sealing properties.

Flashback

A flashback is a backfire where so much energy has been generated that the explosion is forced back along one of the hoses until it either bursts or the pressure wave and flame meet the flame arresting element. If however, flashback arrestors have not been fitted there is a real risk of the explosion passing through the regulator to the gas reservoir, with possible fatal consequences.

The most common cause of a flashback is the presence of mixed gases in the hose at the time of lighting the torch. This situation will have arisen due to the backfeeding of gas at a higher pressure into the other hose which is at a lower pressure. Flashbacks are most common at the time of lighting the torch but they may also occur at other times of work.

If sufficient energy is generated by a backfire then the pressure and flame can be forced right through the system to the flashback arrestor.

The danger of flashback can be greatly reduced however by ensuring that no mixing of the gases is possible upstream of the mixer or injector. This is best done by following the correct lighting up procedure for the type of torch being used (this may differ with certain products) and purging the hoses fully before attempting to light the torch.

Non-return valves will ensure that gas cannot backfeed into the system, but will not stop the force generated by a flashback once it has occurred.

Equipment

Nozzles

The most important item and the one likely to cause most problems is the nozzle or tip, and yet it is the item that tends to get the least attention.

The backfire resistance of different manufactures nozzles varies greatly, and the design and maintenance of the channels through the nozzle are all important.

Only the correct size reamer should be used to clean a nozzle and then it is important that it is inserted and withdrawn in a straight line. The exit passages must remain at 90^{o} to the face of the nozzle, and if the corners are removed forming a bell end the nozzle will be prone to backfire. The seating of the nozzle into the cutting head or mixer is also important. Damage in these areas may cause cross leaks between the seating faces or they may draw air into the gas stream increasing the burning velocity of the flame and make it liable to backfire.

Spatter adhering to the face of the nozzle will cause turbulence and may reduce gas flow, both of which will upset the balance of the flame and cause it to backfire.

Only nozzles recommended by the torch manufacturer for use with the equipment should be used as there are differences in the seating arrangements between products.

Blowpipes

The method of mixing the gases within the system may change between different manufactures products. As a general rule, the less mixed gas within the system, the safer the operation is likely to be.

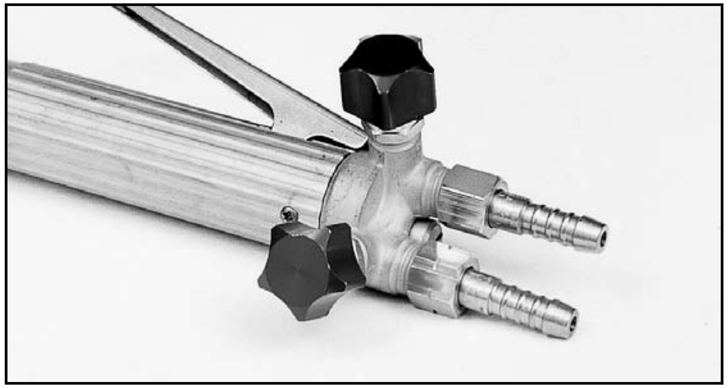
With nozzle-mix cutters, the amount of mixed gas is restricted to that found in the very small passages within the nozzle, and consequently backfiring is normally restricted to the nozzle and is of a minor nature. Even on the rare occasions when a backfire sustains, and the “mixer” is melted, it only requires the replacement of another “mixer” (the nozzle) to safely resume work.

Cutters using the injector principle may mix the gas in a special head or in the body of the cutter. Although less mixed gas is available with head mixing injectors, they tend to be top heavy and cause operator fatigue in use.

In welding and heating blowpipes the gases are mixed either by entrainment through an injector where the Oxygen is fed at high pressure through a venturi and sucks the fuel gas in to the throat of the injector where the gases mix, or through a specially designed gas mixer. The amount of mixed gas in both systems is similar.

Non-return valves (Hose check valves)

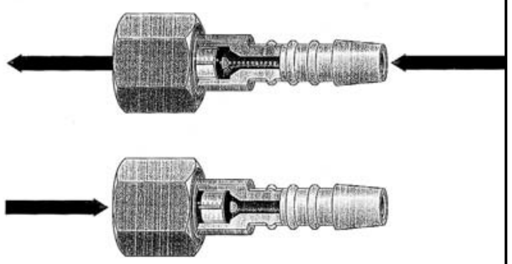
These are available to join the hose to the torch inlets or in some instances to join two lengths of hose. They can also be a component within a flashback arrestor. The closer they are to the flame the better, as their purpose is to ensure that gases cannot backfeed into the system causing a mixed gas situation in one of the hoses.



Their effectiveness varies from manufacturer to manufacturer. The original models were introduced in 1956 and were no more than a metal plate suspended within a small cylinder. The forward pressure of gas forced the plate into a position where gas could feed down-stream to the blowpipe. Any gas feeding in the opposite direction however, should have forced the plate back onto an internal seat and prevented any backfeeding of the gas upstream of the device. They proved to be ineffective as small volumes of gas at low pressure were insufficient to move the plate and thereby allowed the backfeeding that they were designed to eliminate.

Later models incorporated a spring and a more sophisticated sealing system.

Non-return valves will, by their very nature, need to be a compromise between soft springs, which allow the use of very small flows of gas but which may not seal effectively, and stronger springs which will always seal but restrict the use of the equipment if the pressure of gas is insufficient to open the valve in the first place.



Function of a hose check valve

There are British and European standards which cover non-return valves.

They need to be tested frequently as any foreign matter passing through the hose or carbon caused through a flashback, can lodge on the seating and make them ineffective.

Testing can be done by simply passing gas through the hose assembly in the opposite direction to normal and placing the end normally connected to the regulator into a bucket of water. If bubbles are evident the valve is not sealing.

Flashback arrestors

These can be torch or regulator mounted. The closer they are to the point where the gases mix the less damage the flashback is likely to cause. However, due to their size and complexity, it is not practical to fit any but the simplest of arrestors to the blowpipe inlets, and even then they tend to become blocked with carbon quite quickly. If arrestors are fitted into the hose and left lying on the floor they are liable to damage and so the majority of arrestors are, in fact, fitted to the regulator outlets.

These in turn can be grouped in to resettable and non-resettable models, although even then we have to be careful as some resettable models only cut off the gas supply if sufficient heat is generated to de-magnetise the reset mechanism. As little heat is evident with a flashback - it moves

too fast - these arrestors, in practical terms, function in a similar way to the non-resettable models.

The main function of a flashback arrestor is to extinguish the flamefront and ensure that it does not reach the cylinder or gas supply system. For this purpose they contain a sintered metal filter known as a flame arrestor, which allows the gas to flow through it but will extinguish any flame that comes in to contact with it. It must be designed to allow the maximum flow of gas possible, but be dense enough to ensure that it will always quench a flame front.

A. Flame arresting element

The weight, surface area and density of the arresting element give a good indication for how long the arrestor will effectively function. When one considers that some arresting elements are up to eight times heavier than others, and some have a surface area which is four times greater, it is evident that not all flashback arrestors are the same, or will give anything like the same service.

Other components found in some flashback arrestors are:

B. Pressure sensitive shut off valve

These are only available on the more sophisticated re-settable models. The pressure wave generated by the flashback causes this valve to close and stop the flow of gas downsteam of the arrestor. This ensures that no Oxygen or fuel gas can feed any fire in the hose, or pass across any heated surface within the equipment. This greatly reduces the possibility of a sustained backfire.

A visible means of indicating that a flashback has triggered the valve is also fitted.

C. Non-return valve

Again the more sophisticated models include a non-return valve upstream of the arresting element to ensure that hot gases passing into the arrestor cannot ignite any fuel gas passing through the arrestor.

G. Thermal Cut-out

This is activated when the heat-sensitive element reaches approximately 100ºC and cuts off the supply of gas ensuring that any fire is not fed with Oxygen or fuel gas. Some heat sensitive devices are so sensitive that they will trigger if a number of flashbacks are passed through to the arrestor, while others are intended to function only in the case of actual fire.

Other important points that should be considered are the orientation of the outlet to the inlet, (where these are in line they tend to cause the hose to kink and can be prone to damage) the sensitivity of the pressure sensitive mechanism (if too sensitive they can trigger without a flashback and are liable to be made in-operative by the user). The method of resetting, (external arms are prone to damage and can be easily made in-operative, while other reset mechanisms require very long periods to cool down before they can be reset).

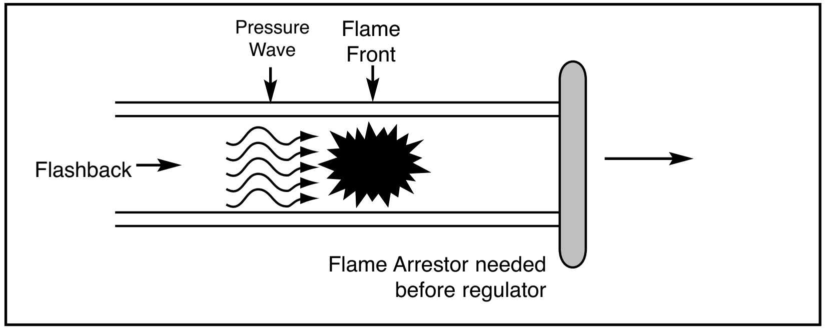
The weight of the arrestor is likely to be a good indication as to the wall thickness and how robust the arrestor will be in service.

Flashback arrestors should be fitted to both Oxygen and fuel gas systems as there is no way of knowing which side of the system the explosion will take.

Although the fitting of non-return valves and flashback arrestors are an essential element in ensuring safe working, they must never be considered to be a substitute for safe operating practice.

The most important factor at the end of the day is the care of the person who holds the torch.

What happens when a flashback occurs



When the flame front enters the Flashback arrestor as shown by the arrows, it passes first through the sintered metal flame filter and is extinguished. The pressure wave causes the flow cut-off valve to operate and the "Pop-Up" button signals this function. The unit is now safe with the flashback extinguished and the incoming gas stopped. In the event of a fire without a pressure wave the Thermal cut-off valve would activate and cut off incoming gas in the same way.

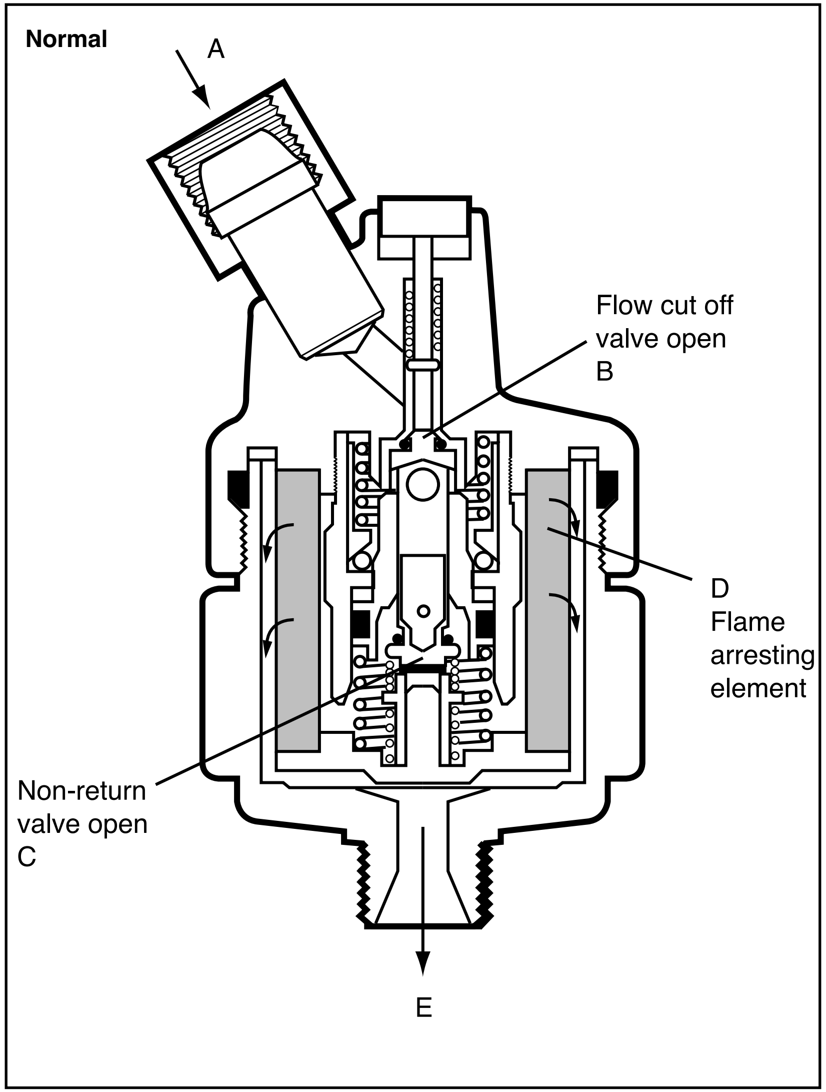
How the Saffire Flashback Arrestor works

Normal Condition

In normal operation the gas enters from the regulator at (A).

The flow cut-off valve (B) and non-return valve (C) are open and the gas passes through the mechanism.

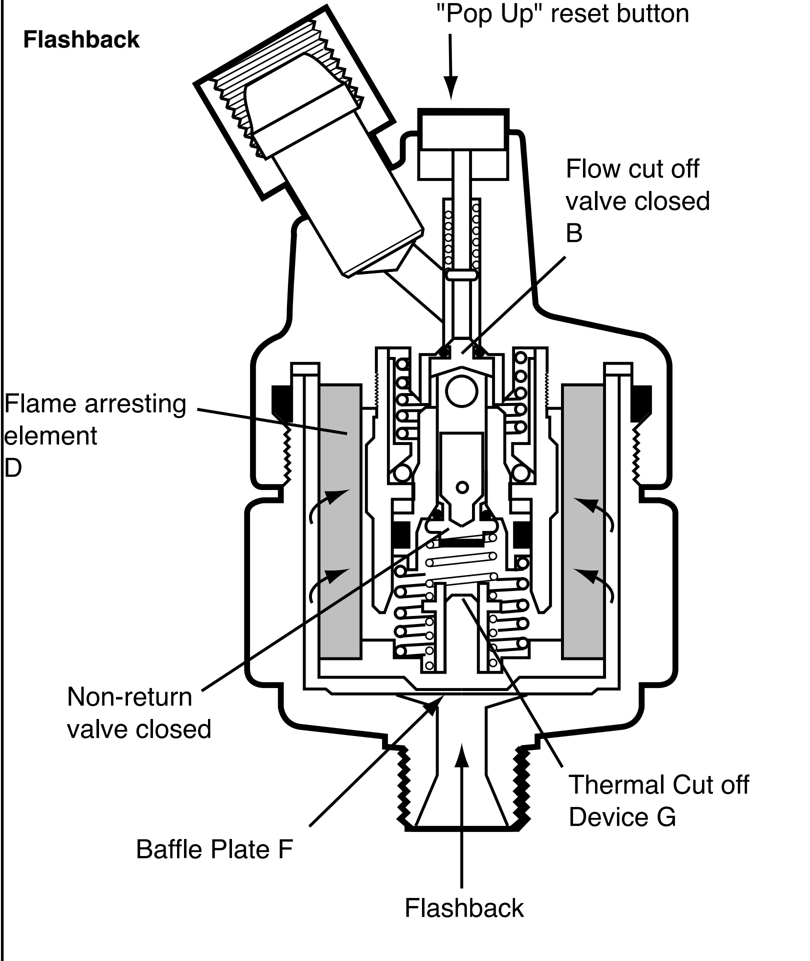
Incoming gas passes through the flame arresting element (D) and out through the hoses at (E).



Flashback condition

In the event of a flashback the flame front strikes the a plate (F) thereby dissipating much of the force. The flame front passes into the absorption chamber and is quenched as it enters the flame arresting element (D). The following pressure wave passes through the filter and activates the flow cut -off valve (B) by its pressure, raising the "Pop Up" reset button. The equipment is then rendered safe with the flashback flame extinguished and the incoming gas supply stopped.

In the event that there is not a pressure wave, as in a fire, the thermal cut-off device (G) will operate when the heat reaches 100ºC. This again cuts off the incoming gas supply and renders the equipment safe.



SAFETY DEVICES - RECOMMENDED LOCATION AND TYPE OF DEVICE TO BE FITTED

All safety devices shall conform to BS EN 730 and be suitable for the intended service. This means that they shall be for the correct gas and have the appropriate flow at the rated service pressure. Depending on the potential hazard ie if the cylinders are at a distance from the operator or could be difficult to isolate then different levels of protection may be required.

MINIMUM PROVISION

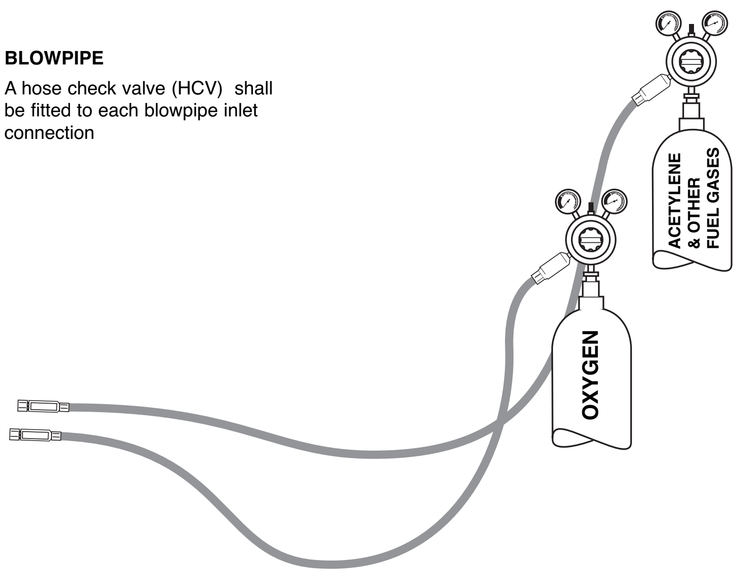
The minimum level of protection is shown below.

REGULATOR

A Flashback Arrestor (FBA) incorporating a flame arresting element, a non-return valve, and **a thermal cut-off device** shall be fitted to each regulator outlet

BLOWPIPE

A hose check valve (HCV) shall be fitted to each blowpipe inlet connection



RECOMMENDED PROVISION

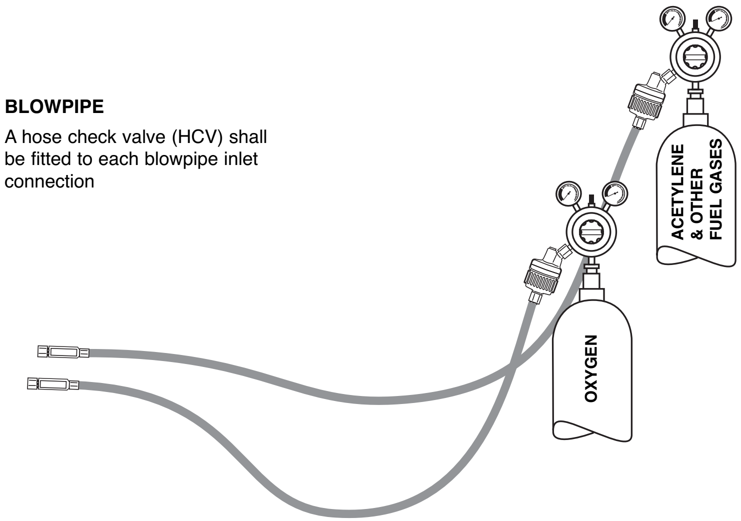
The recommended protection includes both a pressure sensitive flow cut off valve and a thermal cut off incorporated in a regulator mounted Flashback Arrestor. This provides protection from flashbacks by extinguishing the flame and cutting off the incoming gas thereby rendering the system safe. The thermal device protects the system in the event of an external fire or heating. Shown below:

REGULATOR

A Flashback Arrestor (FBA) incorporating a flame arresting element, a non-return valve, a **pressure sensitive flow cut off valve and a thermal cut-off device** shall be fitted to each regulator outlet

BLOWPIPE

A hose check valve (HCV) shall be fitted to each blowpipe inlet connection



CHAPTER FIVE

HOSE, FITTINGS AND ACCESSORIES

HOSE, FITTINGS & ACCESSORIES

Hose is probably the item that purchasers of Gas welding and cutting equipment consider least, and yet it is the item that will receive the most abuse and wear, as it is likely to be employed in the most aggressive working conditions. There can be no question that it is the “weakest link” in most systems, and receives the least attention.

When choosing a hose a number of factors need to be taken into account.

- Minimum length suitable for all applications.

  It is always better to take the gas source to the job, or the job to the gas source, rather than have spare hose getting in the way.

- Maximum gas flow required.
- Method of manufacture and construction.

  These are discussed below.

- Thickness of inner extrusion.

  EN 559 states a minimum of 1.5mm.

- Thickness of outer cover.

  EN 559 states a minimum of 1.00mm.

- Method of reinforcement.

  See below.

- Resistance to fire and heat.

  See EN 559.

- Resistance to chemicals that may feed through with the gas.

  Acetone or dimethyl formamide with Acetylene and n-Pentane with Propane.

  Oxygen hoses should be resistant to ignition in Oxygen enriched atmospheres.

- Flexibility at low temperature.

  Hose may be subject to Temperatures of -25^{o}C

- Resistance to crushing and kinking.

  Regrettably not covered in EN 559, it was a most important component of the old BS 5120, as reduction in gas flow is the main reason for backfires.

- Resistance to ageing, brittling, hardening and Ozone attack.

  Covered in EN 559, and most important to those who have to leave hose out in the open.

- Burst pressure.

  EN 559 states 3 x working pressure, but as this standard allows use of a hose with a working pressure as low as 10 bar this is not adequate. A minimum burst pressure of 60 bar should be required.

- Means of connecting to Flashback arrestor and blowpipe.

  This is discussed below.

Method of construction

Gas welding and cutting hose should be a seamless flexible tube designed to carry one or a number of specified gases.

There are three main methods of construction, all consisting of an inner extruded tube, with a means of reinforcement - this may consist of a number of layers - and an outer cover.

a) Spiral Reinforced

The inner tube is bound around with a rayon (or similar) cord. This may consist of just one layer, or two layers crossing at right angles.

The closer the cords are to one another, the greater the resistance they give to crushing and kinking, but the more likelihood there is of poor adhesion between layers.

One of the major problems with this type of hose is that in manufacture the inner and outer walls form a gully housing the cord reinforcement. With the movement, crushing and bending that hose is inevitably subjected too, there is a tendency for the cord to part from this gully and not return to it, causing a weak area within the hose.

Spiral reinforced hoses differ greatly, but the poorest have little crush resistance and will kink easily. This will be evident to any potential purchaser by forming a figure eight with the hose and pulling the bends tight. A poor hose will be seen to collapse and would obviously restrict flow in service.

On the plus side, these hoses are light in weight, very flexible, will give reasonable service if used indoors and are reasonably priced. It cannot be over-emphasised that with hose, you get what you pay for, and if safety is high on the agenda you should not be considering the cheap hoses that are now flooding the market.

One of the problems we are now faced with is that we have lost the old British Standard BS 5120, which has been replaced with a lower European Standard, designed to meet a market where hoses (with a working pressure of 10bar) were available specifically for welding only. A 10bar working pressure hose should not be used for cutting or heating processes.

Currently there are still hoses available to the old BS standard, (they also meet EN 559 and are marked to that effect) with a working pressure of 20bar, which also meet the old crush and kink resistance tests found in that Standard. These are to be preferred.

b) Wrapped ply

This very old means of construction gave a hose great crush and kink resistance. Reinforcement is achieved by wrapping the inner tube in a woven fabric which has been impregnated with rubber. The outer covering is also covered with fabric at time of manufacture, soaked in water and shrunk to compact the assembly. Once this has been achieved the outer layer of fabric is removed leaving a fabric weave imprint on the casing. Production methods proved to be too labour intensive however, and attempts to mechanise have not proved satisfactory, as it has been impossible to produce to a consistent standard.

By current standards this type of hose is heavy and inflexible. For customers requiring total kink and crush resistance, in areas where one can expect more than average wear, and are willing to pay a high purchase price, this type of hose may still meet their needs. It should be fully leak tested prior to putting into service.

c) Cotton interlaced double braided

This method of construction was designed to take the place of wrapped ply hose, to ensure a consistent quality, with high kink and crush resistance.

It is lighter than wrapped ply hose, much more flexible and can be employed in the most aggressive conditions.

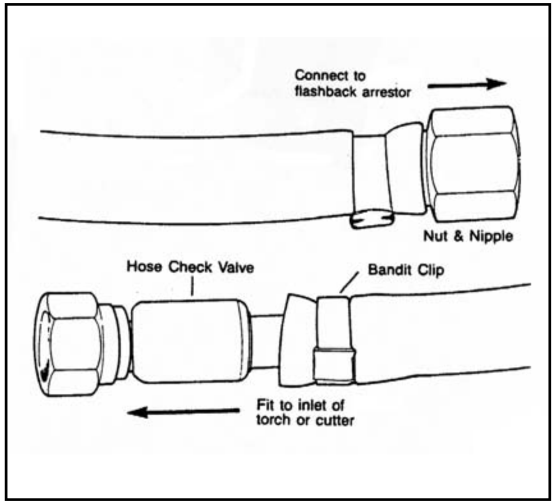
If safety, aligned with operator acceptance are essential requirements this is the hose to choose.

Reinforcement is achieved by “knitting” two layers of cotton yarn held in position by a layer of rubber adhesive, between the inner and outer tubes. Unlike spiral reinforced hose, the reinforcement cannot move, and the assembly is highly flexible and will always recover to it’s original state when bent. This has proved to be very user friendly as the operator is not having to continually “fight” the hose.

The purchase of hose that has been fitted and tested to EN 1256 is essential.

Connections

Hose should be connected to the Flashback arrestor at the gas inlet end by a simple nut and nipple and at the blowpipe end by a non-return valve. Non-return valves are marked with an arrow to denote flow direction to ensure that they are fitted correctly.



Seal is effected by a cone fitting, normally of brass, although some manufactures are now using mazak castings. These are satisfactory as long as the nut, which protects them in use, is made from brass. Aluminium connections were found to damage easily and should no longer be used.

Fuel gas connections are threaded left hand (turn anti-clockwise to tighten) and are identified by the corners of the hexagon nut being notched. Oxygen and inert gas connections have normal right hand threads.

Some non-return valves are manufactured with captive nuts, but it is an advantage to purchase those where the nut is separate, as any damaged sustained to these items normally involves the nut, which if separate is easily replaced. Care must be taken however to ensure that the shoulders of the hole within the nut are of the correct size to pull the cone part of the nipple onto the blowpipe inlet seating.

Some blowpipes do not have threaded inlets, but accept the hose directly onto a nipple which is an integral part of the blowpipe.

These are not recommended however, as they preclude the use of a non-return valve.

Connections in the UK and in much of Europe, are 1/4” BSP and 3/8” BSP, although to meet the EN standard must now have nuts which are metric across flats.

In some industries it is common to connect hose to the gas source by quick couplers. This is so that the operator is responsible for his own equipment, when using gas from a number of different take off points during the work period. This is common practice in shipyards and oil rig manufacture. The use of quick connectors save time as there is no need to use spanners to couple and uncouple equipment.

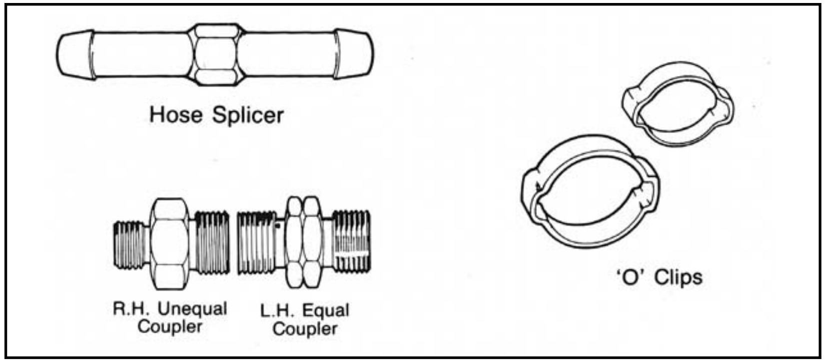
In the main, the industry has been wary of the use of quick couplers, for it is recognised that they do wear in service and it is not uncommon for the connecting probe to become damaged by being dragged along the ground.

Those contemplating their use should ensure that they are not interchangeable between gases and meet EN 7289 and 9090.

A wise precaution would also be to ensure that they are leak tested at least weekly.

Connections should be secured within the hose by suitable “O” clips or ferrules.

It is of interest to note that in Europe, re-usable worm drive clips [Jubilee clips] are frequently used, and the EN standard does not specifically preclude this - simply stating that they must be “suitable”! However, informed opinion in the UK has stated that “Re-usable wormdrive clips shall not be used”.



This is sensible advice, as the teeth on wormdrive clips wear and then do not effect an adequate fixing.

Where it is necessary to occasionally use hoses of a longer length than normal, it is acceptable to join them by means of screwed couplers. Some operatives prefer to use a lightweight hose at the blowpipe, but a larger bore hose for the majority of the length of the run. Connectors are available 3/8” x 3/8”, and 1/4” x 1/4” as well as unequal connectors 3/8” x 1/4” left and right hand fittings.

It is good practice to disconnect the additional hose as soon as possible however, as connections are possible leakpaths, and the more connections the more flow restrictions.

It should be remembered that fitted hose has a non-return valve at one end, so that connecting two hoses means that flow will be restricted through two valves, which will need to be compensated for by increasing pressure at the regulator.

If it is necessary in an emergency to fit hoses on site, - maybe because a hose has become damaged, this can be greatly assisted by placing the hose clip over the hose, assembling the nut and nipple and screwing them to the regulator outlet prior to pushing the hose onto the nipple. A small quantity of washing up liquid on the nipple will ease this operation. Ensure the hose clip is in the centre of the nipple before clamping.

Never use wire to secure the nipple in the hose, even for a temporary repair. Always ensure a supply of the correct size “O” clips are to hand.

Copper tube must not be used for connecting two Acetylene hoses as the gas will react with the copper and may form copper acetlides which are explosive. Temporary repairs can be effected with a brass hose splicer.

Before recommencing operations after a temporary repair, ensure that the whole system is fully purged.

Flow

There can be a number of reasons why there is insufficient flow of gas through the system:

- Incorrect pressures set at the regulator.
- The process demands a greater quantity of gas than is being released from the cylinder.
- Hose blocked by carbon or other foreign matter.

However, a common cause of flow restriction is using a hose of insufficient diameter, possibly made worse by excessive length.

The smaller the internal diameter of the hose (hose sizes specify internal diameter), the greater the friction within the hose, and dirty hose only makes this far worse.

It needs to be remembered that every item fitted within the system is a further restriction to flow. Flashback arrestors which have seen a number of flashbacks, and have badly blocked arresting elements will produce considerable back pressure and effect flow.

Cheap hose that has not been formed on a mandril and has uneven bore will also reduce the flow. Poor quality materials will craze and flake in service and may cause restrictions.

As the flow demand at the nozzle increases, so the pressure at the regulator decreases. With the pressure set at the regulator before commencing any operation, with the blowpipe valves still closed, the pressure at the regulator and at the blowpipe inlet will be the same. However, directly the blowpipe valves are opened, and gas begins to feed through the system, the pressure at the blowpipe will be less than the pressure set at the regulator.

The pressures given in the charts on pages 96-100 are for 10m lengths of 6.3mm hose with all new equipment. As the equipment becomes older, and carbon begins to restrict flow, some adjustment will be necessary to obtain the correct conditions at the nozzle.

Remember, that lack of sufficient flow through the system to sustain the required flame at the nozzle is the major cause of backfiring.

If the hoses are short - say 5 or 10 metres of the correct diameter for the process being attempted, and there are not additional restrictions in the system, then operators should have no problem in setting pressures in line with the guidelines suggested. If equipment is old, the hose blocked with carbon and of lengths of 20 metres or greater, (particularly if 5 or 6.3mm diameter), then there will be significant restriction to flow which will make the operation far more liable to backfires.

A competent operator will "read" the flame condition, recognise any flow restriction and adjust the regulator on the restricted line accordingly.

The very act of bending a hose will cause a restriction, so it is always safer to tend towards too much pressure at the regulator, rather than too little. With some operations such as the Thermit welding of rails, flow is so critical, it is necessary to record pressure at the blowpipe inlet, and gauges are placed in the system at this point to enable this to be done.

Safety

Examine and test hose frequently for signs of leaks, cracking and other damage or wear. If the reinforcement is visible when the hose is kinked it is time to replace it.

Never attempt to stop hose leaks by covering the affected area with tape. If a flashback has burst a hose, do not cut out the affected area and rejoin, as other parts of the hose which may appear satisfactory from the outside, are bound to have been weakened internally. Hose burnt internally will flake and cause restrictions which will effect gas flow.

Always replace with new hose.

Never leave a system with pressure still in the hose.

This is a very common problem and if the hoses are wound around the cylinders one that could be fatal. A fire in a coiled hose is most difficult to extinguish. It will heat the cylinder with possible disastrous results.

Fire in a hose reel is also very difficult to put out, and their use therefore is not recommended.

Use the shortest length of hose possible, and make bridges over hose where there is traffic. Try to keep hose as tidy as possible to ensure each operator is aware which hose is his.

Cylinders, even when mounted on a trolley, can easily be pulled over if the hose is caught by a passing vehicle.

Siamese or twin hose can prove dangerous as it is necessary to part the ends to make connection with the two regulators and the blowpipe inlets. Doing this is likely to weaken the hose walls right at the point where the operator is holding it.

This type of hose has a dangerous spark trap in the "cleavage" where the hoses are joined. With standard hose, sparks will normally bounce off the hose harmlessly, but with this type of hose they are caught and will burn the hose, with the possible release of both Oxygen and fuel gas.

For the same reason it is unwise to tape hoses together at intervals of less than one foot.

It is bad practice to leave hoses out in the open over night if cold weather is expected. Hoses left filled with propane overnight have been found to have split along their whole length when inspected next morning.

Table of colour, material of manufacture and sizes

Gas	Colour of outer cover	Recommended Material
Acetylene, Hydrogen and other combustible gases apart from Propane, natural gas and Methylacetylene - propadiene mixtures	Red	Styrene Butadiene
Propane, Butane, natural gas, Methylacetylene - propadiene	Orange	Nitrile Butadiene and Poly Vinyl Chloride
Oxygen, Air/oxygen mixtures (where oxygen content is excess of 20%)	Blue	Styrene Butadiene
Air, Nitrogen, Argon and CO_2	Black	Styrene Butadiene

Don't allow hose to stand in oil or be contaminated with grease or tar. Oxygen can explode if it comes into contact with these materials under pressure, and some hoses will swell and lose there ability to hold pressure.

Bore Sizes

Min	Max	Marked
4.45mm	5.55mm	5.0mm
5.75mm	6.85mm	6.3mm
7.35mm	8.65mm	8.0mm
9.35mm	10.65mm	10.0mm

Protect hose from sparks or falling slag. Some operatives always work with the hose over their shoulder to ensure it does not get burnt in this way.

Hose often becomes damaged by hot or sharp metal edges.

Don't wave the torch around if someone attracts your attention.

Welding and cutting require 100% concentration and the flame you are holding is hot enough to melt steel!

Because of the probability of hose coming into contact with hot materials, thermoplastic materials are not suitable for hoses used in this industry. However, due to the difficulty in obtaining rubber hose with a bore of less than 4.5mm, they are in fact often employed in dentists and jewellers workshops where Hydrogen is being used as a fuel gas.

Accessories

There are two accessories which fit within the length of hose between the regulator/flashback arrestor and the blowpipe.

1) Gas fluxers

In situations where there are repetitive brazing operations, much time can be saved by introducing the brazing flux along with the gas through the gas hose. This is achieved by fitting a gas fluxer into the system.

This unit consist of a container holding a flux solution suspended in a liquid. By passing the fuel gas through the container sufficient flux is entrained in the gas stream to enable a continuous brazing operation.

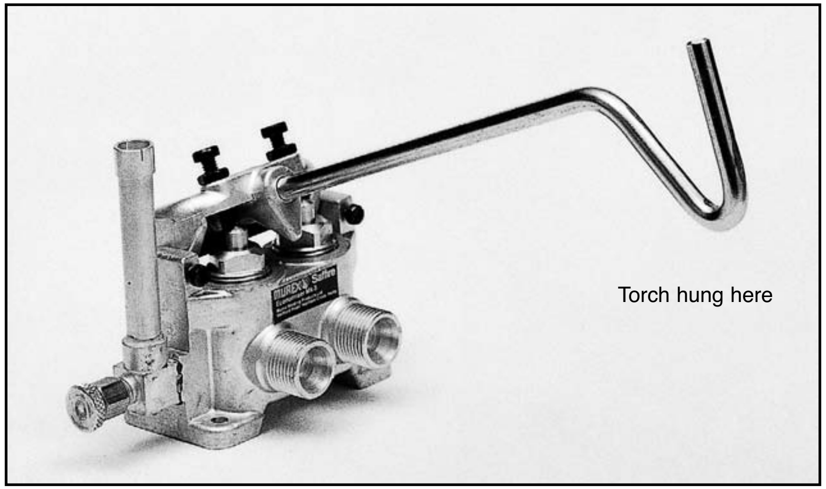
There are considerable dangers with this operation. The liquids that are used will damage the rubber hose that it passes through and any rubber seals in the non-return valve flashback arrestor or blowpipe. The flux itself is abrasive and will damage seatings, valves and clog spring loaded devices.

In practice, those safety devices that are fitted to systems containing gas fluxers, are liable to become inoperative.

Because the liquid being used is highly flammable, it is essential that a flashback arrestor is fitted downstream of the unit, and tested every time the unit is operational.

Great care needs to be taken when handling this liquid as it is a fire hazard in areas where brazing is being undertaken.

Due to the damage to the walls of the hose caused by the flux solution and the abrasive effect of the flux itself, the internal diameter of the hose will increase and there is then a real danger of the hose becoming loose on the nipple to which it is fitted. This will not only give a fuel gas leak to atmosphere, but experience has show that hoses come off their fittings and cause damage to operators through the release of stored energy.



Due to the financial rewards in using gas fluxers, this is a potentially dangerous operation that will continue.

Operatives need to be made away of the dangers and ensure that frequent checks and maintenance are carried out to a strict schedule.

2) Welding economisers

Where welding operations tend to be intermittent, and the operative needs to be frequently handling the workpiece, considerable savings, both in gas and in re-set up time can be achieved by fitting an economiser upstream of the blowpipe. The torch can be hung on an arm, which activates two valves which cut off the gas supplies. When the operative is ready to re-commence welding, he removes the torch from the arm, which releases the gas supply. He is then able to relight the flame from a pilot flame on the unit without having to go to the trouble of having to re-adjust the blowpipe control valves.

Economisers are a very effective hose accessory that will very quickly pay for itself in gas and labour savings. They are supplied with base holes to enable them to be bolted to the work bench.

They are frequently used in training establishments where the supervisor can ensure that correct flame settings are always available to unskilled trainees.

Suppliers instructions regarding set up should be strictly adhered to, to ensure that the economiser valves cut off the gas supplies in the correct manner. If the Oxygen valve precedes the fuel gas valve, there will be a sharp bang and carbon will be deposited within the unit.

MUREX

CHAPTER SIX

BLOWPIPES, CUTTERS AND NOZZLES

BLOWPIPES, CUTTERS AND NOZZLES

Although the term **"BLOWPIPE"** is the one officially used in the International Welding Thesaurus, tradition in the UK has meant that we normally refer to:

- **Welding Torch**
  a device used solely for gas welding. This may or may not have an integral mixer.
- **Combined Blowpipe**
  a device which can be adapted by the addition of various attachments to weld, cut, gouge or heat.
- **Cutter**
  a device used for cutting and associated processes such as gouging, but may also be adapted for heating.

Although these are the terms most frequently used, one will often also hear cutters referred to as "guns" or blowpipe, and combined units as "combined torches".

The word BLOWPIPE appears to go back to a time when to aid manipulation of the heating flame during soldering processes, a tube was placed into the flame which was directed to the required location by gently blowing down it. It was found when doing this that the heat given by the flame would, in fact, be hotter than when the flame was just left to play on the joint to be soldered. We now, of course recognise that this was because additional oxygen was, in fact, being fed into the flame. The tube became known as a BLOWPIPE.

Welding Torches

There are two methods of mixing gases within a welding torch, both of which have their good and bad points.

1) Equal pressure (Mixer) torch

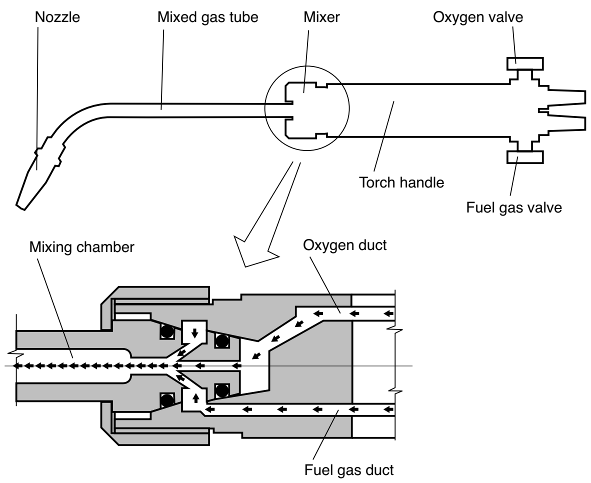
The gases are delivered to the torch at equal pressure and are mixed within a mixer, which can be an integral part of the torch, or a separate component which is screwed to it (sometimes by the addition of a quick fit adaptor).

With welding only torches, one mixer is sufficient to cope with the flow of all welding tips or nozzles.

Down stream of the mixer will be either a swaged nozzle or a neck which will accommodate a selection of small copper or brass tips. The choice of tip or swaged nozzle is discussed later. (See pages 63 and 64).

Some manufacturers also supply a small pepper-pot type heating nozzle complete with neck which will screw straight into the welding mixer.

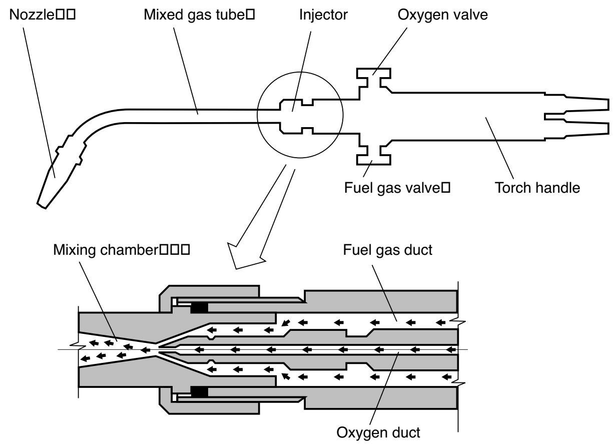
Equal pressure torch



2) Low pressure (Injector) torch

Although referred to as low pressure, it is only the fuel gas which is delivered at low pressure, and in fact the Oxygen will be at a higher pressure than that used in an equal pressure torch.

Injector torch



Rather than employing a simple mixer, a “V” shaped chamber is employed where oxygen is fed through the point of the “V” at high pressure into the throat of a long “V” mixing chamber. The “V”s being point to point. This causes a suction to the channel on the outside of the first “V” chamber which draws through the low pressure fuel gas. At the point where the two “V” chambers meet we will then have fuel gas on the inner walls of the throat of the second chamber enclosing the oxygen stream at the centre of this chamber. As the gases travel along the throat they progressively mix together. The hole at the “V” of the first chamber and the dimensions of the throat of the second chamber are designed in such a way as to ensure that the correct amounts of gas are mixed for the specific nozzle being used.

The advantages of this form of mixing is that inlet pressures are not so critical, because the flow of gas through the system is regulated by the injector being used and excellent gas mixing is achieved. This system is frequently used in Europe, where they very seldom use multi-stage regulators because increase in outlet pressure is not so critical when using injector equipment.

However, there are also disadvantages to using injectors. The first is cost, for where as one mixer will accommodate the full range of nozzles with an equal pressure torch, as explained above, an injector has to be matched with a specific nozzle size, ie a different injector for every nozzle.

All but a very small number of welding torches sold in the UK are equal pressure (mixer).

Design and method of construction

Gun drilled solid aluminium shanks have been well accepted in the UK market for over 30 years, and have proved both to be very serviceable and user friendly. It needs to be recognised that both the inlet and outlet joints need to be manufactured from brass, and therefore there is a requirement for well designed and serviceable means of joining these materials to the main body.

Glued joints have again proved to be suspect because of the rough treatment they often sustain, and better manufactures have now changed to pressure screwed joints, with opposing threads, giving a metal to metal seal, with adhesive used only for additional insurance.

Another method of construction is to screw extruded tubes together, where the inner tube carries the Oxygen and the handle tube outside of it carries the fuel gas. This is satisfactory as long as the joints are also brazed or silver soldered, but a simple screwed joint, or one that is screwed and made leak tight with a sealant is unlikely to withstand the abuse and distortion these torches are often subject to.

Where mixers or injectors are separate from the main body of the torch a flexible sealing face is required. This is often obtained by the use of “O” rings or PTFE washers. In the case of a flashback this seal may well be subject both to heat and be coated with carbon, both of which will effect their sealing qualities.

“O” rings may become brittle or sticky if heated, but do retain their elastic qualities better than PT.E washers which tend to flatten in service.

Torches that have a positive means of locating the mixer, such as interlocking teeth, ensure a positive seal and make the removal of stubborn nozzles which have become bonded in the mixer far simpler.

Connections which do not require a spanner, and can be adequately sealed by hand pressure are a definite advantage to operators.

Valve position is very much a matter of operator preference.

Torches are available with fine adjustment valves located at the front of the torch just behind the mixer, and in a “V” format.

This ensures they are wide apart, and lessen the chance of inadvertent adjustment in service.

Other torches have the valves located to the left side of the handle just in front of the operators hand, while others are located to the rear of the torch behind the hand. These are more liable to inadvertant adjustment by knocking.

Rear mounted valves also have the disadvantage in that they require both hands to adjust, and any valve leak is likely to “soak” the operators clothing in Oxygen or fuel gas. Both of which would cause a real fire hazard.

Welding only torches may have 1/4” or 3/8” inlet fittings threaded left-hand for fuel gas and right-hand for Oxygen. As there is no welding operation that requires greater flows of gas than can be adequately obtained through a 6.3mm diameter hose, 1/4” inlets are perfectly adequate.

Air aspirated torches

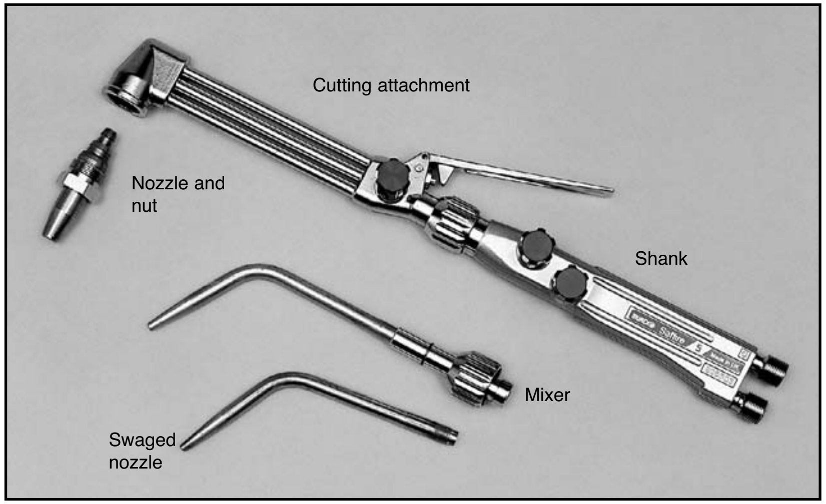
These are not strictly welding torches as they will not produce sufficient heat for a true fusion weld. They are often used for brazing or soldering operations, and larger versions are available for asphalting, roofing and road marking etc.

They differ from standard welding torches in that they have only one inlet connection, which is for the fuel gas. The Oxygen being drawn from the air at the nozzle.

Combined blowpipes

As most hand held welding equipment is used for maintenance work, it is very convenient to be able to adapt the same handle so that it can also be used to cut and heat as well.

The comments on welding torches above also apply to combined blowpipes, but the design is such that the welding mixer may be removed, and either replaced with a cutting attachment, for cutting or gouging, or with a heavy duty mixer and an appropriate neck for heating, either with Acetylene or Propane.



When a cutting attachment is used, control of the heating gases is made by the fuel gas valve on the handle piece (shank) but the heating Oxygen is controlled by the fine adjustment valve on the attachment. To enable this to be done the Oxygen valve on the handle must always be fully open when the attachment is in use.

Control of the cutting Oxygen is by depressing the cutting lever, or by turning the cutting Oxygen control valve if this is fitted instead of a lever. Although seldom used in the UK these valves are used in Europe, and allow the operator to set the cutting Oxygen stream at an intermediate level. Cutting levers are difficult to hold consistently in an intermediate position for any length of time.

Combined blowpipes can be used for all welding operations, and for powder surfacing by the addition of a hopper and spray unit between the nozzle and the handle. This unit has its own in built mixer.

Various lengths of straight and bent necks are available to allow the operator to heat with Acetylene or super-heat with Propane.

Nozzles can be supplied for flame cleaning, which is a very efficient way of cleaning rusty or painted material.

Because the flows required by these operations are greater than needed for welding, special Acetylene or Propane heavy duty mixers are available.

Removing the mixer and adding a cutting attachment to the handle converts the unit into a very versatile cutting unit.

With nozzle mix models Acetylene or Propane can be used as the fuel gas simply by using a different nozzle. The unit may also be used for gouging out unwanted material or producing grooves. Special nozzles are available for this operation allowing grooves up to 12.5mm (1/2”) to be channeled out.

The removing of old rivet heads without damaging the parent metal is much simplified by the use of a rivet cutting nozzle.

It will be seen that virtually all gas equipment processes can be achieved from one base unit which is highly adaptable.

One word of warning however. Although various manufactures claim that their equipment is interchangeable with other manufacturers combined blowpipes, it is always far better to choose the best handle unit one can afford, and add only additional units from that same manufacture.

Problems arise when items are produced from other manufacturers who do not have the sophisticated machine tools to ensure that every product they turn out is to the critical tolerances and dimensions required to ensure leak tight seals between various items of equipment.

Cutting attachments can be obtained using the injector principle of gas mixing, although in the UK they are almost all nozzle mix.

HAND CUTTERS

Although combined blowpipes are now produced that will allow the operator to cut up to 200mm (8”) this is not to be recommended.

For the odd, one off job in an emergency this may well be satisfactory, but if it is recognised that cuts above 100mm (4”) are to be the norm, then the operator would be well advised to invest in a cutter specifically designed for that purpose.

Although the equipment may be able to attain the thicker cuts on a regular basis, the poor operator who has to be that close to the heat source will not!

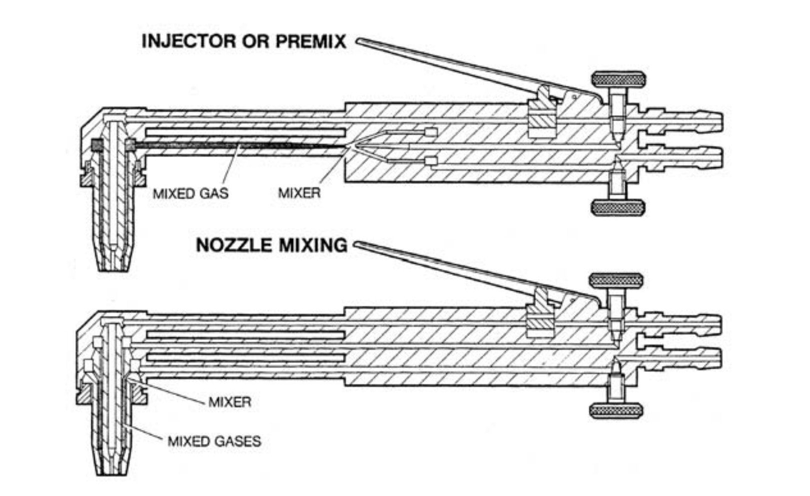
There are three major differences in design of cutter, although this can be greatly multiplied when one considers you can have levers above or below, attached front or rear, press or release to cut and all in a variety of lengths.

The three cutters are:

Nozzle mix cutters

As the name suggests, the Oxygen and fuel gas are kept separate for as long as possible and are only mixed in the actual cutting or gouging nozzle.

The greater the quantity of mixed gas in the system, the greater the force of the explosion if they are ignited.



By not mixing the gases until they reach the nozzle, and even then, by feeding them through a number of very small channels the amount of mixed gas in the system is minute.

As backfires will normally go back to the point where the gases mix, by keeping the quantities very small, and making the point of mixing the nozzle, the worst that will normally occur is the burning out of the nozzle. If this occurs, it is a simple operation to change the gas mixer (the nozzle in this case).

Another advantage is that fuel gases can be readily changed, for although, due to the different densities of the fuel gases a different mixer is required, in this case, the mixer being the nozzle it is only a matter of changing it.

Lighting a nozzle mix torch is both easier and safer, as one is only required to flow the fuel to light, the Oxygen being available from the atmosphere. With injector torches, which rely on the flow of the Oxygen to draw the fuel gas through the system, it is necessary to ignite mixed gases.

Nozzle mix cutters are both simple and efficient, and tend to stand up better to the aggressive environments that they often meet. No one would ever recommend that cutters are used as hammers or levers, but the fact is that they frequently are. The simpler the design, without components with critical mating surfaces which will easily be damaged by crushing or vibration, the longer and safer the service life they are likely to give.

The advantages of nozzle mix cutters are undeniable and it is not surprising that they are chosen in all but a few very specialised cases.

Injector cutters

Injector cutters were first designed because Acetylene could only be generated at very low pressures. Where it was necessary to convey the gas considerable distances, say along a quay side and over the side of a ship, cutters designed for use with coal gas or Hydrogen only could be used.

As explained when looking at welding torches, using high pressure Oxygen to entrain the Acetylene overcame this problem.

The problem, however, is no longer with us, as Acetylene is now available in the dissolved state and under pressure.

If there is a requirement to use natural gas for cutting, which is again at very low pressure, then an injector cutter will be required.

Some operators, will claim that injector cutters give greater control of cutting Oxygen velocity, which is a critical factor in some gouging operations, and therefore also prefer to use a cutter with the injector built into the body.

As discussed above, there is far more mixed gas in the system with an injector cutter, and if a backfire occurs it is likely to be far more serious than with a nozzle mix cutter. Whether in fact backfires are more likely with an injector cutter is a matter of debate. What is not debatable is that you get what you pay for. Injector cutters are precision instruments made to extremely fine tolerances. The design of the injector and throat will determine their backfire resistance, but they need to be handled with care if they are to remain safe in service.

Premix cutters

These cutters were introduced to enable injectors to be employed, but with the least possible amount of mixed gas in the system. They tend, however, to fall between two stools.

They do not give the safety, reliability and simplicity of a nozzle mix cutter, or the suction power, or control of cutting Oxygen flow of the true body injector cutter.

The injector is placed in the head, enabling the gas in the cutter tubes to remain separate.

Because a cutter has three tubes rather than the two found on a body injector cutter, it cannot be assumed therefore that it is a nozzle mix cutter.

Because of the need to place the injector in the head it becomes rather larger than in a nozzle mix cutter, which in turn makes the cutter top heavy and badly balanced, leading to operator fatigue if used for long periods.

Although manufacturers claim multipurpose injectors which can be used with different gases, they are a compromise and to obtain the best results with any injector cutter, the injector should be specific to the gas with which it will be used.

This does mean however, that the cutter cannot be easily converted for use with a different fuel gas, and damage to the injector through sustained backfiring may well mean replacement of the complete cutter.

To summarise:

Type of cutter	Plus +	Minus -
Nozzle mix	Less mixed gas in system. Backfire retained in nozzle. Simple, efficient less prone to damage. Change nozzle to change fuel. Cannot suck acetone from cylinder.	Can't be used with low pressure gas.
Injector [body mix]	Good control of cutting Oxygen stream. Use at pressure as low as 7 water gauge.	Considerable quantities of mixed gas. Need mixed gas to light. Need careful handling.
Premix (injector in head)	Less mixed gas than body injector. Large brass head dissipates heat.	Less suction than body mix poor balance. More prone to backfiring. Needs mixed gas to light.

Design and method of construction

As already intimated, there are a number of variations in each of the different types of cutter.

Nozzle mix cutters are available with control valves forward of the hand when cutting, which is favoured in Europe, as well as to the rear of the handle, which is the norm in the UK.

As gloves should always be used while cutting, some difficulty can be experienced when control knobs are not well spaced apart. This is a problem often experienced with the controls set at the side of the handle in a forward control cutter.

The control available over the cutting Oxygen stream differs greatly depending on the method of control.

Plunger type valves may not give adequate control for operations requiring a start from the centre of the workpiece rather than from the edge, as any sudden increase in cutting Oxygen flow will cause molten material to splash with possible serious damage to the operator.

Long travel, bobbin type cutting oxygen valves, allow a steady, safe and progressive flow of gas for this operation.

Cutting Oxygen levers can be placed on top of the handle or underslung. When placed below the handle they can tend to get in the way of the work piece unless the head is positioned at 75^{o} to the tubes.

Cutters are often available in different lengths, 0.5m, 0.75m and 1.0m being the most common. For specialised operations lengths of up to and over 3m have been supplied.

The angle of the head to the cutting tubes is another option.

Most operators using a 0.5m cutter wish to look down on the head as the cut progresses and therefore favour a 90^{o} head. Where cutting is being consistently performed on vertical surfaces a 180^{o} (sometimes referred to as 0^{o}) head is used. Scrap or heavy duty cutting is normally performed with a longer cutter (0.75m or above) and the operator will favour a 75^{o} head.

The position of the cutting tubes is another factor to be considered. Tubes which are set in a triangle will obstruct the operators view, and may restrict entry into certain enclosed areas. Tubes which are in line overcome this problem, but one should make sure that their thickness is such as to ensure they do not bend when the cutter is used to lever metal that has not been completely severed; a situation which sadly all too often occurs.

Cutters are designed to be used in the most rugged of conditions and are likely to spend most of their life out doors. Bearing this in mind the material type and thickness, and method of construction should be such as to withstand the most severe working conditions.

It will be noted that there are considerable differences in the price of cutters, but once again you get what you pay for. It is worth paying a little more for a cutter that will last twice as long, with the assurance that it is just as safe nearing the end of it's useful service as it was at the beginning.

Aluminium or painted steel handles are unlikely to be satisfactory in the longer term, and screwed inlet connections are prone to leak.

Brass spindles tend to bend if the valve is knocked, while plastic knobs are not man enough for the job and should be rejected.

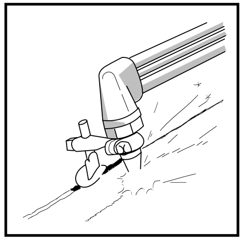
Control knobs should be permanently marked, and of a size that allow easy control with a gloved hand.

If long cuts are contemplated a method of fixing the cutting lever in the "on" position is an advantage.

Cutting Aids

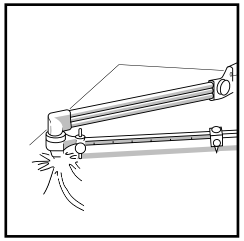
Cutting aids are frequently employed to ensure consistent and accurate work. Their use helps to remove guesswork from the process and produces better results with less operator fatigue. Those who are just learning their skills in training establishments would be well advised to use them.

The items that are readily available are:



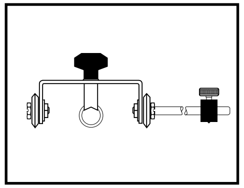
Spade guide

An inexpensive guide which attaches to the cutting nozzle and aids the cutting of straight lines. It is adjustable for height and can be used with most nozzles.



Circle cutting attachments

Flange and circle cutting is considerably simplified by the addition of one these. Ensure you obtain one which is designed for use with the cutting attachment or cutter you are using, as they do differ. Models for different diameter circles are available.



Double roller guides

There are a number of different designs, the better ones allowing use of a radius bar so that it can also be used to aid the cutting of circles. When cutting bevels in the vertical plain, they are indispensable.

Blowpipes for special purposes

The use of blowpipes for cutting is, in the main, restricted to the cutting of ferrous materials, as the process is one of oxidizing the metal.

It is also possible to cut stainless steel by feeding iron powder into the flame, but this requires the use of a powder hopper and compressed air system, in addition to an attachment which fits on the head of a cutting blowpipe. Other means for cutting stainless have, in the main, superseded this method and the equipment is no longer generally available in the UK.

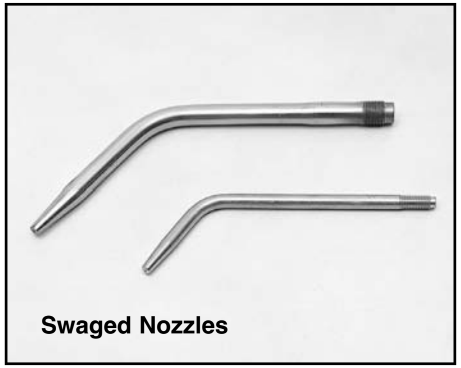
Steel mills prepare billets by scarfing the surface of the material prior to rolling. This requires the use of a special blowpipe designed to produce high flows of Oxygen at low pressure, similar in many respects to flame gouging. To enable quick starts to be made a mechanism to feed a mild steel rod into the flame is an integral part of these blowpipes. Due to the low demand, they are not generally available in the UK and have to be imported.

NOZZLES

We can divide these into three areas:

- Welding nozzles and tips.
- Cutting and Gouging nozzles.
- Heating and special process nozzles.

Welding nozzles and tips



Swaged Nozzles

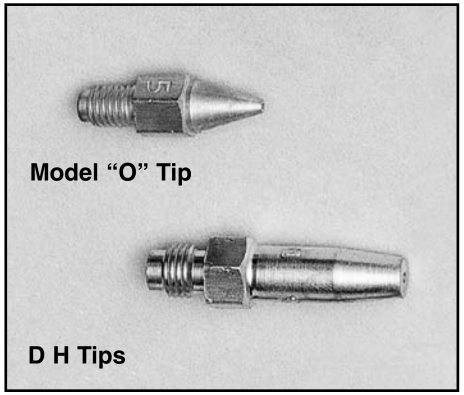
There are two different diameters of welding nozzle, dependent on the torch/mixer they are to be used with, although the amount of gas they flow is the same. They are often referred to as "Lightweight swaged welding nozzles" or "Standard swaged welding nozzles."

Welding only torches will normally take a lightweight nozzle, where combined torches will, depending on the model, either take a lightweight or a standard welding nozzle.

Most welding nozzles sold in the UK bear a number which signifies the cubic feet of gas that it will flow in one hour.

Those most commonly available being:

1, 2, 3, 5, 7, 10, 13, 18 & 25. Sizes 35, 45 & 90, are available in the standard type, for use with combined blowpipes for heavy welding or heating. The larger size nozzles require the higher flow capacity of a heavy duty mixer.



Model "O" Tip

D H Tips

These nozzles are produced from copper tube which is swaged over a mandril to ensure the internal bore is smooth so that a consistent, long pencil shaped flame is obtained. This is ideal for most welding operations and is very backfire resistant.

However, those operators who are heating pipes require a flame which will wrap around the pipe to give even heat over the full circumference. This is better achieved with a bulbous flame obtainable with a welding tip.

This is a small copper or brass tip which is screwed into a brass or copper neck, which in turn is then connected to the mixer.

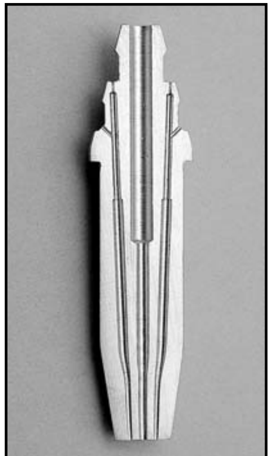
Most welding nozzles are manufactured from copper as it dissipates the heat well, but some of the very small tips, (where heat is not a problem) used by jewellers or dental laboratories are manufactured from brass which enables accurate drilling of their very small flame aperture .

As true fusion welding can only be obtained with an Oxygen/Acetylene mixer, all swaged welding nozzles are designed to be used with these gases.

The small brass welding tips however, may be used with a variety of fuel gases.

Cutting and gouging nozzles

Most cutting in the UK is done with either Acetylene or Propane as the fuel gas, and therefore nozzles are only readily available for these. In other countries, where other fuel gases are more commonly used, nozzles for these are available, but in the main they are simply Propane nozzles with small modifications.



Section of ANM nozzle

Acetylene cutting nozzles, are in the main drilled from solid copper. Their design will depend on the cutter they are manufactured for.

Nozzle mix nozzles are mainly three seat, to ensure the heating gases are kept separated until they mix within the nozzle. The number of heating gas channels may vary, but the most common used in the UK is six. This may be denoted in the nozzle designation, ie an ANM - 6 nozzle, is an acetylene, nozzle mix, 6 heating channel nozzle.

The more heating channels the more even is the heat achieved around the cutting Oxygen stream. This can be an advantage, but because the material between the holes is less the more holes that are drilled, the shorter the nozzle life. Six is recognised as the best compromise.

The method of manufacture of solid drilled nozzles is all important to ensure long life and backfire resistance.

Sheet metal cutting nozzle

It is essential, to fulfil these aims, that the preheat flames are even, and the cutting Oxygen stream parallel and straight.

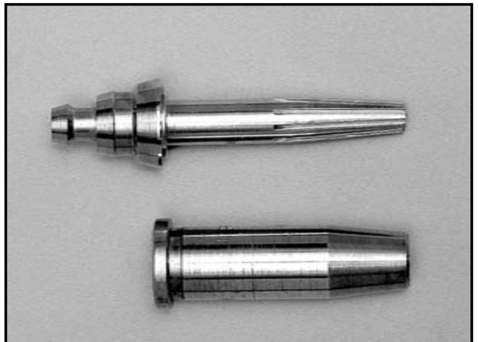
This is achieved by the method of drilling and swaging employed, and the only way to ensure success is to flame test and backfire every nozzle produced.

This is obviously an expensive process, but well worth the extra expense to the operator, who will experience less downtime and backfiring using a quality product.

Acetylene nozzles designed for the cutting of sheet material have only one preheat flame, as it is essential that as little heat is put into the material as possible to ensure it does not buckle.

They are of a stepped design with the preheat orifice between skids so that the nozzle can be placed on the material to be cut, which ensures the distance between the cutting flame and the workpiece is consistent.

Because Propane is a far denser gas than Acetylene, the design of the nozzle is very different. Where as, with an Acetylene the aim is to smooth the passage of the gas through the nozzle, with a Propane nozzle, all is



2 piece PNM nozzle

done to slow it down and produce turbulence within the nozzle to ensure good mixing of the propane with the Oxygen.

This is achieved by having a two piece nozzle, the inner being produced from brass so that the gas passages may be formed by an accurately cut channel, and the outer from copper where the inner wall is scoured to encourage turbulence. The outer nozzle exit also stands proud of the inner to form a skirt that will retain the flame on the end of the nozzle. Once again the number of gas channels may vary.

Similar nozzles may be produced in different lengths, the UK using nozzles 10mm shorter than those used in many other countries.

Gouging nozzles are available both curved and straight, depending on the method of gouging employed and the blowpipe being used.

Gouging nozzle

They differ from cutting nozzles in that the process requires considerable flows of cutting Oxygen delivered at low pressure to “wash” the molten material away without piecing through it.

The condition of the seats of all cutting nozzles is critical if cross head leaking, leading to serious backfiring is to be avoided. Great care needs to be taken when removing a hot nozzle from a blowpipe, for hot copper will easily mark or bruise if the nozzle is dropped or thrown on to a hard surface.

The gas exit ports should always be at 90^{o} to the end of the nozzle. Orifices should be cleaned with the correct size of nozzle cleaner, which should be inserted and drawn straight out.

It should not be twisted and used like a file, or the orifice will be enlarged and the flame shape ruined. Nozzles with bell shaped orifices are more likely to backfire.

Heating and special process nozzles

The choice of heating gas will determine the type of heating nozzle used.

Acetylene nozzles produce an intense flame of great heat and are available in three sizes defined by the cubic feet of gas that they flow. i.e. 25, 50, and 100.

Although manufactures give an indication of the heat produced by these nozzles, it is not normally of much use to the operator as the way the heat dissipates from the material differs greatly.

Acetylene Heating Nozzles

If the requirement is to soak the material with a spread of heat for bending or to preheat materials for an arc welding process, then Propane is preferable, and a super-heating nozzle employed.

These also come in a variety of sizes numbered one to five. In practice, only sizes three and five are used in any quantity.

They are available with the outer skirt with or without castellations.
The castellation being provided so that it is not possible to place the nozzle down and completely block the flame. In practice it is difficult to do this with the larger nozzles due to the considerable pressure of the gases at the nozzle exit. However, even partly blocking the exits and causing a back pressure will cause a backfire.

Propane Heating Nozzles

Recent investigations have shown that operators have little or no training in the use of these nozzles, and tend to use them fuel gas rich and far too close to the workpiece. Special super-heating nozzles are being developed to overcome these problems.

For cutting off the heads of rivets a special nozzle has been developed which enables the rivet head to be removed, without harming the parent material. These have been found to be most useful in other areas where a horizontal cutting flame is required.

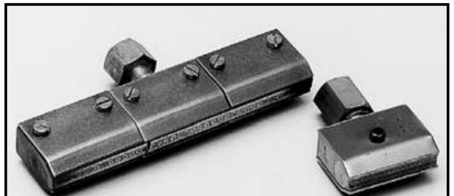
Nozzles or multi-flame heads are available for the cleaning of materials. They are similar to a paint brush in that they are worked across the surface of the material to be cleaned, and the flames reach in to the crevices formed by rust or other coatings, lifting them from the surface.

They are manufactured for use with either Acetylene or Propane, the connections and design of the burner unit being different, and require the use of an Acetylene or Propane heavy duty mixer.

Because of the hotter flame obtainable with Acetylene this gas is more suitable for this process.

Although no longer readily obtainable in the UK nozzles are manufactured for flame washing the rises off castings, the powder cutting of non-ferrous materials and the scarfing of billets.

There are also specialised heads available for cleaning concrete and marble floors.



Flame cleaning heads

Rivet cutting nozzle

MUREX

CHAPTER SEVEN

PERSONAL PROTECTION AND GENERAL SAFETY

PERSONAL PROTECTION AND GENERAL SAFETY

The major obvious hazard with regard to the use of gas welding and cutting equipment is fire. However, there are a number of other areas that we will need to consider such as:

- **Fire or explosion due to the release of fuel gases.**
  These may be due to loose or badly fitting connections, an excessive amount of time between turning on the gas at the blowpipe and igniting it, or simply failing to turn the equipment off correctly.
- **The spread of fire due to Oxygen enrichment.**
  This may also be due to leaks as above or excess Oxygen being released during a cutting operation. Lack of adequate ventilation is often a contributory factor.
- **Explosion due to high pressure Oxygen being in contact with oil or grease.**
  No gas equipment should be lubricated in any way. Gloves which are liable to come into contact with oil or grease, should not then be worn for welding or cutting. Care also needs to be taken when positioning gas equipment that oil does not drip on it from some other apparatus, such as a crane.
- **Burns from contact with a flame or hot material.**
  Never wave a blowpipe around while talking. Put it out first, so that you can give your full attention.

  Materials that have been in contact with a flame are hot, so wear gloves when moving them. The thicker the metal, the longer it will retain it's heat. Remember others may have a need to move metal that has been recently cut, so mark it with the time and date:

  HOT - 13.00 hrs. - 20.11.96.
- **Fires ignited by sparks.**
  It is not generally recognised the distance that sparks can travel. All combustible material should be moved at least 10 metres from the work area, and dry powder or a CO_2 fire extinguisher be to hand. A bucket of water should also be available at the work place for cooling equipment in case of a sustained backfire.

  It is strongly recommended that work is only carried out in areas with non-combustible floors.
- **Release of stored energy.**
  Removing components while still under pressure, badly fitting or loose connections, can cause items to be propelled with considerable force, and hoses to flail around causing personal injury and damage.
- **Physical injuries.**

  Back strain or other physical damage due to falling cylinders or stumbling over other material in the work area. While doing long cuts it is normal to walk backward, therefore care needs to be taken that the way is clear to enable this to be done safely.

  To stumble with a lighted blowpipe can do considerable damage.
- **Eye injuries due to intense glare and ultra - violet radiation.**
  Goggles and filters manufactured to EN 175, with a lense of the strength for the operation being attempted in accordance with EN 166/169, should always be worn to protect both from glare and stray sparks.

  Goggles are available to wear over normal glasses, and some have a secondary clear glass lens to give protection when the filter lens is removed to see the workpiece.

  Goggles should be non-flammable, comfortable to wear and have adequate ventilation. Never purchase goggles without first trying them on.
- **Heat, radiation and fume.**
  Heat and radiation can be a problem when heating or cutting thick or large sections. Normal gloves and overalls may not prove sufficient and special insulated clothing may be required.

  Local extraction equipment placed down wind of the operation will help both with the problem of radiation and the fumes caused by heating lead or zinc coatings, and galvanized material.
- **Ear protection.**
  It is a legal requirement to provide ear protection where the noise levels exceed 85 DB (A), and operatives are not allowed to work without adequate hearing protection if levels of 90 DB (A) are experienced.

  It is not generally appreciated how low 85 DB is, and in fact most cutting operations will exceed this, as will welding material over 4mm.

  Where heavy cutting or super-heating is being done the 90 DB level will be exceeded and ear protection must be worn.

  Other operatives in the immediate vicinity of the work area also need to be protected and this may be possible by using sound proof screening.
- **Flashbacks, backfires and sustained backfires.**
  This subject has been dealt with in Chapter four. Correct working practices i.e. purging of hoses, right choice of nozzle size and correct working pressures etc, will ensure that these are kept to a minimum, but sometimes the cause is outside of the control of the operator, and it is therefore essential that flashback arrestors and non-return valves are fitted.

The following points need to be considered:

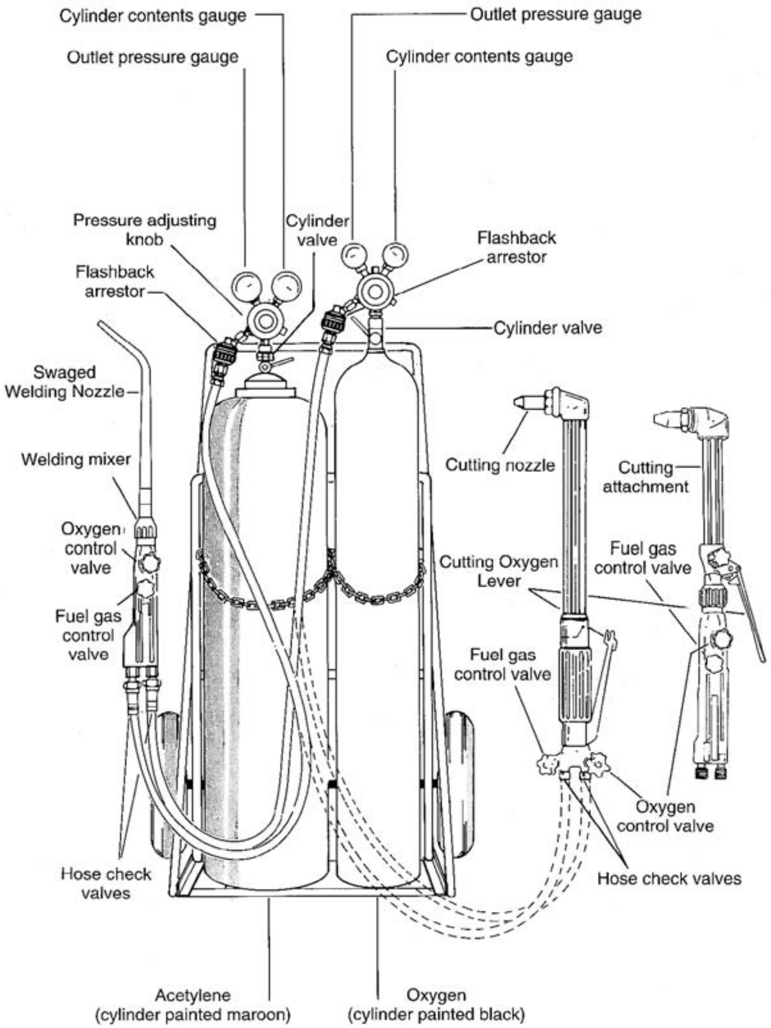
1) Adequate knowledge of the process and the equipment.
   (If you have read through to this point you are well on your way!)
2) Ear defenders.
3) High and close fitting collar to make sure sparks do not enter clothing.
4) Gloves specifically manufactured for either welding or cutting.
5) Boots with toe protection.
6) Trouser legs worn outside boots to stop sparks entering.
   Leather spats may be preferred.
7) Fire retardant overalls - possibly also a leather apron.
8) Comfortable, well fitting goggles with the correct grade lense.
9) Head gear - possibly with neck protection.
   In some situations hard hats will be required.

MUREX

CHAPTER EIGHT

SAFE PRACTICES FOR EQUIPMENT ASSEMBLY FOR WELDING AND CUTTING

A TYPICAL OXYFUEL GAS WELDING AND CUTTING SYSTEM



Equipment assembly

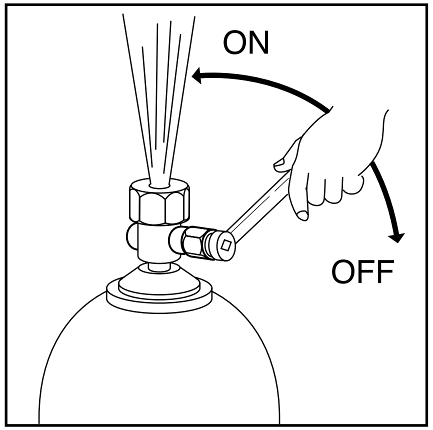
Cylinders should be secured in a trolley or cradle, chained or strapped to a support and held vertically, and the plastic protection caps removed.

The cylinder valve or pipeline valve should be inspected for damage prior to opening. If there is evidence of oil or grease on the valve, the cylinder should be returned to the supplier. Contaminated pipeline valves should be reported to the appropriate management responsible for them.

PTFE tape or other jointing materials should not be used in effecting a seal between the regulator and the cylinder outlet. However some cone fittings employ O-ring seals while flat seats may employ a washer. If O-rings are fitted they should be carefully examined to ensure they are undamaged and have not gone brittle or sticky.

Only original manufacturers replacements which are guaranteed safe in high pressure oxygen service should be used.

Unwind the pressure adjusting screws on the regulators by turning fully anti-clockwise.



Fit a cylinder key to each cylinder valve spindle and ensure that it is in the closed position (turned fully clockwise). The spindle key should remain in the valve the whole time the equipment is in use in case there is a requirement to shut off the gas supply in an emergency. (Some cylinder valves are hand wheel operated). Ensure the cylinder is secured in a position where the cylinder key is fully operational and not restricted in use. If available, use compressed air to clean the cylinder valve outlet. If not, snift (open and close briefly) the cylinder or pipeline valve (except Hydrogen) to dislodge water or foreign matter from the valve/regulator inlet seating. Care should be taken to direct away from personnel or any flame or heat source.

Offer up the regulator to the relevant cylinder valve. The Oxygen one to the black* cylinder which will have right-hand connecting threads (turn clockwise to tighten) and the fuel gas regulator to the appropriate fuel gas cylinder,

ie:	maroon cylinder	Acetylene
	red cylinder	Propane* or Hydrogen

*Oxygen cylinders in countries other than the UK may be blue or green. Check the contents label

Note: Some gas suppliers paint their Propane cylinders in other colours. Users should satisfy themselves that the cylinder is labelled with the gas that it contains and is safe to be used with the regulator available. The stated inlet pressure (service pressure) rating of the regulator must be equal to or greater than that available from the gas source to which it is connected.

Fuel gas cylinders have left-handed threads (tighten anti-clockwise).

Ensure the regulator gauges are facing forward and then tighten the inlet nut with just sufficient pressure to effect a seal.

Inspect the regulator outlets and ensure they are clean and free from contamination. No sealing material should be used on the threads. Offer up the relevant flashback arrestor to the regulator and secure with a spanner - oxygen right-hand threads (turn clockwise), fuel gas left-hand (turn anti-clockwise) - identifiable by the notches cut into the nut corners.

Take the two lengths of hose and identify the ends fitted with the nuts and nipples only. This is the shorter connection and should be screwed to the relevant flashback arrestor outlet.

The other end of the hose should be fitted with a non-return valve to ensure gas cannot reverse flow back into the hose. This should be marked with an arrow facing away from the regulator showing the correct direction of gas flow.

Before connecting the torch, a little gas should be bled through the system to ensure no foreign matter is entrapped. Ensure one line is bled and closed prior to proceeding with the other.

This is carried out by:

a) Opening the cylinder valve one full turn. Note the pressure indicating on the cylinder contents gauge.

b) Closing the cylinder valve.

c) Open the regulator by screwing the pressure adjusting knob in (clockwise).

d) Once both gauges are again recording zero, close the regulator by turning the pressure adjusting knob anti-clockwise.

Having cleaned the system the blowpipe handle torch or cutter can now be connected.

MUREX

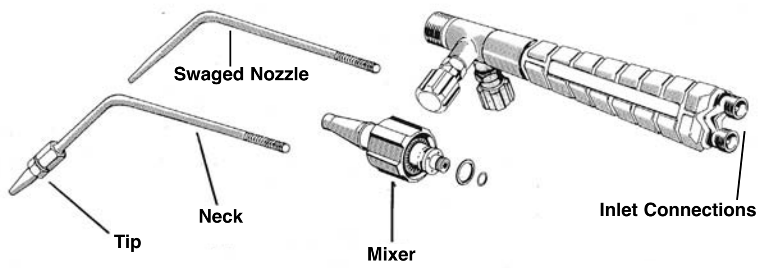
CHAPTER NINE

WELDING AND BRAZING PRACTICE

WELDING AND BRAZING PRACTICE

Lighting Up Procedure Equal Pressure Equipment

Identify the inlet connection marked O or O_2 and ensure it is clean prior to connecting to it the blue Oxygen hose by means of the hose check valve (right-hand threads). Repeat the operation with the fuel gas hose (left-hand threads).



Select the correct size of nozzle for the material to be welded and either screw into the mixer (swaged nozzles) or screw into the relevant neck (DH tips) which in turn is screwed into the mixer.

The size of nozzle can be ascertained from the data tables (Page 96-100).

Offer up the mixer to the shank, ensuring nozzle is at the desired angle and press together. Once engaged the connecting nut can be screwed tight.

Note: If the connections involve the locking of teeth, it is essential that these are seen and felt to fully locate, as the connecting nut will not pull the mixer and shank together to ensure a leak tight seal. Failure to do this could cause a leak, leading to fire at this connection.

Ensure the fine adjustment valves on the shank are closed.

Open both cylinder valves by turning anti-clockwise and note the cylinder contents pressure indicated on the gauge.

Open both regulators by turning the pressure adjusting knobs clockwise until the required pressure according to the nozzle selected is indicated on the working pressure gauges. See Data Charts (Page 96-100).

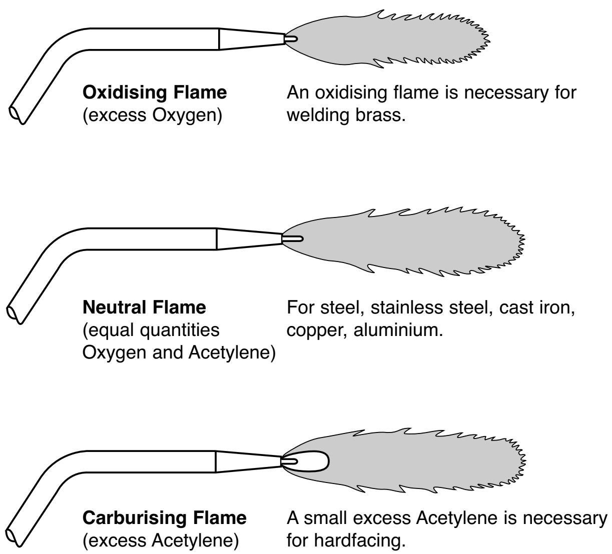
Open the Oxygen fine adjustment valve on the shank (blue) fully and allow gas to flow through it to purge the hose and then re-set the required working pressure at the regulator while the gas is flowing.

Close the Oxygen (blue) valve on the shank.

Open the fuel gas fine adjustment valve on the shank (red) fully and allow gas to flow through it to purge the hose and then re-set the required working pressure at the regulator while the gas is flowing.

Light the fuel gas with a spark lighter pointing in the same direction as the nozzle. If the flame smokes, increase the flow by adjusting the regulator until it ceases to do so. Keep increasing the flow until there is a small gap between the flame and the nozzle, then reduce the flow so the flame just sits on the end of the nozzle.

Welding flame conditions



Slowly open the Oxygen (blue) valve on the shank noting the change from yellow to blue in the flame, until the central cone of the flame is sharply defined with a slight trace of acetylene haze. This is the neutral condition where equal quantities of both gases are being burnt.

The easiest way to ensure a neutral flame, is to first set a carburising flame where there is a slight excess of Acetylene evident in the glowing yellow cone formed in front of the main primary cone. Reduce the Acetylene and increase the Oxygen alternately by small adjustments until the yellow cone just disappears. This is the neutral flame required for welding all types of steel and copper.

Should your nozzle become blocked during welding or cutting, use the special nozzle cleaners to clear the obstruction, never use a damaged nozzle.

Note: One should aim at obtaining the neutral flame condition by adjusting at the regulators only and leaving the shank fine adjustment valves fully open.

Once the neutral flame has been obtained:

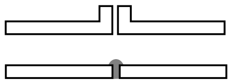
Begin to close the Oxygen (blue) valve on the shank until the flame feather appears at the cone.

Begin to close the fuel gas (red) valve to get rid of the feather and obtain the neutral flame. In this way full control of the flame condition is in the operator's hands at the shank.

JOINT DESIGN FOR WELDING

Types of Joints

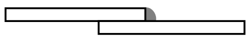
Butt



Joints for metal that is less than 2mm (14 swg) if the design allows it, should be flanged butt welded. From 2mm to 3mm (1/8") they can be butt welded using the forehand method, while from 3mm (1/8") to 6mm (1/4") it is preferable to use the back hand method. However many welders now successfully forehand weld up to 8mm (5/16").

Flange butt joints should be clamped during welding while standard butt joints should be tack joined at 5cm (2") intervals. True, flanged butt welds require no filler metal to be used, but where rod is employed weld bead should be slightly convex and a consistent width.

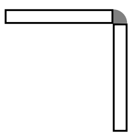
Lap



This consists of one piece of metal lying over another. It is not recommended for most work as it has low resistance to bending and it is difficult to ensure fusion to the root of the joint. It is often very difficult to examine the underside of the weld and to know how satisfactory the joint will be in service. Distortion tends to be greater than with a butt weld and where corrosive fluxes are employed it is unlikely that all traces can be removed after welding.

However lap joints are suitable for bronze welding or brazing operations.

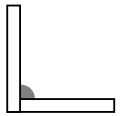
Outside Corner



Outside corners can be welded by overlapping the edges and melting them as in a flanged butt weld, thereby requiring no filler rod. The joint can be produced by mating the internal edge only and filling the corner with a bead.

However, there is a risk of lack of fusion at the inside edge of the joint, particularly where there is the possibility of movement of the plates during welding. For this reason this type of joint is seldom satisfactory for vessels which will hold water or other liquids or be subjected to pressure. A gap should be left to ensure penetration.

Inside, Fillet Welds



Should be avoided if at all possible due to the problems of obtaining sufficient fusion at the root of the joint. If it is unavoidable then the flame should be concentrated on the lower surface of the joint and sufficient rod melted to ensure an adequate bead of metal forming a convex fillet well up the side wall and right into the corner. A nozzle one size larger than specified for the thickness of the material should be used.

TECHNIQUES

Flame Condition

Set the correct flame for the work to be done.

A neutral flame is correct for almost all gas welding, as it consumes the oxygen from the air around the area and gives an uncontaminated weld of maximum strength.

An oxidising flame may be used for welding brass or bronze, while a carburising flame is useful for hard facing materials.

As the welding bead is applied to the join the two edges will be drawn together and the essential penetration gap lost. To overcome this the ends of the two pieces of metal should be tacked together and then the join tacked at 5cm (2") intervals.

Metal Preparation

Joints to be welded should be cleaned of scale, rust, paint or grease.

Impurities in the molten puddle may cause weld failure.

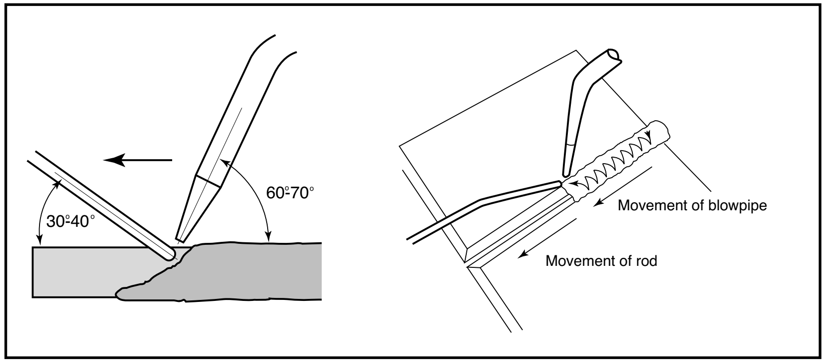
Welding Practice

Oxy-acetylene welding is a means of melting or fusing together two adjoining metal surfaces, by playing a flame on to the area to be joined, until a molten puddle is formed. It may be desirable to feed this puddle by introducing into it a filler rod of the correct material.

Forehand (Leftward) Welding

This is the most common method and is used for steel plate up to 8mm (5/16") due to the better control of the small weld puddle.

If a welding rod is used it proceeds the welding nozzle in the direction in which the weld is to be made. The flame is directed downward at an angle of about 60 to 75º to the work to pre-heat the metal edges. An oscillating or circular action is used to distribute the heat and the molten metal of the weld puddle evenly. The tip of the inner cone should be about 3mm (1/8") above the metal and the cone of the flame should not leave the weld puddle.



The skill in good welding is to be able to “read” the weld puddle. It controls adequate penetration and shows the rate at which metal can be laid down. It also tells you whether you have the right flame condition for the weld being made.

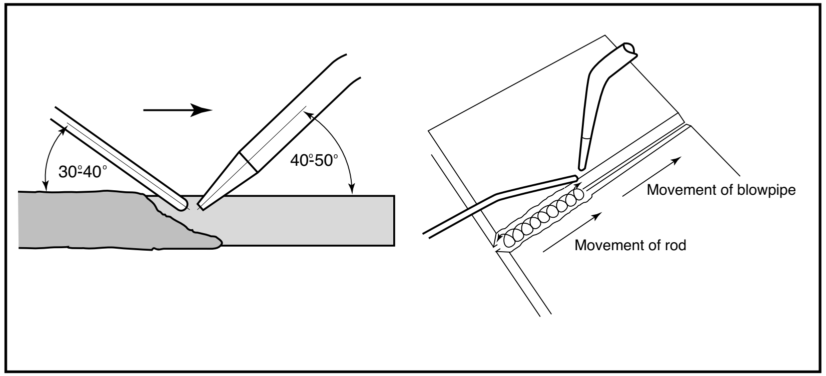
Most Oxy-Acetylene welds will require the addition of a filler rod to ensure adequate penetration. The rod should be preheated by bringing it to about 10mm (3/8”) from the flame prior to dipping it into the weld puddle to retain the correct size of puddle.

At the end of the weld it will be necessary to raise the flame from the metal and increase the amount of filler rod used to ensure a full smooth finish.

Backhand (Rightward) Welding

This is recommended for steel plate over 3mm (1/8”) thick and enables better fusion at the root of the metal for thicker materials. It is also used for welding heavy sections or cast-iron to relieve the stresses created by the welding process.

The filler rod is moved behind the flame which is steadily moved forward while the rod is moved from the flame to the weld puddle in a circular forward motion.



PROCESSES

Brazing

Brazing has the advantage that less heat is required and so there is less risk of deforming the work-piece. A joint clearance of between 0.04 and 0.20mm is required for the capillary action to draw the liquid filler material between the mating surfaces. Good brazing is dependent on well designed, close fitting joints. Most metals including copper and aluminium can be successfully brazed.

The length of overlap in the join should be between 3 to 5 times the thickness of the materials being joined.

After careful cleaning, the correct flux for the materials being joined is applied. A soft neutral flame is used to heat the joint evenly, so that the entire area reaches the temperature required at the same time. Once the joint is heated reduce the Acetylene to give an oxidising flame. The filler material, although heated in the flame must be melted by the metals being joined and not by the flame. If too much heat is applied to the filler material the zinc or copper will be lost and the joint will have a red or coppery colour appearance and may cause porosity in the joint.

Braze Welding

Braze welding is performed in a similar way to forehand (leftward) welding, and requires greater heat than brazing. At ambient temperature the joints can be practically as strong as fusion welded items, and are therefore commonly used in the manufacture of tubular steel sections used in furniture etc.

For brazing steel the joint should be heated to a dull red and the flame kept moving over the surface to ensure it is evenly heated. The width of the weld material will be determined by that that is preheated to the melt temperature of the filling material.

Brazing rods melt quickly and it will be found that the torch will be a little further from the metal and progress faster than during a fusion weld. It is also recommended that a smaller rod is continually dipped rather than a larger rod, which could deposit too much material.

Braze welding joints should have the sharp edges removed prior to welding.

As with brazing the correct flux should be selected and the joint well cleaned prior to applying the flame. Care must again be taken to ensure the filler rod is not destroyed due to leaving it in the flame and burning off the zinc or copper. Flux may be applied by dipping the heated rod into the flux, and applying to the heated joint and mixing with water and painting the joint. The melted flux reacts with the base metal and cleans it. The melted filler rod should flow freely enabling a build up to the desired thickness. Maintain the temperature by continuing to play the flame onto the joint.

Silver Brazing

This is an excellent method to make electrical connections and joints requiring high corrosion resistance. It is used in the chemical industry where corrosion at the joints can be a problem and where a completely reliable leak proof join is imperative. It is also used by jewellers and precision instrument manufacturers due to its very acceptable quality finish.

However, great care must be taken not to overheat the filler rod and if it is found that adhesion is not taking place, it will be necessary to completely re-clean the joint and start again.

During the brazing operation the joint should be shielded by the flame to exclude air from the join.

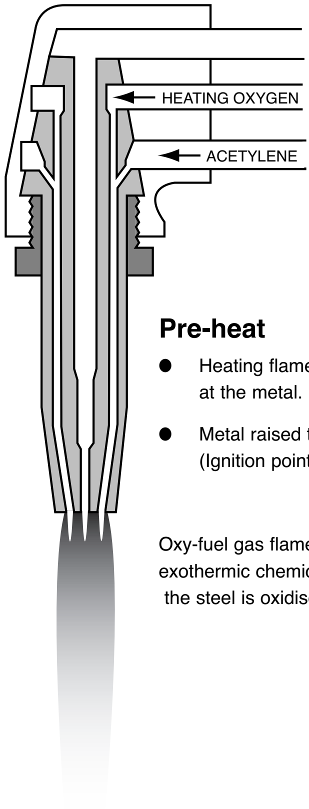
Safety Note: All brazing and braze weld operations should be carried out in a well ventilated area as the materials may generate toxic fumes.

CHAPTER TEN

CUTTING PRACTICE

CUTTING PRACTICE

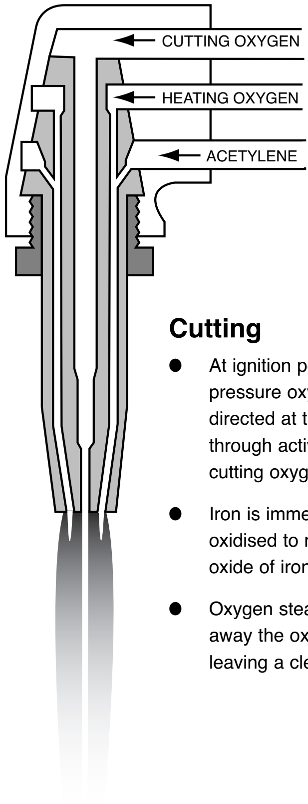
The Oxy-fuel gas cutting process is accomplished by heating the work piece until it is a dull red. At this stage the cutting Oxygen stream is introduced. The metal will burn and the pressure of gas removes the slag that is formed. Because much higher Oxygen pressures are required to ensure the removal of the slag from the cut, sparks can travel considerable distances and great care must be taken in clearing the area of combustible materials.



Pre-heat

- Heating flame is directed at the metal.
- Metal raised to red Heat (Ignition point).

Oxy-fuel gas flame cutting is an exothermic chemical action where the steel is oxidised not melted.



Cutting

- At ignition point, high pressure oxygen directed at the metal through activation of the cutting oxygen lever.
- Iron is immediately oxidised to magnetic oxide of iron (Fe_3O_4).
- Oxygen steam blows away the oxidised area leaving a clean cut.

Setting Up

Inspect the head of the cutter or cutting attachment prior to fitting the correct nozzle. The head must be round for the nozzle to seat correctly and if there is evidence of the head being oval, the torch must not be used. If the seats are contaminated with carbon, this should be removed with a clean cloth, a new nozzle fitted and the assembly tested for head seat leaks, by putting the head under water, while blanking the nozzle exits.

Note: This test will only expose severe fuel gas to atmosphere leaks. If there is clear evidence of a build up of carbon on the nozzle seats, the cutter or cutting attachment should not be used.

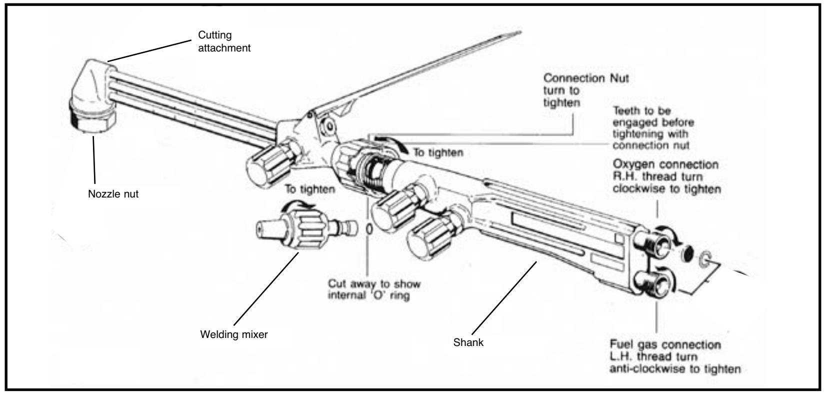
Nozzle exits should be blanked off by forcing a rubber bung against the nozzle exit while holding the head under water. Bare flesh should not be placed into a stream of gas under pressure.

Flow the gas through the heating Oxygen, heating fuel gas and cutting Oxygen channels at 5 lbf/in^2. If there are bubbles evident from the nozzle/head connection the torch should not be used.

Select the correct nozzle for the gas, process and thickness of material to be cut, from the data on pages 96-100. Ensure the nozzle seats are, undamaged and that the exit holes are square to the direction of gas flow and free from burrs or slag.

Fit the nozzle to the head and tighten the head nut firmly with the correct spanner. Excessive torque should not be required.

If a combined torch is being used the cutting attachment should be fitted to the shank. If the shank has previously been used for welding, it will be necessary to first remove the welding mixer.



Note: If the connection involves the locking of teeth, it is essential that these are both seen and felt to locate prior to the hand nut being screwed up. This nut will not draw the shank and cutting attachment together to give a leak tight seal and it is therefore essential that the cutting attachment is pressed hard onto the shank until the teeth are seen and felt to engage, prior to tightening the connection nut.

Lighting Up - Nozzle Mix Cutters and Blowpipes

Ensure that both regulators are closed with the adjusting knobs wound out fully anti-clockwise.

Slowly open both cylinder valves one full turn and ensure that sufficient gas for the job in hand is recorded on the contents gauges.

Ensure that the cutter or cutting attachment and shank valves are all closed.

Open the Oxygen regulator by turning the pressure adjusting knob clockwise until the required pressure is recorded on the working pressure gauge.

Open the Oxygen valve on the cutter or on the cutting attachment and also on the shank.

Note: If there is another valve on the cutting attachment controlling the Oxygen flow the Oxygen valve on the shank should be left fully open during all cutting operations.

Depress the cutting Oxygen lever and re-adjust the regulator to the required pressures as indicated in the data on pages 96-100. Allow sufficient gas to flow to completely purge the system before releasing the cutting Oxygen lever and closing the downstream heating Oxygen valve.

Open the fuel gas regulator by turning the pressure adjusting knob clockwise until the required pressure is recorded on the working pressure gauge.

Remember, the longer the length of hose, the greater the time required to purge it.

Open the shank or cutter valve for the fuel gas and reset the guideline pressure at the regulator in accordance with the data on pages 96-100.

Once sufficient gas has been allowed to flow to purge the system, the torch may be lit.

Note: The torch should be lit with the head facing upward if the fuel gas is Acetylene, as it is lighter than air, and downwards if Propane, as it is heavier than air. This is to ensure that the fuel gas does not enter an Oxygen outlet prior to the gas being lit. Ensure the spark lighter is facing the same direction as the flame and the valve well opened.

If the fuel gas flame smokes, continue to open the cutter or shank valve until it ceases to do so.

Progressively open the heating Oxygen valve on the cutter or cutting attachment and adjust until a neutral flame is obtained.

Depress the cutting Oxygen lever and if necessary re-adjust the heating Oxygen valve so that a neutral flame is retained while the torch is cutting.

If it is found that some preheat flame cones are notably lower than others, close the torch down, loosen the head nut and rotate the nozzle within the head, so that the inlet holes are not directly in line with the holes in the head. Re-tighten the head nut and follow the lighting up procedure.

Light with a sparklighter

Adjust to a neutral heating flame, and then depress the cutting Oxygen lever or turn the cutting Oxygen fine adjustment valve.

This will probably effect the heating flame, and to obtain the neutral flame again it is best to increase the fuel gas until an excess of fuel gas produces a yellow flame, and then reduce it again until the yellow portion coincides with the primary flame.

Closing Down Procedure

Release the cutting Oxygen lever.

Close down the fuel gas (red) control valve and the flame will extinguish.

Close the Oxygen (blue) valve.

Close both cylinder valves.

Open one and then the other of the blowpipe valves for long enough to vent all gas from the system. Ensure one gas is completely vented prior to venting the other.

Ensure all gauges register zero, then wind out anti-clockwise both regulator pressure adjusting knobs.

Close all valves down stream of the regulators.

Note: If a sustained backfire occurs, identified by a rapid machine gun effect, quickly followed by a screaming noise and black soot and sparks being exhausted from the nozzle, it is essential that the fire within the system be starved of Oxygen immediately. In this case the Oxygen (blue) valve should be closed first, followed by the fuel gas (red) valve.

The torch should be plunged into a bucket of water to cool and thoroughly checked over before re-using.

Also remove the nozzle from the head and check the seating.

If a combined torch is being converted from cutting to welding it is essential that the valves on the shank are fully closed and that the Oxygen is vented from the cutting attachment by depressing the cutting Oxygen lever, before undoing the connecting nut.

Cutting practice

i) Inspect the floor area where you are standing to ensure that if there is a need to step backwards as the cut progresses, there is nothing in the way.

ii) Hold the torch, once lit, comfortably in both hands with the preheat cones about 3 to 4mm (1/8") from the plate.

iii) Point the nozzle in towards the edge of the material and heat until it glows a dull red.

iv) Gradually bring the nozzle to the vertical position and move just off the edge so that the full thickness is heated.

v) Slowly press the cutting Oxygen lever and begin to smoothly pass it across the plate. Too fast a movement will lose the cut, while too slow a movement will round the top edge through over-heating and give a poor quality cut.

vi) It is often an advantage to lean the nozzle a little into the cut so that the tip is slightly forward of the head.

vii) As the end of the cut is reached slow down and ensure the bottom edge is fully severed. Continue to move the flame forward and away from the plate.

Remember the two portions of plate that have been cut will be very hot and will remain so for a considerable time.

Handle with gloves and mark with chalk the time and date ie
"HOT 11.00AM 20/4/97".

Piercing

Piercing is where a portion is cut from within a plate, ie. not commencing from one of the edges. The main difference is with the method of commencing the cut.

The start is greatly helped if a large punch mark is made or if there is waste material, a hole is drilled and the cut is moved from the hole to the required pre-drawn cut path.

i) The plate is preheated to a dull red with the preheat cones almost touching the metal. The nozzle tip will be about 6 to 7mm (1/4") from the plate.

ii) The cutting Oxygen stream should be introduced very slowly and the nozzle lifted a little from the surface to ensure that molten material does not block the nozzle exits. Angle the nozzle a little to give clear visibility.

iii) The cut can proceed in the normal manner with the nozzle tip raised to about 12mm (1/2") from the metal. If there is a danger of losing the cut, lower the torch sufficiently to retain the heat but not to allow molten material to block the gas flow.

Note: Circle and bevel cutting can be greatly assisted by the use of a cutting aid.

A quality cut is one that requires little or no additional cleaning or finishing process, and is dependent on:

i) the right nozzle for the thickness being cut

ii) the right condition of nozzle and material

iii) the right pressures and speed of travel

iv) the right distance between the nozzle and the plate

Heating

When using Oxy/fuel gas equipment for heating purposes, careful consideration needs to be given to the fuel gas employed, as well as to the equipment and method to be used.

Oxy/Acetylene Heating

Because of the intense heat and ability to direct to a specific area Oxy/Acetylene heating is used for brazing, silver soldering, glass forming and pipe bending. It can also be adapted for certain flame hardening applications.

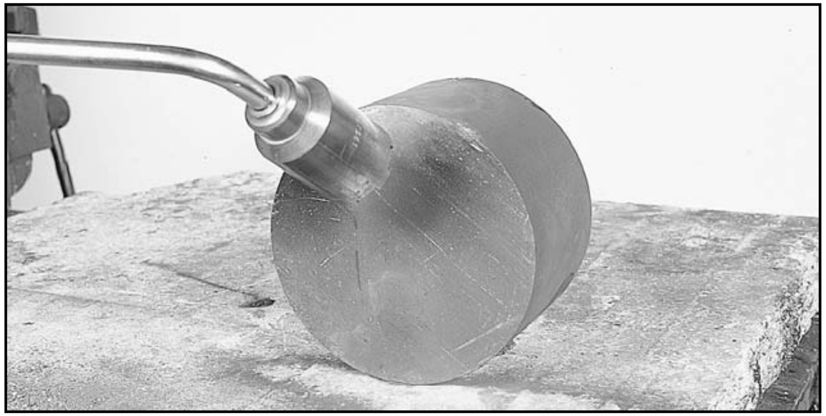
With small combined shanks a 500 L/h neck and nozzle assembly is ideal for the DIY enthusiast, as well as the garage doing small bending jobs and shifting the rusted nut or joint.

The larger combined torches require a heavy duty mixer to enable the three sizes of AHT heating nozzles to be used, giving the ability to heat to 50,000, 70,000 or 140,000 btu's. A range of straight and bent necks are available to ensure complete flexibility and comfort in use.

Oxy/Propane Superheating

Where large volumes of intense heat are required to "soak" the material over a large area, Propane is the better fuel gas to employ. Ideal for straightening, forming or bending large items and brazing heavy copper piping, superheating is extensively employed in the preheating of structures before certain Arc welding processes are performed.

Superheating nozzles may be used with an extended cutting torch (0.75m (27")) fitted with a superheating adaptor or with one of the large combined shanks fitted with a propane mixer and relevant neck.



Lighting Up Equal Pressure Blowpipe or Nozzle Mix Cutter

Ensure the system has been adequately purged.

Oxy/Acetylene

i) Open the fuel gas (red) valve on the shank and light the flame with a spark lighter facing the same direction as the nozzle. Ensure the flame is not directed towards the cylinders or any combustible material.

   Continue to open the fuel gas valve until fully opened.

ii) Increase the flow of Acetylene from the regulator until the flame stops smoking.

iii) Open the Oxygen (blue) valve. The flame will change colour from yellow to blue. Slowly increase the oxygen flow until the feathering at the cone disappears.

iv) Increase the acetylene until a faint transparent bluish flicker or feathering appears at the end of the centre cone.

v) Increase oxygen again until this feather all but disappears. Keep repeating these operations until the flame leaves the nozzle, ie. there is a gap between the flame and the nozzle.

vi) Bring the flame back on to the nozzle by slightly reducing the flow but still retaining the correct flame condition.

   Note: This is the maximum flame condition where the maximum amount of gas is being passed through the nozzle, and is safest in operation. Even if hoses are kinked or crushed there is likely to be sufficient flow of gas to ensure a backfire does not occur.

Oxy/Propane

It is necessary to entrap the gas when lighting an Oxy/Propane superheating nozzle. To do this the nozzle should be held at an angle of about 45^{o} to a non-flammable surface.

i) Open the fuel gas valve on the shank or cutter and light with a spark lighter facing the same direction as the nozzle. Do not direct towards the cylinders or combustible material.

ii) Increase the flow of Propane until the flame ceases to smoke.

iii) Progressively increase first the Oxygen and then the propane until the required size of flame is obtained.

iv) Continue to increase the Oxygen flow. It will be noted that the lengths of the inner cones within the flame get smaller as the Oxygen flow is increased.

v) Continue to increase the Oxygen flow until it is no longer affecting the size of these inner cones. They will now be bluish in colour and the flame has a distinctive roaring noise and slight oxidising appearance.

Note 1:

Dangers of entrapped fuel gas while super-heating with Oxy/Propane.

It is possible for unburnt fuel gas to collect in cavities behind work-pieces when using Oxy/Propane super-heating torches, which may lead to an explosion.

The critical factors likely to bring about this condition are:

a) Incorrect operating pressures.

b) Nozzle too close to the work-piece.

c) The size of any gap or hole in the work-piece through which unburnt gas could feed.

d) The position of any such gap or hole in relation to the cavity behind the work-piece.

e) The size of such cavity, and whether it is open to the atmosphere.

f) The condition of the super-heating nozzle.

Other factors which are also relevant to producing unsafe conditions are:

g) Lack of operator training.

h) Failure of operators to receive or abide by manufactures instructions.

i) Incorrect lighting up procedures.

Trials subsequent to a number of incidents have shown that operators tend to use operating pressures which give highly fuel rich flames. Propane pressures twice those recommended by the manufacturer were common place.

An Oxy/fuel gas flame obtains approximately 40% of it's Oxygen from the atmosphere, and if a super-heating nozzle is held too close to the work-piece this amount is reduced to the extent that the flame becomes fuel gas rich.

The distance between the nozzle and the workpiece should never be less than 50mm (2"), and twice this distance is recommended. It is a fallacy to believe that the closer the nozzle is to the work-piece the hotter it will become. The less Oxygen being used within the flame the cooler the flame is, and therefore if the nozzle is brought too close to the work-piece the less oxygen is drawn into the flame.

Where old and deformed nozzles were being used, the bent castellations were reducing the flow of gas through the nozzle, which also effected the amount of heat being produced.

If there were gaps or holes in the plate being heated, bringing the nozzle to within 50mm (2") of it, forced unburnt gases through these holes which would then mix with the air inside the cavity causing an explosive mixture.

If the hole or gap happened to be close to the bottom of the vessel the danger was considerably reduced, as the unburnt gas being heavier than the air would drop but only mix with a small amount of air. However, if the hole was near the top of the vessel, or the vessel was open to the atmosphere at the top, say, like a dustbin, without it's lid, then the heavy unburnt gas would trap beneath it the full air content of the vessel.

Any subsequent heat applied to the vessel, which would now be full of an air - fuel gas mixture would be likely to explode.

Operators should be made aware of these dangers and receive training on how to lessen the risks of them occurring.

Manufactures must supply operating instructions with this equipment that must be handed to the operator. Not to do so is a contravention of the Health and Safety at Work Act 1974.

If a shank is being used with an extension neck it is essential that the joints between neck and nozzle and neck and shank are kept leak tight. If they are allowed to loosen there is a danger of air being drawn in which may cause sustained backfiring.

A more rigid assembly is obtained with an extended cutter which is less likely to loosen in service and because the Oxygen flow obtainable is higher, will produce greater heat. A special adaptor is required to blank off the heating Oxygen and the full cutting Oxygen stream is used instead. This is safer, more efficient and is to be recommended.

Note 2:

When using a nozzle mix cutter rather than a shank/mixer/extension tube assembly, a superheating adaptor will be required. This adaptor blanks off the heating Oxygen stream within the cutter head and so the Oxygen control valve should be left closed. Oxygen is supplied through the cutting Oxygen stream and the cutting lever and fuel gas control valve should be used.

Note 3:

Never starve heating nozzles or attachments of gas. Always err on the side of caution and set a larger flame. Flames that are smaller than the nozzle is designed for, will overheat and backfire. If a backfire sustains, evident by the nozzle screaming and soot being exhausted from the exit, the fire must be immediately starved of Oxygen by turning off the shank Oxygen control valve, or if using a cutter, releasing the cutting Oxygen lever.

This will probably cause a small explosion but it is the quickest and safest way to extinguish the fire and ensure that the equipment is not damaged and/or a potentially dangerous flashback is averted.

DATA TABLES

Please note the following data is given as an approximate guide. Working conditions, length and diameter of hose, provision of non return valves and flashback arrestors and their fitness for use, will all have an effect on the pressures and flows obtainable at the nozzle. A stable flame of the type required for the job in hand is the true proof that the correct conditions have been met. It is wise always to err on the side of caution and set a flame a little larger than that which could suffice for the process.

Nozzles marked with an asterisk (*) can produce a noise level in excess of 85DB(A). If use is expected to be extensive then ear protection should be worn.

Acetylene cylinders must be manifolded when consumption rates of Acetylene exceed 16.5 litres per minute (35ft³/h) nozzles concerned are indicated (†).

Welding

Nozzle Type Swaged using 6.3mm x 10m fitted hose with resettable flashback arrestors - all in new condition.

Mild Steel Thickness mm	in	swg	Nozzle Size	Operating Pressure Acetylene bar	Acetylene lbf/in²	Oxygen bar	Oxygen lbf/in²	Gas Consumption Acetylene L/M	Acetylene ft³/H	Oxygen L/M	Oxygen ft³/H
0.9	-	20	1	.14	2	.14	2	.47	1	.47	1
1.2	-	18	2	.14	2	.14	2	.94	2	.94	2
2.0	-	14	3	.14	2	.14	2	1.42	3	1.65	3.5
2.6	-	12	5	.21	3	.21	3	2.36	5	2.83	6
3.2	1/8	10	7	.21	3	.21	3	3.30	7	3.77	8
4.0	3/32	8	* 10	.28	4	.28	4	4.7	10	5.2	1.1
5.0	3/16	6	* 13	.28	4	.28	4	6.6	14	7.1	15
6.5	1/4	3	* 18	.35	5	.35	5	8.5	18	9.4	20
8.2	5/16	0	* 25	.4	6	.48	7	11.8	25	12.7	27
10.0	3/8	4/0	* 35	.66	9.5	.66	9.5	16.5	35	17.9(†)	38
13.0	1/2	7/0	* 45	.4	6	.4	6	21.2	45	22.6(†)	48
25+	1+		* 90	.62	9	.62	9	42.5	90	44.8(†)	95

Welding

Nozzle Type Swaged Lightweight & DH Tips using 6.3mm x 10m fitted hose with resettable flashback arrestors in new condition.

Mild Steel Thickness mm	in	swg	Nozzle Size	Operating Pressure Acetylene bar	Acetylene lbf/in²	Oxygen bar	Oxygen lbf/in²	Gas Consumption Acetylene L/M	Acetylene ft³/H	Oxygen L/M	Oxygen ft³/H
0.9	-	20	1	.14	2	.14	2	.47	1	.47	1
1.2	-	18	2	.14	2	.14	2	.94	2	.94	2
2.0	-	14	3	.14	2	.21	3	1.42	3	1.42	3
2.6	-	12	5	.21	3	.28	4	2.36	5	2.83	6
3.2	1/8	10	7	.21	3	.35	5	3.30	7	4.72	10
4.0	3/32	8	*10	.28	4	.35	5	4.72	10	5.2	11
5.0	3/16	6	*13	.35	5	.48	7	6.13	13	7.1	15
6.5	1/4	3	*18	.41	6	.55	8	8.5	18	9.4	20
8.2	5/16	0	*25	.55	8	.69	10	11.8	25	12.7	27

Cutting

Nozzle Type ANM/ANME using 6.3mm x 10m fitted hose with resettable flashback arrestors in new condition.

Mild Steel Plate Thickness mm	in	Nozzle Size	Operating Pressure Oxygen bar	Oxygen lbf/in²	Fuel Gas bar	Fuel Gas lbf/in²	Gas Consumption Cutting Oxy L/M	Cutting Oxy ft³/H	Heat Oxy L/M	Heat Oxy ft³/H	Fuel L/M	Fuel ft³/H
6	1/4	1/32	1.4	20	.3	4	14.15	30	8.5	18	8	17
13	1/2	3/64	2.1	30	.35	5	30.7	65	10.4	22	9.4	20
25	1	*1/16	2.8	40	.4	6	67.5	143	13.2	28	11.8	25
50	2	*1/16	3.1	45	.4	6	78.3	166	13.2	28	11.8	25
75	3	*1/16	3.5	50	.4	6	88.7	188	13.2	28	11.8	25
100	4	*5/64	3.1	45	.31	4.5	121	256	14.6	31	13.2	28
150	6	*3/32	3.1	45	.4	6	175	370	20	43	18.4(†)	39
200	8	*1/8	4.1	60	.45	6.5	283	600	26	55	23.5(†)	50
250	10	*1/8	4.8	70	.45	6.5	377	800	26	55	23.5(†)	50
300	12	*1/8	6.2	90	.45	6.5	434	920	26	55	23.5(†)	50
Sheet		ASNM	1.4	20	.14	2	14.15	30	2.4	5	2.4	5

Cutting

Nozzle Type AFN using 6.3mm x 10m fitted hose with resettable flashback arrestors in new condition.

Mild Steel Plate Thickness		Nozzle Size	Operating Pressure Oxygen		Fuel Gas		Gas Consumption Cutting Oxy		Heat Oxy		Fuel	
mm	in		bar	lbf/in^2	bar	lbf/in^2	L/M	ft^3/H	L/M	ft^3/H	L/M	ft^3/H
6	1/4	1/32	2	30	.14	2	11.8	25	4.2	9	3.8	8
13	1/2	3/64	2	30	.2	3	23.5	50	4.2	9	3.8	8
25	1	*1/16	3	45	.28	4	56.6	120	4.2	9	3.8	8
50	2	*1/16	3.8	55	.35	5	75.5	160	5.2	11	4.7	10
Sheet		ASFN	1.7	25	.4	6	14.2	30	2.1	4.5	1.9	4

Cutting

Nozzle Type PNM/PNME using 6.3mm x 10m fitted hose with resettable flashback arrestors - all in new condition.

Mild Steel Plate Thickness		Nozzle Size	Operating Pressure Oxygen		Fuel Gas		Gas Consumption Cutting Oxy		Heat Oxy		Fuel	
mm	in		bar	lbf/in^2	bar	lbf/in^2	L/M	ft^3/H	L/M	ft^3/H	L/M	ft^3/H
6	1/4	1/32	2	30	.2	3	14.15	30	22.6	48	5.7	12
13	1/2	3/64	2	30	.2	3	30.6	65	25.5	54	6.6	14
25	1	*1/16	2.8	40	.2	3	70.8	150	37.7	80	9.4	20
50	2	*1/16	3.1	45	.2	3	80.2	170	41.5	88	10.4	22
75	3	*1/16	3.4	50	.3	4	99	210	41.5	88	10.4	22
100	4	*5/64	3.4	50	.3	4	113	240	41.5	88	10.4	22
150	6	*3/32	4.1	60	.4	6	160	340	56.6	120	14.2	30
200	8	*1/8	4.8	70	.4	6	245	520	66	140	16.5	35
250	10	*1/8	5.5	80	.55	8	330	700	75	160	18.9	40
300	12	*1/8	6.2	90	.62	9	425	900	75	160	18.9	40

L/M = Litres per min.

Flame Cleaning

Acetylene fuel gas Nozzle Type	Fuel gas pressure bar	lbf/in^2	Oxygen pressure bar	lbf/in^2	Fuel gas pressure L/M	ft^3/H	Oxygen consum L/M	ft^3/H
50mm flat	0.49	7	0.57	8	17.5	37	20(†)	41
100mm flat	0.7	10	0.7	10	33	70	37(†)	78
150mm flat	0.85	12	0.85	12	45	94	50(†)	104

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.

Heat output figures are quoted for combined torches using necks. Up to 20% higher figures will be obtained by using an NM type cutter with a superheating adaptor.

Nozzle	Propane pres.		Oxygen pres.		Propane cons.		Oxygen cons.		Heat output (app.)	
Type	bar	lbf/in^2	bar	lbf/in^2	L/M	ft^3/H	L/M	ft^3/H	W	Btu/H
1H *	0.14	2	0.7	10	13.8	29	58	121	244800	72,000
	0.49	7	2.1	30	32	65	122	255	554200	163,000
2H *	0.21	3	1.1	15	20	41	80	168	346800	102,000
	0.56	8	2.5	35	35	75	145	304	639200	188,000
3H*	0.28	4	1.8	25	35	75	138	290	622200	183,000
	1.1	15	5.0	70	68	144	275	575	1227400	361,000
4H	0.35	5	2.5	35	45	94	177	370	802400	236,000
	1.3	18	5.7	80	77	162	310	650	1380400	406,000
5H	0.85	12	3.5	50	53	112	212	444	955400	281,000
	2.1	30	8.7	125	117	246	467	985	2101200	618,000

Heating

Nozzle Data for ACETYLENE fuel gas.

Nozzle Type	Acet pres. bar	Acet pres. lbf/in²	Oxygen pres. bar	Oxygen pres. lbf/in²	Acet cons. L/M	Acet cons. ft³/H	Oxygen cons. L/M	Oxygen cons. ft³/H	Heat output (app.) W	Heat output (app.) Btu/H
A-LHT500L*	0.49	7	0.7	10	6.3	13.3	7	14.7	62000	20,000
A-HT 25*	0.35	4	0.35	4	18(†)	36	18.3	40	176800	57,000
A-HT 50 *	0.43	6	0.43	6	30(†)	63	33	70	309400	91,000
A-HT 100*	0.49	7	0.7	10	45(†)	96	50	106	472600	139,000

Gouging

A-GNM Acetylene Nozzles.

Maximum groove width mm	Maximum groove width in	Nozzle size	Operating pressure Oxygen bar	Operating pressure Oxygen lbf/in²	Operating pressure Acetylene bar	Operating pressure Acetylene lbf/in²	Gas consumption Cutting Oxygen L/m	Gas consumption Cutting Oxygen ft³/H	Gas consumption Heating Oxygen L/m	Gas consumption Heating Oxygen ft³/H	Acetylene L/m	Acetylene ft³/H
8	5/16	13*	4.0	60	0.5	7	61	130	16.5	35	15	32
11	7/16	19*	5.0	75	0.5	7	156	330	31	66	28(†)	60
12	1/2	25*	5.5	85	0.55	8	271	575	38	81	35(†)	74

Rivet Cutting

A-RCNM*

Operating Pressures Acetylene bar	Operating Pressures Acetylene lb/n²	Operating Pressures Oxygen bar	Operating Pressures Oxygen lb/n²	Gas Consumption Acetylene L/m	Gas Consumption Acetylene ft³/H	Pre-heat Oxy. L/m	Pre-heat Oxy. ft³/H	Cutting Oxy. L/m	Cutting Oxy. ft³/H
0.31	4.5	3.1	45	6.84	14.5	6.84	14.5	78	166

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/1n² = 0.069 bar.

3 Gas consumption in LITRES PER MINUTE.

CAUTIONARY NOTE

Historically, Oxy-fuel gas processes have proved to be very safe. This is largely due to the care taken by the original equipment designers, the gas supply companies focus on safety and the BCGA and BSI development of Standards and Codes of Practice.

We at ESAB Group want to keep the industry safe.

In recent years much of the sales of Oxy-fuel gas equipment has been through the Distributive Trade and although this has brought good benefits to us all the contact between the equipment user and the original manufacturer has been reduced. This change has also led to a growth in the unauthorised repair of gas equipment as the purchaser is often unaware of the origin of his product when he exchanges a damaged item.

Why are independently repaired items often unsafe?

1. ESAB Groups records over the last 10 years show that almost all oxy-fuel gas accidents involved a repaired product.
2. There are no Controlling Authorities and no Officially Recognised Repairers.
3. The BCGA does not qualify or approve any Repairers.
4. Repairers do not have access to manufacturing data thereby preventing safe assembly.
5. There are no qualifications required to set up as a Repairer.
6. Most end users do not recognise that they have been sold a repair usually believing it to be genuine.

Imported Products.

In recent years the importation of oxy fuel gas equipment from the Far East and Asia has significantly increased. Users should be warned that tests have shown that some of these imports do not conform to recognised EN Standards even though they are marked with the Standard number. In order to provide protection to the operatives, persons working in the vicinity and peace of mind to the buyer it is strongly advised that the supplier be asked to provide a Certificate of Conformity and Origin at the time of purchase. These Certificates are normally backed by a report from a 3rd party test house to ensure independence.

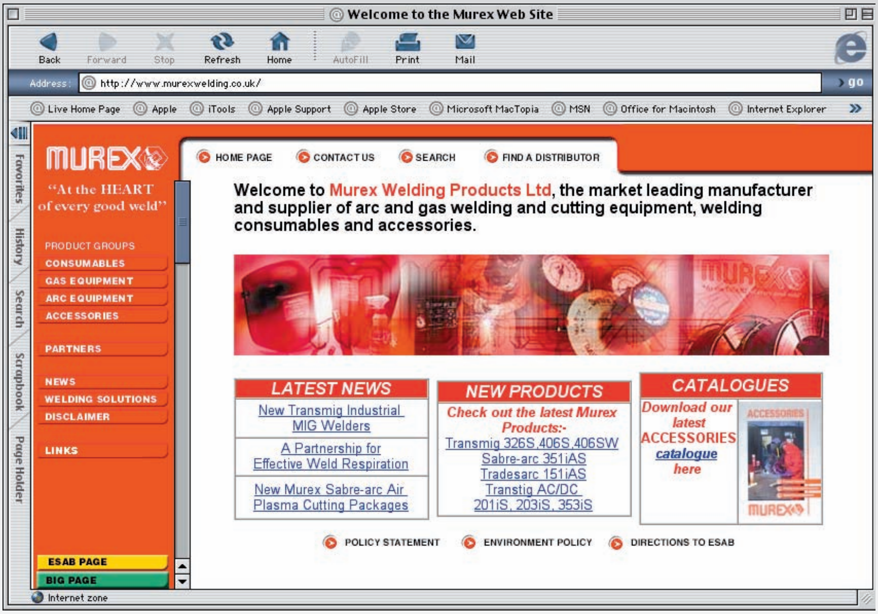
THIS BOOKLET CONTAINS ESSENTIAL SAFETY INFORMATION ON THE FOLLOWING SUBJECTS

- LEGISLATION, STANDARDS AND CODES OF PRACTICE
- SAFE HANDLING OF CYLINDERS AND GASES
- DESIGN AND USE OF PRESSURE REGULATORS
- SAFETY DEVICES FOR OXY-FUEL GAS PROCESSES
- WELDING HOSES, FITTINGS AND ACCESSORIES
- DESIGN AND USE OF BLOWPIPES AND NOZZLES
- PERSONAL PROTECTION AND SAFE PRACTICES
- WELDING AND CUTTING TECHNIQUES
- OPERATING INFORMATION AND DATA SHEETS

NOTES

NOTES

Further Information



Contact Details

Murex Welding Products are available from a Nationwide Distributor Network. For information about Murex Welding Products call us on 01992 710000, visit your local Murex Distributor or visit the Murex Welding Products Website: www.murexwelding.co.uk

Additional Material

Murex Welding Products Limited offer a comprehensive range of:

- **Arc Welding and Cutting Equipment**
- **Gas Welding and Cutting Equipment**
- **Welding Consumables**
- **Welding Accessories**

MUREX

Murex Welding Products Ltd
Telephone: (01992) 710000
Website: www.murexwelding.co.uk
E-mail: info@esab.co.uk

REGISTERED ISO 9001 QUALITY ASSURED COMPANY

PWX 370/02/06 104485