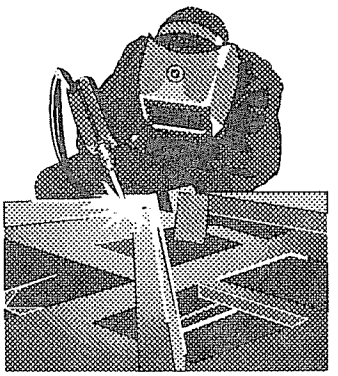
WELDING, CUTTING AND BRAZING
SUBPART Q

INTRODUCTION



Many welding and cutting operations require the use of compressed gases. When compressed gases are consumed in the welding process, such as oxygen-fuel gas welding, requirements for their handling, storage, and use are contained in Subpart Q.

General requirements for the handling, storage, and use of compressed gases are contained in Subpart H - Hazardous Materials, §§ 1910.101 - 1910.105. Certain welding and cutting operations require the use of compressed gases other than those consumed in the welding process. For example, gas metal arc welding utilizes compressed gases for shielding. Handling, storage, and use of compressed gases in situations such as these requires compliance with the requirements contained in Subpart H.

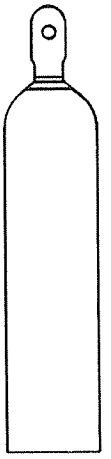
Many hazards are involved in compressed gas handling, storage, and use. To understand these hazards, we must realize that compressed gases are stores of potential energy. It takes energy to compress and confine the gas. That energy is stored until purposely released to perform useful work or until accidental release by container failure or other causes.

Some compressed gases, for example, acetylene, have high flammability characteristics. Flammable compressed gases, therefore, have additional stored energy besides simple compression-release energy. Other compressed gases, such as nitrogen, have simple asphyxiating properties. Some compressed gases, such as oxygen, can augment or compound fire hazards.

Compressed Gases

GENERAL REQUIREMENTS - 1910.101

Cylinder Inspection

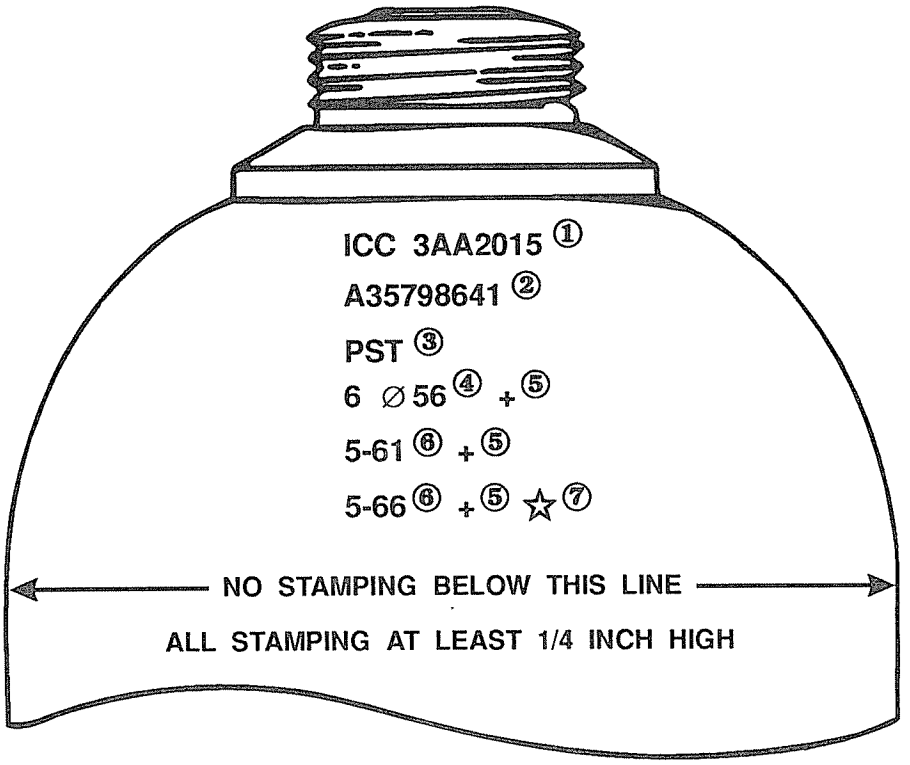


Employers shall determine that compressed gas cylinders under their control are in a safe condition to the extent that this can be determined by visual inspection. Visual and "other" inspections are required, but "other" inspections are not defined. These inspections must be conducted as prescribed in the Hazardous Materials Regulations of the Department of Transportation (DOT) contained in 49 CFR Parts 171-179 and 14 CFR Part 103. Where these regulations are not applicable, these inspections shall be conducted in accordance with Compressed Gas Association (CGA) Pamphlets C-6 and C-8. According to DOT regulations:

> "A cylinder that leaks, is bulged, has defective valves or safety devices, bears evidence of physical abuse, fire or heat damage, or detrimental rusting or corrosion, must not be used unless it is properly repaired and requalified as prescribed in these regulations."

The term "cylinder" is defined as a pressure vessel designed for pressures higher than 40 psia (pounds per square inch absolute) and having a circular cross section. It does not include a portable tank, multiunit tank car tank, cargo tank, or tank car.

DOT requires basic information markings on all cylinders. Each required marking on a cylinder must be maintained so that it is legible. A summary of the DOT marking requirements is shown below.



1. DOT or ICC marking may appear - new manufacture must read "DOT." 49 CFR 171.14.
   "3AA" indicates spec. in 49 CFR 178.37.
   "2015" is the marked service pressure.

2. Serial number - no duplications permitted with any particular symbol-serial number combinations.

3. Symbol of manufacturer, user, or purchaser.

4. "6 56" date of manufacture. Month and year.
   "∅" disinterested inspector's official mark.

5. Plus mark (+) indicates cylinder may be 10% overcharged per 49 CFR 173.302(c).

6. Retest dates.

7. 5 pointed star indicates ten year retest interval. See 49 CFR 173.34(e)(15).

Handling, Storage, and Utilization

The in-plant handling, storage, and utilization of all compressed gases in cylinders, portable tanks, rail tankcars, or motor vehicle cargo tanks shall be in accordance with Compressed Gas Association (CGA) Pamphlet P-1.

Safety Relief Devices

Compressed gas cylinders, portable tanks, and cargo tanks shall have pressure relief devices installed and maintained in accordance with CGA Pamphlets S-1.1 and S-1.2.

SPECIFIC GASES

The OSHA regulations contain some sections regulating specific compressed gases, including acetylene, hydrogen, oxygen, nitrous oxide, anhydrous ammonia, and liquefied petroleum gases.

There are many compressed gases that are in common use which fall under regulation 1910.101. Examples include chlorine, vinyl chloride, sulfur dioxide, methyl chloride, hydrogen sulfide, ethane, compressed air, and nitrogen.

These compressed gases do not receive explicit coverage by the OSHA regulations, but are covered by the requirements of 1910.101.

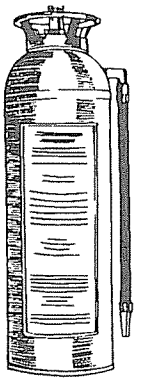
Welding, Cutting, and Brazing

GENERAL REQUIREMENTS - 1910.252

Fire Prevention and Protection

Basic Precautions

The basic precautions for fire prevention in welding or cutting work are:



- If the object to be welded or cut cannot readily be moved, all movable fire hazards in the vicinity shall be taken to a safe place.

- If the object to be welded or cut cannot be moved and if all the fire hazards cannot be removed, then guards shall be used to confine the heat, sparks, and slag, and to protect the immovable fire hazards.

- If the above requirements cannot be met, then welding and cutting shall not be performed.

Special Precautions

Suitable fire extinguishing equipment shall be maintained in a state of readiness for instant use. Such equipment may consist of pails of water, buckets of sand, hose or portable extinguishers depending upon the nature and quantity of the combustible material exposed.

Fire watchers are required whenever welding or cutting is performed in locations where other than a minor fire might develop, or any of the following conditions exist:

- Appreciable combustible materials, in building construction or contents, closer than 35 feet to the point of operation.

- Appreciable combustibles more than 35 feet away but are easily ignited by sparks.

A fire watch shall be maintained for at least a half hour after completion of welding or cutting operations to detect and extinguish possible smoldering fires.

Cutting or welding shall not be permitted in the following situations:

- In areas not authorized by management.

- In sprinklered buildings while such protection is impaired.

- In the presence of explosive atmospheres (mixtures of flammable gases, vapors, liquids, or dusts with air), or explosive atmospheres that may develop inside uncleaned or improperly prepared tanks or equipment which have previously contained such materials, or that may develop in areas with an accumulation of combustible dusts.

Welding or Cutting Containers

No welding, cutting, or other hot work shall be performed on used drums, barrels, tanks or other containers until they have been cleaned so thoroughly as to make absolutely certain that there are no flammable materials present or any substances such as greases, tars, acids, or other materials which when subjected to heat, might produce flammable or toxic vapors. Any pipe lines or connections to the drum or vessel shall be disconnected or blanked.

Confined Spaces

When arc welding is to be suspended for any substantial period of time, such as during lunch or overnight, all electrodes shall be removed from the holders

and the holders carefully located so that accidental contact cannot occur and the machine shall be disconnected from the power source.

In order to eliminate the possibility of gas escaping through leaks or improperly closed valves, when gas welding or cutting, the torch valves shall be closed and the gas supply to the torch positively shut off at some point outside the confined area whenever the torch is not to be used for a substantial period of time, such as during lunch hour or overnight. Where practicable, the torch and hose shall also be removed from the confined space.

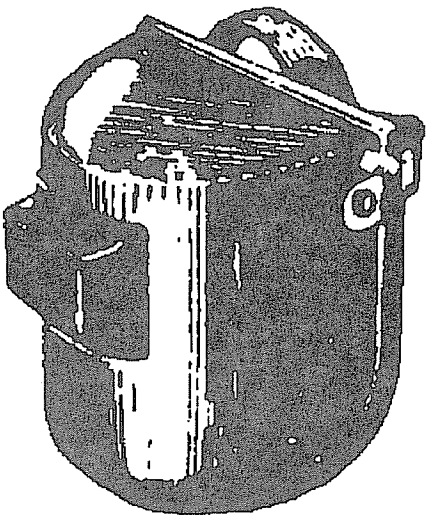
Protection of Personnel

General

A welder or helper working on platforms, scaffolds, or runways shall be protected against falling through the use of railings, safety belts, life lines, or some equally effective safeguards.

Eye Protection

Helmets or hand shields shall be used during all arc welding or arc cutting operations, excluding submerged arc welding. Helpers or attendants shall be provided with proper eye protection.



Helmets and hand shields shall be made of a material which is an insulator for heat and electricity. Helmets, shields and goggles shall not be readily flammable and shall be capable of withstanding sterilization.

Helmets and hand shields shall be arranged to protect the face, neck and ears from direct radiant energy from the arc.

Where the work permits, the welder should be enclosed in an individual booth painted with a finish of low reflectivity such as zinc oxide (an important factor for absorbing ultra-violet radiations) and lamp black, or shall be enclosed with non-combustible screens similarly painted. Booths and screens shall permit circulation of air at floor level. Workers or other persons adjacent to the welding areas shall be protected from the rays by non-combustible or flameproof screens or shields or shall be required to wear appropriate goggles.

Protective Clothing

Employees exposed to the hazards created by welding, cutting, or brazing operations shall be protected by personal protective equipment in accordance with the requirements of § 1910.132. Appropriate protective clothing required for any welding operation will vary with the size, nature and location of the work to be performed. Welders should always select clothing materials which will provide maximum protection from sparks and hot metal. Protective eyewear, safety shoes, clean, fire-resistant clothing, and fire-resistant gauntlet gloves are recommended. Additionally, the shirt should have full sleeves, no pockets and should be worn outside the trousers with collar buttoned. The trousers should have no cuffs and should extend well down to the safety shoes.

Work in Confined Spaces

A confined space is defined in this regulation to be a relatively small or restricted space such as a tank, boiler, pressure vessel, or small compartment of a ship.

Adequate ventilation is a prerequisite to work in confined spaces. Ventilation requirements are discussed later in this section.

When welding or cutting is being performed in any confined space, the gas cylinders and welding machines shall be left on the outside.

Where welders must enter a confined space through a manhole or other small opening, means shall be provided for quickly removing them in case of emergency. An attendant with a pre-planned rescue procedure shall be stationed outside to observe the welder at all times and be capable of putting rescue operations into effect.

When arc welding is to be suspended for any substantial period of time, such as during lunch or overnight, all electrodes shall be removed from the holders and the holders carefully located so that accidental contact cannot occur and the machine disconnected from the power source.

In order to eliminate the possibility of gas escaping through leaks of improperly closed valves, when gas welding or cutting, the torch valves shall be closed and the fuel-gas and oxygen supply to the torch positively shut off at some point outside the confined area whenever the torch is not to be used for a substantial period of time, such as during lunch or overnight. Where practicable, the torch and hose shall also be removed from the confined space.

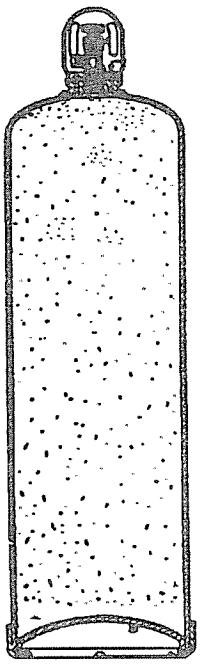
Health Protection and Ventilation

Mechanical ventilation is required when welding or cutting is done with materials not specifically mentioned in this section. These materials - fluorine compounds, zinc, lead, beryllium, cadmium, mercury, cleaning compounds, and stainless steel are particularly hazardous and have specific control requirements.

OXYGEN-FUEL GAS WELDING AND CUTTING - 1910.253

General Requirements

Under no conditions shall acetylene be generated, piped (except in approved cylinder manifolds), or utilized at a pressure in excess of 15 psig (pounds per square inch gauge) or 30 psia (pounds per square inch absolute). The 30 psia limit is intended to prevent unsafe use of acetylene in pressurized chambers such as caissons, underground excavations or tunnel construction. (Absolute pressure is equal to gauge pressure plus atmospheric pressure, which at sea level averages 14.7 psi. Thus, at sea level, a gauge pressure reading of 15 psi is equal to an absolute pressure of 29.7 psi.) This requirement is not intended to apply to storage of acetylene dissolved in a suitable solvent in cylinders manufactured and maintained according to U.S. Department of Transportation requirements, or to acetylene for chemical use.



Using acetylene at pressures in excess of 15 psi gauge pressure (or about 30 psi absolute pressure) is a hazardous practice. Free gaseous acetylene is potentially unstable at pressures above 15 psig and could decompose with explosive violence. Experience indicates that 15 psig is generally acceptable as a safe upper pressure limit.

The decomposition characteristics of acetylene gas are avoided by keeping the gas in liquid solution and storing it in cylinders of unique construction. Internally, acetylene cylinders are <u>not</u> designed like other kinds of compressed gas cylinders. Acetylene cylinders are <u>never</u> hollow. These cylinders contain a porous, calcium silicate filler and a suitable solvent, usually acetone, because,

under pressure, acetylene by itself is unstable. Acetone is used because it has the ability to absorb over 400 times its own volume of acetylene at 70° F.

Millions of microscopic pores make up the calcium silicate filler. Although it appears to fill the steel shell, approximately 90 percent of the filler's volume consists of "pore space" for holding and evenly distributing the acetylene/acetone solution.

When absorbed in this filler, the acetylene is divided into such small units that, should acetylene decomposition take place in one pore, the heat released is not enough to raise the temperature of the acetylene in surrounding pores to the point where it, too, will decompose.

Acetylene is usually supplied in cylinders which have a capacity of up to 300 cubic feet of dissolved gas under pressure of 250 psig at 70° F.

Cylinders and Containers

Approval and Marking

All portable cylinders used for the storage and shipment of compressed gases shall be constructed and maintained in accordance with the regulations of the U.S. Department of Transportation, 49 CFR parts 171-179.

Compressed gas cylinders shall be legibly marked, for the purpose of identifying the gas content, with either the chemical or trade name of the gas. Such marking shall be by means of stenciling, stamping, or labeling, and shall not be readily removable. Whenever practical, the marking shall be located on the shoulder of the cylinder.

Storage of Cylinders - General

Cylinders shall be kept away from radiators and other sources of heat.

Inside of buildings, cylinders shall be stored in a well-protected, well-ventilated, dry location, at least 20 feet (6.1 m) from highly combustible materials.

Cylinders should be stored in definitely assigned places away from elevators, stairs, or gangways, or other areas where they might be knocked over or damaged by passing or falling objects, or subject to tampering.

Empty cylinders shall have their valves closed.

Valve protection caps, where the cylinder is designed to accept a cap, shall always be in place, hand-tight, except when cylinders are in use or connected for use. The valve protection cap is designed to take the blow in case the cylinder falls.

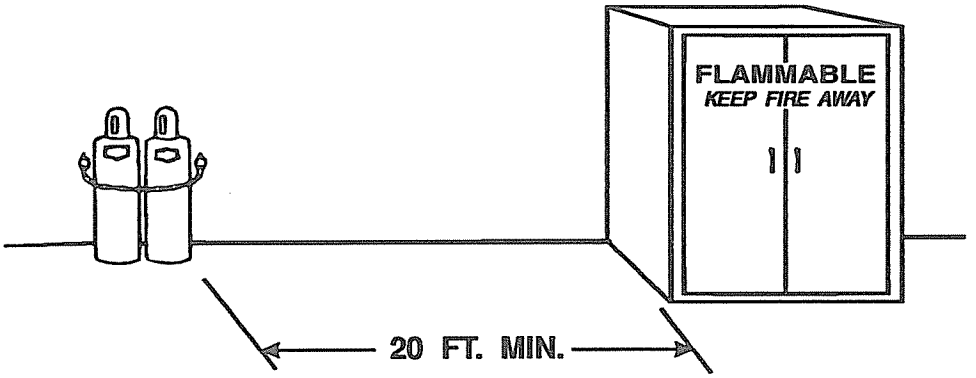
Fuel Gas Cylinder Storage

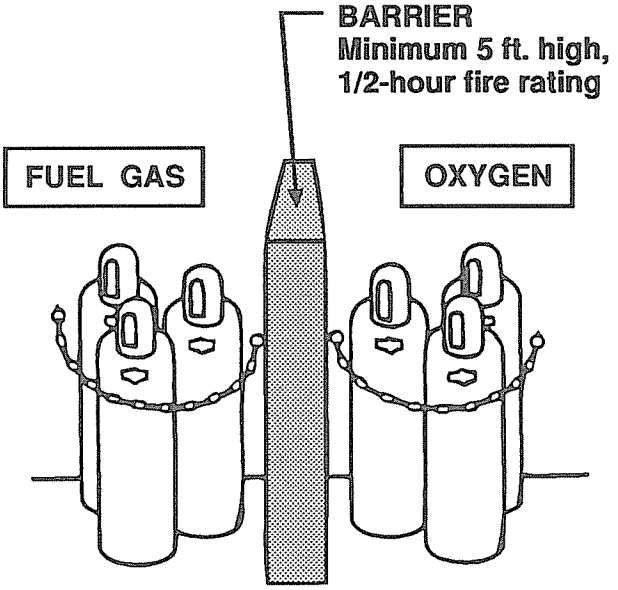
Inside a building, cylinders, except those in actual use or attached ready for use, shall be limited to a total gas capacity of 2,000 cubic feet (56 m^3) or 300 pounds of liquefied petroleum gas.

Acetylene cylinders shall be stored valve end up. If the cylinder is on its side, acetone may leak out and create a dangerous condition.

Oxygen Storage

Oxygen cylinders in storage shall be separated from fuel-gas cylinders or combustible materials (especially oil or grease), a minimum distance of 20 feet (6.1 m) or by a non-combustible barrier at least 5 feet (1.5 m) high having a fire-resistance rating of at least one-half hour. This requirement is intended to reduce the possibility of any fire support when a fire occurs among the fuel gas storage. This is illustrated in the figure below.


FLAMMABLE
KEEP FIRE AWAY
20 FT. MIN.


BARRIER
Minimum 5 ft. high,
1/2-hour fire rating
FUEL GAS
OXYGEN

Operating Procedures

Cylinders, cylinder valves, couplings, regulators, hose and apparatus shall be kept free from oily or greasy substances. Oxygen cylinders or apparatus shall not be handled with oily hands or gloves. A jet of oxygen must never be permitted to strike an oily surface, greasy clothes, or enter a fuel oil or other storage tank.

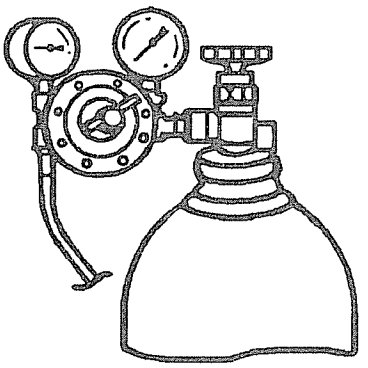
Valve-protection caps shall not be used for lifting cylinders from one vertical position to another. The cap may accidently and suddenly come loose. Should the cylinder fall or be knocked over, the valve may be damaged or sheared off, causing a sudden release of pressure.

Should the valve outlet of a cylinder become clogged with ice, thaw with warm -*not boiling*- water.

Unless cylinders are secured on a special truck, regulators shall be removed and valve-protection caps, when provided for, shall be put in place before cylinders are moved.

Cylinders not having fixed hand wheels shall have keys, handles, or non-adjustable wrenches on valve stems while these cylinders are in service.

Unless connected to a manifold, always attach a regulator to the compressed gas cylinder before use. Make certain that the regulator is proper for the particular gas and service pressure. Make sure the regulator is clean and has a clean filter installed in its inlet nipple.

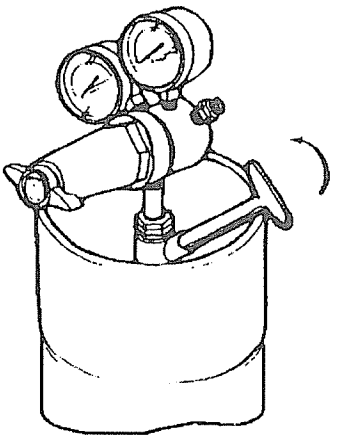


Before attaching the regulator, remove the protective cap from the cylinder. Stand to one side of the

cylinder. Open the cylinder valve slightly for an instant, and then close it. This "cracking" of the cylinder valve will clean the valve of dust or dirt which may have accumulated during storage. Dirt can damage critical parts of a regulator, and may cause a fire or explosion.

Before a regulator is removed from a cylinder valve, the valve shall be closed and the gas released from the regulator.

An acetylene cylinder valve shall not be opened more than one and one-half turns of the spindle. This permits adequate flow of acetylene and allows ready closing of the valve in an emergency situation.

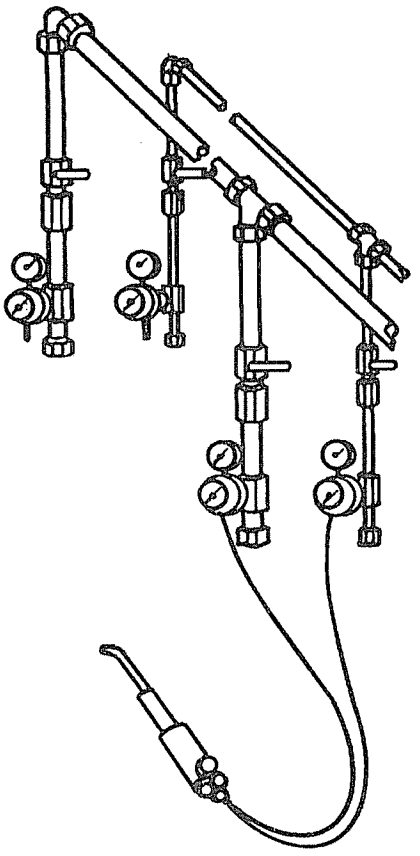


Manifolding of Cylinders

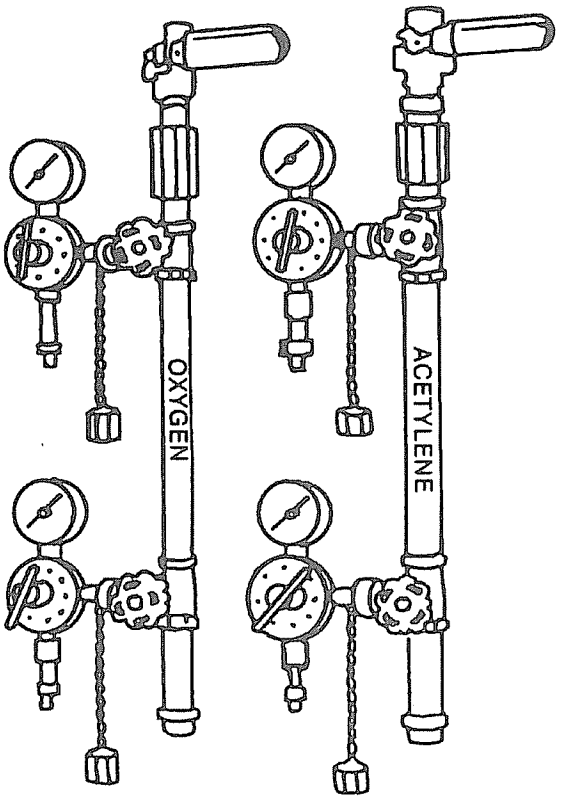
Portable Outlet Headers

Portable outlet headers shall not be used indoors except for temporary service where the conditions preclude a direct supply from outlets located on the service piping system.

Each outlet on the service piping from which oxygen or fuel gas is withdrawn to supply a portable outlet header shall be equipped with a readily accessible shut-off valve. This is illustrated in the figure below.



Each service outlet on portable outlet headers shall be provided with a valve assembly that includes a detachable outlet seal cap, chained or otherwise attached to the body of the valve.



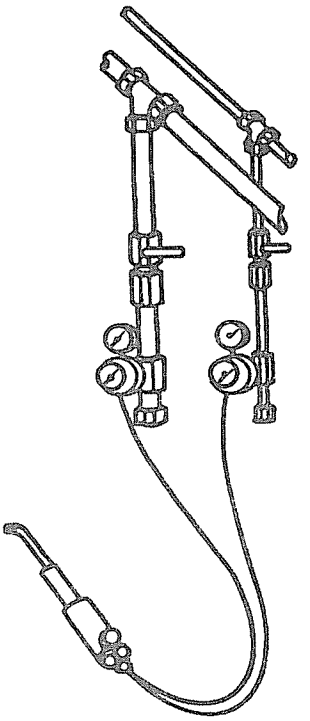
The primary reason for using a seal cap is to protect the outlet pipe thread from damage and to prevent the deposit of oil or grease on the threads. Many times the caps are not used! Damage to threads and ground seals causes leaky connections!

Service Piping Systems

Materials and Design

Pipe shall be at least Schedule 40 and fittings shall be at least standard weight in sizes up to and including 6-inch nominal.

Schedule 40 pipe is standard black iron pipe which has a working pressure of up to 125 psi and is always tested before use. Problems might arise when line extensions are made with other types of pipe or aluminum tubing. Therefore, a close inspection is necessary.



When oxygen is supplied to a service piping system from a low pressure oxygen manifold without an intervening pressure regulating device, the piping system shall have a minimum design pressure of 250 psig. A pressure regulating device shall be used at each station outlet when the connected equipment is for use at pressures less than 250 psig.

Piping for acetylene or acetylenic compounds shall be steel or wrought iron. Unalloyed copper shall not be used for acetylene or acetylenic compounds except in listed equipment. Under certain conditions, acetylene forms explosive compounds with copper (as well as silver and mercury).

Installation

All piping shall be run as directly as practicable, protected against physical damage, proper allowance being made for expansion and contraction, jarring and vibration. Pipe laid underground in earth shall be located below the frost line and protected against corrosion. After assembly, piping shall be thoroughly blown out with air, nitrogen, or carbon dioxide to remove foreign materials. For oxygen piping, only oil-free air, oil-free nitrogen, or oil-free carbon dioxide shall be used.

Low points in piping carrying moist gas shall be drained into drip pots constructed so as to permit pumping or draining out the condensate at necessary intervals. Drain valves shall be installed for this purpose having outlets normally closed with screw caps or plugs. No open end valves or petcocks shall be used, except that in drips located out of doors, underground, and not readily accessible, valves may be used at such points if they are equipped with means to secure them in the closed position. Pipes leading to the

surface of the ground shall be cased or jacketed where necessary to prevent loosening or breaking.

Piping from overhead lines shall have drip pots at each station. These drip pots either have a plug or petcock on the bottom. Underground installations have no draining system. Pipes leading to the surface from underground lines have to be secured to prevent breaking or to avoid other damage to them.

Painting

Underground pipe and tubing and outdoor ferrous pipe and tubing shall be covered or painted with a suitable material for protection against corrosion.

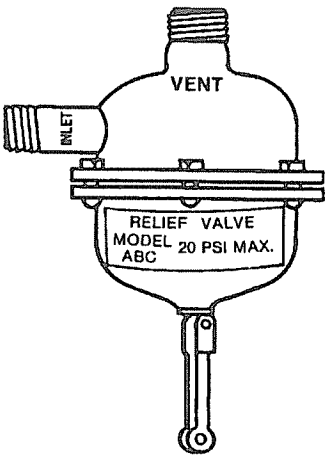
Testing

Piping systems shall be tested and proved gas tight at 1½ times the maximum operating pressure, and shall be thoroughly purged of air before being placed in service. The material used for testing oxygen shall be oil free and non-combustible. Flames shall not be used to detect leaks.

Protective Equipment, Hose, and Regulators

Pressure Relief Devices

Service piping systems shall be protected by pressure relief devices set to function at not more than the design pressure of the systems and discharging upwards to a safe location. Pressure relief valves are required in fuel gas piping systems to prevent excessive pressure build up within the system. Relief valves will vent automatically at preset pressures or may be manually operated to relieve pressure in the system.



Piping Protective Equipment

Approved protective equipment (designated P_F in Figures Q-1, Q-2, and Q-3 below) shall be installed in fuel-gas piping to prevent:

- Backflow of oxygen into the fuel-gas supply system;
- Passage of a flash back into the fuel-gas supply system; and
- Excessive back pressure of oxygen in the fuel-gas supply system.

The three functions of the protective equipment may be combined in one device or may be provided by separate devices.

Figures Q-1, Q-2, and Q-3 below illustrate the accepted location of approved protective equipment in fuel-gas piping systems. The protective equipment shall be located in the main supply line, as in Figure Q-1 or at the head of each branch line, as in Figure Q-2 or at each location where fuel-gas is withdrawn, as in Figure Q-3.

System Q-1 has the most protection, that is, protective equipment is installed in the main supply and one check valve is installed before each outlet. System Q-2 has protective equipment in each branch circuit plus check valves at each outlet. System Q-3 has protective equipment at the fuel gas outlet and check valves at each outlet.

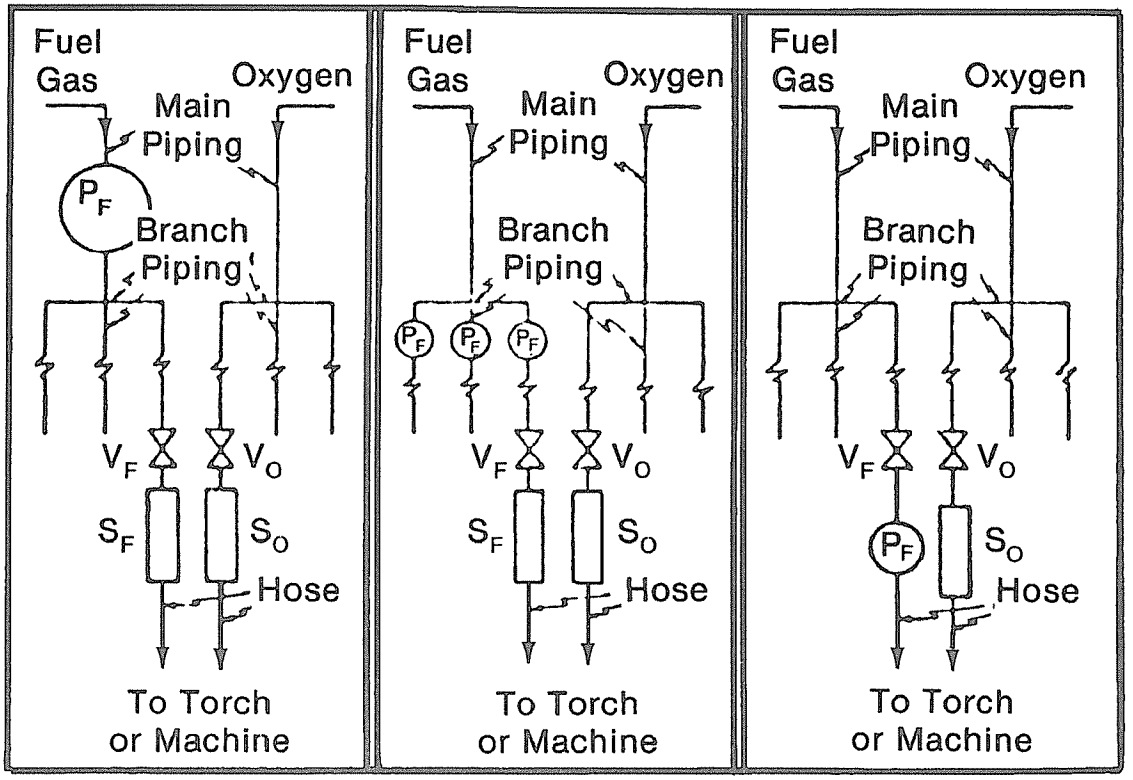
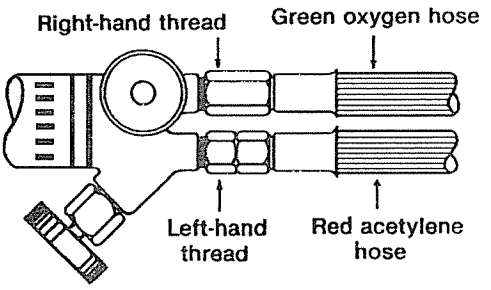


Fig. Q-1 Fig. Q-2 Fig. Q-3

P_F—Protective equipment in fuel gas piping
V_F—Fuel gas station outlet valve
V_O—Oxygen station outlet valve
S_F—Backflow prevention device(s) at fuel gas station outlet
S_O—Backflow prevention device(s) at oxygen station outlet

Hose and Hose Connections

The operator must use the proper hose. Fuel gas hose is usually red (sometimes black) and has a left-hand threaded nut for connecting to the torch. Oxygen hose is green and has a right-hand threaded nut for connecting to the torch.

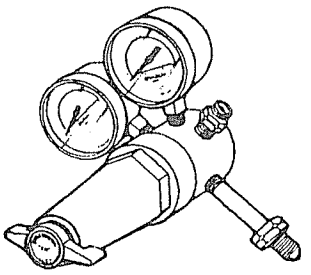


Hose and hose connections shall be clamped or otherwise securely fastened in a manner that will withstand, without leakage, twice the pressure to which they are normally subjected in service, but in no case less than a pressure of 300 psi. Oil-free air or an oil-free inert gas shall be used for the test.

Hose showing leaks, burns, worn places, or other defects rendering it unfit for service shall be repaired or replaced. When inspecting hoses, look for charred sections close to the torch. These may have been caused by flash-back. Also check that hoses are not taped up to cover leaks.

Pressure-Reducing Regulators

Pressure-reducing regulators shall be used only for the gas and pressures for which they are intended. When regulators or parts of regulators, including gages, need repair, the work shall be performed by skilled mechanics who have been properly instructed. Most production shops do not have the proper equipment to make repairs. For any equipment repairs or if there are questions about performance reliability, contact the manufacturer.



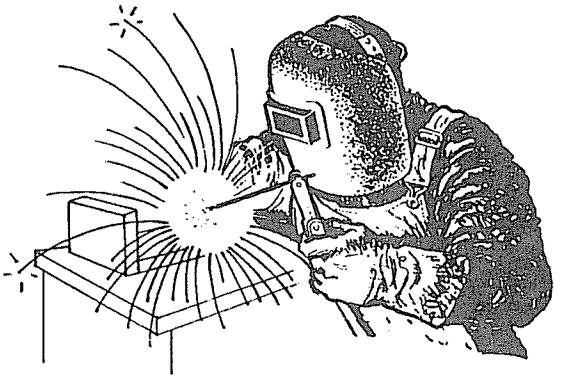
Gages on oxygen regulators shall be marked "USE NO OIL."

ARC WELDING AND CUTTING - 1910.254

Introduction

General

In the arc welding process, an electric current passing through the welding rod, or electrode, is forced to jump or arc across a gap. The resulting arc produces the intense heat necessary for the welding or cutting operation.



Arc welding is used to fabricate nearly all types of carbon or alloy steels, the common nonferrous metals, and is indispensable in the repair and reclamation of metallic machine parts.

Arc cutting is primarily used for rough cuts or for scrapping because of the unevenness of the cut obtained. It has also been used for underwater cutting in salvaging operations.

While most precautions and safe practices are common to oxy-fuel gas welding, there are some that are unique to either gas or arc welding.

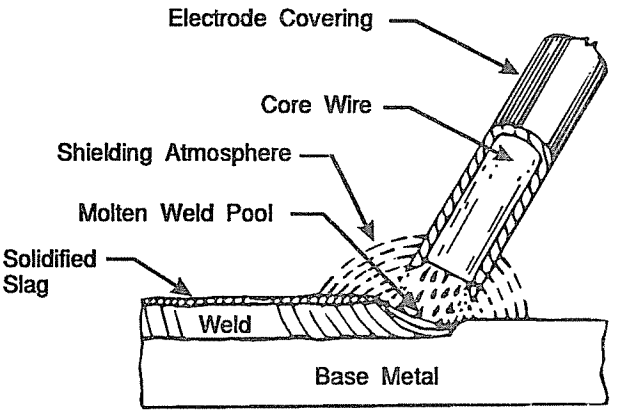
Shielding

It has long been known that welds will have better chemical and physical properties if the air can be kept away from the weld puddle. Such gases as oxygen, hydrogen, nitrogen, and water vapor (moisture) all tend to reduce the quality of the weld. Dirt, dust, and metal oxides (contaminants) also reduce the weld quality. Shielding of the arc is normally provided in order to preserve the integrity of the weld joint. Shielding is provided either by decomposition of the electrode covering, known as the flux, or by a gas (or gas mixture) which may or may not be inert.

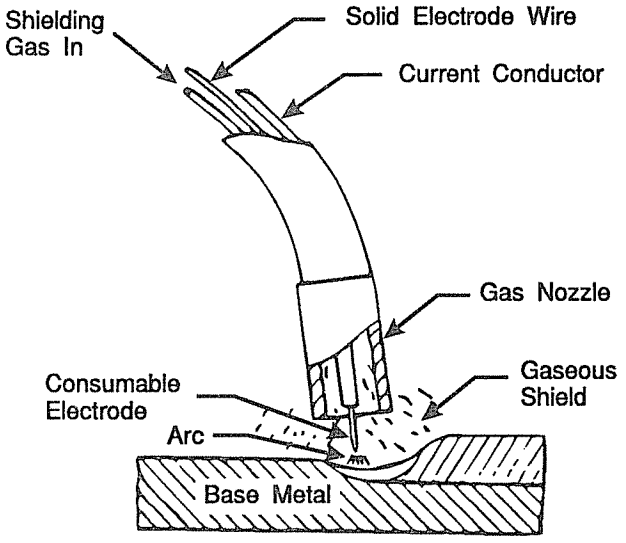
Common Arc Welding and Cutting Processes

Some of the more common arc welding and cutting processes are briefly discussed below.

Shielded Metal-Arc Welding (SMAW). This is the most widely used type of arc welding, commonly referred to as "stick" welding. In this process, coalescence is achieved by heating with an electric arc between a covered (or coated) electrode and the work surface. Shielding is provided by decomposition of the electrode covering, known as the flux, while filler metal is obtained from the electrode's metal core.



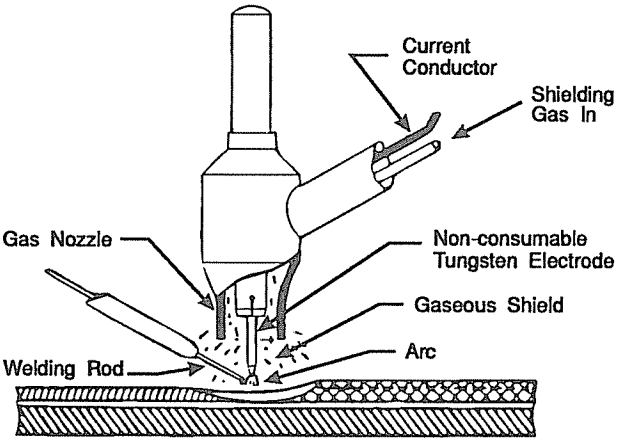
Shielded Metal-Arc Welding (SMAW)



Gas Metal Arc Welding (GMAW)

Gas Metal Arc Welding (GMAW). Commonly known as "MIG" welding. In the gas metal arc welding process, coalescence is achieved by the heat of an electric arc maintained between the end of an electrode and the work surface. Shielding of the arc is provided by a gas (or gas mixture) which may or may not be inert. The electrode is fed continuously to the weld where it is melted in the intense heat of the arc and deposited as weld metal.

Gas Tungsten Arc Welding (GTAW). Commonly known as "TIG" welding. In gas tungsten arc welding, coalescence is achieved by the arc and electrode method described above, except that the tungsten electrode is not consumed. Shielding is provided by an inert gas. This process offers high precision welds.



Gas Tungsten Arc Welding (GTAW)

Flux Cored Arc Welding (FCAW). Flux cored arc welding is a process which produces coalescence by means of an arc between a continuous consumable electrode and the work surface. Shielding is provided by flux contained within the tubular electrode. Additional shielding may be obtained from a gas or gas mixture.

Submerged Arc Welding (SAW). In this process, coalescence is produced by heating with an arc between a bare metal electrode and the work surface. The arc is shielded by a blanket of granular, fusible flux. The tip of the electrode and the welding zone are surrounded and shielded by the molten flux and a layer of unused flux in the granular state. In this process, there is no visible evidence of the passage of current between the electrode and the work surface. This eliminates the sparks, spatter, and smoke ordinarily seen in other arc welding processes. Fumes are still produced, but not in quantities generated by other processes.

Arc Cutting. Arc cutting is the general process in which the cutting or removal of metals is done by melting with the heat of an arc between an electrode and the base metal.

Plasma Arc Cutting (PAC). In plasma arc cutting, the metal is cut by melting a localized area with a constricted arc and removing the molten material with a high velocity jet of hot, ionized gas.

Air Carbon-Arc Cutting (AAC). Air carbon-arc is a type of arc cutting in which the metal is cut by melting with the heat of an arc, with use of an air stream to facilitate cutting.

Arc Gouging. Arc gouging is an application of arc cutting used to produce a groove or bevel in the metal surface.

Application

Voltage

The following limits shall not be exceeded:

	Alternating Current (AC)	Direct Current (DC)
Manual	80 Volts	100 Volts
Automatic[1]	100 Volts	100 Volts

For AC welding under wet conditions or warm surroundings where perspiration is a factor, the use of reliable automatic controls for reducing no-load voltage is recommended to reduce the shock hazard. Some of the older AC machines do not have an automatic control and are on load all the time. It is easy to receive an electric shock when the equipment is not handled properly.

[1] Machine or mechanized

Installation

Grounding

The frame or case of the welding machine (except engine-driven machines) shall be grounded under the conditions and according to the methods prescribed in Subpart S, Electrical.

Conduits containing electrical conductors shall not be used for completing a work-lead circuit. Pipelines shall not be used as a permanent part of a work-lead circuit, but may be used during construction, extension or repair providing current is not carried through threaded joints, flanged bolted joints, or caulked joints and that special precautions are used to avoid sparking at connection of the work-lead cable.

Operation and Maintenance

Machine Hook Up

Before starting operations, all connections to the machine shall be checked to make certain that they are properly made. The work lead shall be firmly attached to the work; magnetic work clamps shall be freed from adherent metal particles of spatter on contact surfaces. Coiled welding cable shall be spread out before use to avoid serious overheating and damage to insulation.

Electric Shock

Cables with splices within 10 feet (3m) of the holder shall not be used. Welders should not coil or loop welding electrode cable around parts of their body.

Maintenance

Cables with damaged insulation or exposed bare conductors shall be replaced. Joining lengths of work and electrode cables shall be done by the use of connecting means specifically intended for the purpose. The connecting means shall have insulation adequate for the service conditions.

RESISTANCE WELDING - 1910.255

General

Installation

All equipment shall be installed by a qualified electrician in conformance with Subpart S, Electrical.

Spot and Seam Welding Machines

Interlocks

All doors and access panels of all resistance welding machines and control panels shall be kept locked and interlocked to prevent access, by unauthorized persons, to live portions of the equipment.

Guarding

All press welding operations, where there is a possibility of the operator's fingers being under the point of operation, shall be effectively guarded by the use of a device such as an electronic eye safety circuit, two hand controls, or protection similar to that prescribed for punch press operations.

Shields

The hazard of flying sparks shall be, wherever practical, eliminated by installing a shield guard of safety glass or suitable fire-resistant plastic at the point of operation. Additional shields or curtains shall be installed as necessary to protect passing persons from flying sparks.

Foot Switches

All foot switches shall be guarded to prevent accidental operation of the machine.

Stop Buttons

Two or more safety emergency stop buttons shall be provided on all special multispot welding machines, including 2-post and 4-post weld presses.

Portable Welding Machines

Safety Chains

All portable welding guns, transformers and related equipment suspended from overhead structures, eye beams, trolleys, etc., shall be equipped with safety chains or cables. Safety chains or cables shall be capable of supporting the total shock load in the event of failure of any component of the supporting system.

POWER OPERATIONS HOT WORK CHECKLIST

1. **DESCRIPTION - JR#**_____
   Location _____ Elevation _____
   Work to be done: Welding ___ Brazing ___ Open Flame Cutting/Heating _____
   Equipment _____

   NOTE: ***Before authorizing welding, cutting, heating, and brazing, this checklist must be completed.***

2. **PRE-WORK INSPECTION**
   Hot Work shall not be performed in the following situations:

   a. In areas not authorized by management.

   b. In sprinklered buildings while such protection is impaired unless authorized by management.

   c. In the presence of explosive atmospheres or explosive atmospheres that may develop inside uncleaned or improperly prepared tanks, pipes, or equipment.

   d. In areas near the storage of large quantities of exposed, readily ignitable materials.

   Prior to welding, cutting brazing, and heating (W/C/H/B), you shall perform these basic precautions:

   a. Move the object to be W/C/H/B to an area free of fire hazards.

   b. If the object to be W/C/H/B cannot readily be moved, then you shall remove all movable fire hazards within the vicinity to a safe place.

   c. If the object to be W/C/H/B cannot be moved and if all the fire hazards within 35 feet cannot be removed (including cable trays), then immovable fire hazards shall be shielded and a fire watch provided.

   IF THESE BASIC PRECAUTIONS ARE NOT FOLLOWED, WELDING, CUTTING, HEATING AND BRAZING SHALL NOT BE PERFORMED. COMPLETE CHECK LIST.

3. **ADDITIONAL FIRE WATCH PROVISIONS**

N/A	YES	NO		
☐	☐	☐	a.	Can more than a minor fire develop?
☐	☐	☐	b.	Are combustible materials closer than 35 feet to the point of operation?
☐	☐	☐	c.	Are combustibles more than 35 feet away, but easily ignitable by sparks?
☐	☐	☐	d.	Do wall or floor openings within a 35 foot radius expose combustible materials in adjacent areas including concealed spaces in walls or floors?
☐	☐	☐	e.	Are combustible materials adjacent to the opposite side or metal partitions, walls, ceilings, or roofs and are they likely to be ignited by conduction or radiation?

NOTE: **If you answered yes to any of the above, a fire watch is required. Complete checklist. All of the following conditions must be met, if applicable.**

4. PRECAUTIONS

N/A	YES	NO		
☐	☐	☐	a.	A fire watch will be provided during and for 30 minutes following welding, cutting, heating and brazing.
☐	☐	☐	b.	The fire watch shall be supplied with a proper portable fire extinguisher in addition to installed operable plant equipment.
☐	☐	☐	c.	Cutting and welding equipment is in good condition.
☐	☐	☐	d.	Combustible materials are protected with covers, guards, or metal shields, or material is removed prior to start of work.
☐	☐	☐	e.	Nearby workers are suitably protected against heat, sparks, slag, and flash.
☐	☐	☐	f.	Wall or floor openings are covered or enclosures provided. For elevated work, covers are suspended beneath to collect sparks or area below is free of combustibles.
☐	☐	☐	g.	Enclosed equipment is cleaned of all combustible material and purged of flammable vapors.
☐	☐	☐	h.	Ducts and/or conveyors are suitable protected or shutdown.
☐	☐	☐	i.	For work near walls, partitions, ceiling or roofs, proper precautions have been taken to prevent ignition of combustibles inside the barrier of adjacent areas.
☐	☐	☐	j.	For work on pipes or other metal in contact with combustible walls, partitions, ceilings, or roofs precautions have been taken to prevent ignition by conduction of heat.
☐	☐	☐	k.	Other

Pre-Work Inspection

Supervisors initials	_____	Date	_____	Time	_____
Supervisors initials	_____	Date	_____	Time	_____
Supervisors initials	_____	Date	_____	Time	_____
Supervisors initials	_____	Date	_____	Time	_____
Supervisors initials	_____	Date	_____	Time	_____
Supervisors initials	_____	Date	_____	Time	_____
Supervisors initials	_____	Date	_____	Time	_____

Post Work Inspection

Supervisors initials	_____	Date	_____	Time	_____
Supervisors initials	_____	Date	_____	Time	_____
Supervisors initials	_____	Date	_____	Time	_____
Supervisors initials	_____	Date	_____	Time	_____
Supervisors initials	_____	Date	_____	Time	_____
Supervisors initials		Date		Time	_____

DEFINITIONS

1. Combustible Material - Any material that, if in the form and under the conditions used, could ignite and burn.

2. Minor Fire - A fire which, if no action is taken to extinguish it, will self-extinguish (burn out), will not propagate (spread to other materials through continuity of combustibles), and will not damage any permanent plant equipment.

WELDING HEALTH HAZARDS

I. Chemical Agents

ZINC

Zinc is used in large quantities in the manufacture of brass, galvanized metals, and various other alloys. Inhalation of zinc oxide fumes can occur when welding or cutting on zinc-coated metals. Exposure to these fumes is known to cause metal fume fever. Symptoms of metal fume fever are very similar to those of common influenza. They include fever (rarely exceeding 102° F), chills, nausea, dryness of the throat, cough, fatigue, and general weakness and aching of the head and body. The victim may sweat profusely for a few hours, after which the body temperature begins to return to normal. The symptoms of metal fume fever have rarely, if ever, lasted beyond 24 hours. The subject can then appear to be more susceptible to the onset of this condition on Mondays or on weekdays following a holiday than they are on other days.

CADMIUM

Cadmium is used frequently as a rust-preventive coating on steel and also as an alloying element. Acute exposures to high concentrations or cadmium fumes can produce severe lung irritation, pulmonary edema, and in some cases, death. Long-term exposure to low levels of cadmium in air can result in emphysema (a disease affecting the ability of the lung to absorb oxygen) and can damage the kidneys.

BERYLLIUM

Beryllium is sometimes used as a alloying element with copper and other base metals. Acute exposure to high concentrations of beryllium can result in chemical pneumonia. Long-term exposure can result in shortness of breath, chronic cough, and significant weight loss, accompanied by fatigue and general weakness.

IRON OXIDE

Iron is the principal alloying element in steel manufacture. During the welding process, iron oxide fumes arise from both the base metal and the electrode. The primary acute effect of this exposure is irritation of nasal passages, throat, and lungs. Although long-term exposure to iron oxide fumes may result in iron pigmentation of the lungs, most authorities agree that these iron deposits in the lung are not dangerous.

MERCURY

Mercury compounds are used to coat metals to prevent rust or inhibit foliage growth (marine paints). Under the intense heat of the arc or gas flame, mercury vapors will be produced. Exposure to these vapors may produce stomach pain, diarrhea, kidney damage, or respiratory failure. Long-term exposure may produce tremors, emotional instability, and hearing damage.

LEAD

The welding and cutting of lead-bearing alloys or metals whose surfaces have been painted with lead-based paint can generate lead oxide fumes. Inhalation and ingestion of lead oxide fumes and other lead compounds will cause lead poisoning. Symptoms include metallic taste in the mouth, loss of appetite, nausea, abdominal cramps, and insomnia. In time, anemia and general weakness, chiefly in the muscles of the wrists, develop. Lead adversely affects the brain, central nervous system, circulatory system, reproductive system, kidneys, and muscles.

FLUORIDES

Fluoride compounds are found in the coatings of several types of fluxes used in welding. Exposure to these fluxes may irritate the eyes, nose, and throat. Repeated exposure to high concentrations of fluorides in air over a long period may cause pulmonary edema (fluid in the lungs) and bone damage. Exposure to fluoride dusts and fumes has also produced skin rashes.

CHLORINATED HYDROCARBON SOLVENTS

Various chlorinated hydrocarbons are used in degreasing or other cleaning operations. The vapors of these solvents are a concern in welding and cutting because the heat and ultraviolet radiation from the arc will decompose the vapors and form highly toxic and irritating phosgene gas. (See Phosgene.)

PHOSGENE

Phosgene is formed by decomposition of chlorinated hydrocarbon solvents by ultraviolet radiation. It reacts with moisture in the lungs to produce hydrogen chloride, which in turn destroys lung tissue. For this reason, any use of chlorinated solvents should be well away from welding operations or any operation in which ultraviolet radiation or intense heat is generated.

CARBON MONOXIDE

Carbon monoxide is a gas usually formed by the incomplete combustion of various fuels. Welding and cutting may produce significant amounts of carbon monoxide. In addition, welding operations that use carbon dioxide as the inert gas shield may produce hazardous concentrations of carbon monoxide in poorly ventilated areas. This is caused by a "breakdown" of shielding gas. Carbon monoxide is odorless and colorless and cannot be detected. Common symptoms of overexposure include pounding of the heart, a dull headache, flashes before the eyes, dizziness, ringing in the ears, and nausea.

NITROGEN OXIDES

The ultraviolet light of the arc can produce nitrogen oxides (NO, NO_2), from the nitrogen (N) and oxygen (O_2) in the air. Nitrogen oxides are produced by gas metal arc welding (GMAW or short-arc), gas tungsten arc welding (GTAW or heli-arc), and plasma arc cutting. Even greater quantities are formed if the shielding gas contains nitrogen. Nitrogen dioxide (NO_2), one of the oxides formed, has the greatest health effect. This gas is irritating to the eyes, nose and throat but dangerous concentrations can be inhaled without any immediate discomfort. High concentrations can cause shortness of breath, chest pain, and fluid in the lungs (pulmonary edema).

OZONE

Ozone (O_3) is produced by ultraviolet light from the welding arc. Ozone is produced in greater quantities by gas metal arc welding (GMAW or short-arc), gas tungsten arc welding (GTAW or heli-arc), and plasma arc cutting. Ozone is a highly active form of oxygen and can cause great irritation to all mucous membranes. Symptoms of ozone exposure include headache, chest pain, and dryness of the upper respiratory tract. Excessive exposure can cause fluid in the lungs (pulmonary edema). Both nitrogen dioxide and ozone are thought to have long-term effects on the lungs.

II. Physical Agents

ULTRAVIOLET RADIATION

Ultraviolet radiation (UV) is generated by the electric arc in the welding process. Skin exposure to UV can result in severe burns, in many cases without prior warning. UV radiation can also damage the lens of the eye. Many arc welders are aware of the condition known as "arc-eye," a sensation of sand in the eyes. This condition is caused by excessive eye exposure to UV. Ultraviolet rays also increase the skin effects of some industrial chemicals (coal tar and cresol compounds, for example).

INFRARED RADIATION

Exposure to infrared radiation (IR), produced by the electric arc and other flame cutting equipment may heat the skin surface and the tissues immediately below the surface. Except for this effect, which *can* progress to thermal burns in some situations, infrared radiation is not dangerous to welders. Most welders protect themselves from IR (and UV) with a welder's helmet (or glasses) and protective clothing.

INTENSE VISIBLE LIGHT

Exposure of the human eye to intense visible light can produce adaptation, pupillary reflex, and shading of the eyes. Such actions are protective mechanisms to prevent excessive light from being focused on the retina. In the arc welding process, eye exposure to intense visible light is prevented for the most part by the welder's helmet. However, some individuals have sustained retinal damage due to careless "viewing" of the arc. At no time should the arc be observed without eye protection.

FILTER LENS SHADE NUMBER GUIDE

WELDING OPERATION	SHADE NUMBER
Shielded Metal-Arc Welding, up to 5/32" (4mm) electrodes	10
Shielded Metal-Arc Welding, 3/16 to 1/4" (4.8 to 6.4mm) electrodes	12
Shielded Metal-Arc Welding, over 1/4" (6.4mm) electrodes	14
Gas Metal-Arc Welding (Nonferrous)	11
Gas Metal-Arc Welding (Ferrous)	12
Gas Tungsten-Arc Welding	12
Atomic Hydrogen Welding	14
Carbon Arc Welding	10-14
Torch Soldering	2
Torch Brazing	3 or 4
Light Cutting, up to 1" (25 mm)	3 or 4
Medium Cutting, 1" to 6"(25 to 150 mm)	4 or 5
Heavy Cutting, over 6" (150 mm)	5 or 6
Gas Welding (light), up to 1/8" (3.2 mm)	4 or 5
Gas Welding (medium), 1/8" to 1/2" (3.2 to 12.7 mm)	5 or 6
Gas Welding (heavy), over 1/2" in (12.7 mm)	6 or 8

Note: In gas welding or oxygen cutting where the torch produces a high yellow light, it is desirable to use a filter lens that absorbs the yellow or sodium line in the visible light of the operation spectrum.