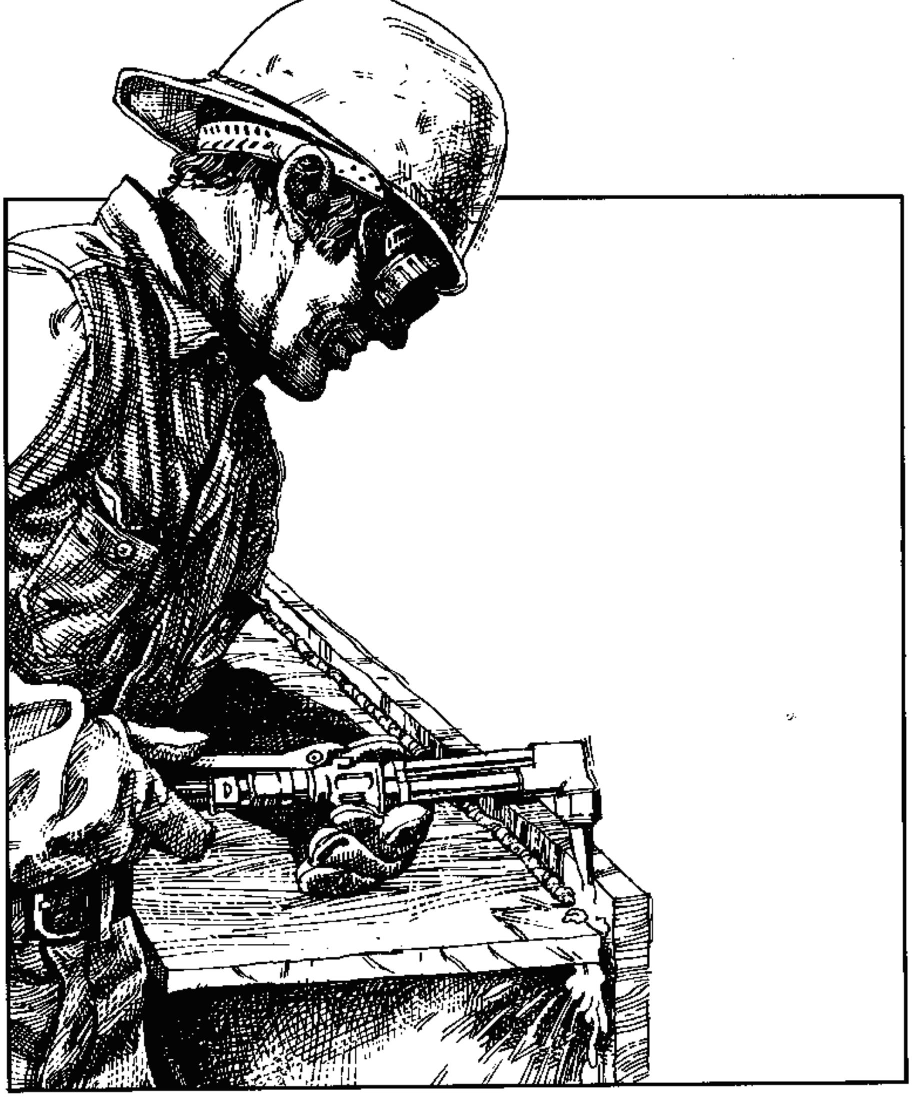
WELDING, CUTTING & HEATING GUIDE



SET-UP AND SAFE OPERATING PROCEDURES

VICTOR®

Notes

Arc Welding

Structural Contact rod – (easy to use) = 7014
Structural Contact rod – low hydrogen (harder to use) = 7014
Heat = rod dia * 100 = amps, i.e .125” rod would be 125 amps

Oxy/Acetylene

To weld aluminum, preheat sheets thicker than ¼” to 400˚ deg. Temperature can be estimated by coating the surface with oxy/acetylene soot, then heat just until the soot disappears.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

This booklet contains information related to oxy-fuel welding, cutting and heating apparatus. The included instructions ensure safe and efficient use of the apparatus. Detailed safety and operating instructions are in ANSI Standard Z49.1, "Safety in Welding and Cutting," and other publications from ANSI, AWS, OSHA, CGA and NFPA.

⚠WARNING DO NOT attempt to use the apparatus unless you are trained in its proper use or are under competent supervision. For your safety, practice the safety and operating procedures described in this booklet every time you use this apparatus. Deviating from these procedures may result in fire, explosion, property damage and/or operator injury. Industrial welding, cutting and heating operations must conform to the applicable Federal, State, County or City regulations for installation, operation, ventilation, fire prevention and protection of personnel.

If at any time the apparatus you are using does not perform in its usual manner, or you have any difficulty in the use of the apparatus, STOP using it immediately. DO NOT use the apparatus until the problem is corrected.

IMPORTANT

Throughout this booklet, a system of notices, cautions and warnings emphasizes important safety and operating information. The method used to identify these notes, and the purpose of each type of note is as follows:

NOTICE Denotes any information which may be useful to the operator in the safe and efficient use of the apparatus.

⚠CAUTION Highlights information which when followed carefully prevents damage to the apparatus or creation of a potential hazard.

⚠WARNING Follow the information shown under this note carefully to avoid injuring the operator or anyone in the operating area.

DO NOT disregard NOTICES, CAUTIONS or WARNINGS. Potential hazards of fire or explosion are inherent in oxy-fuel welding, cutting and heating operations. Proper safety and operating procedures minimize potential hazards. Welding and cutting apparatus is designed and manufactured with your safety as our principle concern. Use it safely.

SECTION 1: GENERAL SAFETY INFORMATION

A number of inherent hazards exists in the use of oxy-fuel welding and cutting apparatus. It is, therefore, necessary that proper safety and operating procedures are understood prior to using such apparatus. Read this booklet thoroughly and carefully before attempting to operate oxy-fuel welding, cutting and heating apparatus. A thorough understanding of the proper safety and operating procedures minimizes the hazards involved and add to the pleasure and efficiency of your work.

The following preliminary safety checklist is the basis for further specific safety information noted throughout this booklet.

The Work Area

1. The work area must have a fireproof floor. We recommend concrete floors.
2. Use heat-resistant shields to protect nearby walls or unprotected flooring from sparks and hot metal.
3. Maintain adequate ventilation to prevent the concentration of oxygen/fuel gas, flammable gases and/or toxic fumes. It is important to remember that oxygen itself will not burn. The presence of pure oxygen, however, serves to accelerate combustion and causes materials to burn with great intensity. **Oil and grease in the presence of oxygen can ignite and burn violently.**
4. During oxy-fuel processes use work benches or tables with fireproof tops. Fire bricks commonly top these surfaces and support the work.
5. Chain or otherwise secure oxygen and fuel gas cylinders to a wall, bench, post, cylinder cart, etc. This will protect them from falling and hold them upright.

Protective Apparel

1. Protect yourself from sparks, flying slag, and flame brilliance at all times. Wear goggles with tempered lenses shaded 4 or darker to protect eyes from injury and to provide good visibility of the work.
2. Wear protective gloves, sleeves, aprons and shoes to protect skin and clothing from sparks and slag. **Keep all clothing and protective apparel absolutely free of oil or grease.**

Fire Prevention

Practice fire prevention techniques whenever oxy-fuel operations are in progress. A few simple precautions prevents most fires and minimizes damage in the event a fire does occur. Always practice the following rules and safety procedures.

1. Inspect oxy-fuel apparatus for oil, grease or damaged parts. **DO NOT** use the oxy-fuel apparatus if oil or grease is present or if damage is evident. Have the oxy-fuel apparatus cleaned and/or repaired by a qualified repair technician before using it.
2. Never use oil or grease on or around any oxy-fuel apparatus. Even a trace of oil or grease can ignite and burn violently in the presence of oxygen.
3. Keep flames, heat and sparks away from cylinders and hoses.
4. Flying sparks can travel as much as 35 feet. Move combustibles a safe distance away from areas where oxy-fuel operations are performed.
5. Use approved heat-resistant shields to protect nearby walls, floors and ceilings.
6. Have a fire extinguisher of the proper type and size in the work area. Inspect it regularly to ensure that it is in proper working order. Know how to use it.
7. Use oxy-fuel equipment only with the gases for which it is intended.
8. **DO NOT** open an acetylene cylinder valve more than approximately 1 1/2 turns and preferably no more than 3/4 of a turn. Keep the cylinder wrench, if one is

required, on the cylinder valve so the cylinder may be turned off quickly if necessary.

9. All gases except acetylene: Open the cylinder valve completely to seal the cylinder back seal packing.
10. Never test for gas leaks with a flame. Use an approved leak-detector solution.
11. When work is complete, inspect the area for possible fires or smoldering materials.

SECTION 2: INDUSTRIAL GASES

⚠CAUTION Fuel gases may be toxic. Contact your gas supplier for the appropriate Material Safety Data Sheet (MSDS) for each gas you use. The Hazardous Materials Regulations of the Department of Transportation (DOT) regulates the transportation of industrial gases and the cylinders used to transport them. Disposal of fuel gases may also be controlled. Contact your local/state Department of Labor for further information.

Oxygen

Oxygen is required to support any burning process. It is, therefore, combined with a "fuel" gas to produce the desired operating flame. Oxygen itself is not flammable. However, the presence of pure oxygen will drastically increase the speed and force with which burning takes place. Oxygen can turn a small spark into a roaring flame or explosion.

⚠WARNING Oil and/or grease in the presence of oxygen become highly flammable or explosive. Never allow oxygen to contact oil, grease or other flammable substances.

Oxygen is ordinarily supplied in standard drawn steel cylinders. The 244-cubic foot cylinder is most commonly used. Smaller and larger sizes are available. Full oxygen cylinders are normally pressurized in excess of 2000 pounds per square inch. Determine oxygen cylinder contents by reading the high pressure gauge on the regulator when in use. For example, half the full cylinder pressure rating indicates half the volume (c/f) of oxygen remaining. The maximum charging pressure is always stamped on the cylinder.

Due to the high pressure under which oxygen is bottled, cylinders must always be handled with great care. The potentially violent reaction of oil, grease or all other contaminants in the presence of oxygen cannot be overstressed. Serious injury may easily result if oxygen is used as a substitute for compressed air.

⚠WARNING Never use oxygen:

- **In pneumatic tools**
- **In oil preheating burners**
- **To start internal combustion engines**
- **To blow out pipelines**
- **To dust off clothing or work area**
- **To create pressure**
- **For ventilation**

Use oxygen only in oxy-fuel welding, cutting and heating applications.

Valve Outlet and Regulator Inlet Connections

CGA 540 up to 3000 PSIG
CGA 577 up to 4000 PSIG
CGA 701 up to 5500 PSIG

Acetylene

Acetylene is a compound of carbon and hydrogen (C_2H_2). It is a versatile industrial fuel gas used in cutting, heating, welding, brazing, soldering, flame hardening, metallizing, and stress relieving applications. It is produced when calcium carbide is submerged in water or from petrochemical processes. The gas from the acetylene generator is then compressed into cylinders or fed into piping systems. Acetylene becomes unstable when compressed in its gaseous state above 15 PSIG. Therefore, it cannot be stored in a hollow cylinder under high pressure the way oxygen, for example, is stored. Acetylene cylinders are filled with a porous material creating, in effect, a "solid" as opposed to a "hollow" cylinder. The porous filling is then saturated with liquid acetone. When acetylene is pumped into the cylinder, it is absorbed by the liquid acetone throughout the porous filling. It is held in a stable condition (see Figure 1). Filling acetylene cylinders is a delicate process requiring special equipment and training. Acetylene cylinders must, therefore, be refilled only by authorized gas distributors. Acetylene cylinders **must never** be transfilled.

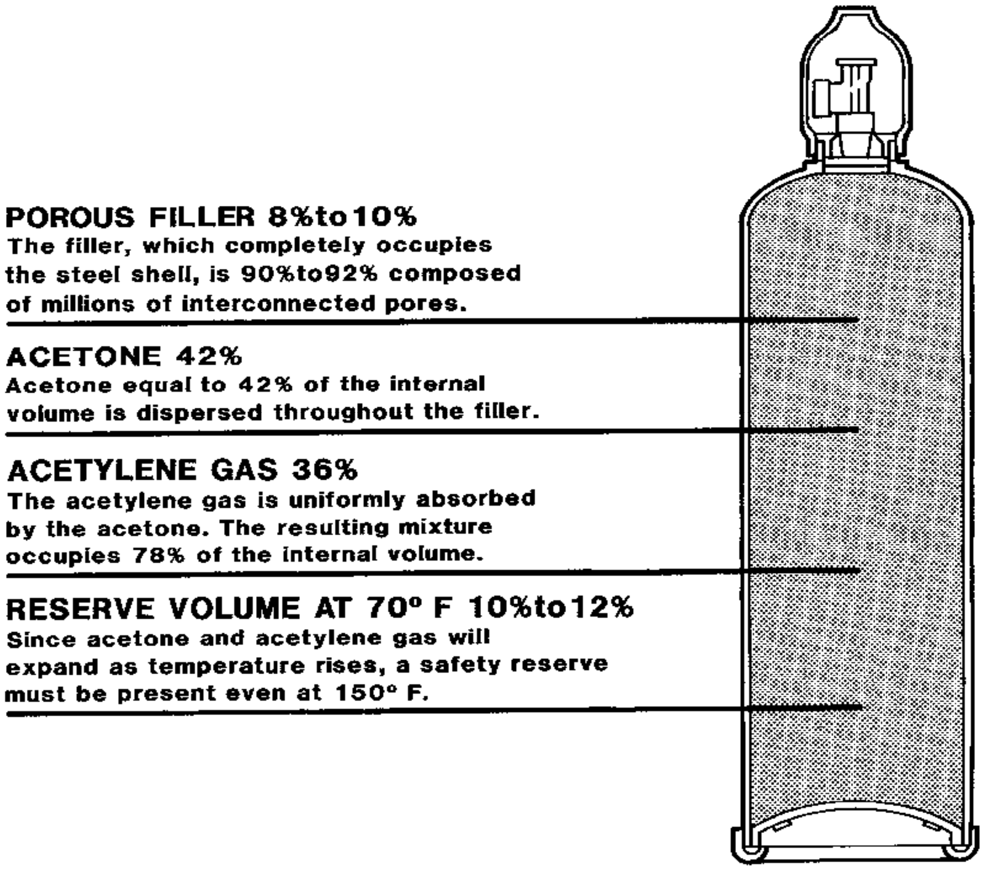


Figure 1, Acetylene Cylinder Interior

Acetylene Cylinders

Acetylene is most commonly available in cylinders with capacities of 10, 40, 60, 75, 100, 130, 190, 225, 290, 300, 330, 360 and 390 cubic feet. A cylinder with a capacity of 850 cu ft. is also available. Acetylene cylinders manufactured in the U.S.A. must conform to DOT 8 and 8AL specifications. Contact your fuel gas supplier for the specific properties of the fuel gas, if more detailed specifications are required.

Specifications

Safety

Shock sensitivity ....Unstable over 15 PSIG outside cylinder
Explosive limits in oxygen, % 3.0-93
Explosive limits in air, % 2.5-80
Maximum allowable use pressure............15 PSIG
Tendency to backfire............Considerable
Toxicity ....Low
Max. Withdrawal Rate ....1/7 of cylinder contents per hour

Combustion Properties

Neutral flame temperature (°F) 5720
Burning velocity in oxygen (ft./sec.) 22.7
Primary flame (BTU/cu. ft.)............507
Secondary flame (BTU/cu. ft.)............963
Total heat (BTU/cu. ft.)............1470
Total heating value (BTU/lb.)............21,600
Autoignition temperature (°F)............763-824

Valve Outlet and Regulator Inlet Connections

Standard connection ....CGA 510
Alternate standard connection............CGA 300
Small valve series (10 cu. ft. cyl.)............CGA 200
Small valve series (40 cu. ft. cyl.)............CGA 520

All values are approximate.

MAPP® Gas

MAPP® gas, a registered trademark of Air Reduction Company Inc., is a mixture of stabilized methylacetylene and propadiene. It is an industrial fuel gas used for flame cutting, flame hardening, metallizing, brazing, soldering, preheating, and stress relieving.

MAPP® Gas Cylinders

MAPP® gas is available in 1000 or 2000 gallon on-site bulk storage tanks. It is also available in portable 7 1/2 lb. and 30 lb. units, and in larger 70 lb., 115 lb., and 420 lb. cylinders. Contact your fuel gas supplier for the specific properties of the fuel gas, if more detailed specifications are required.

Specifications

Safety

Shock sensitivity ....Stable
Explosive limits in oxygen, % 2.5-60
Explosive limits in air, % 3.4-10.8
Maximum allowable use pressure............Cylinder (94 PSIG @ 70°F)
Tendency to backfire............Slight
Toxicity ....Low

Combustion Properties

Neutral flame temperature (°F) 5301
Burning velocity in oxygen (ft./sec.) 15.4
Primary flame (BTU/cu. ft.)............517

Secondary flame (BTU/cu. ft.)	1889
Total heat (BTU/cu. ft.)	2406
Total heating value (after vaporization) (BTU/lb.)	21,000

All values are approximate.

Valve Outlet and Regulator Inlet Connection

CGA 510-.885" - 14 NGO-LH-INT (POL outlet)

Natural Gas and Propane

Natural gas is available throughout most areas of the U.S.A. and Canada. It is collected in oil fields and transmitted by pipelines. Physical properties vary according to the geographical location. A typical analysis shows a methane content of approximately 93% with a heating value of approximately 1000 BTU/cu. ft.

Propane is recovered from natural gas associated with or dissolved in crude oil and from petroleum refinery gases. It is known in popular terms as LPG (Liquefied Petroleum Gas), the term used also for Butane and mixtures of propane and butane.

Both natural gas and propane are used as industrial fuel gases for flame cutting, scarfing, heating, flame hardening, stress relieving, brazing and soldering. Contact your fuel gas supplier for the specific properties of the fuel gas, if more detailed specifications are required.

Natural Gas and Propane Cylinders

Natural gas is transmitted by pipeline to most installations that use natural gas as a fuel gas. Natural gas/methane is authorized for shipment in a nonliquefied compressed gas cylinder under DOT regulations.

Propane is available in on-site bulk storage tanks. It is also available in 6 lb. cylinders and larger.

Specifications

Safety	*Natural Gas*	*Propane*
Shock sensitivity	Stable	Stable
Explosive limits in oxygen, %	5.0-59	2.4-57
Explosive limits in air, %	5.0-15	2.1-9.5
Maximum allowable use pressure	Determined by Equipment to be Used	
Tendency to backfire	Slight	Slight
Toxicity	Low	Low

Combustion Properties

Neutral flame temperature (°F)	4600	4579
Burning velocity in oxygen (ft./sec.)	15.2	12.2
Primary flame (BTU/cu. ft.)	55	295
Secondary flame (BTU/cu. ft.)	995	2268
Total heat (BTU/cu. ft.)	1,050	2,563
Total heating value (after vaporization)(BTU/lb.)	24,800	21,600
Autoignition temperature (°F)	999	874

All values are approximate.

Valve Outlet and Regulator Inlet Connection

Natural Gas	By Pipeline
Methane	CGA 350

Methane ....CGA 695 up to 5500 PSIG
Propane ....CGA 510

Propylene and Propylene Based Fuel Gases

These gases are hydrocarbon based products. They are industrial fuel gases used for flame cutting, scarfing, heating, flame hardening, stress relieving, brazing and soldering. They are used in certain applications for welding cast iron and aluminum. Listed below are general specifications for a commercial grade propylene gas. Contact your fuel gas supplier for the specific properties of the fuel gas, if more detailed specifications are required.

Gas Cylinders

The fuel gas is available in on-site bulk storage tanks. It is also available in portable 30 lb. cylinders, and in larger 60/70 lb. and 100/110 lb. cylinders.

SPECIFICATIONS

Safety

Shock sensitivity ....Stable
Explosive limits in oxygen, % 2.0-57
Explosive limits in air, % 2.0-10
Maximum allowable use pressure...................................Cylinder (135 PSIG @ 70°F)
Tendency to backfire ....Moderate
Toxicity ....Low

Combustion Properties

Neutral flame temperature (°F) 5240
Burning velocity in oxygen (ft./sec.) 15.0
Primary flame (BTU/cu. ft.)..403
Secondary flame (BTU/cu. ft.)..1969
Total heat (BTU/cu. ft.)..2372
Total heating value (after vaporization) (BTU/lb.)...20,000
Autoignition temperature (°F) 896
All values are approximate.

Valve Outlet and Inlet Connection

CGA 510-.885" - 14 NGO-LH-INT (POL Outlet)

Fuel Gases with Natural Gas or Propane Base Plus Liquid Hydrocarbon Additive

These fuel gases consist of a natural gas or propane base which is enriched by a liquid hydrocarbon additive. The liquid hydrocarbon additive is usually a low-boiling point, petroleum ether fraction of n-pentane and/or iso-pentane. N-pentane has a heating value of approximately 4249 BTU/cu. ft. Pentane added to natural gas will show a greater percentage increase in heating value, as the BTU heat value of natural gas is approximately 1050 BTU/cu. ft. This is not meant to imply that all the fuel gases listed above use n-pentane or iso-pentane as the liquid hydrocarbon additive.

The physical and combustion properties of these fuel gases vary according to the percentage of additives added to the base of natural gas or propane. Use the general specifications for natural gas and propane as listed above as a guide only. Contact your fuel gas supplier for the specific properties of the fuel gas, if more detailed specifications are required.

SECTION 3: OXY-FUEL APPARATUS

Description/Function

Typical oxy-fuel workstations normally include the following items, each designed to perform a specific function: oxygen and fuel supply, regulators, hose, torch handle, cutting attachment and tip(s), welding nozzle(s), heating nozzle(s) and operator safety equipment.

Oxygen and Fuel Supply

There are two types of workstations, portable and stationary. The portable station is usually supplied by cylinders mounted on a cart. The stationary type is supplied by cylinders chained to a wall or post near the work table. Some stationary units are supplied by piping or manifold systems. The stationary system restricts the operator to the length of hose attached to the welding torch.

> ⚠CAUTION **Always be aware of the gases in use at the station. Use only the type of apparatus designed for use with those gases.**

Regulators

Oxygen and fuel pressure regulators are attached to the cylinders or manifold outlets to reduce high cylinder or supply pressures to suitable low working pressures for cutting and welding applications. Never use high pressure gases directly from the cylinder without a suitable pressure-reducing regulator. Become familiar with the external parts of a regulator as follows (see Figure 2): inlet connection with filter, pressure adjusting screw, high pressure gauge, low pressure gauge, outlet connection, relief valve (where provided).

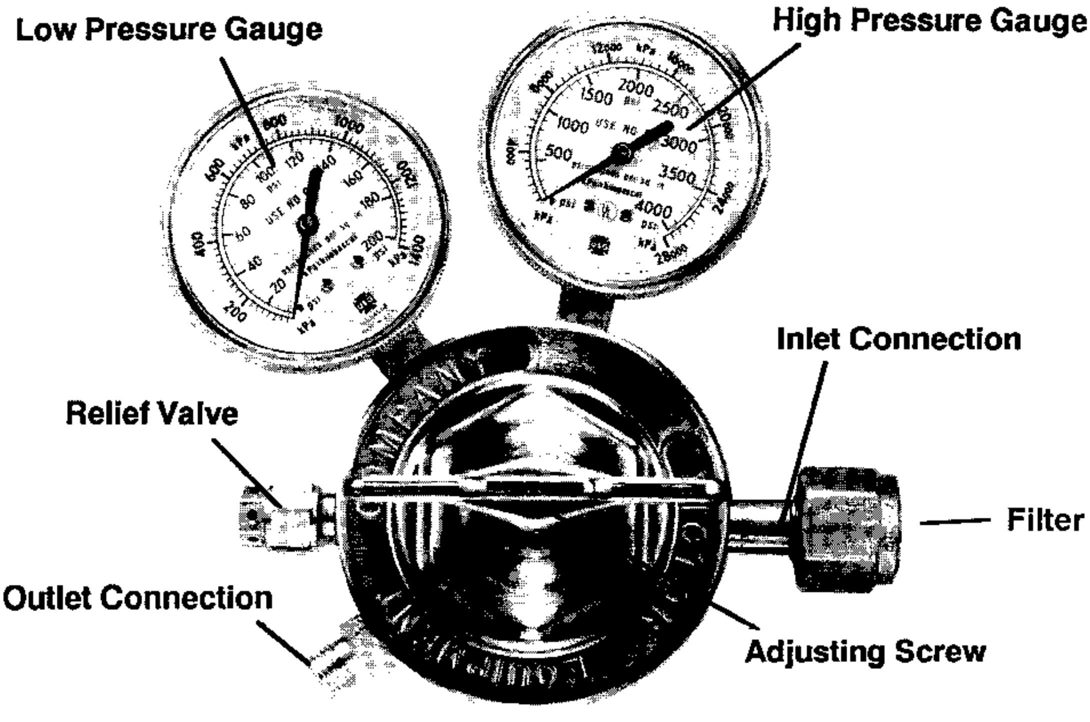


Figure 2, Regulator Parts

NOTICE **The internal working parts of the regulator are precision units. Only qualified technicians should clean or repair a regulator.**

Inlet Connection

Regulators are attached to the cylinders or manifolds by their "inlet connections." All inlet connections conform to specifications and standards set by the Compressed Gas Association (CGA) and are marked with an identifying CGA number. CGA numbers identify the cylinder valve/gas service for which that inlet connection is designed. Examples: CGA 510 has been designated for standard fuel gas cylinder connections such as acetylene, methyl acetylene and propane. CGA 540 connections are designated for oxygen service only. Fuel gas inlet connections usually have left-hand threads. Those with left-hand threads also have a "V" notch around the inlet nut to further designate the connection for fuel gas service. All oxygen connections have right-hand threads. All inlet connections must have a clean filter.

⚠WARNING **Always keep the regulator free of oil, grease and other flammable substances. Never use oil or grease on the regulator, cylinder or manifold connection. DO NOT change the inlet connection on a regulator in an attempt to use the regulator for a different gas service.**

Pressure Adjusting Screw

The regulator adjusting screw controls the delivery pressure of the gas to the hose. As previously stated, the regulators function to reduce high supply pressures to a suitable working pressure range. When the adjusting screw is turned clockwise, the regulator allows gases to flow through the regulator to the hoses and to the torch. The threaded adjusting screw applies mechanical force to a spring and diaphragm which controls a pressure valve in the regulator. If the adjusting screw is turned fully counterclockwise, tension on the spring is released and the regulator does not allow the gas to flow.

Pressure Gauges

The high pressure gauge indicates the cylinder or supply pressure entering the regulator. The low pressure gauge indicates the delivery pressure from the regulator to the hose. All gauges are precision instruments, handle with care.

Outlet Connections

Welding hoses are attached to the regulator outlet connections. Fuel gas regulators have left-hand threaded outlet connections to mate with the left-hand hose connections and have a "V" notch around the outlet connection to further designate the connection for fuel gas service. Oxygen regulators have right-hand threaded outlet connections to mate with the right-hand hose connections.

Relief Valve (where provided)

The relief valve is designed to protect the low pressure side of the regulator from high pressures. **Relief valves are not intended to protect downstream equipment from high pressures.**

⚠WARNING **DO NOT tamper with the relief valve or remove it from the regulator.**

Hose

The welding hose transports low pressure gases (maximum 200 PSIG) from the regulators to the cutting or welding torch. Proper care and maintenance of the hose assists the operator in maintaining a safe, efficient shop or work area.

Hose Construction

Industrial welding hose is usually color-coded for gas service identification. Oxygen hose is usually green and fuel hose is red. The hose walls are constructed of continuous layers of rubber or neoprene material over a braided inner section. All approved domestically fabricated type VD grade "RM" and "T" hose are flame retardant. They will burn, but will not support a flame if the heat source is removed. Grade "T" hose is recommended for all fuel gases and grade "RM is for acetylene only. The hose is marked to indicate its grade.

Hose Care

Welding hoses are often exposed to severe abuse. They can provide efficient service with proper care. Molten slag and sparks can come into contact with hoses and burn into the hose exterior. Falling metal in cutting operations can crush or cut into welding hoses. The operator should frequently inspect the hoses and, when necessary, replace the hose. Observe the following safety and operating procedures:

Important Safety Notes

- **Keep welding hoses clear of any falling metal, slag or sparks.**
- **Never allow hoses to become coated with oil, grease or dirt. Such coatings could conceal damaged areas.**
- **Examine the hoses before attaching to welding torch handle or regulators. If cuts, burns, worn areas or damaged fittings are found, replace the hose.**
- **Completely replace welding hose if it contains multiple splices or when cracks or severe wear is noticed.**

Torch Handle

A torch handle is essentially a set of gas tubes with control valves. One tube and valve controls the fuel supply and the other tube and valve controls the oxygen supply. The torch handle is not designed to mix the gases for oxy-fuel processes. The cutting or welding apparatus attached to the handle mixes the oxygen and fuel gases. The handle is a means of control for the gas supply.

The basic elements of a torch handle are listed as follows (see Figure 3): the control valves with internal reverse flow check valves, the body "Y", the barrel and tubes (located inside the barrel) and the torch head.

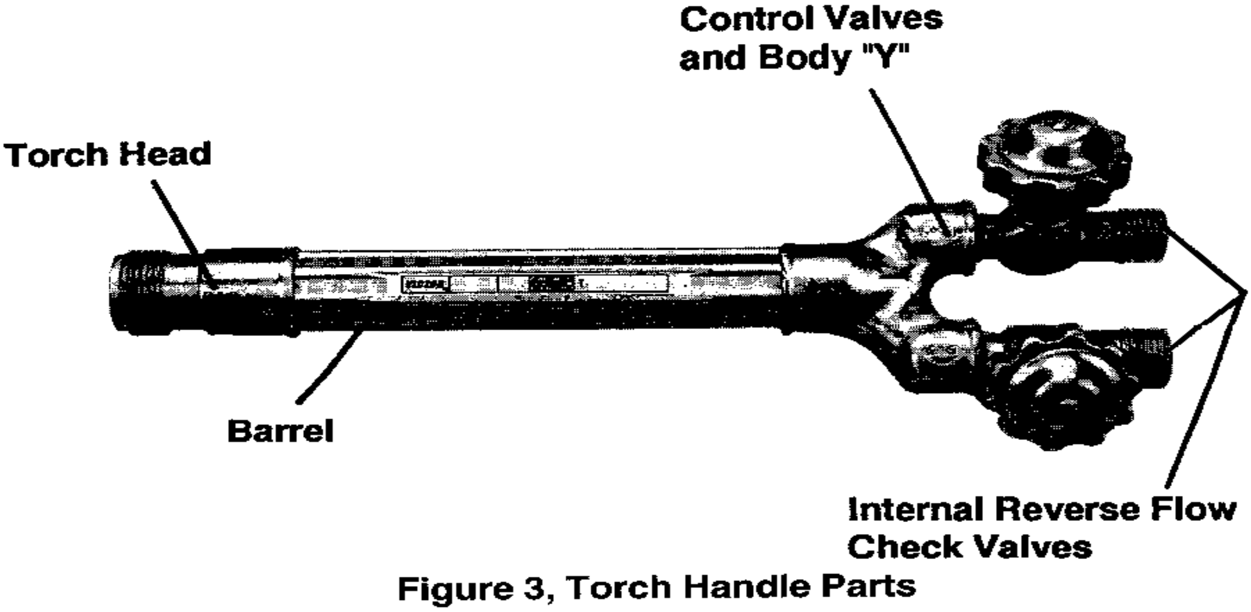


Figure 3, Torch Handle Parts

Control Valves and Body "Y"

The torch handle has two control valves installed in the body "Y." The valve bodies are marked to distinguish between the two valves. The body of one valve has left-hand threads to accept the fuel gas hose. The other has right-had threads to accept the oxygen hose. The control valves never require lubricating. Occasionally, the packing nuts may require slight adjustment.

Barrel

The barrel and inner oxygen tube unit is designed to keep the oxygen and fuel gases separated. A tube-within-a-tube design allows the oxygen supply to move through the inner tube to the head while the fuel supply travels through the interior barrel cavity.

Torch Head

The torch head is threaded onto the barrel, creating a metal-to-metal seal. The oxygen supply from the inner tube is directed through the center hole in the head while the fuel supply passes through drilled orifices around the centered oxygen port. Tapered surfaces inside the head mate with o-rings when the cutting or welding attachment is connected. This creates a gas-tight seal. If damaged, the external threads and internal surfaces of the head may be reconditioned by a qualified technician. Never lubricate these surfaces.

Internal Reverse Flow Check Valves

Most of VICTOR welding torch handles are equipped with patented internal check valves. This reduces the possibility of explosion or fire which may occur as a result of fuel gases and oxygen becoming mixed inside the hoses or regulators. VICTOR strongly recommends installing accessory reverse flow check valves to any torch not equipped with internal check valves.

> NOTICE **The purpose of an internal check valve is to reduce the possibility of reverse flow gas. It is not intended to act as fire stop! Ensure that the internal check valves are working properly by testing at least every six months, more often if the hoses are frequently removed from the torch.**

Flashback Arrestors

Flashback arrestors are designed to prevent a flashback from reaching upstream equipment. They offer added safety and often include reverse flow check valves in a single unit. Flashback arrestors can be used with oxy-fuel gas welding, heating, cutting and allied processes. They are usually installed in the gas system between the outlet of the regulator and the inlet of the hose leading to the torch or between the hose and the torch.

Flashback arrestors can provide a certain measure of protection. To maintain this protection, routinely inspect the flashback arrestor for damage.

Cutting Attachment

The cutting attachment functions as a convenient and economical approach to cutting operations where the frequency and/or application does not require a torch designed strictly for cutting. When connected to a torch handle, the cutting attachment functions as a cutting torch. It provides the operator with a wide range of cutting capabilities.

The basic elements of a cutting attachment are as follows (see Figure 4, page 13): the cone end and coupling nut, the preheat oxygen control valve, the mixing chamber, the cutting oxygen lever and tube, and the cutting attachment head.

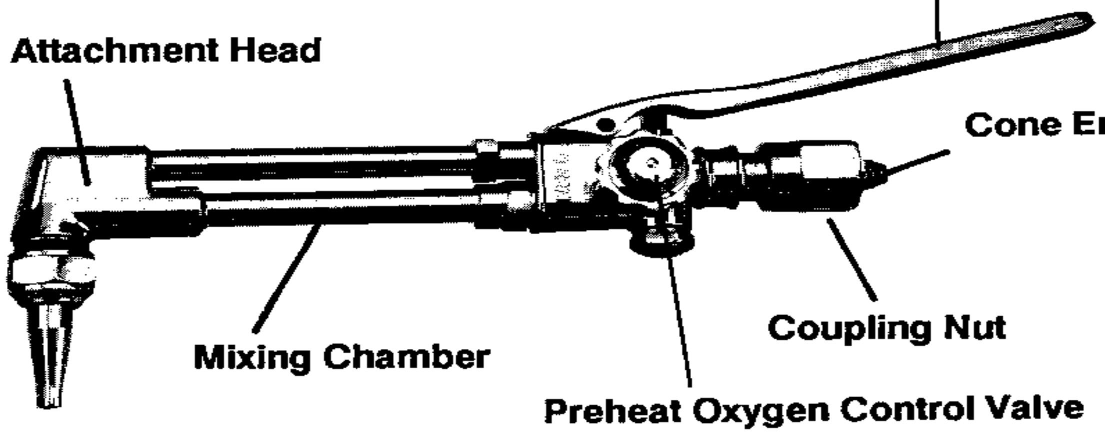


Figure 4, Cutting Attachment Parts

Cone End and Coupling Nut

The cone end and coupling nut are designed to permit easy attachment to the torch handle. The tapered cone end is machined to mate with the internal taper of the torch handle head. O-rings on the cone end allow continued separation of oxygen and fuel gases. The o-rings also provide a hand-tight connection.

> ⚠WARNING **There must always be two o-rings on the cone end. The absence or damage of either of these o-rings allows premixing and leaks of oxygen and fuel gases. This can lead to flashback within the torch handle or cutting attachment.**

The center orifice of the cone end, like the center port of the torch handle head, allows the passage of the oxygen supply. The orifices around the oxygen port allow the fuel gas to travel to the mixing chamber in the lower tube of the cutting attachment.

Preheat Oxygen Control Valve

When the cutting attachment is connected to the torch handle, the preheat oxygen control valve on the cutting attachment controls the preheat oxygen supply from the regulator. To function in this manner, open the oxygen valve on the torch handle completely. The preheat oxygen supply is then increased or decreased by opening or closing the cutting attachment control valve. The fuel gas supply is controlled by the fuel valve on the torch handle.

Mixing Chamber Tube

Fuel and oxygen must ultimately be mixed to produce the desired preheating flame. To accomplish the necessary mixing of gases, oxygen and fuel are fed into a mixing chamber located in the forward portion of the cutting attachment mixing chamber tube. Oxygen is directed to the mixer through the inner oxygen tube. The fuel gas is drawn from the exterior cavity of the attachment lower tube around the mixer. Mixed gases then flow through the preheat orifices of the cutting attachment head and into the preheat orifices of the cutting tip.

Cutting Oxygen Lever and Tube

The cutting oxygen lever is located above the body of the cutting attachment. When the oxygen control valve on the torch handle is open, depressing the lever allows cutting oxygen to flow through the upper tube of the cutting attachment and the center port of the cutting attachment head. The upper oxygen tube is designed to allow the maximum supply of oxygen to the cutting operation and to provide structural strength by the utilization of high strength tubing.

Cutting Attachment Head

The cutting attachment head is designed to allow the cutting oxygen and the mixed preheat gas to stay separated in the cutting operation. The exterior of the torch head is threaded and the interior of the head is tapered. The internal taper of the head is stepped so the preheat gases can feed the cutting tip through the exterior orifices and the cutting oxygen can travel uninterrupted through the center port of the tip to the heated base metal (see Figure 5). The exterior threads on the head allow a tip nut to compress a cutting tip into the tapered head. This creates a firm gas-tight metal-to-metal seat.

Cutting Tip

Cutting tips are available in a wide variety of configurations and sizes. Cutting tips keep the preheat gas mixture and cutting oxygen stream separated and provide flame characteristics needed for a particular cutting application. Tips are sized according to the thickness of metal they can cut. For instance, a number 000 tip is designed to cut metal 1/16" to 1/8" in thickness, and a number 00 tip will cut metal 1/8" to 1/4" in thickness. Charts are available to assist operator with tip selection (see page 42).

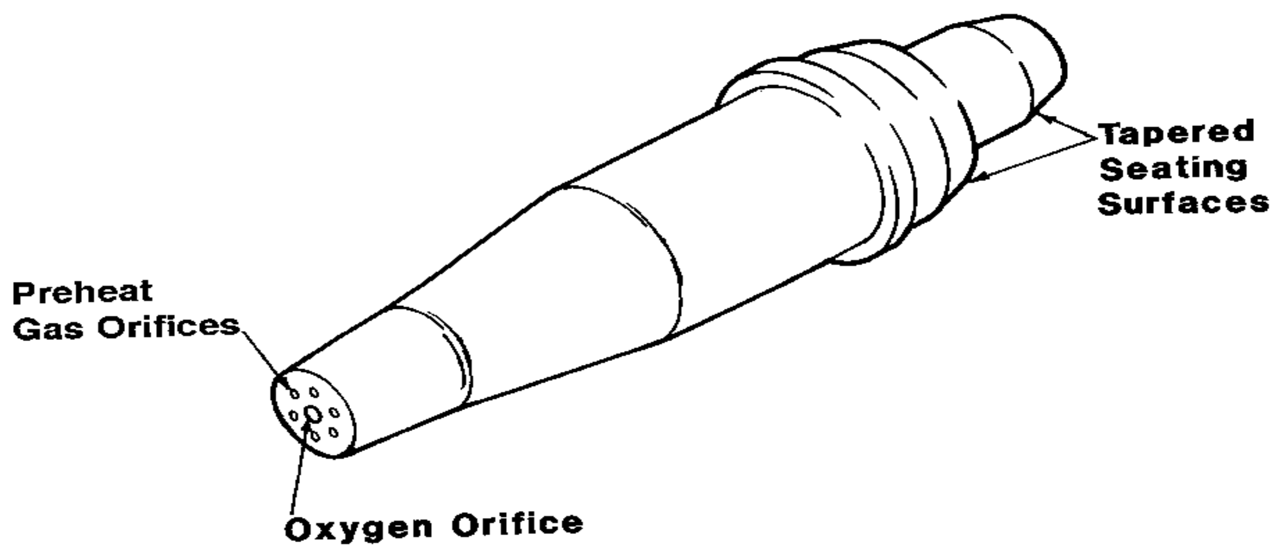


Figure 5, Cutting Tip

⚠CAUTION Always make sure your equipment is rated for the size tip you have selected. A tip with too much capacity for the equipment can starve or choke the tip. This causes overheating of the head and a flashback may result. Use only genuine VICTOR tips, welding nozzles and multi-flame nozzles to ensure leak-free connections and balanced equipment.

Tapered Seating Surfaces

The tapered end of the tip is machined to fit into the cutting attachment head. A tip nut secures the tip into the head. The tapered surfaces form a metal-to-metal seal (see Figure 5, page 14). Inspect both head and tip tapers frequently for signs of damage or wear.

> **⚠WARNING** **A damaged seating surface on either the tip or the head can create a dangerous condition, resulting in a fire or flashback. This may damage the cutting attachment. If the seating surface of a tip becomes damaged, DO NOT use it. Discard the damaged tip. If the head requires repair, take the torch to a qualified repair technician.**

Preheat Orifices and Oxygen Orifices

Cutting tips are subjected to much abuse in cutting operations. Molten metal can splatter and stick to the cutting tip, clogging or obstructing the passages through which the gas must flow. Remove splatter from the tip orifices with small round files (tip cleaners). Repeated cleaning, however, can affect the flame configuration and render the tip unsuitable for precision work.

Welding Nozzle

The welding nozzle is usually an assembly consisting of a welding tip, a gas mixer, and a coupling nut.

A wide range of tips and nozzle configurations is available for attachment to the torch. Typical nozzle and tip applications include welding, brazing, soldering, heating and hardfacing.

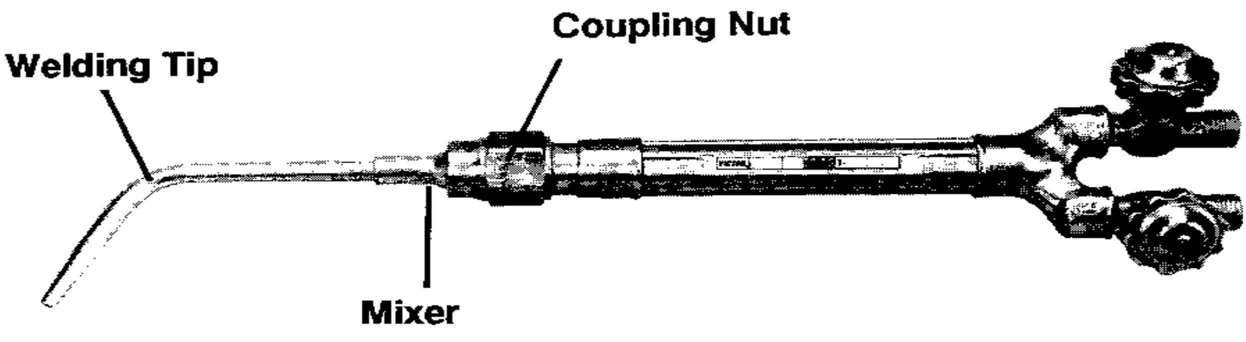


Figure 6, Welding Nozzle

Welding Tip

The welding tip is a tellurium copper tube that has been swaged to a specific orifice size on one end. Like cutting tips, welding tips have a calibrated orifice for welding various thicknesses of metal. Charts are available to the welder for nozzle selection (see page 42). In the oxy-fuel welding process, molten mental can splatter and clog the tip orifice. Remove spatter from the orifice with a round file (tip cleaners). Repeated cleaning, however, may alter the orifice size requiring adjustments to the gas supply.

Gas Mixer

The welding nozzle cone end is similar to that of the cutting attachment cone end. The difference is that the welding tip cone end is designed to mix the oxygen and fuel gases, whereas the cone end in the cutting attachment is not. When the oxygen meets with the fuel gas, a homogenizing mixing effect occurs. This complete mixing of the gases results in a well-balanced flame composition. Like the cutting attachment cone end, the welding nozzle has two o-rings. They maintain the separation of gases prior to the point at which mixing occurs. They allow a hand-tight connection of the welding tip and the torch handle.

> ⚠WARNING **There must always be two o-rings on the cone end. The absence or damage of either of these o-rings allows premixing and leaks of oxygen and fuel gases. This can lead to flashback within the torch handle.**

Coupling Nut

The welding nozzle coupling nut is similar in design to the coupling nut on the cutting attachment. A locking ring in the welding nozzle tip nut mates with a groove in the forward portion of the welding nozzle cone end, thus allowing the nut to protect the cone end (see Figure 6, page 15). Examine the o-rings by twisting and pushing the coupling nut away from the cone end.

Multi-Flame Heating Nozzles

The multi-flame heating nozzle is basically a large welding tip. The cone end coupling nut and mixer assembly are similar in design to a welding tip. The multi-flame tip is machined to utilize numerous flames. This provides additional heating capacity for heavy heating applications.

> ⚠CAUTION **Never starve or choke a multi-flame heating nozzle. This causes overheating of the head and a flashback may result. Should a flashback occur (flame disappears and/or a hissing sound is heard, the flame is burning inside the nozzle), immediately turn off the oxygen valve on the torch handle. Then, turn off the fuel valve. Allow the nozzle to cool before using. If a flashback reoccurs, have the apparatus checked by a qualified technician before using again.**

SECTION 4: SETTING UP EQUIPMENT FOR WELDING

⚠CAUTION **Use only VICTOR torch handles, welding nozzles and multi-flame nozzles together to ensure leak-free connections and balanced equipment.**

Cylinders

Place the oxygen and fuel gas cylinders together where they are used. Secure them properly (see Figure 7). Chain or secure cylinders to a cylinder cart, wall, work bench, post, etc.

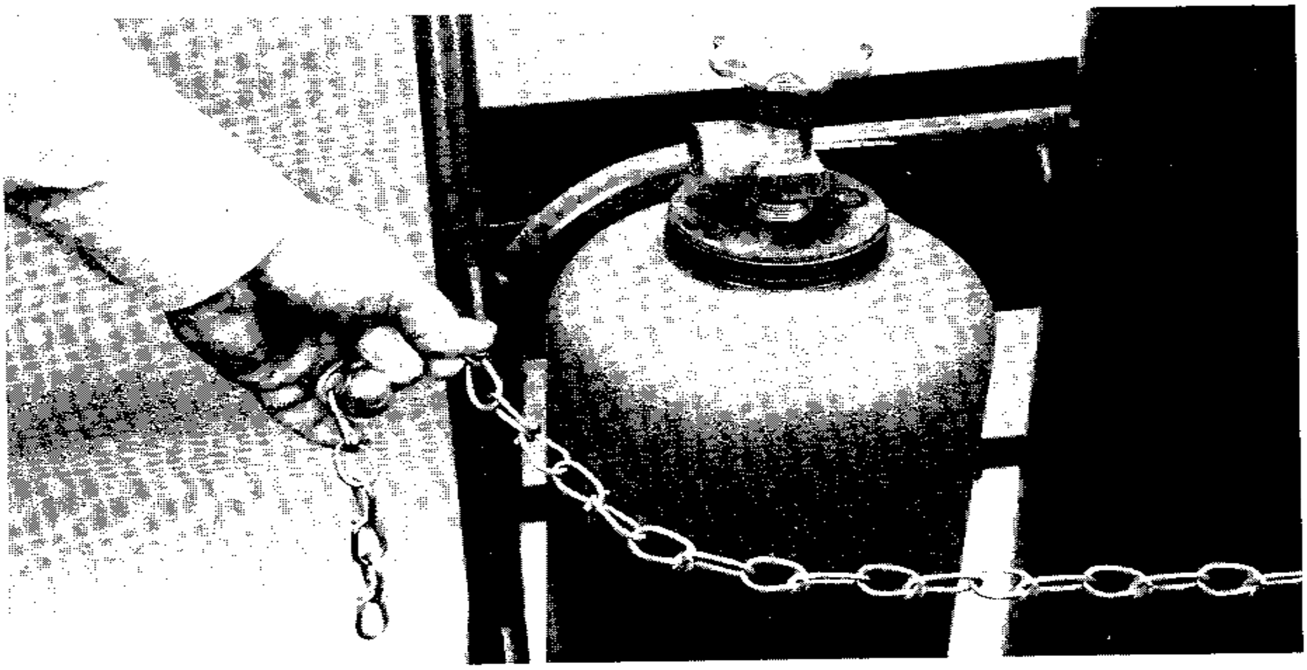


Figure 7, Securing the Cylinders

⚠CAUTION **Cylinders are highly pressurized. Always handle with care. Never allow cylinders to be dropped, knocked over or subjected to excessive heat. When moving cylinders, always be certain that valve protection caps are secured in place. Place valve protection caps where they are easily found. Replace cap when cylinders are empty.**

Important Safety Notes

- **Always keep cylinders secured properly in a vertical position.**
- **Do not strike, drop or apply heat to any cylinder or valve.**
- **Always keep valve protection caps in place whenever cylinders are moved or are in storage (full or empty).**
- **Mark empty cylinders "empty" or "MT."**
- **Close valves completely on empty cylinders.**
- **Do not use a cylinder that does not have a gas identification label attached to it.**

Regulators

1. Carefully inspect the cylinder valve and regulator threads and mating surfaces for traces of oil or grease. Make sure the regulator has the correct pressure rating for the cylinder being used (see Figure 8).

Figure 8, Inspecting the Cylinder and Cylinder Valve

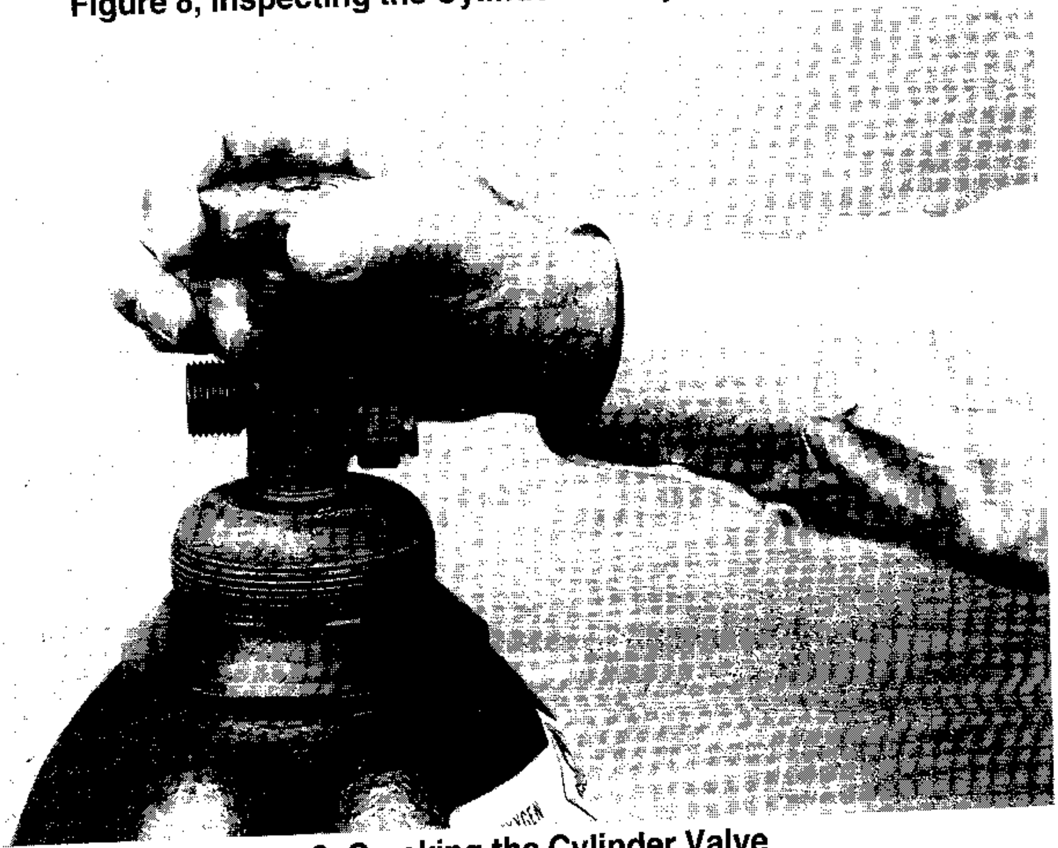


Figure 9, Cracking the Cylinder Valve

⚠WARNING **DO NOT use the regulator if oil, grease or damaged parts are detected on the regulator or the cylinder valve or if the inlet filter is missing or dirty. Inform your gas supplier of this condition immediately. Have a qualified repair technician clean or repair the regulator.**

2. Momentarily open and close (called "cracking") the cylinder valve. This dislodges any loose contaminant that is present (see Figure 9, page 18).

⚠CAUTION **Open the cylinder valve only slightly. If the valve is opened too much the cylinder could tip over. When "cracking" the cylinder valve, DO NOT stand directly in front of the valve. Stand behind or to one side (see Figure 9, page 18). Crack the cylinder valve only in a well ventilated area. If an acetylene cylinder sprays a mist when it is cracked, let it set for 15 minutes. Then try to crack the cylinder valve again. If the problem persists, contact your gas supplier.**

3. Attach the oxygen regulator to the oxygen cylinder valve. Tighten securely (see Figure 10).
4. Attach the fuel gas regulator to the fuel gas cylinder valve. Tighten securely in the direction necessary for the particular fuel gas connection in use (see Figure 10).
5. Before opening the cylinder valves, release the tension on the regulator adjusting screws by turning them counterclockwise until all spring pressure is released.

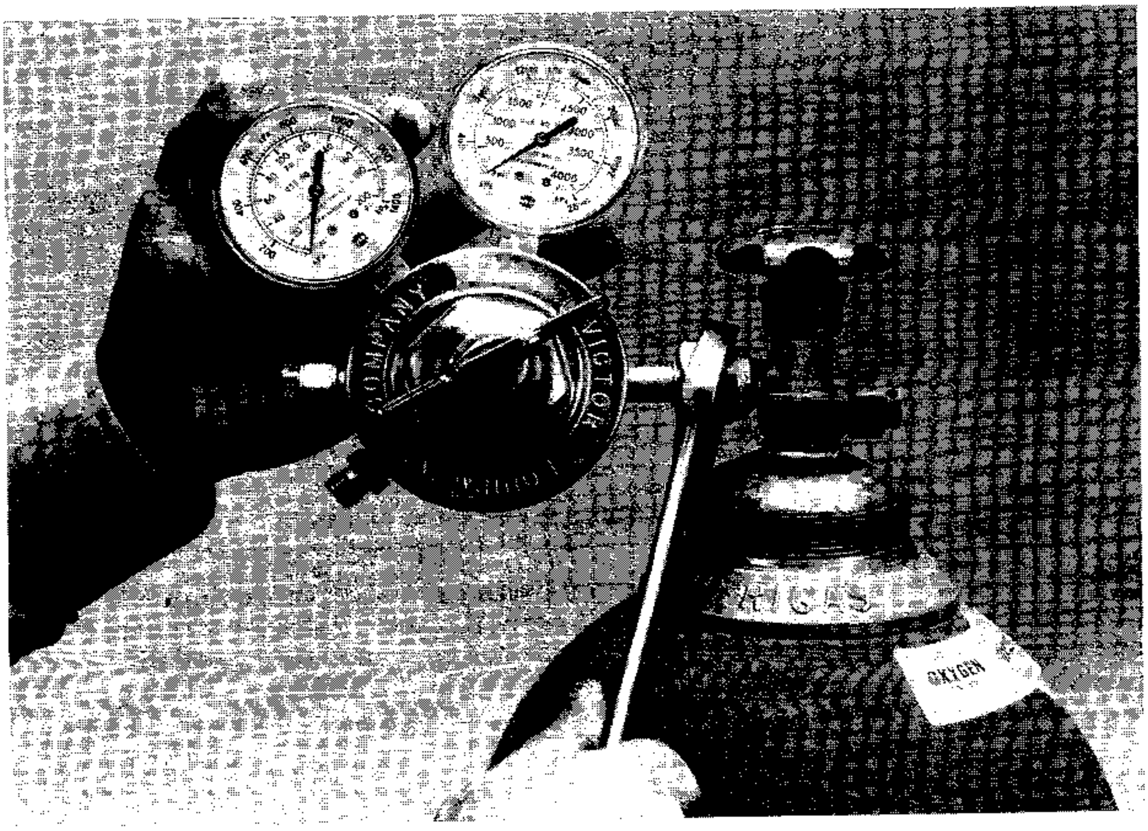


Figure 10, Tightening the Regulator

Turning on the Cylinders

1. Be certain that tension on the regulator adjusting screws is released. Stand so the cylinder valve is between you and the regulator.

> **⚠WARNING** **NEVER STAND IN FRONT OR BEHIND A REGULATOR WHEN OPENING THE CYLINDER VALVE. ALWAYS STAND SO THAT THE CYLINDER IS BETWEEN YOU AND THE REGULATOR.**

2. Slowly and carefully open the oxygen cylinder valve until the maximum pressure registers on the high pressure gauge. Now, open the oxygen cylinder valve completely to seal the valve packing (see Figure 11).

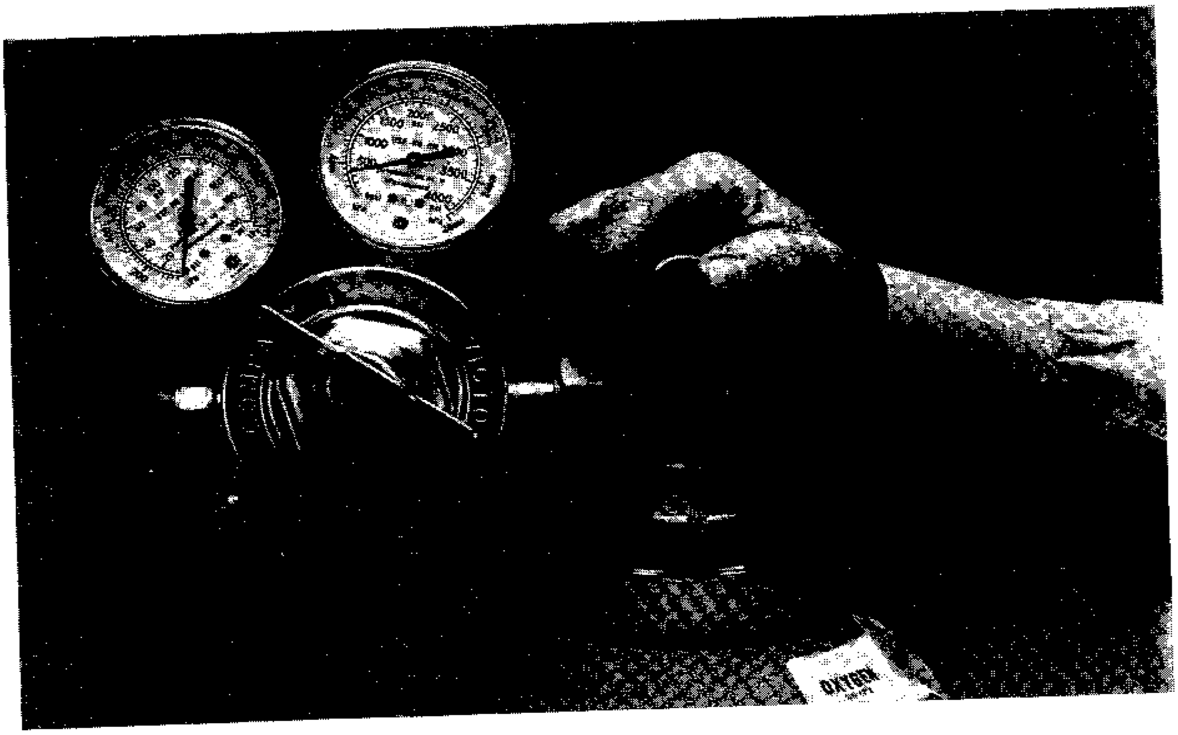


Figure 11, Opening the Cylinder Valve

3. Slowly open the fuel gas cylinder valve in the same manner.

> **NOTICE** **DO NOT open acetylene cylinder valves more than 1 1/2 turns and, preferably, no more than 3/4 turn. Keep the cylinder wrench, if one is required, on the cylinder valve so the cylinder may be turned off quickly, if necessary.**

We strongly recommend using reverse flow check valves on the regulator and/or torch handle to reduce the possibility of mixing gases in the hoses and regulators. Mixed gases will burn rapidly once the torch is lighted. Mixed gases can explode in the hoses, regulators, or cylinders, resulting in serious damage to the equipment or injury to the operator. We, also, recommend using flashback arrestors to prevent a flashback from reaching upstream equipment.

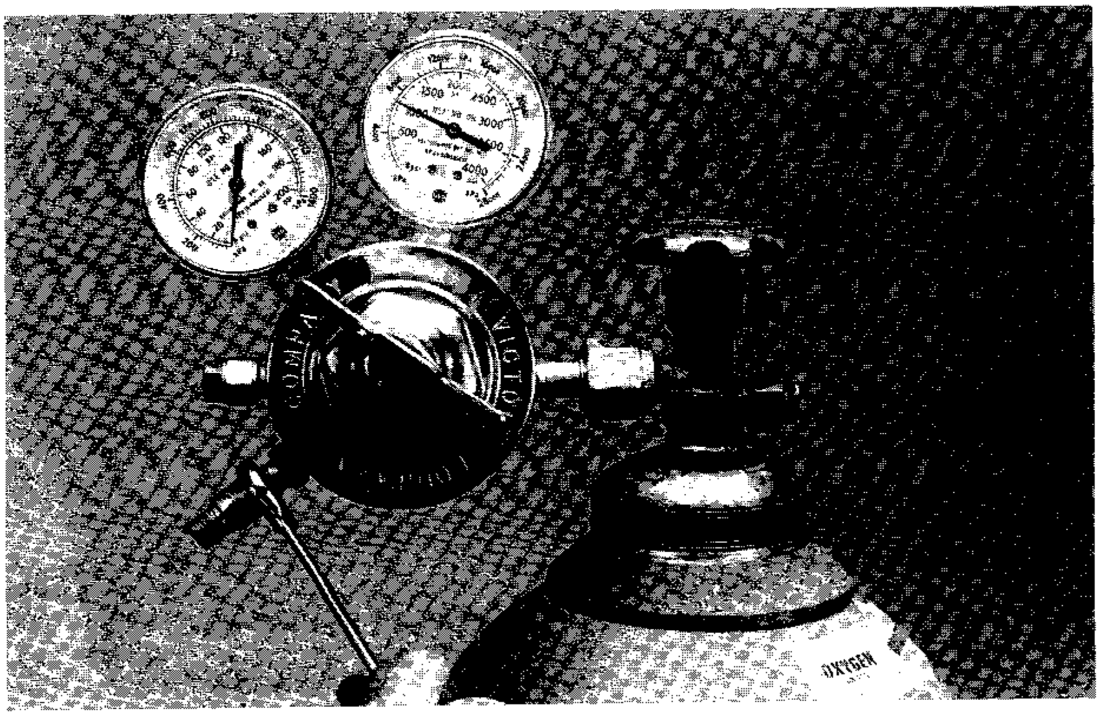


Figure 12, Connecting the Reverse Flow Check Valves

4. Install reverse flow check valves at the regulators by screwing the reverse flow valves onto the regulator outlet connection. Tighten securely with the proper wrench (see Figure 12). Test reverse flow check valves at least every six months. Test more often if the hoses are frequently removed from the torch or regulator.

5. If using flashback arrestors, follow manufacturer's installation instructions.

Important Safety Notes

- **Be certain cylinder valves and regulator connections are completely free of dirt, dust, oil or grease.**
- **If oil , grease or damage is detected on the cylinder valves, DO NOT use. Notify cylinder supplier immediately.**
- **If oil , grease or damage is detected on the regulator, DO NOT use. Have it cleaned or repaired by a qualified repair technician.**
- **Never stand directly in front or behind a regulator when opening the cylinder valve. Stand so the cylinder valve is between you and the regulator.**
- **Always open cylinder valves slowly and carefully.**
- **Always check for leaks on the regulator and cylinder valve connections.**

Welding Hoses

1. Connect the oxygen hose to the oxygen regulator. Tighten the connection firmly with a wrench (see Figure 13, page 22).
2. Adjust the oxygen regulator to allow 3 to 5 PSIG to escape through the hose. Allow oxygen to flow 5 to 10 seconds to clear the hose of dust, dirt, or preservative. Then, shut off the oxygen flow.
3. Attach and clear the fuel hose in the same manner.

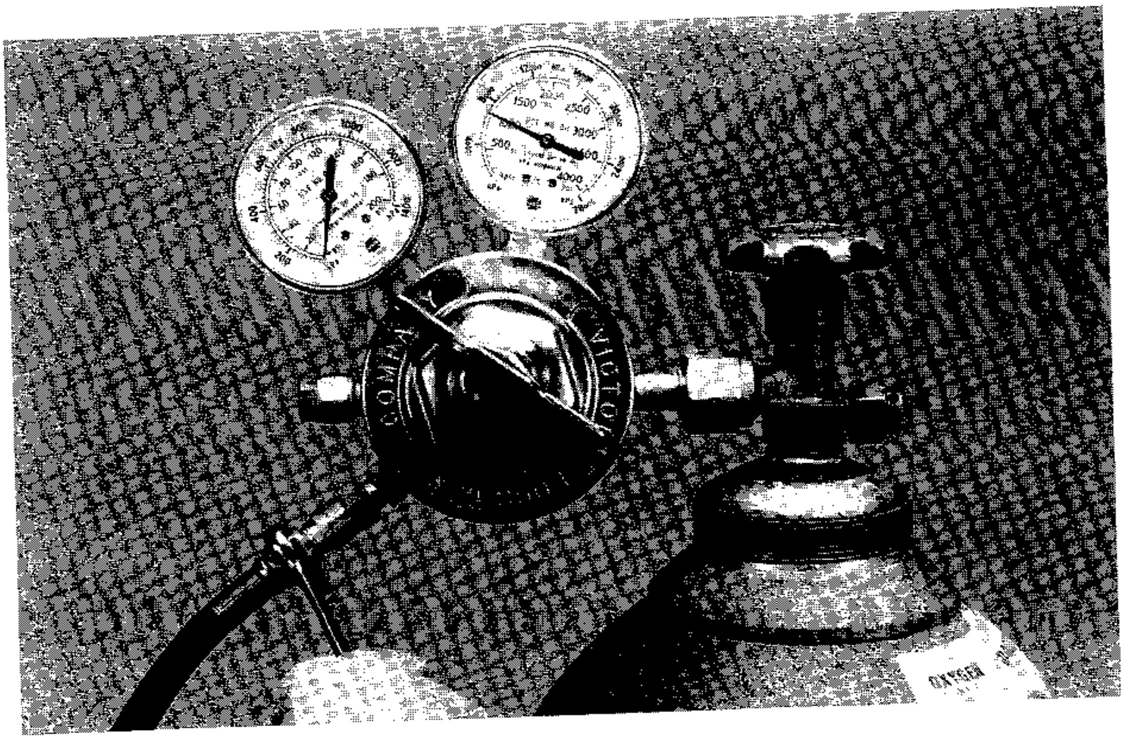


Figure 13, Connecting the Hose

⚠WARNING

• Be sure to clear hoses in a well-ventilated area! The escaping gases create conditions for fires and explosions!
• Keep welding hoses clear of any falling metal, slag, or sparks.
• Never allow hoses to become coated with oil, grease or dirt. Such coatings could conceal damaged areas.
• Examine the hoses before attaching the torch handle or regulators. If cuts, burns, worn areas, or damaged fittings are found, repair or replace the hose.

Torch Handle

The torch handle is probably the most frequently used item in a welding shop. Since cutting attachments, welding tips and heating nozzles are all connected to the torch handle, always protect the torch handle from possible damage or misuse.

1. Inspect the torch handle head, valves and hose connections for oil, grease or damaged parts.
2. Inspect the welding hose connections in the same manner. **DO NOT** use if oil, grease or damage is detected.
3. Inspect the torch head. The tapered seating surfaces must be in good condition. If dents, burns or burned seats are present, the seat must be resurfaced. If the torch is used with poor seating surfaces, backfire or flashback may occur.
4. Most VICTOR torch handles are equipped with internal check valves. However, some models may require accessory check valves. We strongly recommend the use of check valves on any torch handle to reduce the possibility of mixing gases in the hoses and regulators. If accessory check valves are required, connect them to the proper control valve.
5. We, also, recommend using flashback arrestors to prevent a flashback from reaching upstream equipment. Follow manufacturer's installation instructions.

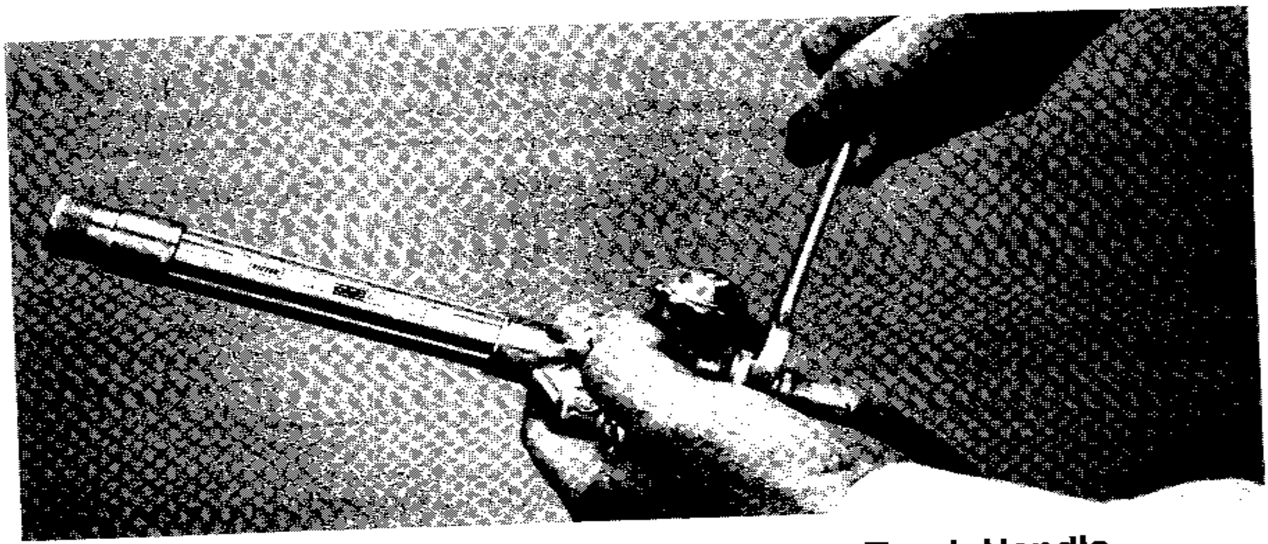


Figure 14, Connecting the Hose to the Torch Handle

6. Attach the welding hose to the torch handle or reverse flow check valves. Tighten securely (see Figure 14).

Welding Nozzle

1. Inspect the cone end, coupling nut, o-rings and welding nozzle for damage, oil or grease.

> **⚠WARNING** **There must always be two o-rings on the cone end. The absence or damage of either of these o-rings allows premixing and leaks of oxygen and fuel gases. This can lead to flashback within the torch handle.**

2. Connect the welding nozzle to the torch handle. Tighten the coupling nut hand-tight only. Wrench tightening may damage o-rings and create a faulty seal (see Figure 15).

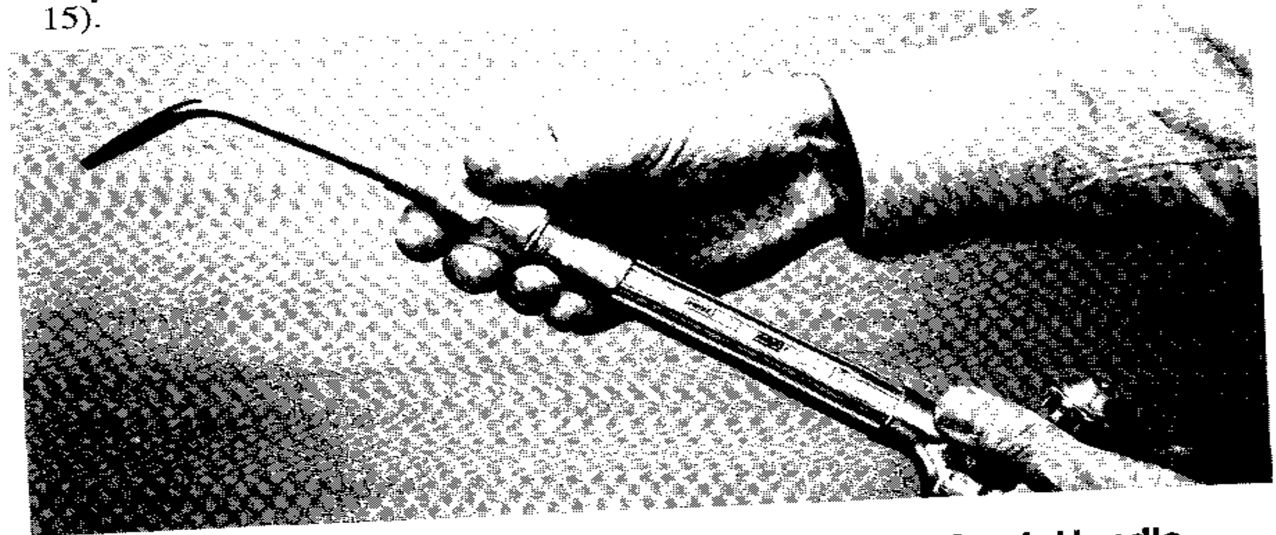


Figure 15, Connecting the Welding Nozzle to Torch Handle

Multi-Flame Heating Nozzles

Multi-flame heating nozzles are set up exactly as the welding tip or nozzle. Follow the safety and operation procedures described above for the welding nozzle.

⚠WARNING Never starve or choke a multi-flame heating nozzle. This will cause overheating of the head and a flashback may result. Should a flashback occur (flame disappears and/or a hissing sound when the flame burns inside the nozzle), immediately turn off the oxygen valve on the torch handle. Then, turn off the fuel valve. Allow the nozzle to cool before attempting to reuse. If a flashback or burnback reoccurs, have the apparatus checked by a qualified repair technician before using again.

Leak Testing the System

The system MUST be tested for leaks before lighting the torch. Leak test the system by performing the following steps:

1. With the oxygen cylinder valve open, adjust the oxygen regulator to deliver 20 PSIG.
2. With the fuel cylinder valve open, adjust the fuel regulator to deliver 10 PSIG.
3. Be sure that both the oxygen and fuel control valves on the torch handle are closed.
4. Close both the oxygen and fuel cylinder valves.
5. Turn the adjusting screws counterclockwise one (1) turn.
6. Observe the gauges on both regulators for five minutes. If the gauge readings do not change, then the system is leak tight. If there is a leak, use an approved leak detection solution to locate it.

   If the H.P. gauge reading decreases, there is a leak at the cylinder valve or inlet connection. Tighten the inlet connection after the pressure has been released from the regulator. If the inlet connection still leaks, take the regulator to a qualified repair technician. Never tighten a cylinder valve. If the cylinder valve is leaking, remove the regulator from the cylinder, place the cylinder outdoors. Notify your gas supplier immediately.

   If the L.P. gauge reading decreases, there is a leak at the regulator outlet connection, within the hose, at the torch inlet connection or at the control valves on the torch handle. Tighten the regulator outlet connection and the torch handle inlet connection after the pressure has been released from the system. If these connections are still leaking, take the regulator or torch handle to a qualified repair technician. If the hoses are leaking, replace them.
7. After leak testing the system, open the cylinder valves and proceed.

Setting Up to Weld, Lighting the Torch and Adjusting the Flame

⚠WARNING Perform all welding in a well ventilated area to help prevent the concentration of flammable and/or toxic fumes.

1. Check the thickness of the metals to be welded. Prepare as described in Figure 20, page 27.
2. Refer to welding tip selection chart to determine the tip size required and regulator pressures for the job (see page 42).
3. Open the oxygen valve on the torch handle. Adjust the oxygen regulator to the desired delivery range (see Figure 16, page 25).
4. Close the torch handle oxygen valve.

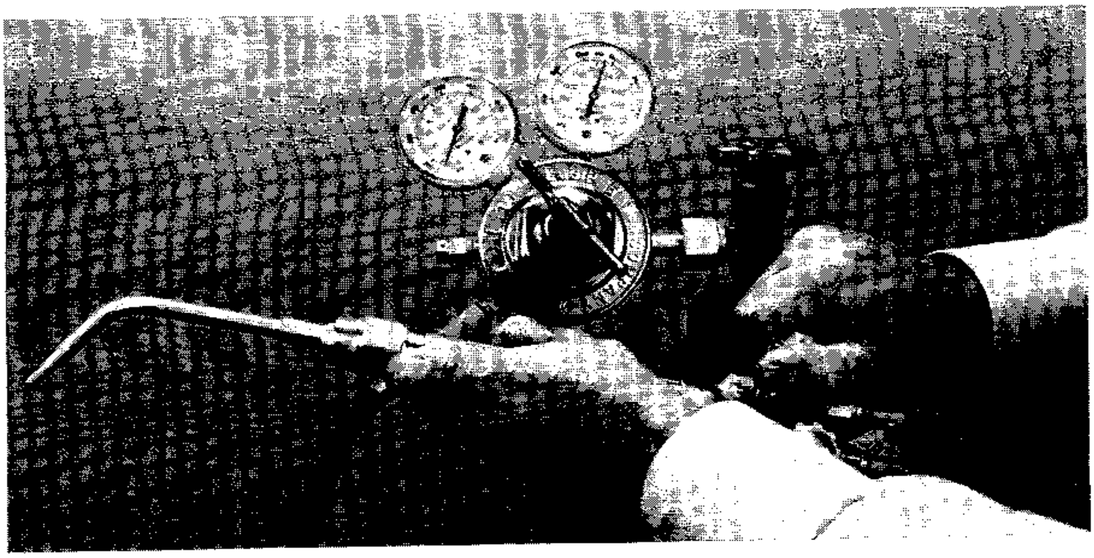


Figure 16, Setting Operating Pressures

5.Open the fuel valve on the torch handle. Adjust the fuel regulator to the required delivery range.
6.Close the torch fuel control valve.

⚠WARNING If the torch handle and hoses are already connected to the regulators, the system MUST still be purged after every shut-down. Open the oxygen valve 1/2 turn. Allow the gas to flow ten seconds for tips up to size 3 and 5 seconds for sizes 4 and larger for each 25 feet of hose in the system. Close the oxygen valve. Purge the fuel system in the same manner.

7.Wear protective goggles to shield eyes from bright light and protective clothing as required.

NOTICE The following instructions cover torch adjustment procedures for *acetylene* only. Contact your gas supplier for instructions on use of other fuel gases.

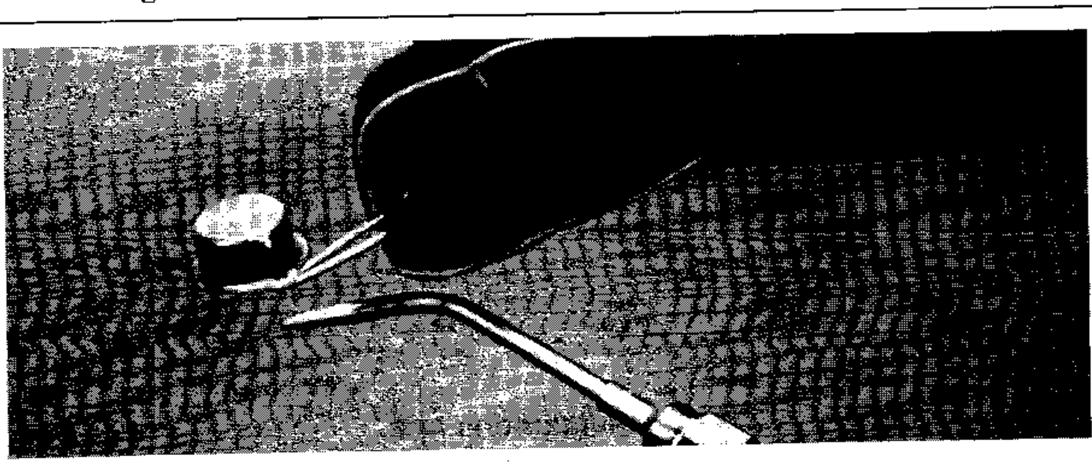


Figure 17, Lighting the Torch

8. Hold the torch in one hand and the spark lighter in the other (see Figure 17, page 25). Be sure the spark lighter is away from the tip and not obstructing the gas flow.

9. Open the torch fuel valve approximately 1/8 turn. Ignite the gas.

⚠CAUTION **Point the flame away from people, equipment, and any flammable materials.**

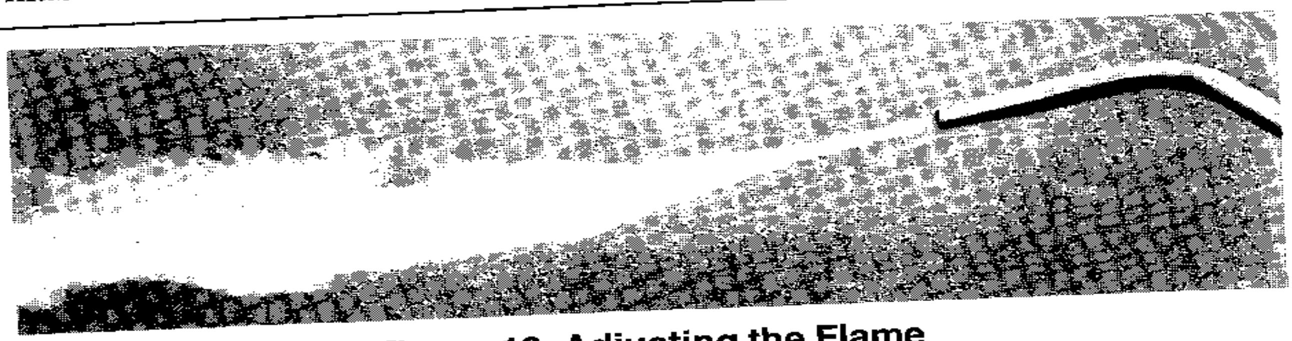


Figure 18, Adjusting the Flame

10. Continue opening the fuel valve until the flame stops smoking (see Figure 18).

11. Open the torch oxygen valve until a bright neutral flame is established (see Figure 19).

NOTICE **If the flame produces too much heat for the work to be welded, DO NOT decrease the pressures or close the valves. Use a smaller tip.**

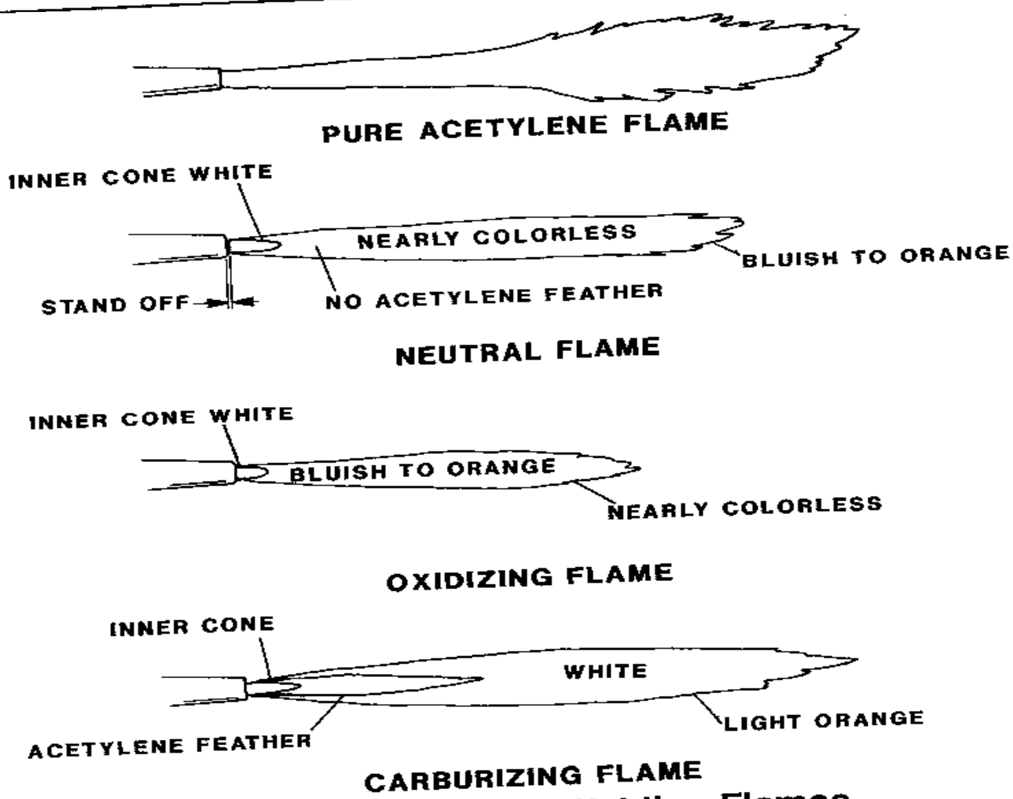


Figure 19, Acetylene Welding Flames

⚠WARNING **If you experience a backfire or flashback (a shrill hissing sound when the flame is burning inside the welding nozzle), immediately turn off the oxygen valve. Then, turn off the fuel valve. Allow the torch and nozzle to cool before attempting to reuse. If backfire and flashback reoccurs, bring the apparatus to a qualified repair technician for repair before using again.**

SECTION 5: WELDING PROCEDURES

In oxy-fuel welding, two metals are joined by melting or fusing their adjoining surfaces. This is accomplished by directing an oxy-fuel flame over the metals until a molten puddle is formed. A filler rod may be introduced into the puddle to help the metals form together.

Preparing the Metals to be Welded

1. Clean the metal joints to be welded of all scale, rust, dirt, paint and grease. Any foreign material in the molten puddle changes the metal composition and weakens it.

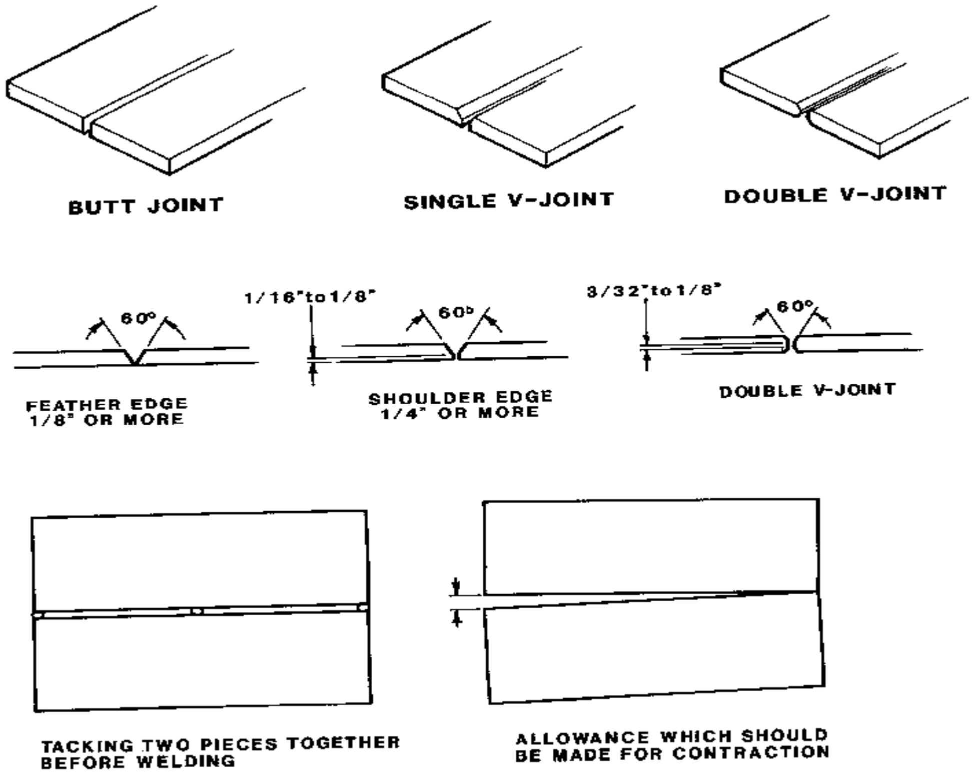


Figure 20, Preparing the Metal

2. Base metals 1/8" or less do not require beveling. Thicker metals require additional preparation (see Figure 20).
3. Place the metal to be welded on the work table. Determine if and where tacking may be required.

NOTICE **As a welding bead is applied, the two pieces of metal may tend to pull together, closing the penetration gap.**

To prevent warping:

1. Fuse the ends of the two pieces of metal together before welding. Long pieces may need to be fused every few inches or so along the joint (see Figure 20).
2. Long pieces may require additional penetration gap. Add 1/8" to 1/4" per linear foot.

Forehand and Backhand Welding Techniques

Two techniques are employed for oxy-fuel welding; forehand and backhand welding (see Figure 21). The forehand technique is recommended for welding material up to 1/8" thickness because of better control of the small weld puddle. Backhand welding is, generally, more suitable for material 1/8" and thicker. Increased speed and better fusion at the root of the weld is normally achieved with backhand welding.

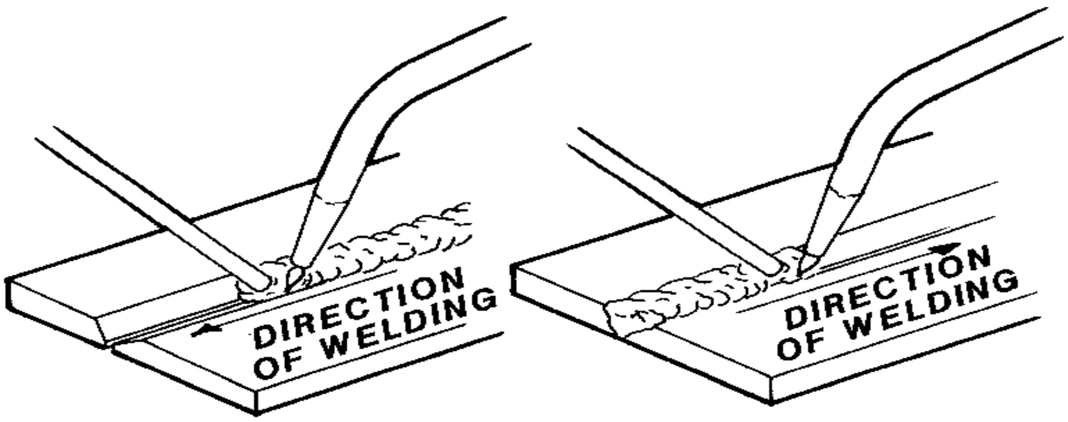


Figure 21, Forehand and Backhand Welding

In the forehand technique, the welding rod precedes the tip in the direction of the weld. The flame is pointed in the same direction as the weld. It is directed downward at an angle which preheats the edge of the joint. The torch tip and welding rod are manipulated with opposite oscillating motions in semicircular paths to distribute the heat and molten metal uniformly.

In backhand welding, the torch tip precedes the rod in the direction of the weld. The flame is pointed back toward the molten puddle and completed weld. The end of the welding rod is placed in the flame between the tip and the weld. Less manipulation is required in backhand welding than in forehand welding.

Starting and Finishing the Weld

The forehand butt weld with filler rod is one of the most common joints made. The basic procedures of the butt weld can be applied to any other type of joint.

1. Tack or fuse the base metals at the predetermined intervals.
2. Hold the torch nozzle at an angle of approximately 45° to the base metal gap (see Figure 22, page 30).
3. Move the torch tip over the starting edges of the joint. Rotate the flame near the metal in a circular or semicircular motion until the base metals run into a small puddle.
4. Dip the end of the filler rod in and out of the molten puddle. The molten puddle will melt the rod and add to the puddle.
5. Continue the dipping motion of the filler rod in the puddle. Move the torch back and forth across the penetration gap.
6. Advance the circular or semicircular motion approximately 1/16" per motion until the end of the joint is reached.
7. Since the angle of the tip flame is preheating the metals ahead of the weld, the last 1/2" of weld is critical. Slightly raise the welding tip and increase the addition of filler rod to ensure a full smooth weld. Refer to Figure 23, page 31 for visual characteristics of good and bad weld joints.

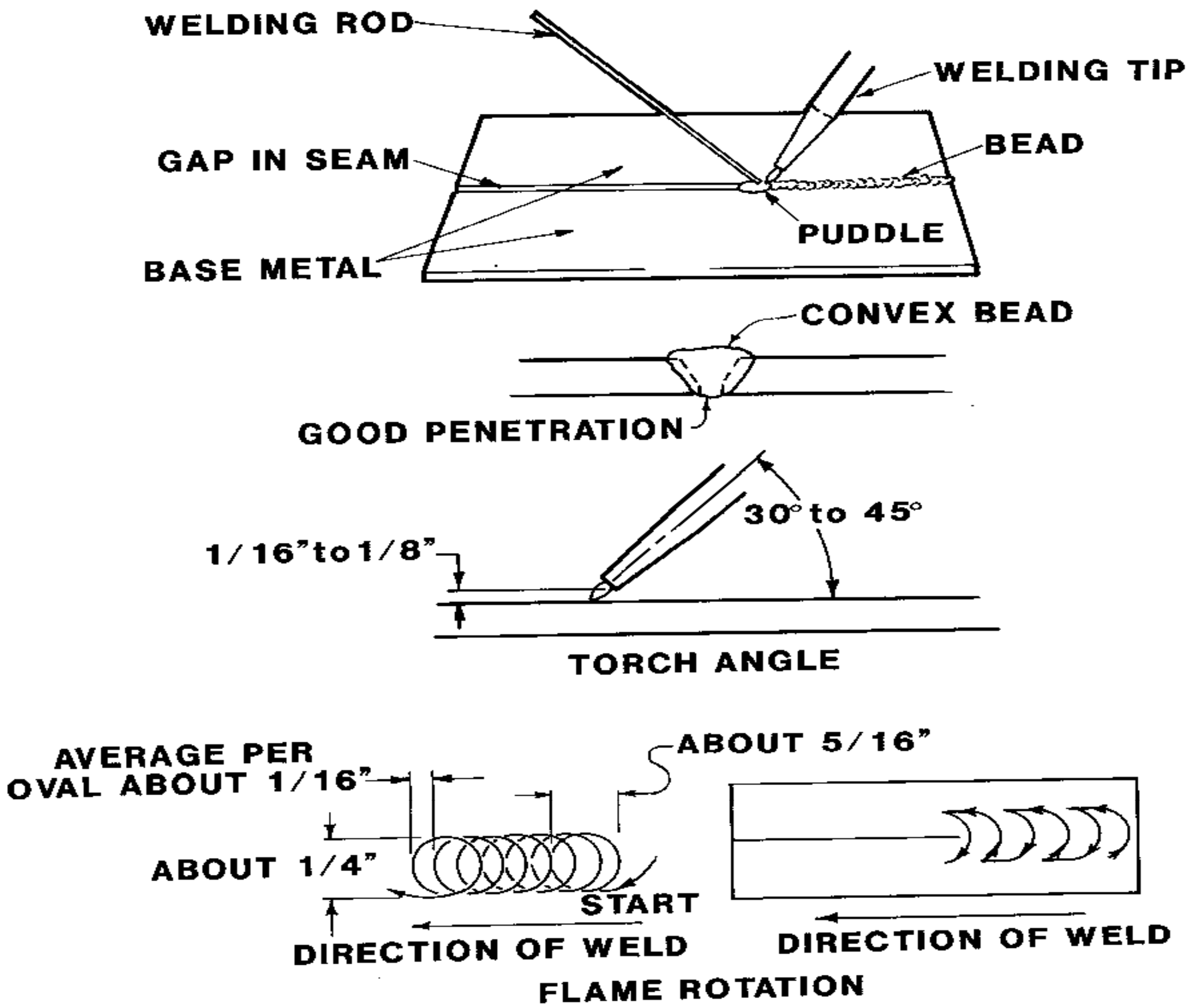


Figure 22, Starting and Finishing the Weld

When You Finish Your Welding Operation

1. First, shut off the torch oxygen valve. Then, shut off the torch fuel valve. If this procedure is reversed, a "pop" may occur. The "pop" throws carbon soot back into the torch and may in time partially clog gas passages.
2. Close both cylinder valves.
3. Open the torch handle oxygen valve. Let the oxygen in the system drain out. Close the torch oxygen valve.
4. Turn the adjusting screw on the oxygen regulator counterclockwise to release all spring pressure.
5. Open the torch handle fuel valve. Release the pressure in the system. Close the torch fuel valve.
6. Turn the adjusting screw on the fuel gas regulator counterclockwise to release all spring pressure.
7. Check the H.P gauges after a few minutes to be sure the cylinder valves are turned off completely.

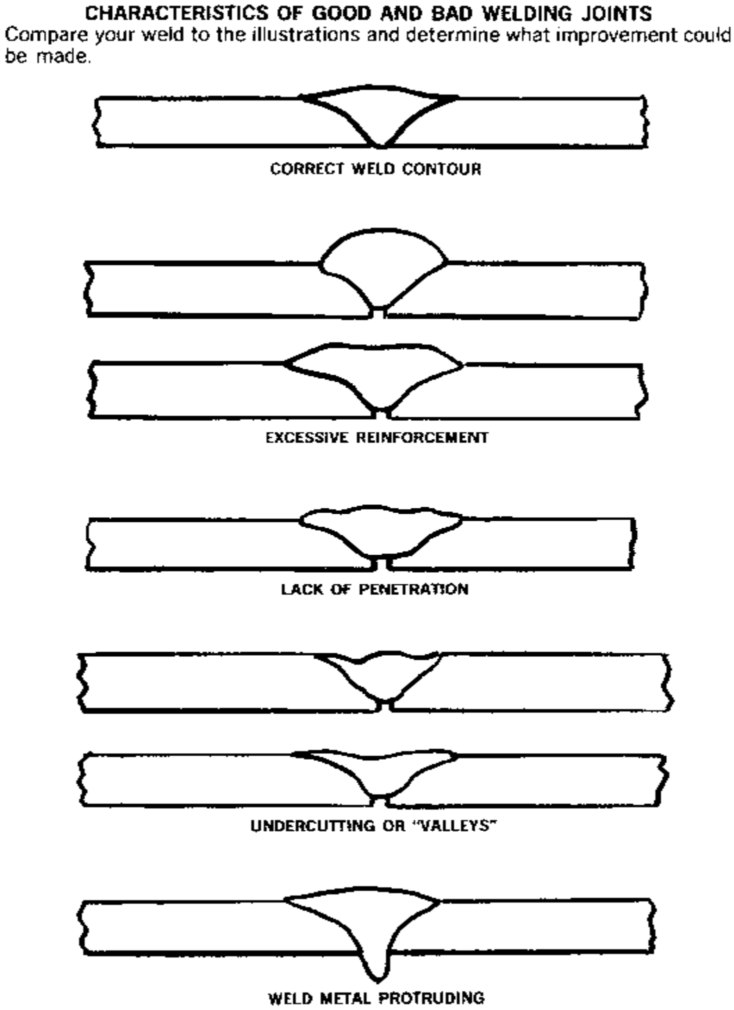


Figure 23, Characteristics of Good and Bad Welding Joints

Oxy-Fuel Brazing and Braze Welding

Brazing is a form of welding characterized by heating the base metal to temperatures above 700°F, but below its melting point. Most metals can be joined by brazing. However, the proper filler rod and flux must be used. Contact your local supplier for charts on the various filler rods and fluxes that are available. Flux is required to prepare the metals for joining. The filler rod bonds the base metals together.

Preparing the Metals to be Brazed

The successful brazing operation depends on close joint tolerances. Usually the clearance is between 0.001 and 0.010 inch. Clean away paint, rust, grease and dirt prior to beginning the brazing operation. After cleaning the parts, assemble or secure the joints for brazing at the welding station.

⚠CAUTION Perform all brazing processes in a well-ventilated area. Toxic fumes may be generated by the brazing process. Refer to the Material Safety Data Sheet (MSDS) for the brazing rod.

Setting Up for Brazing Applications

1. Refer to the Welding Nozzle Data Charts (page 42) to select the proper welding nozzle size and regulator pressure settings.
2. Follow safety and operating procedures for setting up welding and heating nozzles.
3. Follow safety and operating procedures for setting up cylinders and regulators.

Brazing Sheet Steel

The brazing procedures described apply to brazing strips of sheet steel. The techniques can be utilized in all brazing applications.

1. Heat the tip of the brazing rod and dip into the flux. Some flux will adhere to the heated rod.

NOTICE	**Some rods already have a flux coating.**

2. Preheat metal only to a dull red color. If the base metal is heated to a higher temperature, a porous deposit will result.
3. Touch the fluxed rod to the heated metal. Allow some flux to melt and react with the base metal. The melted flux reacts to chemically clean the base metal.
4. Melt off small amounts of fluxed rod as you braze. If the rod flows freely and "tins" (adheres to the heated base metal), you have reached the correct temperature. Maintain this temperature by continually moving the flame over the metal.
5. Continue to tip the rod into the flux. Add sufficient rod to the base metal to build up the bead.
6. Continue to tin and build a bead until the desired section is covered.

When You Finish Your Brazing Operation

Follow the same procedures as for shutting down the welding operation.

SECTION 6: SETTING UP EQUIPMENT FOR CUTTING

⚠CAUTION Use only VICTOR torch handles, cutting attachments and cutting tips together to ensure leak free connections and balanced equipment.

The oxy-fuel cutting process consists of preheating the base metal to a bright cherry red. Then, a stream of cutting oxygen is introduced. This ignites and burns the metal, carrying away the slag or oxidized residue. Oxy-fuel cutting can be applied to plain carbon steels, low-alloy steels and some other ferrous metals. Nonferrous metals, stainless steels and cast iron are not usually cut using oxy-fuel equipment.

Setting Up for Cutting Applications

1. Inspect the cone end, coupling nut, and torch head for oil, grease, or damaged parts. Inspect the cone end for missing or damaged o-rings.

⚠WARNING If you find oil, grease or damage, DO NOT use the apparatus until it has been cleaned and/or repaired by a qualified repair technician. There must be two o-rings in good condition on the cone end. The absence of either of these o-rings allows pre-mixing of oxygen and fuel gases. This can lead to flashback within the cutting attachment.

2. Inspect the cutting tip and cutting attachment head. All tapered seating surfaces must be in good condition. Discard damaged cutting tips. If you find dents, burns or burned seats, resurface the torch head. If you use the cutting attachment with poor seating surfaces, backfire or flashback may occur.

⚠WARNING These seating surfaces prevent premature mixing of gases that can cause fires and explosions. If the tapered seats on the tip are damaged, DO NOT use it!

3. Inspect the preheat and cutting oxygen holes on the tip. Splatter can stick on or in these holes. If the holes are clogged or obstructed, clean them out with the proper size tip cleaner.

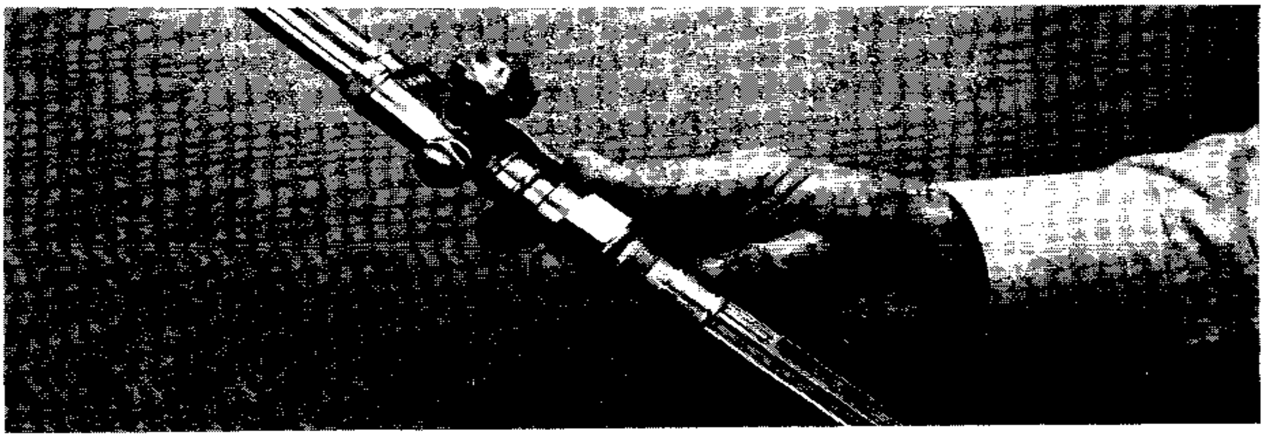


Figure 24, Connecting Cutting Attachment to Torch Handle

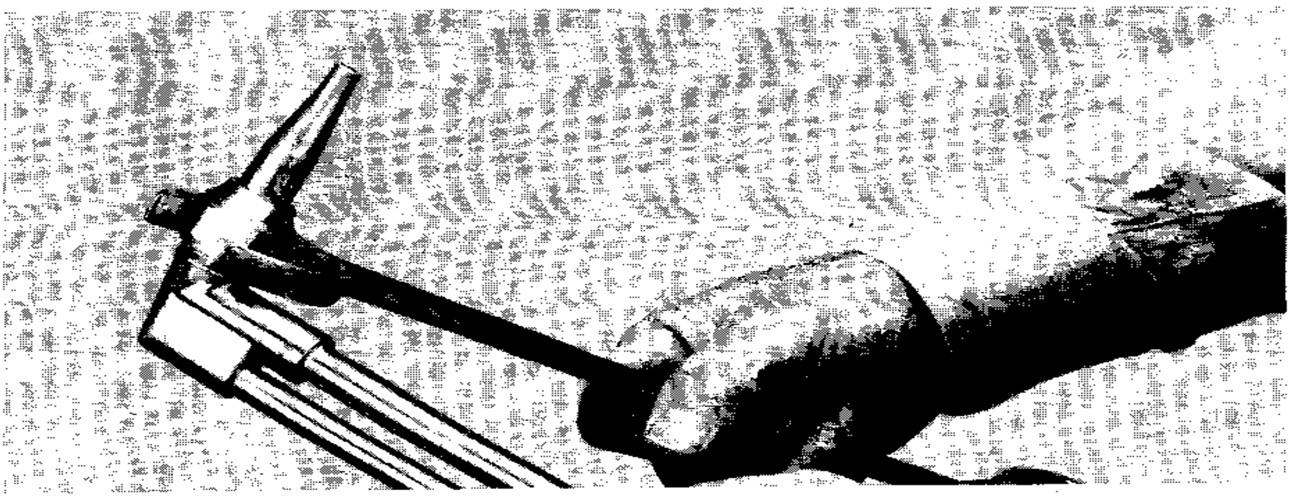


Figure 25, Tightening the Tip Nut

4. Insert the tip in the cutting attachment head. Tighten the tip nut securely with a wrench (15 to 20 lbs. torque) (see Figure 25).
5. Connect the cutting attachment to the torch handle and tighten the coupling nut, hand-tight only. Wrench tightening may damage o-rings, creating a faulty seal (see Figure 24, page 33).
6. Refer to the Tip Flow Data Charts for correct cutting tip, regulator pressures, and travel speed (see page 42).
7. Follow cylinder and regulator safety and operating procedures.
8. Open the oxygen valve on the torch handle completely.
9. Open the preheat oxygen control valve on the cutting attachment. Adjust the oxygen regulator to the desired delivery pressure.
10. Close the preheat oxygen control valve.
11. Open the fuel valve on the torch handle. Adjust the fuel regulator delivery range.
12. Close the fuel control valve on the torch handle.
13. Momentarily, depress the cutting oxygen lever to purge the cutting oxygen passage.

⚠WARNING If the torch handle and hoses are already connected to the regulators, the system MUST still be purged after every shut-down. Open the oxygen valve 1/2 turn. Allow the gas to flow ten seconds for tips up to size 3 and 5 seconds for sizes 4 and larger for each 25 feet of hose in the system. Close the oxygen valve. Purge the fuel system in the same manner.

13. Open the fuel valve on the torch handle approximately 1/8 turn. Ignite the gas with a spark lighter. Be sure the spark lighter is away from the tip and not obstructing the gas flow.

NOTICE Wear protective clothing. Use goggles to shield the eyes from bright light.

14. Continue to increase the fuel supply at the torch handle until the flame stops smoking.

15.Slowly open the preheat oxygen control valve on the cutting attachment until the preheat flames establish a sharp inner cone. The configuration of the short inner cone is called the Neutral Flame.

16.Depress the cutting oxygen lever. If the preheat flame changes slightly to a carburizing flame, continue to depress the cutting oxygen lever. Increase the preheat oxygen at the cutting attachment until the preheat flames are again neutral. If the preheat flames are not the same size and the cutting oxygen not straight, turn off the torch. Let it cool. Clean the tip.

> ⚠WARNING **If you experience a backfire or flashback (flame disappears and/or a shrill hissing sound when the flame is burning inside the cutting attachment) immediately turn off the preheat oxygen control valve on the cutting attachment. Then, turn off the torch handle fuel valve. Allow the cutting attachment to cool before attempting to relight. If backfire and flashback reoccurs, have the apparatus checked by a qualified repair technician before using again.**

IMPORTANT

Inspect the areas where molten metal and sparks will fall. Serious fires and explosions are caused by careless torch operations. Take all possible precautions. Have fire extinguishers available. Remove or protect flammable substances, including oxygen and fuel hoses, before starting to work. Refer to Figure 30, page 37 for a graphic sequence of recommended proceures for efficient flame cutting.

17.Hold the cutting attachment or torch handle comfortably in both hands. Stabilize the torch with one hand. Position the cutting tip preheat flames approximately 1/8" from the base metal. The other hand is free to depress the cutting oxygen lever.

18.Direct the preheat flame to the spot where you want to start the cut (see Figure 26). Before the cutting action can start, preheat the base metal to a bright cherry red. When the red spot appears, depress the cutting oxygen lever slowly and fully.

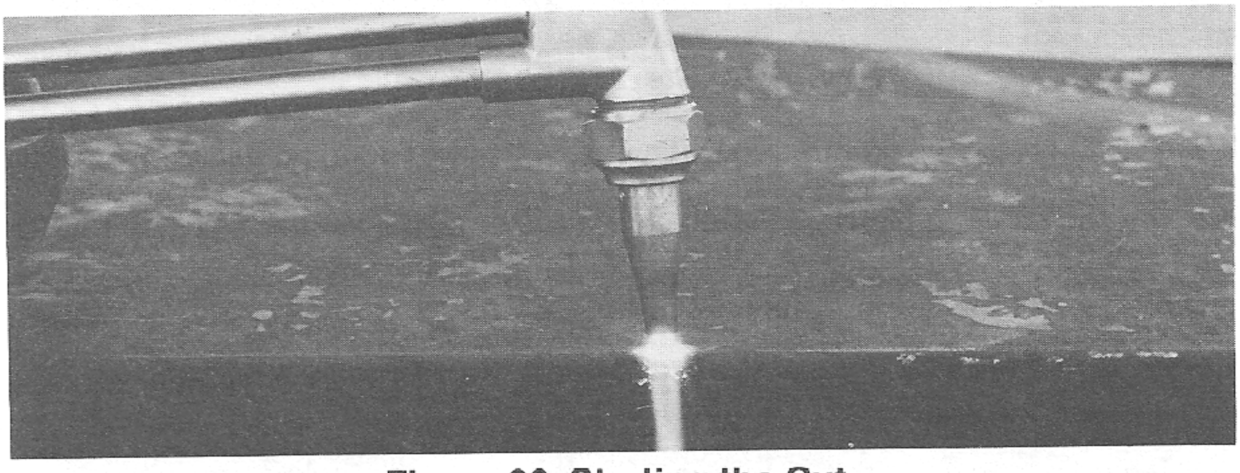


Figure 26, Starting the Cut

19.When the cut starts, move the torch in the direction you wish to cut (see Figure 27, page 36).

> NOTICE **Moving too slowly allows the cut to fuse together. Moving too fast will not preheat the metal and the cut will be lost.**

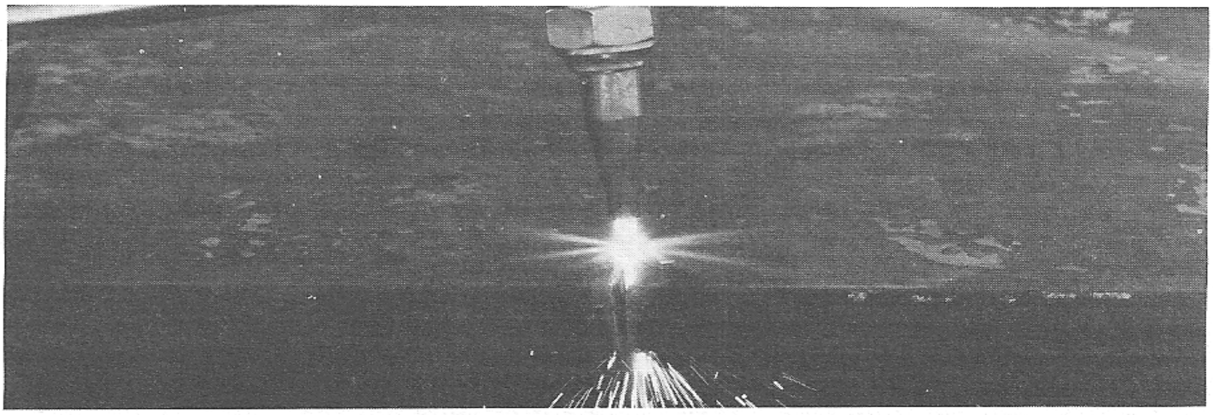


Figure 27, Cutting

20.Continue to depress the cutting oxygen lever past the final edge of the base metal for a good drop cut (see Figure 30, page 37).

Starting a Cut by Piercing

1.Preheat a small spot on the base metal to a bright cherry red (see Figure 28).

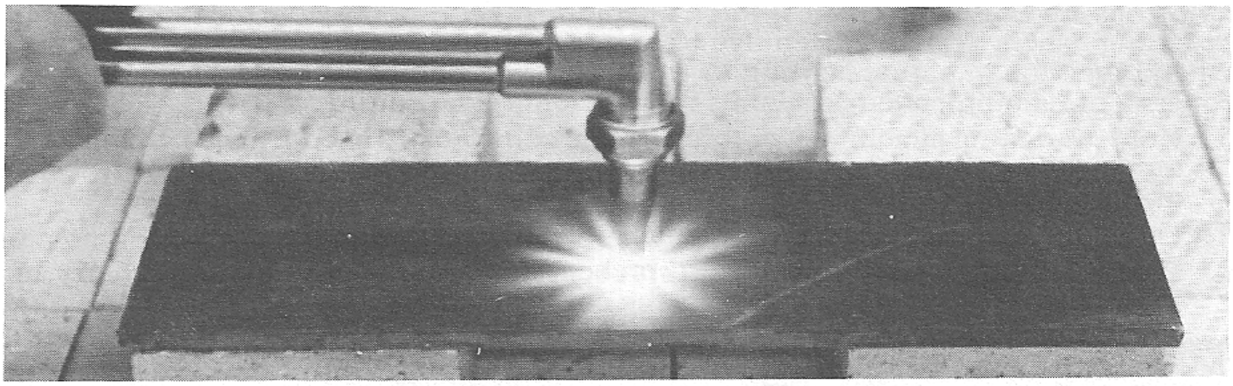


Figure 28, Starting to Pierce

2.Tilt the torch tip slightly to one side. This prevents the sparks and slag from blowing towards you.

3.When the metal is pierced, straighten the torch. Move the torch steadily in the direction you wish to cut (see Figure 29).

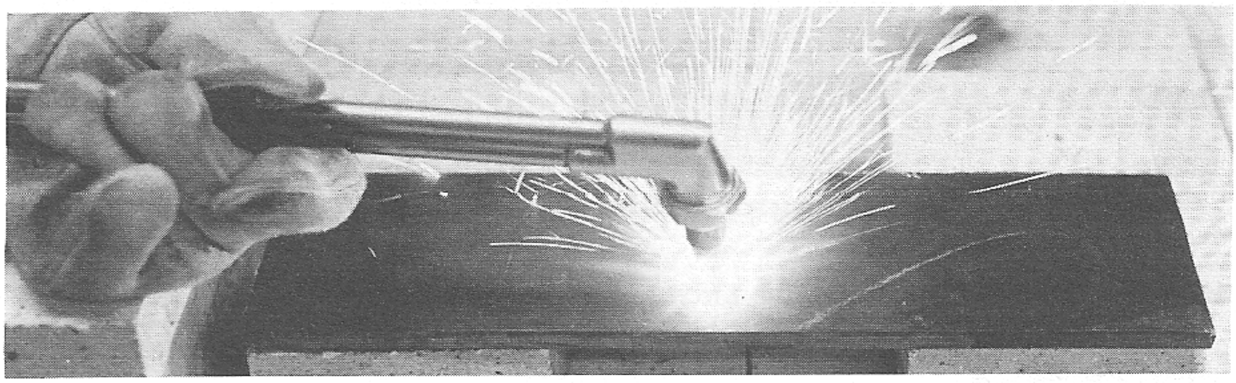
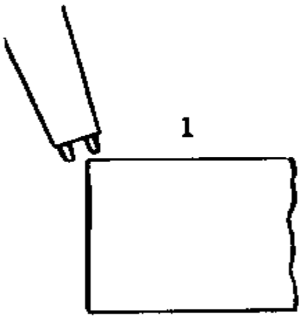
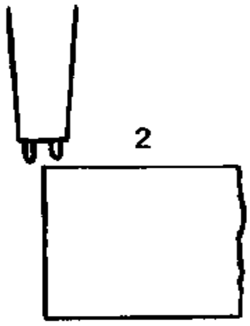


Figure 29, Piercing

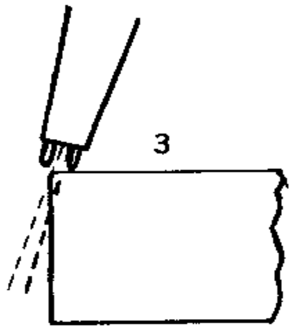
Recommended Procedure for Efficient Flame Cutting of Steel Plate



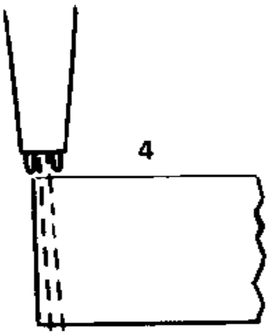
1. Start to preheat; point tip at angle on edge of plate.



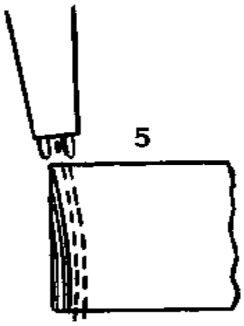
2. Rotate tip to upright position.



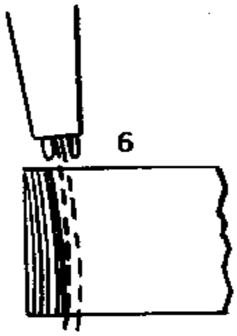
3. Press oxy valve slowly; as cut starts, rotate tip backward slightly.



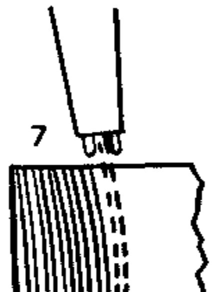
4. Now rotate to upright position without moving tip forward.



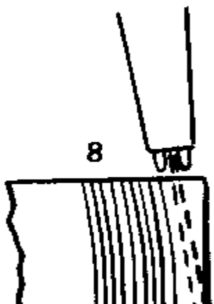
5. Rotate tip more to point slightly in direction of cut.



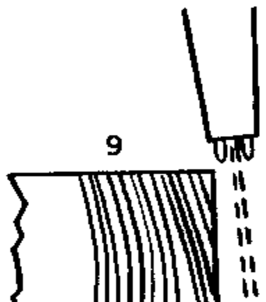
6. Advance as fast as good cutting action will permit.



7. Do not jerk; maintain slight leading angle toward direction of cut.



8. Slow down; let cutting stream sever corner edge at bottom.



9. Continue steady forward motion until tip has cleared end.

Fig. 30,Recommended Procedures for Efficient Flame Cutting

NOTICE **If the metal is not pierced all the way through, it probably means that you are not using enough cutting oxygen pressure.**

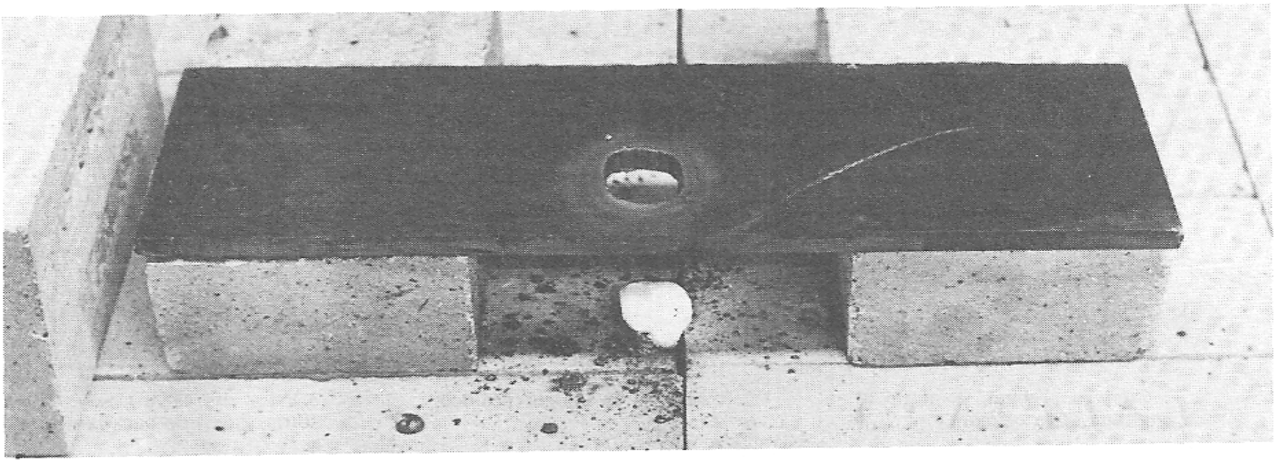


Figure 31, Cutting by Piercing

When You Finish Your Cutting Operation

1. First, close the oxygen preheat valve. Then, close the torch fuel valve. If this procedure is reversed, a pop may occur. The pop throws carbon soot back into the torch and may, in time, partially clog gas passages.
2. Close both cylinder valves.
3. Open the preheat oxygen valve and/or depress the cutting oxygen lever. Release the pressure in the system. Close the preheat oxygen valve and the torch handle oxygen valve.
4. Turn the adjusting screw on the oxygen regulator counterclockwise to release all spring pressure.
5. Open the torch handle fuel valve. Release the pressure in the system. Close the fuel valve.
6. Turn the adjusting screw on the fuel gas regulator counterclockwise to release all spring pressure.
7. Check the H.P. gauges after a few minutes to be sure the cylinder valves are shut off completely.
8. Remove slag left on the cut edge with a chipping hammer or brush. Never remove slag from the cut edge with the torch head or cutting tip.

OXY-FUEL CUTTING REFERENCE CHART

PART I — DESCRIPTION OF VARIABLES/CONDITIONS

	Top Edge	Bottom Edge	Plate Face Condition and Drag Line Pattern	Sound of Cut	Slag Pattern	Possible Drop Cut
Quality cut — all adjustments correct — see Fig. 1	Clean and square with no roll over. No slag on top of plate.	Square and free of slag.	Surface is smooth and clean. Drag lines show uniform, vertical pattern. Plate requires no additional processing.	Smooth and regular —	Regular — Consistently vertical through length of cut.	Yes
Travel speed too fast — see Fig. 2	Relatively clean and square.	Considerable slag adheres to bottom edge — cutting oxygen stream moving too fast to allow complete oxidation.	Occasional gouges appear, drag lines are pronounced, and slant away from direction of cut.	No noticeable sputtering.	Irregular pattern as cutting oxygen stream intermittently lags behind the position of tip.	No
Travel speed too slow — see Fig. 3	Rough and uneven. Slightly melted away due to excess pre-heat exposure.	Considerable slag adheres to bottom edge.	Upper portion is clean and smooth. Lower section severely gouged due to wandering oxygen stream.	Erratic — noticeable sputtering.	Irregular and erratic due to uneven progress of oxygen stream	50/50
Cutting oxygen pressure too high see Fig. 4	Uneven, out of square. Excessive amount of top edge oxidized as oxygen stream expands upon entry.	Relatively clean and square — free of slag.	Plate is relatively free of pits or gouges but draglines irregular and erratic due to excessive oxygen stream turbulence.	Smooth and regular but exceptionally loud.	Distinct and regular due to force of oxygen stream.	Yes
Cutting oxygen pressure too low see Fig. 5	Generally clean and square.	Considerable slag adheres to plate as cutting oxygen has difficulty penetrating metal.	Plate is fairly smooth but much slag adheres to bottom. Draglines slant away from cut.	Irregular and occasional sputtering.	Irregular and weak — oxygen pressure not sufficient to carry through metal.	No
Too much pre-heat — see Fig. 6	Rounded edge produced by excessive heat. Molten beads also deposited on top of plate.	Moderate amount of slag. Usually adheres to bottom edge.	Draglines are fairly regular and smooth. Excessive metal being removed from plate leaves much slag on bottom edge.	Regular and even but louder than normal (higher flow on pre-heat).	Regular and consistent.	Yes
Too little pre-heat — see Fig. 7	Top edge slightly rounded and out of square.	Often irregular — moderate amount of slag may appear.	Pits and gouges sometimes appear. Draglines uniform and well defined.	Erratic and uneven.	Erratic and uneven.	Not Normally
Tip too far from plate — see Fig. 8	Flared and partially blown away — out of square	Relatively even — little if any slag adhesion.	Smooth and even. Draglines are uniform and vertical.	Smooth and even — constant.	Smooth and even.	Yes
Tip too close to plate — see Fig. 9	Generally rough due to pre-heats interrupting cutting oxygen stream.	Relatively even and slag free.	Occasional gouges will result from pre-heat popping. Draglines show irregular pattern.	Relatively even sputtering.	Usually regular.	50/50

NOTE: Cutting tip may also be damaged if allowed to contact plate.

OXY-FUEL CUTTING REFERENCE CHART

PART II — ILLUSTRATIONS

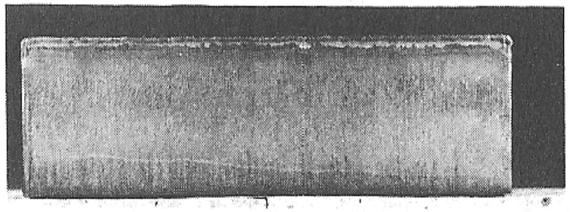


Fig. 1 Quality Cut

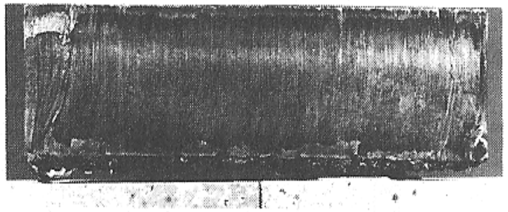


Fig. 2 Travel Speed Too Fast

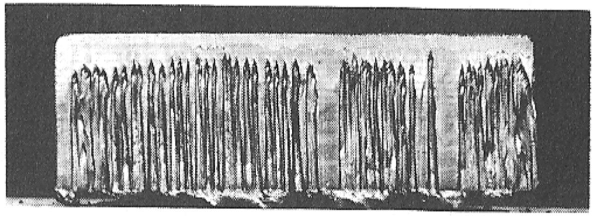


Fig. 3 Travel Speed Too Slow

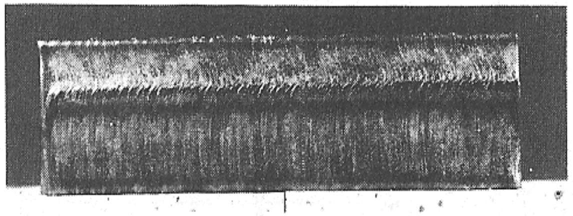


Fig. 4 Cutting Oxygen Pressure Too High

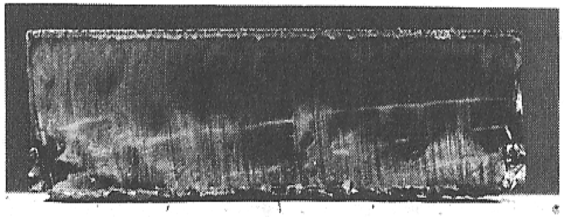


Fig. 5 Cutting Oxygen Pressure Too Low

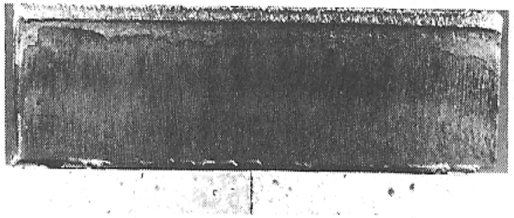


Fig. 6 Too Much Pre-Heat

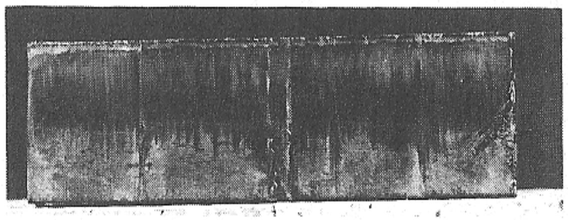


Fig. 7 Too Little Pre-Heat

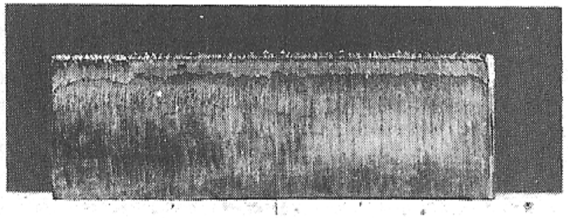


Fig. 8 Tip Too Far From Plate

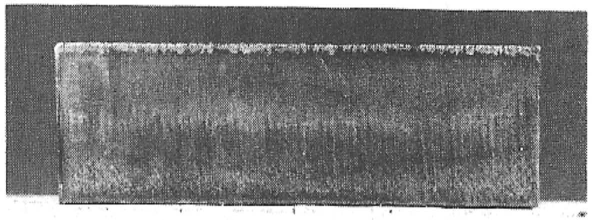


Fig. 9 Tip Too Close to Plate

WELDING NOZZLE FLOW DATA

Metal Thickness	Tip Size	Drill Size	Oxygen Pressure (PSIG)		Acetylene Pressure (PSIG)		Acetylene Consumption (SCFH)	
			Min.	Max.	Min.	Max.	Min.	Max.
Up to 1/32"	000	75 (.022)	3	5	3	5	1	2
1/16" - 3/64"	00	70 (.028)	3	5	3	5	1 1/2	3
1/32" - 5/64"	0	65 (.035)	3	5	3	5	2	4
3/64" - 3/32"	1	60 (.040)	3	5	3	5	3	6
1/16" - 1/8"	2	56 (.046)	3	5	3	5	5	10
1/8" - 3/16"	3	53 (.060)	4	7	3	6	8	18
3/16" - 1/4"	4	49 (.073)	5	10	4	7	10	25
1/4" - 1/2"	5	43 (.089)	6	12	5	8	15	35
1/2" - 3/4"	6	36 (.106)	7	14	6	9	25	45
3/4 - 1 1/4"	7	30 (.128)	8	16	8	10	30	60
1 1/4" - 2"	8	29 (.136)	10	19	9	12	35	75
2 1/2" - 3"	10	27 (.144)	12	24	12	15	50	100
3 1/2" - 4"	12*	25 (.149)	18	28	12	15	80	160

TYPE MFA HEATING NOZZLES

Tip Size	Acetylene Pressure Range PSIG	Oxygen Pressure Range PSIG	Acetylene Cubic Feet per Hour		Oxygen Cubic Feet per Hour		BTU per Hour
			Min.	Max.	Min.	Max.	
4	6-10	8-12	6	20	7	22	SEE NOTICE, page 43
6	8-12	10-15	14	40	15	44	
8	10-15	20-30	30	80	33	88	
10	12-15	30-40	40	100	44	110	
12*	12-15	50-60	60	150	66	165	
15*	12-15	50-60	90	220	99	244	

⚠WARNING **At no time should the withdrawal rate of an individual acetylene cylinder exceed 1/7 of the cylinder contents per hour. If additional flow capacity is required, use an acetylene manifold system of sufficient size to supply the necessary volume.**

MFN HEATING NOZZLES

Tip Size	Propane Pressure Range PSIG	Oxygen Pressure Range PSIG	Propane Cubic Feet per Hour		Oxygen Cubic Feet per Hour		BTU per Hour
			Min.	Max.	Min.	Max.	
8	10-15	10-20	10	35	40	140	SEE NOTICE, page 43
10	12-20	10-30	20	80	80	320	
12*	15-25	30-125	30	160	120	640	
15*	15-25	30-125	50	200	200	800	
20*	20-30	40-135	75	250	300	1000	

*Use model HD310C torch and 3/8" hose.

TYPE 55 NOZZLES

Tip Size	Oxygen Pressure PSIG	Fuel Gas Pressure PSIG	Consumption (SCFH)		BTU per Hour
			Oxygen	Fuel Gas	
10*	70-100	15-25	350-460	150-200	SEE NOTICE BELOW
15*	90-120	20-35	600-800	250-350	
20*	100-150	30-50	900-1150	400-500	

*Use Model HD310C torch and 3/8" hose.

NOTICE **Approximate gross BTU contents per cubic foot:**

- **Acetylene - 1470**
- **Butane - 3374**
- **Natural Gas - 1000**
- **Propane - 2458**
- **MAPP - 2406**
- **Methane - 1000**
- **Propylene - 2371**

TYPES 1-101, 3-1-1 & 5-101 (Oxy-Acetylene)

Metal Thickness	Tip Size	Cutting Oxygen		Pre-heat Oxygen* PSIG	Acetylene		Speed IPM	Kerf Width
		Pressure*** PSIG	Flow *** SCFH		Pressure PSIG	Flow SCFH		
1/8"	000	20-25	20-25	3-5	3-5	6-11	20-30	.04
1/4"	00	20-25	30-35	3-5	3-5	6-11	20-28	.05
3/8"	0	25-30	55-60	3-5	3-5	6-11	18-26	.06
1/2"	0	30-35	60-65	3-6	3-5	9-16	16-22	.06
3/4"	1	30-35	80-85	4-7	3-5	8-13	15-20	.07
1"	2	35-40	140-160	4-8	3-6	10-18	13-18	.09
2"	3	40-45	210-240	5-10	4-8	14-24	10-12	.11
3"	4	40-50	280-320	5-10	5-11	18-28	10-12	.12
4"	5	45-55	390-450	6-12	6-13	22-30	6-9	.15
6"	6**	45-55	500-600	6-15	8-14	25-35	4-7	.15
10"	7**	45-55	700-850	6-20	10-15	25-35	3-5	.34
12"	8**	45-55	900-1050	7-25	10-15	25-35	3-4	.41

*Applicable for 3-hose machine cutting torches only. With a two hose cutting torch, preheat pressure is set by the cutting oxygen.

**For best results use ST 1600C-ST 1900C series torches and 3/8" hose using tip size 6 and larger.

***All pressures are measured at the regulator using 25' x 1/4" hose through tip size 5, and 25' x 3/8" hose for tip size 6 and larger.

⚠WARNING **At no time should the withdrawal rate of an individual acetylene cylinder exceed 1/7 of the cylinder contents per hour. If additional flow capacity is required, use an acetylene manifold system of sufficient size to supply the necessary volume.**

TYPES 303M, GPM, GPN, GPP

Metal Thickness	Tip Size	Cutting Oxygen Pressure*** PSIG	Cutting Oxygen Flow SCFH	Pre-heat Oxygen* PSIG	Pre-heat Fuel Gas** Pressure PSIG	Pre-heat Fuel Gas** Flow SCFH	Speed IPM	Kerf Width
1/8"	000	20-25	12-14	SEE NOTICE BELOW	3-5	5-6	20-30	.04
1/4"	00	20-25	22-26		3-5	5-7	20-28	.05
3/8"	0	25-30	45-55		3-5	8-10	18-26	.06
1/2"	0	30-35	50-55		3-5	8-10	16-22	.06
3/4"	1	30-35	70-80		4-6	10-12	15-20	.08
1"	2	35-40	115-125		4-8	12-15	13-20	.09
1 1/2"	2	40-45	125-135		4-8	12-15	13-18	.09
2"	3	40-45	150-175		5-9	14-18	11-13	.10
2 1/2"	3	45-50	175-200		5-9	14-18	10-12	.10
3"	4	40-50	210-250		6-10	16-20	8-10	.12
4"	5	45-55	300-360		8-12	20-30	6-9	.14
5"	5	50-55	330-360		8-12	20-30	4-7	.14
6"	6	45-55	400-500		10-15	25-35	3-5	.17
8"	6	55-65	450-500		10-15	25-35	3-4	.18
12"	8**	60-70	750-850		10-14	25-120	3-4	.41

NOTICE **The above data applies to all torches with the following exceptions:**

Torch Series	Pre-heat Oxygen	Pre-heat Fuel
MT 600N	25 PSIG-Up	8 OZ.-Up
ST 900C Series	N/A	5 PSIG-Up
ST 1600C/1700C Series	N/A	1 PSIG-Up
ST 1800C/1900C Series	N/A	1 PSIG-Up
MT 200 Series	N/A	8 OZ.-Up
MT 300 Series	10-50 PSIG	8 OZ.-Up

*Applicable for 3-hose machine cutting torches only. With a 2-hose cutting torch, preheat pressure is set by the cutting oxygen.

**For best results use ST 1600C - ST 1900C series torches and 3/8" hose when using tip size 6 or larger.

***All pressures are measured at the regulator using 25' x 3/8" hose for tip size 6 and larger.

⚠WARNING **High gas withdrawal rates require use of a manifold system of sufficient size to supply the necessary volume.**

TYPES MTHM, N, P

Metal Thickness	Tip Size	Cutting Oxygen		Pre-heat Oxygen		Pre-heat Fuel Gas		Speed IPM	Kerf Width
		Pressure*** PSIG	Flow SCFH	Pressure PSIG	Flow SCFH	Pressure PSIG	Flow SCFH		
1/4"	00	85-95	68-75	SEE NOTICE BELOW	23-140	SEE NOTICE BELOW	12-65	23-30	.05
3/8"	00	85-95	68-75		23-140		12-65	22-29	.05
1/2"	0	85-95	110-120		23-140		12-65	20-28	.06
3/4"	0	85-95	110-120		23-140		12-65	18-26	.06
1"	1	85-95	145-160		23-140		12-65	17-24	.07
1 1/4"	1	85-95	145-160		23-140		12-65	16-20	.07
1 1/2"	1	85-95	145-160		23-140		12-65	12-16	.07
2"	2	85-95	230-250		23-140		12-65	11-15	.09
2 1/2"	2	85-95	230-250		23-140		12-65	10-13	.09
3"	2	85-95	230-250		23-140		12-65	9-11	.09
4"	3	85-95	285-320		23-140		12-65	7-10	.11
5"	3	85-95	285-320		23-140		12-65	6-8	.11
6"	3	85-95	285-320		23-140		12-65	5-7	.11
7"	4	85-95	390-450		23-140		12-65	5-6	.14
8"	4	85-95	390-450		23-140		12-65	4-6	.14
9"	5	85-95	670-720		23-140		12-65	4-5	.18
10"	5	85-95	670-720		23-140		12-65	3-5	.18

NOTICE **The above data applies to all torches with the following exceptions:**

Torch Series	Pre-heat Oxygen	Pre-heat Fuel
MT 300N Series	10-50 PSIG	8 OZ.-Up
MT 600N Series	25 PSIG-Up	8 OZ.-Up

***All pressures are measured at the torch inlet on MTH Series Tips.

⚠WARNING **High gas withdrawal rates require use of a manifold system of sufficient size to supply the necessary volume.**

TYPE HPM, N, P

Metal Thickness	Tip Size	Cutting Oxygen		Pre-heat Oxygen		Pre-heat Fuel Gas		Speed IPM	Kerf Width
		Pressure*** PSIG	Flow SCFH	Pressure PSIG	Flow SCFH	Pressure* PSIG	Flow SCFH		
3/4"	1	30-35	70-80	SEE NOTICE BELOW	44-240	3-6	22-110	15-20	.08
1"	2	35-40	115-125		44-240	3-6	22-110	14-18	.09
1 1/2"	2	40-45	125-135		44-240	4-8	22-110	12-16	.09
2"	3	40-45	150-175		44-240	4-8	22-110	10-14	.10
2 1/2"	3	45-50	175-200		44-240	5-9	22-110	9-12	.10
3"	4	40-50	210-250		44-240	6-9	22-110	8-11	.12
4"	5	45-55	300-360		44-240	6-9	22-110	7-10	.14
5"	5	50-55	330-360		44-240	6-10	22-110	6-9	.14
6"	6**	45-55	400-500		44-240	6-10	22-110	5-7	.17
8"	6**	55-65	450-500		44-240	8-12	22-110	4-6	.18
12"	8**	60-70	750-850		50-265	10-14	25-120	3-4	.41
15"	10**	45-55	1000-1200		50-265	10-16	25-120	2-4	—
18"	12**	45-55	1150-1350		60-290	—	30-130	2-3	—

*Applicable for 3-hose machine cutting torches only. With a two hose cutting torch, preheat pressure is set by the cutting oxygen.

**For best results use ST 1600C-ST 1900C series torches and 3/8" hose using tip size 6 and larger.

***All pressures are measured at the regulator using 25' x 1/4" hose through tip size 5, and 25' x 3/8" hose for tip size 6 and larger.

⚠WARNING **High gas withdrawal rates require use of a manifold system of sufficient size to supply the necessary volume.**

NOTICE **The above data applies to all torches with the following exceptions:**

Torch Series	Pre-heat Oxygen	Pre-heat Fuel
MT 200N Series	N/A	8 OZ.-Up
MT 300N Series	10-50 PSIG	8 OZ.-Up
MT 600N Series	25 PSIG-Up	8 OZ.-Up
ST 900C Series	N/A	5 PSIG-Up
ST 1600C-ST 1900C Series	N/A	2 PSIG-Up
STN 2300C Series	N/A	2 PSIG-Up

CUTTING TIP PREHEAT AND CUTTING ORIFICE DRILL SIZE

Tip Size Orifice Size*	Cutting Oxygen Size	Cleaning Drill	Preheat Sizes for the Various Types of Tips													
			1-100 3-100	1-101 3-101 5-101	1-104	1-108 3-108	1-110 3-110 5-110	1-111	1-112 3-112	1-129	1-200 3-200 5-200	1-116 3-116	1-117	1-118 3-118	1-207	1-218
000	71	72		74												
00	67	68		74			65		67							
0	60	61	71	74		75	60	64	60		67			71		
1	56	57	67	71		73	56		56		64					
2	53	54	60	67		66	54	56	53	57	62	66		63	55	
3	50	51		66		63	53		52		60	64				
4	45	46		66		60		53	52	55	56	61		56	53	57
5	39	40		66							55					
6	31	32		63							54			57		57
7	28	29		63												
8	20	21		63	55								63	57		56
10	13	14			55									57		55
12	2	7/32												56		

*Same for all types except scarfing, gouging, deseaming and high speed

GLOSSARY

This section explains the meaning of terms most used by welders. Technical engineering terms have been simplified.

A

ACETYLENE - Gas composed of two parts of carbon and two parts of hydrogen. When burned in the atmosphere of oxygen, it produces one of the highest flame temperatures obtainable.

ACETYLENE CYLINDER - (See Gas Cylinder)

ACETYLENE HOSE - (See Hose)

ACETYLENE REGULATOR - Manually adjustable device used to reduce cylinder pressure to torch pressure and to keep the pressure constant. They are **never** to be used as oxygen regulators.

ALLOY - A mixture of two or more metals.

ANNEALING - Softening metals by heat treating. This most commonly consists of heating the metals up to a critical temperature and then cooling them slowly.

ANSI - Abbreviation for American National Standard Institute.

AWS - Abbreviation for American Welding Society.

AXIS OF WELD - (See Weld Axis)

B

BACKHAND WELDING - A welding technique in which the welding torch is directed opposite to the progress of welding.

BEAD - (See Weld Bead)

BEVEL - An angular edge preparation.

BLOWPIPE - (See Torch)

BOND - Junction of the weld metal and the base metal.

BRAZE WELDING - A welding process variation in which a filler metal, having a liquidus above 840°F (450°C) and below the solidus of the base metal is used. Unlike brazing, in braze welding the filler metal is not distributed in the joint by capillary action.

BRAZING - A group of welding processes that produces coalescence of materials by heating them to the brazing temperature in the presence of a filler metal having a liquidus above 840°F (4500°C) and below the solidus of the base metal. The filler metal is distributed between the closely fitted surfaces of the joint by capillary action.

BUILDUP - A surfacing variation in which surfacing metal is deposited to achieve the required dimensions.

BURNED METAL - Term occasionally applied to the metal which has been combined with oxygen so that some of the carbon changed into carbon dioxide and some of the iron into iron oxide.

BURNING - A nonstandard term for OXYGEN CUTTING.

BUTT JOINT - A joint between two members aligned approximately in the same plane.

C

CARBON - An element which, when combined with iron, forms various kinds of steel. In steel, it is the changing carbon content which changes the physical properties of the steel. Carbon is also used in a solid form as an electrode for arc welding and as a mold to hold metal.

CARBONIZING FLAME - A nonstandard term for REDUCING FLAME.

CARBURIZING FLAME - A nonstandard term for REDUCING FLAME.

CASE HARDENING - Adding of carbon to the surface of a mild steel object and heat treating to produce a hard surface.

CASTINGS - Metallic forms that are produced by pouring molten metal into a shaped container (mold).

CGA - Abbreviation for Compressed Gas Association.

CONCAVE FILLET WELD - A weld having a concave face.

CONE - The conical part of an oxy-fuel flame next to the orifice of the tip.

CONTINUOUS WELD - A weld that extends continuously from one end of the joint to the other. Where the joint is essentially circular, it extends completely around the joint.

CONVEX FILLET WELD - A fillet weld having a convex face.

CORNER JOINT - A joint between two members located approximately at right angles to each other.

CRACKING - Action of opening a valve slightly and then closing the valve immediately.

CROWN - Curve or convex surface of finished weld proper.

CUTTING TORCH - A device used in gas cutting.

CYLINDER - (See Gas Cylinder)

D

DOT - Abbreviation for Department of Transportation.

E

EDGE JOINT - A joint between the edges of two or more parallel or nearly parallel members.

ELONGATION - Percentage increase in the length of a specimen when stressed to its yield strength.

EROSION - A condition caused by dissolution of the base metal by molten filler metal resulting in a reduction in the thickness of the base metal.

F

FACE OF WELD - (See Weld Face)

FILLER WIRE - A nonstandard term for Welding Wire.

FILLET - Weld metal in the internal vertex, or corner, of the angle formed by two pieces of metal, giving the joint additional strength to withstand unusual stress.

FILLET WELD - A weld of approximately triangular cross section joining two surfaces approximately at right angles to each other in a lap joint, T-joint or corner joint.

FILTER LENS - A round filter plate.

FLAME CUTTING - A nonstandard term for OXYGEN CUTTING.

FLAT POSITION - The welding position used to weld from the upper side of the joint; the face of the weld is approximately horizontal.

FLUX - Materials used to prevent, dissolve or facilitate removal of oxides and other undesirable surface substances.

FORGING - Metallic shapes being derived by either hammering or squeezing the original piece of metal into the desired shapes or thicknesses.

FOREHAND WELDING - A welding technique in which the welding torch is directed toward the progress of welding.

FUSION - The melting together of filler metal and base metals.

G

GAS CYLINDER - A portable container used for transportation and storage of a compressed gas.

GAS POCKETS - Cavities in weld metal caused by entrapping gas.

GOUGING - The removal of a bevel or groove material removal.

H

HEAT-AFFECTED ZONE - That portion of the base metal that has not been melted, but whose mechanical properties of microstructure has been altered by the heat of welding, cutting or heating.

HEAT CONDUCTIVITY - Speed and efficiency of heat energy movement through a substance.

HORIZONTAL POSITION - The position in which welding is performed on the upper side and approximately horizontal surface and against an approximately vertical surface.

HOSE - Flexible medium used to carry gases from regulator to the torch. It is made of fabric and rubber or neoprene.

HYDROGEN - A gas formed of the single element hydrogen. It is considered one of the most active gases. When combined with oxygen, it forms a very clean flame.

I

INSIDE CORNER WELD - Two metals fused together; one metal is held 90 degrees to the other. The fusion is performed inside the vertex of the angle.

INTERMITTENT WELD - A weld which the continuity is broken by recurring unwed spaces.

J

JOINT - The junction of members or the edges of members which are to be joined or have been joined.

JOINT PENETRATION - The depth a weld extends from its face into a joint, exclusive of reinforcement.

L

LAP JOINT - A joint between two overlapping members in parallel planes.

LAYER - A certain weld metal thickness made of one or more passes.

LEG OF A FILLET WELD - (See Fillet Weld Leg)

LENS - (See Filter Lens)

M

MIXING CHAMBER - That part of the welding torch or cutting torch in which the fuel gas and oxygen are mixed.

N

NEUTRAL FLAME - An oxy-fuel gas flame in which the portion used is neither oxidizing nor reducing.

NFPA - Abbreviation for National Fire Protection Association.

NOZZLE - (See Tip)

O

ORIFICE - Opening through which gas flows. It is usually the final opening controlled by a valve.

OSHA - Abbreviation for Occupational Safety and Health Administration.

OUTSIDE CORNER WELD - Fusing two pieces of metal together with the fusion taking place on the underpart of the seam.

OVERHEAD POSITION - The position in which welding is performed from the underside of the joint.

OVERLAP - The protrusion of weld metal beyond the weld toe or weld root.

OXIDIZING - Combining oxygen with any other substance. For example, a metal is oxidized when the metal is burned, i.e., oxygen is combined with all the metal or parts of it.

OXIDIZING FLAME - An oxy-fuel gas flame having an oxidizing effect due to excess oxygen.

OXY-ACETYLENE CUTTING - An oxy-fuel gas cutting process used to sever metals by means of the reaction of oxygen with the base metal as elevated temperatures. The necessary temperature is maintained by gas flames resulting from the combustion of acetylene with oxygen.

OXY-ACETYLENE WELDING -An oxy-fuel gas welding process that produces fused metals by heating them with a gas flame or flames obtained from the combustion of acetylene with oxygen. The process may be used with or without the application of pressure and with or without the use of a filler metal.

OXYGEN - A gas formed of the element oxygen. When oxygen very actively supports combustion it is called burning; when oxygen is slowly combined with a substance it is called oxidation.

OXYGEN CUTTING - Cutting metal using the oxygen jet which is added to an oxygen-acetylene flame.

OXYGEN CYLINDER - (See Gas Cylinder)

OXYGEN HYDROGEN FLAME - The chemical combining of oxygen with the fuel gas hydrogen.

OXYGEN HOSE - (See Hose)

OXYGEN L.P. GAS FLAME - Chemical combining of oxygen with the fuel gas L.P. (liquefied petroleum).

OXYGEN REGULATOR - Manually adjustable device used to reduce cylinder pressure to torch pressure and to keep the pressure constant. They are never to be used as fuel gas regulators.

P

PASS - (See Weld Pass)

PENETRATION - A nonstandard term for JOINT PENETRATION.

PWG WELD - A weld in a circular hole in one member of a joint fusing that member to another member.

POROSITY - Cavity type discontinuities formed by gas entrapment during solidification.

POSTHEATING - The application of heat to an assembly after welding, cutting or heating.

PRECOATING - Coating the base metal in the joint prior to soldering or brazing.

PREHEATING - The application of heat to the base metal immediately before welding or cutting.

PUDDLE - A nonstandard term for WELD POOL.

R

REDUCING FLAME - A flame having a reducing effect due to excess fuel gas.

REINFORCEMENT OF WELD - (See Weld Reinforcement)

ROOT OF WELD - (See Weld Root)

S

SLAG INCLUSION - Non-metallic solid material entrapped in the weld metal or between weld metal and base metal.

SOLDERING - A group of welding processes that produces coalescence of materials by heating them to the soldering temperature and by using a filler metal having a liquidus not exceeding 840°F (4500°C) and below the solidus of the base metals. The filler metal is distributed between the closely fitted surfaces of the joint capillary action.

STRAIN - Reaction of an object to a stress.

STRESS - Load imposed on an object.

STRESS RELIEVING - Even heating of a structure to a temperature below the critical temperature followed by a slow, even cooling.

T

TACK WELD - A weld made to hold the parts of a weldment in proper alignment until the final welds are made.

TANK - (See Gas Cylinders)

T-JOINT - Joint formed by placing one metal against another at an angle of 90 degrees. The edge of one metal contacts the surface of the other metal.

TENSILE STRENGTH - Maximum pull stress which a specimen is capable of withstanding.

THROAT OF A FILLET WELD - Distance from the weld root to the weld face.

TINNING - A nonstandard term for PRECOATING.

TIP - Part of the torch at the end where the gas burns, producing the high temperature flame.

TOE OF WELD - (See Weld Toe)

TORCH - (See Cutting Torch or Welding Torch)

U

UNDERCUT - A groove in the base metal adjacent to the weld toe or weld root and left unfilled by weld metal.

V

VERTICAL POSITION - The position of welding in which the weld axis is approximately vertical.

W

WELD AXIS - A line through the length of the weld, perpendicular to and at the geometric center of its cross section.

WELD BEAD - A weld resulting from a pass.

WELD FACE - The exposed surface of the weld on the side from which welding was done.

WELDING - A materials joining process used in making welds.

WELDING ROD - A form of welding filler metal, normally packaged in straight lengths.

WELDING SEQUENCE - The order of making welds in a weldment.

WELDING TORCH - The device used in gas welding.

WELDING WIRE - Metal wire that is melted and added to the welding puddle to produce the necessary increase in bead thickness.

WELDMENT - Assembly of component parts joined together by welding.

WELD METAL - Fused portion of base metal or fused portion of base metal and filler metal.

WELD PASS - A single progression of welding or surfacing along a joint or substrate. The result of a pass is a weld bead or layer.

WELD POOL - The localized volume of molten metal is a weld prior to its solidification as weld metal.

WELD REINFORCEMENT - Weld metal in excess of the quantity required to fill a joint.

WELD ROOT - The points, as shown in cross section, at which the back of the weld intersects the base metal.

WELD TOE - The junction of the weld face and the base metal.

Y

YIELD STRENGTH - Stress at which a specimen assumes a permanent set.

NOTICE **Other terms and definitions may be found in the AWS A3.085 or later edition titled "Standard Welding Terms and Definitions," available from the AWS, Miami Florida 33135.**

How do I TIG weld?

"How-To Weld" Summary

1. Establish an arc.

2. Create a weld puddle.

3. Add filler metal "dip" into the puddle while pushing the weld puddle along the weld joint.

4. End the arc and leave the torch over the weld puddle to protect it until the puddle cools.

How do I get started TIG welding?

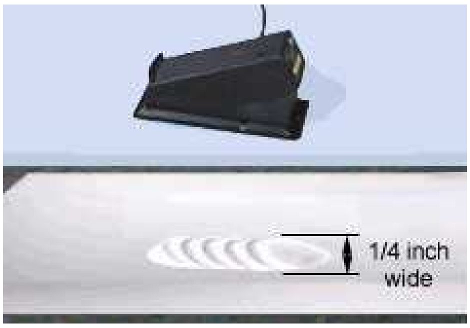
WARNING
See your Owner's Manual for complete safety precautions and procedures.

1. Safety
Make sure you have all the necessary safety equipment and appropriate clothing. For example,

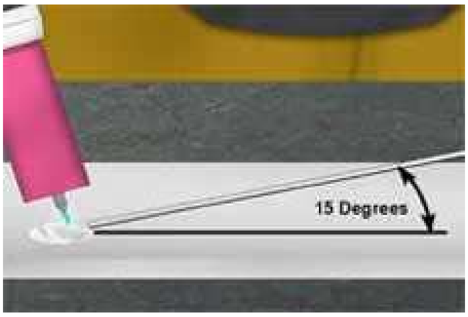
- Dry, hole-free insulating gloves and body protection
- Approved welding helmet fitted with a proper shade of filter lenses to protect your face and eyes when welding or watching
- Approved safety glasses with side shields under your helmet

- Protective clothing made from durable, flame-resistant material (leather, heavy cotton, or wool) and foot protection.

2. Torch Placement
Hold the TIG torch in your hand at a 70° or 80° angle. Raise the torch so that the tungsten is off of the work piece no more than 1/8 to 1/4 in. Don't let the tungsten touch the work piece or it will contaminate your material and you will need to regrind your tungsten.



3. Foot Pedal Control
Practice controlling the heat with the foot pedal to see the weld puddle increase and decrease. Ideally, you want your weld puddle to be about 1/4 inch wide. Keep your puddle size consistent so it doesn't grow, shrink, spread or narrow while you are welding.



4. Filler Metal
Pick up your filler metal in your other hand so it rests horizontally at a 15° angle from the work piece - not pointed down. Heat up the base metal and gently dab the filler into the puddle. Dab rather quickly so you don't leave large deposits.

How do I prepare my weld joint?

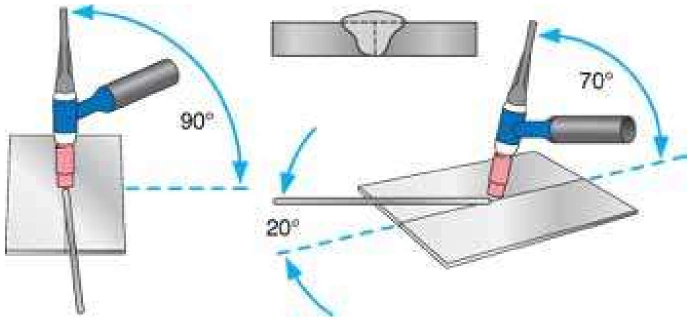
1. **Clean**
   Cleaning both the weld joint area and the filler metal is an important preparation. Remove all oil, grease, dirt, paint, etc. The presence of these contaminants may result in arc instability or contaminated welds.

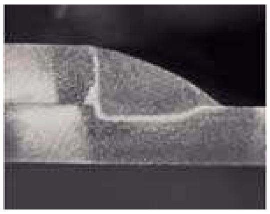
2. **Clamp**
   Clamping may be required if the work piece cannot be supported during welding.

3. **Tack weld**
   Make short 1/4 in. tack welds along the work pieces to hold them together.

How do I position my TIG torch for different types of joints?

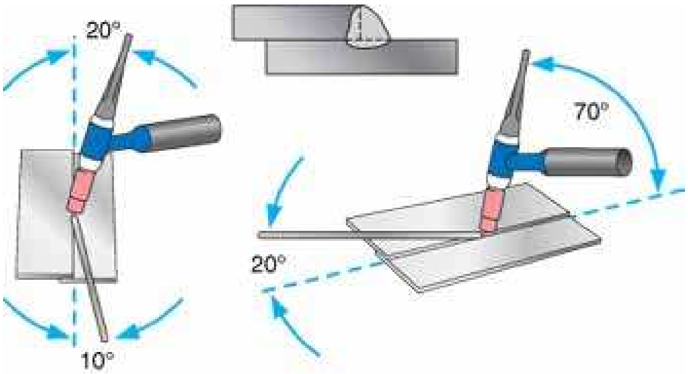
Butt welds
When welding a butt joint, center the weld pool on the adjoining edges. When finishing, decrease the heat (amperage) to aid in filling the crater.

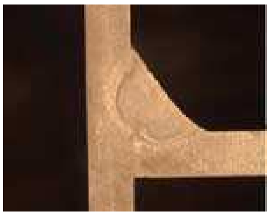

90°
70°
20°



Lap joint

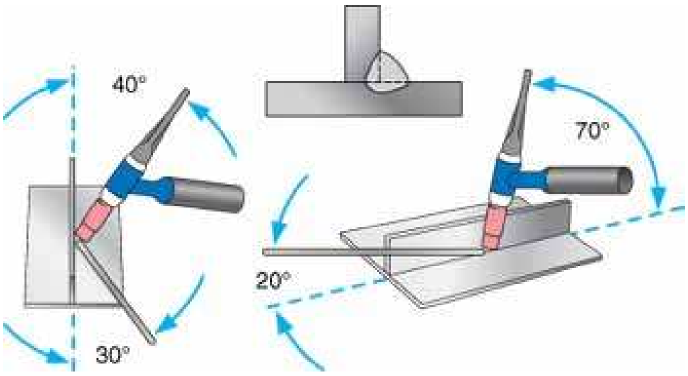
For a lap weld, form the weld pool so that the edge of the overlapping piece and the flat surface of the second piece flow together. Since the edge will melt faster, dip the filler rod next to the edge and make sure you are using enough filler metal to complete the joint.





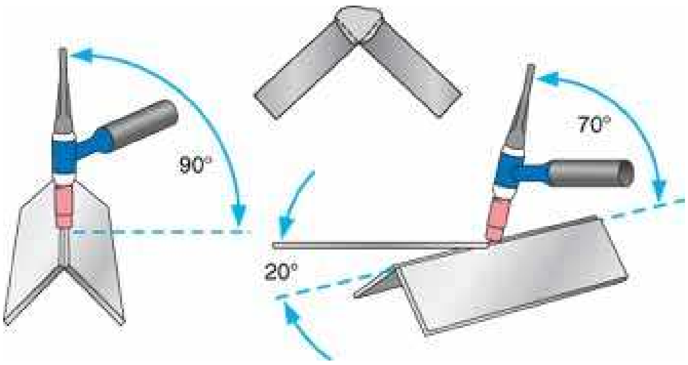
T-joint

When welding a T-joint, the edge and the flat surface are to be joined together, and the edge will melt faster. Angle the torch to direct more heat to the flat surface and extend the electrode beyond the cup to hold a shorter arc. Deposit the filler rod where the edge is melting.



Corner joint

For a corner joint, both edges of the adjoining pieces should be melted and the weld pool should be kept on the joint centerline. A convex bead is necessary for this joint, so a sufficient amount of filler metal is needed.



What can I do to improve arc starting?

- Use the smallest diameter tungsten possible for the amperage you are using. Match the tungsten electrode size with the collet size.

- Purchase the highest quality tungsten available - ask your distributor for Miller-branded tungsten.
- Use a premium quality torch and work leads.
- Keep the torch and work leads as short as possible and move the power source as close as possible to the work.
- Make sure the Stick electrode holder is detached from the machine before TIG welding.
- Check and tighten all connections.
- Keep the torch cable from contacting any grounded metal.
- Use 100% argon shielding gas.
- When welding aluminum, use AC current and a ceriated (orange identifying band) or 1.5% lanthanated (gold identifying band) tungsten.
- When welding steel and stainless steel, use DC-Straight Polarity (DCEN) and a 2% thoriated (red identifying band) tungsten . Prepare a pointed-end.
- Always use a push technique with the TIG torch.
- When welding a fillet, the leg of the weld should be equal to the thickness of the parts welded.

Why would I use Ceriated or Thoriated tungsten instead of Pure?

With the introduction of new power source technologies, the use of pure tungsten is decreasing.

Pure tungsten melts at a lower temperature causing it to easily form a rounded ball at the tip. When the ball grows too large, it interferes with your ability to see the weld puddle and causes the arc to become unstable.

Ceriated tungsten can withstand higher temperatures and works very well with the new squarewave and inverter machines for the following reasons:

- Holds a point longer and starts well at low amperages.
- Can be used on both AC and DC polarities. When welding aluminum, it has become very acceptable to grind a point on ceriated tungsten (especially when welding on thinner materials).
- Allows welding amperages to be increased by 25-30% compared to Pure tungsten of the same diameter.

Types of Tungsten Electrodes

Type of Tungsten	Color Code	Remarks

(Alloy)		
Pure	Green	Provides good arc stability for AC welding. Reasonably good resistance to contamination. Lowest current carrying capacity. Least expensive. Maintains a balled end.
Ceriated CeO_2 1.8% to 2.2%	Orange	Similar performance to thoriated tungsten. Easy arc starting, good arc stability, long life. Possible replacement for thoriated.
Thoriated ThO_2 1.7% to 2.2%	Red	Easier arc starting. Higher current capacity. Greater arc stability. High resistance to weld pool contamination. Difficult to maintain balled end on AC.
Lanthanated La_2O_3 1.3% to 1.7%	Gold	Similar performance to thoriated tungsten. Easy arc starting, good arc stability, long life, high current capacity. Possible replacement for thoriated.
Zirconiated ZrO_2 0.15% to 0.40%	Brown	Excellent for AC welding due to favorable retention of balled end, high resistance to contamination, and good arc starting. Preferred when tungsten contamination of weld is intolerable.

Typical Current Ranges for Tungsten Electrodes

		Typical Current Range (Amps)				
		Direct Current, DC	**Alternating Current, AC**			
		DCEN	**70% Penetration**		**(50/50) Balanced Wave AC**	
Tungsten Diameter	**Gas Cup (Inside Dia.)**	**Ceriated Thoriated Lanthanated**	**Pure**	**Ceriated Thoriated Lanthanated**	**Pure**	**Ceriated Thoriated Lanthanated**
.040	#5 (3/8 in)	15–80	20–60	15–80	10–30	20–60
.060 (1/16 in)	#5 (3/8 in)	70–150	50–100	70–150	30–80	60–120
.093 (3/32 in)	#8 (1/2 in)	150–250	100–160	140–235	60–130	100–180
.125 (1/8 in)	#8 (1/2 in)	250–400	150–200	225–325	100–180	160–250
All values are based on the use of Argon as a shielding gas. Other current values may be employed depending on the shielding gas, type of equipment, and application. DCEN = Direct Current Electrode Negative (Straight Polarity).						

Recommended Current Type, Tungsten and Gas for TIG Welding

Metal	Thickness	Type of Current	Tungsten	Shielding Gas
Aluminum	All	AC	Pure Ceriated Thoriated Lanthanated	Argon
	All	AC Squarewave	Ceriated Thoriated Lanthanated	Argon
	over 1/4"	AC	Ceriated Thoriated Lanthanated	Argon
Copper, copper alloys	All	DCEN	Ceriated Thoriated	Argon
Magnesium alloys	All	AC	Ceriated Thoriated Lanthanated	Argon
Plain carbon, steels	All	DCEN	Ceriated Thoriated Lanthanated	Argon
Stainless steel	All	DCEN	Ceriated Thoriated Lanthanated	Argon

What if I have problems TIG Welding?

The following chart addresses some of the common problems of TIG welding. In all cases of equipment malfunction, the manufacturer's recommendations should be strictly adhered to and followed.

PROBLEM 1: Burning Through Tungsten Fast	
PROBABLE CAUSES	SUGGESTED REMEDY
1. Inadequate gas flow.	Check to be sure hose, gas valve, and torch are not restricted or the tank is not out of gas. Gas flow should typically be set at 15 to 20 cfh.
2. Operating on electrode positive (DCEP).	Switch to electrode negative (DCEN).
3. Improper size tungsten for current used.	General purpose tungsten size is 3/32" diameter at a maximum of 220 amps.
4. Excessive heating in torch	Air-cooled torches do get very warm. If using a water-cooled torch, coolant flow may be restricted or coolant may be low.

body.	
5. Tungsten oxidation during cooling.	Keep shielding gas flowing 10–15 seconds after arc stoppage. 1 second for each 10 amps of weld current.
6. Use of gas containing oxygen or CO2.	Use Argon gas.
7. Tungsten melting back into cup (AC).	If using pure tungsten, change to ceriated or lanthanated . If machine has Balance Control, adjust setting towards maximum penetration (70-90). Tungsten diameter may be too small for the amount of current being used. Increase tungsten size.
PROBLEM 2: Tungsten Contamination	
PROBABLE CAUSES	SUGGESTED REMEDY
1. Tungsten melting into weld puddle.	Use less current or larger tungsten. Use ceriated (AC) , thoriated (DC), or lanthanated tungsten.
2. Touching tungsten to weld puddle.	Keep tungsten from contacting weld puddle. Raise the torch so that the tungsten is off of the work piece 1/8" to 1/4".
PROBLEM 3: Porosity and Poor Weld Bead Color	
PROBABLE CAUSES	SUGGESTED REMEDY
1. Condensation on base metal.	Blow out all air and moisture condensation from lines. Remove all condensation from base metal before welding. Metals stored in cold temperatures will condensate when exposed to warm temperatures.
2. Loose fittings in torch or hoses.	Tighten fittings on torch and all hoses.
3. Inadequate gas flow.	Adjust flow rate as necessary. Gas flow should typically be set at 15 to 20 cfh.
4. Defective gas hose or loose connection.	Replace gas hose and check connections for leaks, cuts, or pin holes.
5. Contaminated or improper filler metal.	Check filler metal type. Remove all grease, oil, or moisture from filler metal.
6. Base metal is contaminated.	Remove paint, grease, oil, and dirt, including mill scale from base metal.
PROBLEM 4: Yellow Powder or Smoke on Cup—Tungsten Discolor	
PROBABLE	SUGGESTED REMEDY

CAUSES	
1. Shielding gas flow rate too low.	Increase flow rate. Gas flow should typically be set at 15 to 20 cfh.
2. Incorrect shielding gas or mixture.	Use argon gas.
3. Inadequate post flow.	Increase post flow time. Set at 10 to 15 seconds.
4. Improper tungsten size or cup size.	Match tungsten size and cup size to joint being welded. General purpose tungsten size is 3/32" diameter and #8 cup.
PROBLEM 5: Unstable Arc	
PROBABLE CAUSES	SUGGESTED REMEDY
While DC Welding	
1. Weld circuit polarity is incorrect.	Check polarity switch on welder. Select DCEN (Direct Current Electrode Negative).
2. Tungsten is contaminated.	Remove 1/2" of contaminated tungsten and repoint tungsten.
4. Arc too long.	Shorten arc length. Lower torch so that the tungsten is off of the work piece no more than 1/8" to 1/4".
5. Base metal is contaminated.	Remove paint, grease, oil, and dirt, including mill scale from base metal.
While AC Welding	
1. Excessive rectification in base metal.	Increase travel speed. Increase balance control toward more penetration. Add filler metal.
2. Improper shielding gas.	In some cases, when welding on 3/8" to 1/2" thick aluminum, argon/helium is used.
3. Incorrect arc length.	Use correct arc length. Adjust the torch so that the tungsten is off of the work piece 1/8" to 1/4".
4. Tungsten is contaminated.	Remove 1/2" of contaminated tungsten and repoint tungsten.
5. Base metal is contaminated.	Remove paint, grease, oil, and dirt, including mill scale from base metal.
6. Frequency set too low.	On welders with adjustable AC frequency, increase frequency to give proper arc stability and direction. 100 to 180 Hertz is acceptable.
7. Improperly prepared tungsten.	With Squarewave and inverter machines, use pointed tungsten. Point will eventually round off after welding.
PROBLEM 6: High-Frequency Present — No Arc Power	

PROBABLE CAUSES	SUGGESTED REMEDY
1. Incomplete weld circuit.	Check work connection. Check all cable connections.
2. No shielding gas.	Check for gas flow at end of torch. Check for empty cylinder or closed shut-off valve. Gas flow should typically be set at 15 to 20 cfh.
PROBLEM 7: Arc Wanders	
PROBABLE CAUSES	SUGGESTED REMEDY
While DC Welding	
1. Improper arc length/tungsten in poor condition.	Lower the torch so that the tungsten is off of the work piece 1/8" to 1/4". Clean and sharpen tungsten.
2. Improperly prepared tungsten.	Grind marks should run lengthwise with tungsten, not circular. Use proper grinding method and wheel.
3. Light gray frosted appearance on end of tungsten.	Remove 1/2" of tungsten and repoint tungsten.
4. Improper gas flow.	Gas flow should typically be set at 15 to 20 cfh.
While AC Welding	
1. Improper tungsten preparation.	With Squarewave and inverter machines, use pointed tungsten. Point will eventually round off after welding.
2. Tungsten is contaminated.	Remove 1/2" of contaminated tungsten and repoint tungsten.
3. Base metal is contaminated.	Remove paint, grease, oil, and dirt, including mill scale from base metal.
4. Incorrect balance control setting.	Increase balance toward more penetration. Normal Balance Control setting is 70 - 90.
5. Improper tungsten size and type.	Select proper size and type. General purpose tungsten size is 3/32" diameter and ceriated or thoriated .
6. Excessive rectification in base metal.	Increase travel speed. Increase balance setting toward more penetration. Add filler metal.
7. Improper shielding gas flow.	Gas flow should typically be set at 15 to 20 cfh.
8. Frequency set too low.	Increase AC frequency on machines so equipped to stabilize and direct the arc. The higher the frequency, the narrower and deeper the penetration.
PROBLEM 8: Arc Will Not Start or is Difficult to Start	

PROBABLE CAUSES	SUGGESTED REMEDY
While DC Welding	
1. No shielding gas.	Gas flow should typically be set at 15 to 20 cfh.
2. Incorrect power supply switch positions.	Place switches in proper positions, either HF impulse or start HF.
3. Improper tungsten electrode.	Use ceriated or thoriated tungsten.
4. Loose connections.	Tighten all cable and torch connections.
5. Incomplete weld circuit.	Make sure work clamp is connected.
6. Improper tungsten size.	Use smallest tungsten possible. Most common tungsten size is 3/32" diameter.
While AC Welding	
1. Incomplete weld circuit.	Check work clamp to assure it is securely fastened to work.
2. Incorrect cable installation.	Check circuit breakers and fuses. Check and tighten all cable connections.
3. No shielding gas.	Check for gas flow at end of torch. Check for empty cylinder or closed shut-off valve. Gas flow should typically be set at 15 to 20 cfh.
4. Loss of high frequency.	Check torch and cables for cracked insulation or bad connections. Check spark gaps and adjust if necessary.
5. Improper tungsten size.	Use smallest tungsten possible. Most common tungsten size is 3/32" diameter.
6. Incorrect tungsten type.	Use ceriated, thoriated, or lanthanated tungsten.

Tig Welding Notes

Sharpen tip by placing in drill motor and bevel to about 45° deg angle

For aluminum welding, arc tip briefly against brass or copper to form a small ball end.