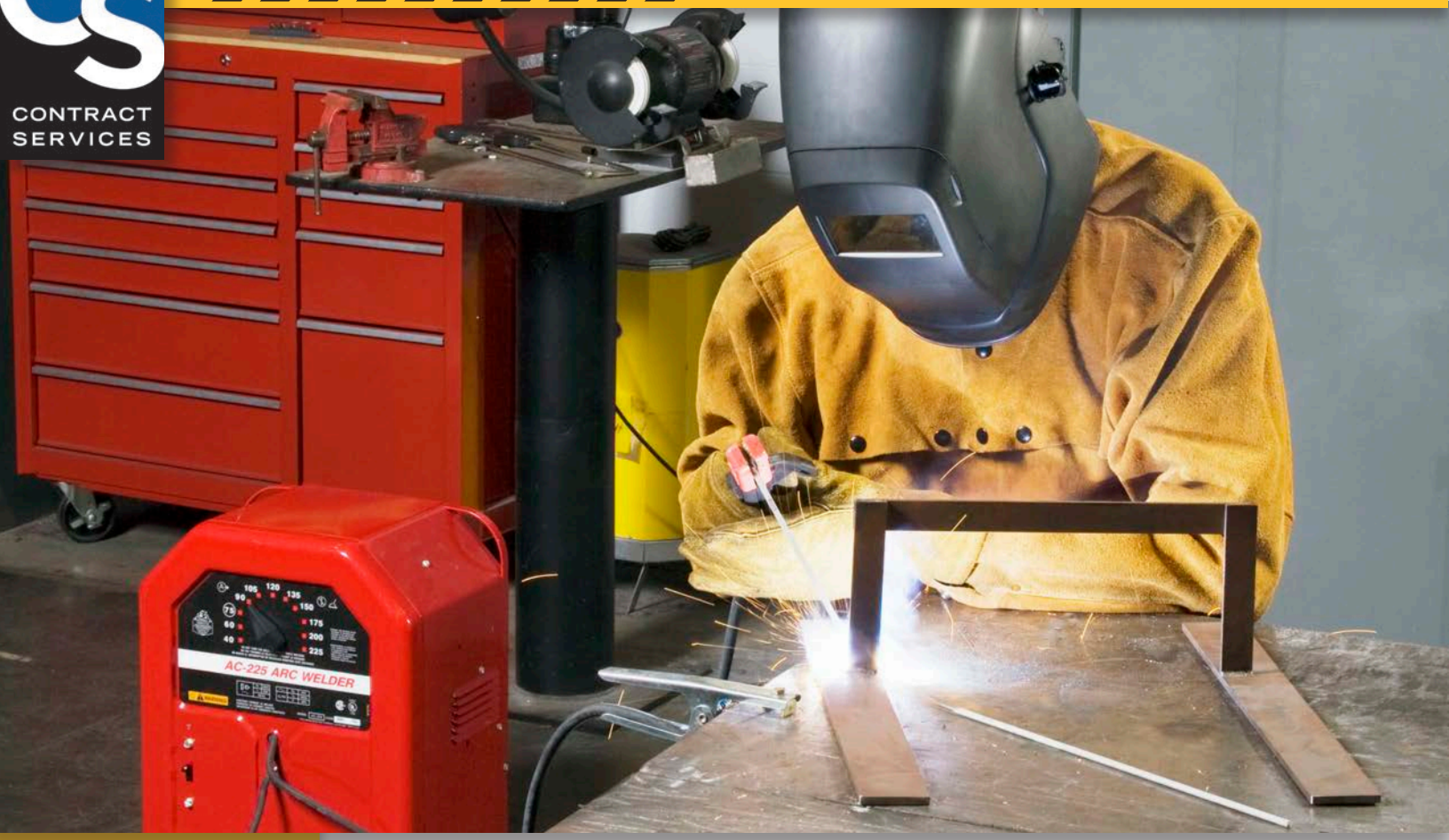
CONTRACT SERVICES




Safety Training Course J

# WELDING AND CUTTING

Presented by

**Contract Services**

As part of the

**Safety Pass Training Program for the Motion Picture and Television Industry**

Individuals completing this course will not become qualified or certified in welding.

J

Second Edition
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# Safety Pass Training Program

The Entertainment Industry is committed to maintaining a safe and healthful working environment. To that end, all major studios have a safety representative on staff. In addition, all employers have a safety program in force. This Safety Pass Program has been designed to further promote safety and health and to prevent injuries, illnesses, and accidents on all productions, both on-lot and off-lot.

Studios and production companies may have more restrictive safety requirements than those mandated by local, state, or federal laws or regulations. They also may assign different duties or responsibilities to employees. Therefore, in addition to this Safety Pass training course, employees should refer to the safety manual and materials provided by their employers.

Employees must adhere to all safety rules and regulations. Failure of any employee to follow safety rules and regulations can lead to disciplinary action, up to and including discharge. However, no employee shall be discharged or otherwise disciplined for refusing to perform work that the individual reasonably believes is unsafe.

No safety training can comprehensively cover all possible unsafe work practices. Each production and its employees, therefore, should fully promote each employee's personal obligation to work safely in order to prevent accidents involving, and injuries to, the employee and to his/her fellow employees.

The Safety Pass Program derives from Federal and California Occupational Safety and Health Administration (OSHA) safety regulations. However, the material included in this workbook and its accompanying presentation should be used only as a general guideline. It is not intended as a legal interpretation of any federal, state, or local safety standard.

During the course of your employment, you may be acting as a supervisor or manager. In California, individuals with management authority and actual authority for the safety of a business practice could be convicted of a crime if they have actual knowledge of a serious concealed danger and fail to warn the affected employees and report the hazard. If a hazard exists, immediately notify the employer or studio safety department of the hazard and insure that potentially affected employees are informed of the danger and that steps are taken immediately to mitigate it.

Although the information contained in this training program has been compiled from sources believed to be reliable, the Alliance of Motion Picture and Television Producers, Contract Services Administration Trust Fund, Contract Services Administration Training Trust Fund, and the instructor make no guarantee nor warranty as to, and assume no responsibility for, the accuracy, sufficiency, or completeness of such information.

**The Entertainment Industry is committed to maintaining a safe and healthful working environment.**

# Injury and Illness Prevention Program


**This class is part of the employer's safety program.**

Employers must provide workers a place of employment free from recognized hazards and must have a safety training program in place.

In the State of California, this is known as an Injury and Illness Prevention Program (IIPP). One of the key requirements of an IIPP is that every employee must be properly trained in safety.

Remember, the IIPP and the employer's safety program are one and the same.

# Contents

# Introduction

The nature of welding and cutting exposes workers to certain risks. Sparks can ignite fires, ultraviolet radiation can produce serious burns, electrical currents can produce shocks, and the melting of welding rods can create fumes that are dangerous for workers and others to breathe. However, welding can be a safe activity when sufficient measures are taken for protection from these potential hazards.

Safety measures protect workers from dangers. Precautions such as using the proper personal protective equipment (PPE), performing appropriate maintenance, using equipment properly, and designing the work space to minimize hazards can protect welders from serious injury and harm.

Cal/OSHA General Industry and Construction Industry Safety Orders must be followed when welding and cutting.

In addition, the American National Standards Institute (ANSI) Standard Z49.1, *Safety in Welding, Cutting, and Allied Processes*, must be followed. This standard is for the protection of persons from injury and illness and the protection of property (including equipment) from damage by fire and explosions arising from welding and other allied processes.

By following safety regulations and guidelines, risks are minimized, and a safe work environment is promoted.

**Always follow safety guidelines and regulations.**

## Welding and Cutting

Welding is a fabrication process that joins materials (usually metals) of similar compositions and melting points. By melting the separate pieces and adding a filler material, the metals flow together and create a molecular bond. As this bond cools, a strong joint is formed between the pieces. This process is known as fusion welding.

Cutting uses the heat of an electric arc or gas flame to melt metal and then cut it by blowing the molten metal away with compressed gas.

There are two basic types of welding and cutting: oxy-fuel gas welding and cutting, and electric arc welding and cutting. Both types use a source of heat to melt metal pieces in order to join or separate the pieces.

**Employers are responsible for providing training and approved welding equipment.**

## Employer Responsibilities

- Provide training to welders and supervisors in the safe operation of equipment, emergency procedures, and the safe practices required during the welding process.
- Communicate all hazards and safety precautions prior to the start of work.
- Designate approved work areas for welding and cutting.
- Authorize welding and cutting outside of approved work areas.
- Provide approved welding equipment and PPE and ensure employees are using the equipment properly.
- Select contractors who use only trained and qualified personnel to perform welding and cutting.
- Ensure that fire-protection and fire-extinguishing equipment are available.
- Ensure that employees know and follow fire-watch and hot-work procedures.

## Employee Responsibilities

- Participate in training for the safe operation of equipment, emergency procedures, and safe work practices during welding and cutting.
- Handle equipment safely in order to reduce danger to lives and property.
- Understand the hazards involved and the proper procedures to control hazardous conditions.
- Use the approved welding equipment and PPE provided by the employer.
- Confirm that fire-protection and fire-extinguishing equipment are in place prior to starting work.
- Know what flammable and combustible materials are present in the work location.
- Protect materials from ignition by moving the work area and the combustible items a safe distance apart or by properly shielding combustibles against ignition.
- Know and follow the employer's fire-watch and hot-work procedures.
- Obtain permission from the employer prior to beginning hot work or entering a confined space.
- Obtain permission from the employer before beginning to weld or cut outside of the designated, approved work area.
- Set up light curtains to protect others from eye damage.
- Mark hot materials to warn others of the danger of accidental contact.
- Weld or cut only when all safety precautions have been met.

Only qualified personnel who have been properly instructed in the use and maintenance of the equipment are allowed do any welding or cutting.

Before engaging in any welding or cutting, check with the employer or safety department for specific guidelines.

**Note:** Completion of this class will not provide the training required to be classified as a qualified or certified welder.

**Always wear the proper PPE when welding and cutting.**

**Notes**

## Scene 1

# Oxy-Fuel Gas Welding and Cutting

**Figure 1.1.** Compressed gas cylinders are used to store welding fuel gases.

Oxy-fuel gas welding and cutting combines oxygen with a fuel gas such as acetylene for welding, cutting, brazing, and soldering of materials.

## Compressed Gas Cylinders

Oxygen and acetylene gases are stored under pressure in compressed gas cylinders to provide a source of heat for welding and cutting procedures (Figure 1.1). These cylinders contain gases that can cause serious damage, injury, or death if not handled properly.

Cylinders contain gases at pressures of approximately 2,500 pounds per square inch gauge (psig), and sometimes higher. A sudden release of the contents can cause a cylinder to become very dangerous. Because of the high pressure, it is very important that the cylinders are handled safely during transportation, storage, and use.

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 (DOT) 49 CFR Parts 171-179.

Only the owner of the cylinder, or a person authorized by the owner, shall refill a cylinder. Only the gas supplier shall mix gases in a cylinder or transfer gases from one cylinder to another.

**Follow all rules and regulations when handling compressed gas cylinders.**


**Figure 1.2.** All cylinders must be legibly marked with the contents.

## Inspection of Cylinders

All cylinders must be inspected before each use to ensure they are safe. Any cylinder showing physical damage, corrosion (rust), or fire damage must not be used.

All cylinders are required to be identified with the chemical or trade name of the gas (Figure 1.2). **Never rely on the color of the cylinder for identification.** If the label is missing or illegible, the cylinder must not be used and should be returned to the supplier as soon as possible.

Most cylinders containing oxygen or inert shielding gases such as carbon dioxide or argon must be hydrostatically tested every five years to make sure they remain safe to use. A star symbol after the test date indicates that the cylinder may require testing only every 10 years if used for certain gases. The DOT maintains a list of the gases that qualify for the longer inspection period.

The outer shells of acetylene cylinders must be manufactured according to DOT-8 or DOT-8AL specifications, and must be inspected and requalified every 10 years. The porous filler inside must be requalified at least once, no sooner than five years and no later than 20 years after cylinder manufacture.

## DOT Markings

DOT standards require that each cylinder must be marked with the following information:

- DOT specification
- Service pressure
- Serial number
- Manufacturer's symbol
- Date cylinder was first tested and put into service
- Date of the most recent inspection
- Tare weight—empty cylinder (not required on all cylinders)
- Neck ring owner identification (optional)

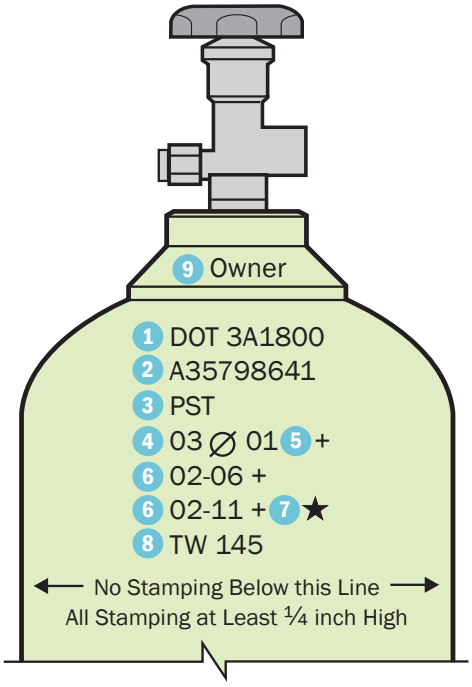
Generally, the DOT specification marking appears first, followed by the service pressure. For example, DOT 3AA1800 would indicate that the cylinder is a 3AA rated bottle and is rated for 1800 pounds of service pressure. Next is the serial number of the cylinder, followed by the manufacturer's symbol.

Below the serial number is the date the cylinder was first tested and put into service. For example, 03-01 would indicate the cylinder was inspected and put into service in March of 2001. After the in-service date, there will be a date showing the last time the cylinder was inspected.

A plus sign after the manufacture or retest date indicates the cylinder qualifies for a 10% overcharge. A star after the manufacture or retest date indicates the cylinder meets the requirements for needing a retest only every ten years. Figure 1.3 shows the general appearance of the markings, but the look may vary by manufacturer.

All markings must be stamped permanently on the shoulder, top head, or neck of the cylinder. The lettering must be ¼" or larger.

**Do not use unlabeled cylinders.**




**Examples of Cylinder Markings**

1. DOT cylinder type and service pressure
2. Serial number
3. Manufacturer's inspection marking
4. Date of manufacture
5. + indicates cylinder may be 10% overcharged
6. Retest date (if applicable)
7. ★ indicates 10-year retest interval
8. Tare weight—empty cylinder (not required on all cylinders)
9. Neck ring owner identification (optional)

**Figure 1.3.** Cylinder must be permanently marked with the information shown.

# Cylinder Safety

## Storing Cylinders

Cylinders must be stored in a well-protected, ventilated, dry location, and away from elevators, stairs, or gangways. Areas where cylinders might be knocked over or damaged from passing equipment or falling objects are not suitable for storage of compressed gases.

Store cylinders a minimum of 20 ft. away from flammable and combustible materials such as wood, paper, packing material, oil, grease, and flammable liquids. Store cylinders at least 35 ft. away from welding or other hot work areas.

**Cylinders in a cart must be used within 24 hours.**

Cal/OSHA General Industry Safety Orders require all oxygen cylinders to be stored a minimum of twenty feet away from fuel cylinders such as acetylene or be protected by a non-combustible barrier at least 5 ft. high. The barrier must have a fire-resistance rating of at least one hour. In addition, the barrier must be eighteen inches higher than the tallest cylinder.

Storage temperature must not exceed 125° F. The storage area must be marked with the appropriate signage. Do not store cylinders in a locker.

When cylinders are in use, the temperature must not exceed 120° F.

**Figure 1.4.** Cylinders must be strapped or chained to protect against tipping or movement.

Compressed gas cylinders must be secured in an upright position when being stored, transported, or while in use. A good method of securing the cylinder is with a chain or strap secured ⅔ of the way up the cylinder and attached to a fixed object such as a wall, post, or railing (Figure 1.4).

Cylinders must also be secured when used in a welding cart. Cylinders in a cart must be used within 24 hours; otherwise, the cylinders must be removed from the cart and stored properly.

Identify all cylinders as full, in use, or empty. Separate cylinders by types of gases, and separate empty cylinders from full cylinders. Use them in rotation as received from the supplier, using older ones first.

If a cylinder is leaking, move it to a safe location outdoors and notify the supplier, employer, and the safety department. If the cylinder cannot be moved outside, evacuate the area and immediately notify the fire department, employer, and safety department.

**Do not hang equipment or personal items on the cylinder.**

## Valves and Valve Protection

All cylinder valves should be protected by the use of a valve protection cap or with a collar or recess (Figure 1.5). Valve protection caps must be in place before cylinders are moved, transported, or stored.

Whenever the cylinders are not in use, regulators should be removed, valves closed, and the valve caps put back in place. This includes empty cylinders because even when empty, cylinders retain some gas.

**Figure 1.5.** Valve cap (left) and no valve cap (right).

**Proper PPE must be worn while moving cylinders.**

## Transporting and Moving Cylinders

Cylinders should be handled with care. Do not drop, strike, or allow objects to strike the cylinders. This may damage the cylinder, valve, or valve cap.

Regulators should be removed and valve protection caps put in place before moving cylinders. Never lift a cylinder by the valve or valve cap, or roll a cylinder on its side.

For short distances, cylinders may be moved by tilting and rolling them on their bottom edges while still keeping them upright. They may not be rolled over any electrical cable, wet surface, or sloped area.

Cylinders must be secured (chained or strapped) in an upright position before moving or transporting in a vehicle, hand truck, or cart. Remember to separate oxygen from fuel gas cylinders when transporting.

When transporting Class 2 cylinders, the type of cylinders used for welding and cutting, no shipping paperwork is required by either the DOT or the California Vehicle Code if all of the following conditions are met (materials of trade exemption):

- The weight of individual cylinders is 220 pounds or less
- The aggregate gross weight of all materials is 440 pounds or less
- The cylinders are not being transported for a fee

If these limits are exceeded or the cylinders are being transported for a fee, both the DOT and the California Vehicle Code require shipping papers to be carried in the vehicle.

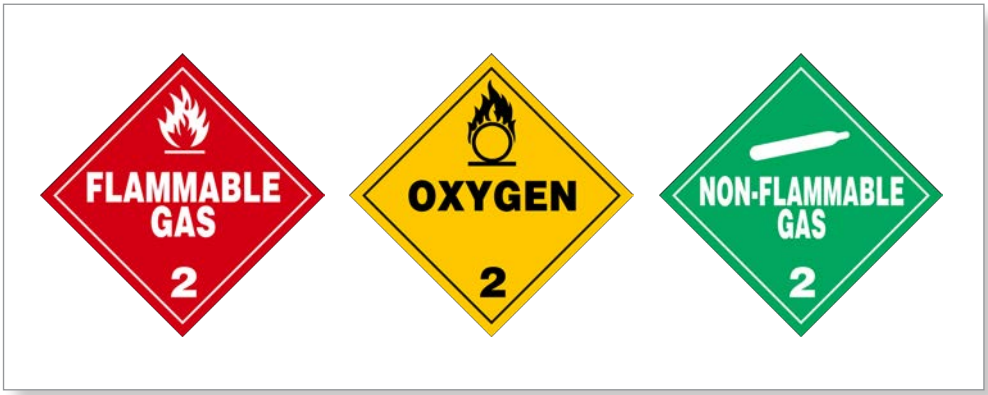



**Figure 1.6.** DOT warning placards.

### Transporting Cylinders for a Fee

In California, if transporting cylinders for a fee and the total weight of the cylinders transported is between 500 and 1001 pounds, the California Vehicle Code requires that:

- Drivers have a hazardous material endorsement on their commercial driver license.
- Shipping papers be carried in the vehicle.
- A copy of the transportation company's Hazardous Material Transportation License (HMTL) be carried in the vehicle.

Nationwide, whether or not a cylinder is being shipped for a fee, if the aggregate gross weight of Class 2 cylinders and contents is 1001 pounds or more, then the above three conditions must be met, and:

- DOT warning placards are required on all four sides of the vehicle (Figure 1.6).

Other classes of cylinders may have different requirements regarding weight, packaging, and documentation.

Check with the employer, safety or transportation department for additional guidelines in determining transportation restrictions and for help in meeting DOT and California requirements.

**Check with the employer, safety department or the transportation department for requirements when shipping cylinders.**

**To avoid flashback, make sure there is enough fuel to complete the welding procedure.**

# Hoses, Regulators, Gauges, and Torches

All connections should be hand tightened; do not use a wrench because of the danger of over-tightening the connection. Keep all cylinder valves, couplings, regulators, and hoses free from oily or greasy substances.

Check all connections for leaks before lighting the torch. Soapy water is a safe way of checking for a leak. **NEVER** use a flame to check for a leak.

## Hoses

Purge the hoses of gas:

- At the beginning of the workday
- Before lighting the torch for the first time each day
- After changing a cylinder
- Before disconnecting hoses

Fuel gas hose and oxygen hose shall be easily distinguishable from each other. The contrast may be made by different colors or by surface characteristics readily distinguishable by the sense of touch.

When parallel lengths of oxygen and fuel gas hose are taped together for convenience and to prevent tangling, not more than 4 in. out of every 12 in. shall be covered by tape.

Generally accepted color coding for hoses:

- Red for fuel gases such as acetylene
- Green for oxygen
- Black for inert gases such as argon or nitrogen

Flashback arrestors, also called one-way valves, must be attached to the hose—either at the torch end or the regulator end—to prevent the backflow of gases and flame into the cylinders (Figure 1.7).

Flashback can occur from running out of fuel in the middle of a welding or cutting procedure. Check fuel levels at the beginning of the shift.

**Figure 1.7.**
Flashback arrestors.

## Regulators and Gauges

Before connecting a regulator, crack open the cylinder valve slightly to clear the valve of any dust and dirt. Close the valve immediately afterward. The person cracking the valve shall stand to one side of the outlet, not in front of it. Do not open the valve in an area where the gas might reach sparks, flame, or other sources of ignition.

The regulator must be correct for the type of gas being used and labeled with the name of the gas—oxygen, acetylene, argon, etc (Figure 1.8). Using the wrong regulator is unsafe and a violation of Cal/OSHA regulations. For example, putting a brass oxygen regulator on an acetylene cylinder may cause explosive acid salts to form inside the regulator.

In order to prevent the wrong regulator from being attached to a cylinder, Compressed Gas Association (CGA) standards require:

- Non-fuel regulators, such as those used for oxygen or argon, to be a right-hand thread (clockwise).
- Fuel regulators, such as those used for acetylene or other fuel gases, to be a left-hand thread (counter-clockwise).

**Figure 1.8.** Regulators and gauges are gas specific and are not interchangeable.

## Torches

Always use the proper size and type of torch for the kind of welding or cutting work being performed (Figure 1.9). Cutting torches have an additional lever to add more oxygen to cut or blow the molten metal.

When using torches:

- Inspect the torch and connections before each use to make sure everything is connected properly and there are no leaks.
- Inspect the torch tip to make sure it is not clogged.
- Light the torch with a friction lighter or striker.
- Do not light the torch with matches or a cigarette lighter.
- Do not attempt to light the torch by contacting hot metal.
- Point the torch tip away from people and combustible materials when lighting.
- Do not touch the lighted torch to the work piece during the welding or cutting process.

**Touching the lighted torch tip to the work piece can cause flashback.**

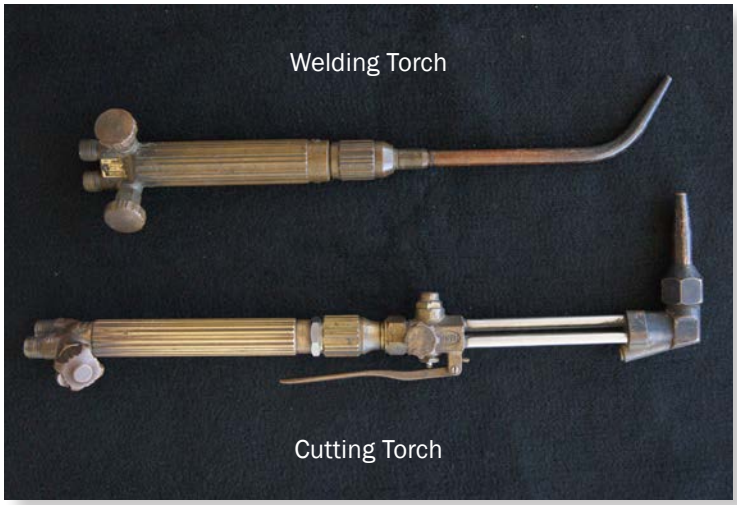



**Figure 1.9.** Welding and cutting torches.

# Protection of Cylinders During Welding and Cutting

Keep cylinders away from the actual welding or cutting operation so that sparks, hot slag, or flame will not reach them. If this is not practical, fire-resistant shields must be used.

- Do not place cylinders where they can become part of an electrical circuit.
- Fuel gas cylinders must be placed with the valve end up.
- Do not take cylinders containing oxygen, acetylene, or other fuel gases into confined spaces.

**Protect the cylinders from sparks, hot slag, and flames.**

## Oxygen

When in use, the oxygen cylinder valve should be opened **all the way** (do not turn the valve back). An oxygen cylinder valve is double seated; if not opened fully, it may not seat properly.

Oxygen regulator pressure will vary depending on the task being performed. Welding may require oxygen pressure as low as 2–4 psig, while cutting may require pressure of 50 psig or higher, depending on the thickness of the material being cut. Check the manufacturer's recommendations for the correct pressure for the nozzle and process being used, and follow those recommendations.

Keep all oxygen cylinders, valves, couplings, regulators, hoses, and torches free from oil, grease, or other flammable substances (Figure 1.10). Oxygen is not flammable, but accelerates combustion of other materials causing them to burn violently. Oil or grease may ignite when exposed to oxygen.

All oxygen regulators must have the words "use no oil" printed on the face of the regulator dial.

**Figure 1.10.** Keep regulators and connectors clean and free of oil or grease.

## Acetylene

Acetylene is the most common gas used for fueling welding and cutting torches. It is extremely flammable and highly unstable.

The acetylene cylinder valve should be open ¾ of a turn and never more than one and 1½ turns. The recommended regulator pressure for acetylene is 7.5 psig and must never exceed 15 psig (Figure 1.11). Pressures greater than 15 psig can cause hazardous decomposition of the acetylene which may result in an explosion.

Acetylene forms explosive compounds with copper, brass, copper salts, and other copper-containing compounds. Under no circumstances should acetylene gas come in contact with unalloyed copper, except in a torch. Unalloyed copper is 100% copper.


**Figure 1.11.** Acetylene regulator at 15 psig.

**Keep the acetylene cylinder in an upright position at all times.**

Any contact with high-alloyed copper piping will generate copper acetylide, which is very reactive and may result in a violent explosion. High-alloy copper is an alloy with copper content greater than 94%.

To safely store and use acetylene in cylinders, the compressed gas is dissolved in an acetone solution. The cylinder is filled with porous material which absorbs the acetone solution and controls the release of acetylene gas.

All acetylene and liquefied-gas cylinders must be placed with the valve end up at all times. To prevent the liquid from flowing into the hoses and regulators and spurting out the valves, use acetylene cylinders in an upright position.

Never place or store an acetylene cylinder on its side. This will defeat the safety features, and can cause the release of liquid, rather than gas. Damage to the regulator and hazardous situations may occur.

**Note:** Also follow these safety standards when using compressed gas cylinders during electric arc welding and cutting. Inert gases such as argon or helium are sometimes used in arc welding as a shielding gas to protect the weld from impurities.

## Scene 2
# Arc Welding and Cutting

In arc welding, the intense heat needed to melt metal is produced by an electric arc. The arc is formed between the work piece and an electrode (stick or wire) that is manually or mechanically guided along the joint (Figure 2.1).

The arc produces a temperature of about 6,500° F at the tip, but certain arc-welding processes are capable of producing temperatures in excess of 10,000° F.

**Only qualified personnel who have been properly instructed in the use and maintenance of the equipment are allowed to do any welding or cutting.**

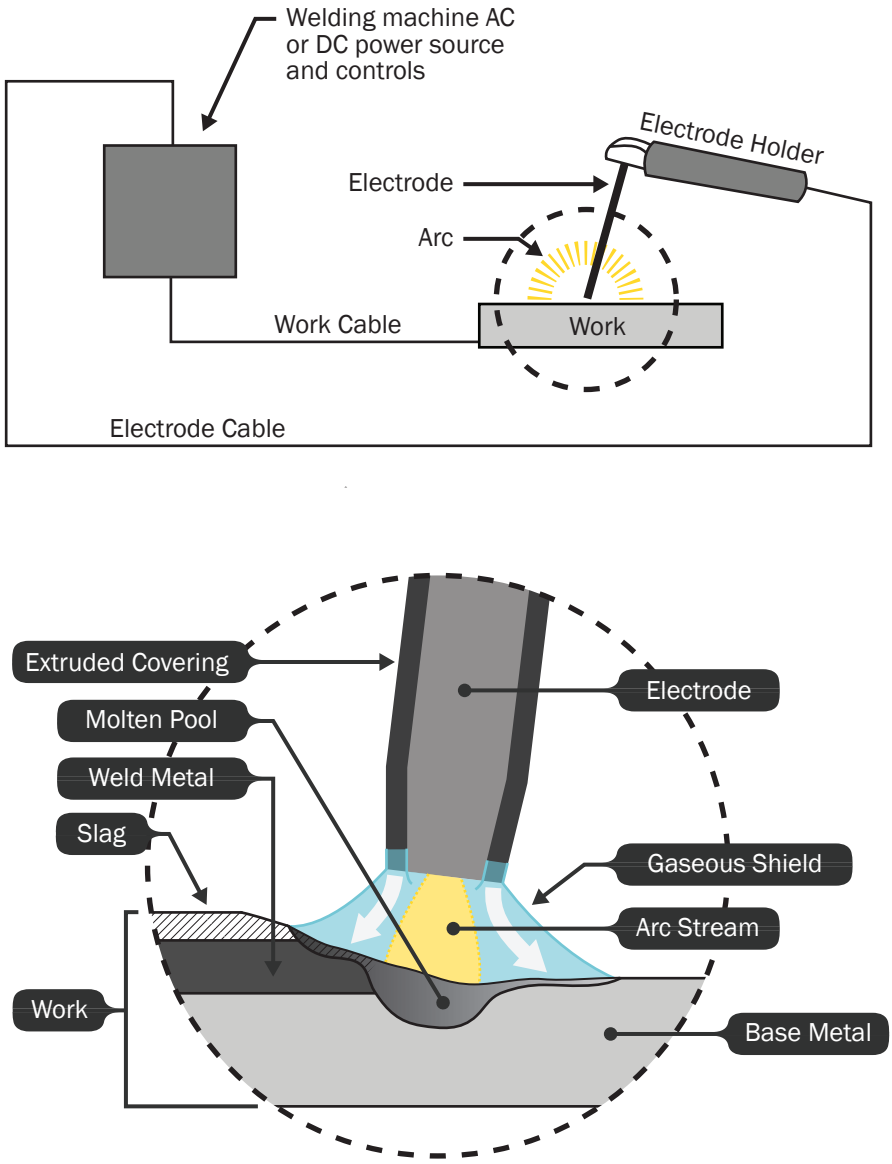



**Figure 2.1.** Stick welding.

## Arc Welding and Cutting Processes

There are many different types of processes used for arc welding and cutting. Detailed below are some of the more common ones.

### Shielded Metal Arc Welding

Shielded metal arc welding (SMAW), commonly referred to as stick welding, derives the heat for welding from an electric arc established between a consumable stick electrode and the part to be welded (Figure 2.2). Stick welding is a widely used form of arc welding because it gives the strongest bond and penetration.

**Figure 2.2.** Stick welding.

**Figure 2.3.** TIG welding.

### Gas Tungsten Arc Welding

Gas tungsten arc welding (GTAW), commonly referred to as tungsten inert gas (TIG) welding, derives the heat for welding from an electric arc established between a non-consumable tungsten electrode and the part to be welded (Figure 2.3). Tungsten is used because it has an extremely high melting point—6,192° F.

TIG welding is capable of producing very high-quality welds in almost all metals and alloys and is well suited for welding thin materials where requirements for quality and finish are exacting.

> **Note:** Use thorium-free tungsten electrodes whenever possible. Thoriated tungsten electrodes, widely used in TIG welding, contain thorium, a low-level radioactive material. Caution should be taken when using these electrodes as radioactive dust is formed during the grinding of the tips, creating a potential inhalation, ingestion, and disposal hazard. Check with the employer or safety department for additional guidelines.

**Check with the employer or safety department before using thoriated tungsten electrodes.**

Figure 2.4. MIG welding.

### Gas Metal Arc Welding

Gas metal arc welding (GMAW), commonly referred to as metal inert gas (MIG) welding, is an arc-welding process which incorporates the automatic feeding of a continuous, consumable wire electrode that is shielded by an externally supplied gas. MIG welding is the most popular welding process in North America (Figure 2.4).

### Flux Cored Arc Welding

Flux cored arc welding (FCAW) is similar to MIG welding but uses a wire which contains flux materials in its core that, when burned by the heat of the arc, produce shielding gases and fluxing agents without the need for external shielding gas. FCAW is often used outdoors in windy conditions.

### Plasma Cutting

Plasma cutting is a process that uses a high velocity jet of ionized gas (the plasma) that is delivered from a small opening (Figure 2.5). The benefits of plasma cutting include ease of use, higher quality cuts, and faster travel speeds. Plasma cutting is ideal for cutting steel and non-ferrous material less than one inch thick.

**Before engaging in any welding or cutting, check with the safety department for specific guidelines.**

The focused flame of a plasma cutting torch is capable of reaching temperatures of 50,000° F. Special care must be taken around the flame and cup area.

Figure 2.5. Plasma cutting.

**Figure 2.6.** Engine-driven arc welder.

## Engine-Driven Arc Welders

Engine-driven arc welders are typically used when electric power is not available for arc welding (Figure 2.6). Though usually used outdoors, engine-driven arc welders are often used indoors when it is not convenient to supply power to an electric plug-in arc welder. When operating engine-driven arc welders indoors, vent the exhaust outside or use in large spaces with good ventilation.

### Grounding Engine-Driven Arc Welders

Because engine-driven arc welders create their own power, it is not necessary to connect the frame to an earth ground unless the machine is connected to the premises wiring of a building. If the engine-driven arc welder is connected to the premises wiring of a building, the frame of the welder must be bonded to the building's system ground. This should also be done if the engine-driven welder is supplying power to equipment being used in the building.

**Check with the employer or safety department before using an engine-driven arc welder indoors.**


**Figure 2.7.** When on a vehicle, the welder must be properly bonded (left) using the machine grounding stud (right).

When an engine-driven welder is mounted on a truck or a trailer (Figure 2.7), the frame must be electrically bonded to the metal frame of the vehicle by using a #8 or larger copper wire securely connected between the machine grounding stud and the frame of the vehicle.

When the engine-driven arc welder is used to supply power to other equipment, that equipment must be grounded to the frame of the engine-driven welder by using a three-prong grounded plug or be double insulated.

## Grounding Other Types of Arc Welders

Hard-wired or cord-and-plug type welders (Figure 2.8) must be grounded. Portable plug-in models must have a three-prong plug connected to a grounded three-prong electrical outlet.

**Figure 2.8.** Cord-and-plug connected welders must be grounded using a 3-plug electrical outlet.

Check the manual for the grounding requirements for the type of arc welder being used.

## Arc Welding and Cutting Safety

Before starting to weld or cut, check that the arc welder is grounded properly, if grounding is required.

Check all connections to the machine. The electrode, work lead, and ground connection should be securely attached, tight, clean, and dry. Maintain insulation on weld cables, electrode holders, guns, and torches to provide protection. Use dry, insulating gloves and other means to insulate the welder from the welding circuits.

Take special care to avoid electrical shock when using either alternating current (AC) or direct current (DC) arc welders. DC welding units take AC power and convert it to DC power. The power produced in DC mode is not true DC power, but rectified AC power which carries the same inherent dangers as AC power.

Avoid contact with live electrical parts. Electric shock can cause severe burns or death.

When the power is on, all parts of the welding circuit are energized including the electrode, the work piece, the wire and wire reel, and any metal part touching the electrode. Never touch the energized electrode with a bare hand. Wear dry, insulating gloves in good condition without holes or rips.

**Note:** Wearers of pacemakers and other electronic equipment vital to life should check with their doctor or the manufacturer of the life-supporting device to determine if any hazard exists when working near arc-welding or cutting equipment.

**All arc-welding equipment must be in compliance with National Electrical Manufacturers Association requirements and ANSI Z49.1-94.**

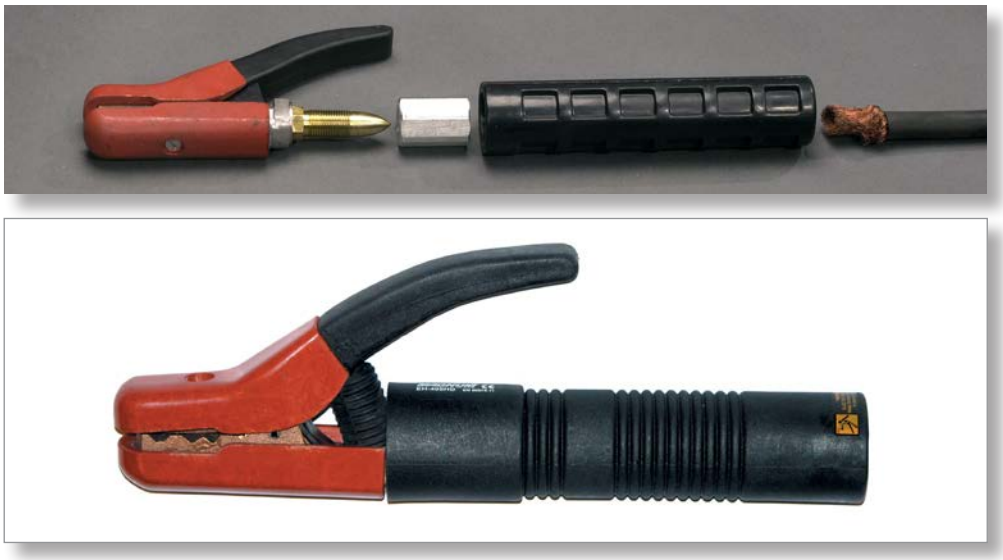


**Figure 2.9.** An electrode holder in exploded view (top) and ready for use (bottom).

**Do not touch metal energized by the arc.**

When energized, do not allow the electrode or electrode holder (Figure 2.9) to make contact with any person, grounded or conducting object, or compressed gas cylinder. Always use fully insulated electrode holders. Never dip the electrode or electrode holder into water. Remove metal and carbon electrodes from electrode holders when not in use.

Never attach the work lead to pipelines containing gases or flammable liquids or conduits containing electrical circuits.

Confirm that the work lead (Figure 2.10) is firmly attached to the work. Never use chains, wire rope, or hoists as a work lead connection. Do not confuse the work lead with the ground lead; they are not the same. The work lead is connected directly to the piece being welded. The ground lead is designed to safely ground the work piece and the equipment to the earth.

**Figure 2.10.** Work lead.

Firmly attach work cables to clean bare metal, close to the welding arc. Never attach cables to a painted panel or a rusty surface. These surfaces act as electrical insulators and will not allow current to flow properly.

Stand on dry, insulating mats or wear American Society for Testing and Materials approved rubber-soled boots. Spread out coiled welding cable to prevent serious overheating and damage to the insulation. Never allow cables to wrap around the welder's body—keep them off to one side.

To minimize electric and magnetic field (EMF) exposure, stand with the shortest possible run of cable between the welder and the weld table.

Never use cables with damaged insulation or exposed, bare conductors. The portion exposed shall be repaired using insulation equivalent in performance capacity to the original.

Use cables free from repair or splices for 10 ft. from the electrode holder, unless insulated connectors or splices with insulating quality equal to that of the cable are used.

Make sure equipment is turned off when not in use. Equipment that is left unattended or out of service should be disconnected and de-energized.

Disconnect and de-energize arc-welding equipment (Figure 2.11) before performing installation, maintenance, repair, or removal of the equipment. If the arc welding equipment cannot be unplugged, additional training in lockout/tagout procedures and authorization from the employer is required before performing those tasks.

Report any equipment defects or safety hazards to a supervisor or the safety department. Discontinue use of equipment until defects have been repaired by a qualified person and all safety hazards have been eliminated.

Do not use damaged or defective equipment. Remove from service and tag "Out of Service" or "Do Not Use."

**Do not place your body between the electrode and work lead.**


**Figure 2.11.** Disconnect (left) or de-energize (right) equipment before performing any installation, maintenance, or repair.

**Notes**



## Scene 3
# Fire Prevention

Before any welding or cutting work begins, check with the employer or safety department for specific fire-prevention guidelines. A permit may be required before starting work.

## Hot-Work Permit

When welding or cutting outside of a designated welding area, inspection and authorization by a designated management representative is required. On a studio lot, check with the employer or safety department to determine the correct procedures and to obtain authorization. In addition to the employer or safety department, permission may be required from the fire department.

On a location, contact the employer or safety department to determine the requirements and the appropriate authority having jurisdiction (AHJ) to contact in order to obtain a hot-work permit.

**A hot-work permit may be needed before welding.**

## Fire Prevention

Welding or cutting should be done in a designated, approved area that has been designed to minimize the risk of fire. If authorized to weld or cut outside of a designated, approved work area, maintain at least a 35-ft. radius free from all combustibles, including wood floors.

**Contact the employer or safety department for fire-prevention guidelines.**

Combustible floors such as wood must be clean and protected with water, or covered with non-flammable material such as damp sand or sheet metal, except when wood floors are laid directly on concrete. Provisions shall be taken to protect personnel from electric shock when floors are wet.

Cracks and openings in floors, walls, and windows, such as expansion cracks or joints in concrete, must be covered or closed to prevent sparks and spatter from passing through to adjacent areas.

Do not weld in flammable atmospheres. Remove all combustibles from the area. If it is not possible to remove the combustibles, they must be covered with a fire-resistant blanket.

Strip any highly flammable, hardened-preservative coatings from the surface area prior to welding or cutting as these materials may ignite.

Do not dispose of hot slag or any electrode in containers holding combustible material.

A dry chemical or carbon dioxide fire extinguisher rated at least 10 BC must be kept near operations where bottled fuel gases are being used.

## Fire Watch

Fire watch is required when:

- Combustible materials are closer than 35 ft. from the welding and cutting operation.
- Combustible materials are more than 35 ft. away from the welding and cutting operation but are easily ignited by sparks.
- Walls or floor openings within a 35-ft. radius expose combustible materials in adjacent areas, including concealed spaces in walls or floors.
- Combustible materials adjacent to the opposite side of metal partitions, walls, ceilings, or roofs or in contact with pipes are likely to be ignited by conduction or radiation.

Suitable fire-extinguishing equipment must be available and ready for instant use in the work area. Pails of water, buckets of sand, hoses, or portable extinguishers may be used. Employer policy and the AHJ will determine the method used based on the nature and quantity of the combustible materials involved.

A fire watch requires someone to be present during the welding or cutting to observe where the sparks and spatter are going, to sound an alarm, or put out any fires. The person assigned shall be trained in the use of fire-extinguishing equipment, knowledgeable in the duties of a fire watch, and have the means to quickly contact the fire department dispatch.

The person assigned to the fire watch must be someone other than the person doing the welding and may not have any other duties that interfere with the assigned watch.

The fire watch must remain in place for at least 30 minutes after the welding or cutting is finished. The individual hot-work permit or employer safety policy may require a longer fire watch after the completion of welding or cutting.

**The AHJ may have additional requirements for the person performing fire-watch duties, including who may perform these duties and the training required.**

**Figure 3.1.** Do not weld on containers unless they have been inspected and declared safe.

## Welding or Cutting Containers

**Containers must be cleaned of flammable residues, inspected, and vented before any welding can be performed.**

No welding or cutting should take place on any drum, barrel, tank, or container unless the container has been cleaned of all flammable residues and has been inspected and declared safe by a qualified person (Figure 3.1).

Before heat is applied to a drum, barrel, tank, container, or any other hollow vessel, a vent or opening must be provided for the release of pressure build-up caused by the application of heat.

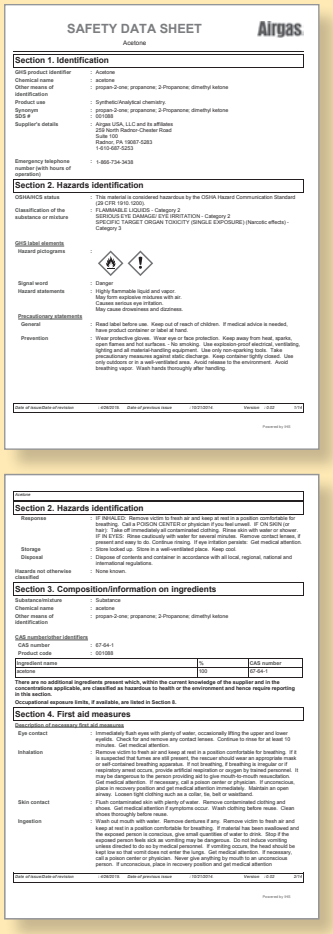

# Scene 4
# Welding and Cutting Health Hazards

## Respiratory Hazards

Welders should take precautions to avoid breathing airborne contaminants contained in welding fumes, gases, and vapors. Protection can be provided by adequate ventilation or respiratory protection.

Safety Data Sheets (SDS) are the best way to learn about the hazards of exposure from each compound used during welding or cutting (Figure 4.1). Always read the SDS for the metals, solders, fluxes, welding rods, wires, and gases used, and follow the recommendations regarding proper protection.

Some of the hazards associated with welding and cutting, depending on the materials used are discussed on the following pages.


SAFETY DATA SHEET
Airgas
Acetone

**Section 1. Identification**

GHS product identifier : Acetone
Chemical name : acetone
Other means of identification : propan-2-one; propanone; 2-Propanone; dimethyl ketone
Product use : Synthetic/Analytical chemistry.
Synonym : propan-2-one; propanone; 2-Propanone; dimethyl ketone
SDS # : 001088
Supplier's details : Airgas USA, LLC and its affiliates
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

Emergency telephone number (with hours of operation) : 1-866-734-3438

**Section 2. Hazards identification**

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).
Classification of the substance or mixture : FLAMMABLE LIQUIDS - Category 2
SERIOUS EYE DAMAGE/ EYE IRRITATION - Category 2
SPECIFIC TARGET ORGAN TOXICITY (SINGLE EXPOSURE) (Narcotic effects) - Category 3

GHS label elements
Hazard pictograms :

Signal word : Danger
Hazard statements : Highly flammable liquid and vapor.
May form explosive mixtures with air.
Causes serious eye irritation.
May cause drowsiness and dizziness.

Precautionary statements
General : Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand.
Prevention : Wear protective gloves. Wear eye or face protection. Keep away from heat, sparks, open flames and hot surfaces. - No smoking. Use explosion-proof electrical, ventilating, lighting and all material-handling equipment. Use only non-sparking tools. Take precautionary measures against static discharge. Keep container tightly closed. Use only outdoors or in a well-ventilated area. Avoid release to the environment. Avoid breathing vapor. Wash hands thoroughly after handling.

Date of issue/Date of revision : 4/24/2015 Date of previous issue : 10/27/2014 Version : 0.02 1/14

Powered by SDS


Acetone

**Section 2. Hazards identification**

Response : IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing. Call a POISON CENTER or physician if you feel unwell. IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water or shower. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If eye irritation persists: Get medical attention.
Storage : Store locked up. Store in a well-ventilated place. Keep cool.
Disposal : Dispose of contents and container in accordance with all local, regional, national and international regulations.

Hazards not otherwise classified : None known.

**Section 3. Composition/information on ingredients**

Substance/mixture : Substance
Chemical name : acetone
Other means of identification : propan-2-one; propanone; 2-Propanone; dimethyl ketone

CAS number/other identifiers
CAS number : 67-64-1
Product code : 001088

| Ingredient name | % | CAS number |
|---|---|---|
| acetone | 100 | 67-64-1 |

**There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.**

**Occupational exposure limits, if available, are listed in Section 8.**

**Section 4. First aid measures**

Description of necessary first aid measures
Eye contact : Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Get medical attention.
Inhalation : Remove victim to fresh air and keep at rest in a position comfortable for breathing. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention. If necessary, call a poison center or physician. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.
Skin contact : Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.
Ingestion : Wash out mouth with water. Remove dentures if any. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Stop if the exposed person feels sick as vomiting may be dangerous. Do not induce vomiting unless directed to do so by medical personnel. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Get medical attention. If necessary, call a poison center or physician. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention.

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Powered by SDS

**Figure 4.1.** Sample SDS.

**To avoid ingestion of hazardous materials, do not eat, drink, or smoke in exposure areas.**

# Chemical Agents

## Zinc

The manufacturing of brass, galvanized metals, and other alloys use zinc. Welders may be exposed to zinc-oxide fumes when working on zinc-coated metals.

Zinc is known to cause metal fume fever. Symptoms are similar to the flu: fever, chills, nausea, cough, fatigue, aching, and sweating. Symptoms last about 24 hours. A metallic, sweet taste in the mouth can also be a warning sign of zinc exposure.

## Cadmium

Cadmium is used as a rust-preventive coating on steel and as an alloying element.

High concentrations can produce severe lung irritation and fluid in the lungs. Exposure can be fatal. Long-term exposure to low levels of cadmium can result in emphysema and kidney damage. Cadmium is classified as a potential human carcinogen.

## Beryllium

Beryllium is used as an alloying element with copper and other base metals.

Long-term exposure can result in shortness of breath, chronic cough, significant weight loss, fatigue, and general weakness. High concentrations can result in chemical pneumonia. Because of its high toxicity, when beryllium is present both local exhaust ventilation and a supplied airline respirator are required.

## Iron Oxide

The principal alloying element in steel is iron oxide.

Fume exposure to iron oxide can irritate nasal passages, throat, and lungs.

## Mercury

Mercury compounds are used to coat metals to prevent rust and inhibit foliage growth, such as in marine paints.

Under the intense heat of an electric arc or a gas flame, mercury vapors are produced. Exposure may produce stomach pain, diarrhea, kidney damage, and respiratory failure. Long-term exposure may produce tremors, emotional instability, and hearing damage.

## Lead

Sometimes lead is used as an alloy in brass and bronze and is also found in solder used for repairs to the leaded joints of cast-iron pipes.

Inhalation and ingestion of lead-oxide fumes and other lead compounds will cause lead poisoning affecting the brain, central nervous system, circulatory system, reproductive system, kidneys, and muscles. A metallic, sweet taste in the mouth can also be a warning sign of lead exposure.

## Flux

Flux is used in various welding, brazing, and soldering processes to prevent oxidation of the base and filler materials. Fluxes are available in various forms such as granule, powder, paste, or liquid, and also are found in certain types of welding rods or wire.

Overexposure to flux dust, fumes, and gases may irritate the skin, eyes, and respiratory system causing headache, dizziness, shortness of breath, and bleeding of exposed tissue. Exposure may also cause metal fume fever, fluid in the lungs, or abdominal pain, vomiting, and paralysis. Chronic overexposure to certain flux compounds may result in silicosis or cancer.

## Fluoride

Flouride compounds are found in the coatings of several types of fluxes.

Exposure may irritate the eyes, nose, and throat. Repeated exposure to high concentrations over a long period may cause fluid in the lungs and bone damage.

**Read the SDS for the metal, solder, flux, rod, wire, and gas being used.**

**Grinding metal or slag can create hazardous dust.**

## Chlorinated Hydrocarbon Solvent

Chlorinated hydrocarbon solvent is used in degreasing or other cleaning operations.

Heat and ultraviolet radiation from arc welding and cutting will decompose the vapors and form highly toxic and irritating phosgene gas. Phosgene reacts with moisture in the lungs to produce hydrogen chloride which can destroy lung tissue. Chlorinated solvents should not be used around welding operations. Keep all solvents at least 200 ft. from the welding work area.

## Carbon Monoxide

The incomplete combustion of fuels while welding and cutting forms carbon monoxide.

The breakdown of carbon dioxide when used as an inert gas shield may also produce carbon monoxide. Carbon monoxide is odorless, colorless, and tasteless. It is a chemical asphyxiant that prevents oxygen from entering the bloodstream, causing suffocation.

## Ozone and Nitrogen Oxide

The ultraviolet light from welding and cutting produces ozone and nitrogen oxide.

These gases can irritate the eyes, nose, and throat. High concentrations can cause fluid in the lungs.

## Thorium

Thorium is used in thoriated tungsten electrodes.

Thorium is a radioactive material that can pose health and environmental risks because of the dust created during grinding of the electrode tip. There is a potential hazard of internal radiation exposure by inhalation or ingestion of the dust. If inhaled, thorium may remain in the lungs for long periods of time.

## Hexavalent Chromium, also known as Chromium 6

When performing hot work on stainless steel or other high-alloy steels containing chromium and/or nickel, hexavalent chromium is formed and may be present in trace amounts when welding some carbon steels. Exposure is greatest in welding processes such as SMAW, FCAW, and GMAW that use flux or electrode wire, or create fumes. TIG welding produces the least amount of fume.

Workplace exposure may cause lung cancer in workers who breathe airborne hexavalent chromium. Irritation or damage to the nose, throat, and lungs can also occur with inhalation. Irritation or damage to the eyes and skin can occur if workers are exposed to high concentrations.

> Inert-gas metal-arc welding on stainless steel is not allowed unless exposed employees are protected either by local exhaust ventilation or by wearing supplied air respirators.

# Physical Agents

## Ultraviolet Radiation

Electric arcs generate ultraviolet radiation (UV).

Exposure can cause burns to the skin and damage to the lenses of the eyes. The intense UV light emitted by the arc can cause inflammation of the cornea, known as arc eye. It is characterized by a sensation of sand in the eyes and may occur with excessive exposure to UV light.

## Infrared Radiation

Infrared radiation is heat produced by the electric arc and gas flame.

Can cause thermal burns of the skin and tissue if protective clothing and a welder's helmet are not worn. Infrared radiation can cause retinal burning and cataracts.

**To avoid electrical shock, de-energize hard-wired equipment before servicing.**

## Intense Visible Light

Bright light produced by welding and cutting is called intense visible light.

At no time should the light be viewed without eye protection; sustained retinal damage may result.

## Electric Shock

Electric shock can cause arc burns, explosions, ventricular fibrillation, and electrocution.

Before servicing hard-wired equipment, turn off input power using the disconnect switch at the fuse box or circuit breaker and lock out/tagout the equipment. Disconnect plug and cord equipment from power source.

Before servicing engine-driven welders, shut down the engine and disconnect cables.

## Electric and Magnetic Field

During the use of spot-welding guns, strong-pulsed magnetic fields occur in the direct vicinity of the welding gun. This is known as electric and magnetic field (EMF).

Use the following procedures to minimize exposure to EMF.

- Route the electrode and work cables together. Secure them together with tape when possible.
- Never coil the electrode lead around the body.
- Do not stand between the electrode and the work cables. If the electrode cable is on the right side, the work cable should also be on the right side.
- Connect the work cable to the work piece as closely as possible to the area being welded.
- Do not work next to the welding power source.

Exposure to EMF may be dangerous.

**To minimize exposure to EMF, do not stand between the electrical and the work cable.**

**Notes**

## Scene 5
# Ventilation

Proper ventilation can be obtained either naturally or mechanically.

Ventilation is affected by:

- Work space volume and configuration
- Number and type of operations generating contaminants
- Welding process and the current used
- Material welded, including paint or plating
- Natural airflow rate where operations are taking place
- Locations of the welders' and other workers' breathing zones in relation to the contaminants or sources of room air
- Consumables used
- Allowable exposure levels for each material used. These levels can be found in the SDS for each product.

**Keep your head out of the fumes.**

**Contact the employer or safety department for questions or concerns about exposure levels, adequate ventilation, and respiratory protection.**

Adequate ventilation should be supplied so that exposure to concentrations of airborne contaminates remains below hazardous levels. Keep the head and breathing zone out of welding fumes, gases, and vapors at all times. Shielding gases used for arc welding can displace air and cause injury or death.

Natural ventilation may be considered sufficient to meet requirements if all of the following conditions are met:

- The room or welding area contains at least 10,000 ft.$^3$ for each welder (for example, an area measuring 25' W × 25' D × 16' H = 10,000 ft.$^3$).
- The ceiling height is 16 ft. or higher.
- Cross-ventilation is not blocked by partitions, equipment, or other structural barriers.
- Welding is not done in a confined space.

Spaces that do not meet all of these requirements should be equipped with mechanical ventilating equipment that exhausts at least 2,000 ft.$^2$ per minute of air for each welder, except when local exhaust hoods, booths, or supplied airline respirators are used (Figure 5.1). Mechanical ventilation using exhaust hoods or booths must provide a minimum air velocity of 100 linear ft. per minute in the welding zone.

Source extraction using fume capture nozzles or suction nozzles positioned near the weld is an effective method of controlling welding fumes.

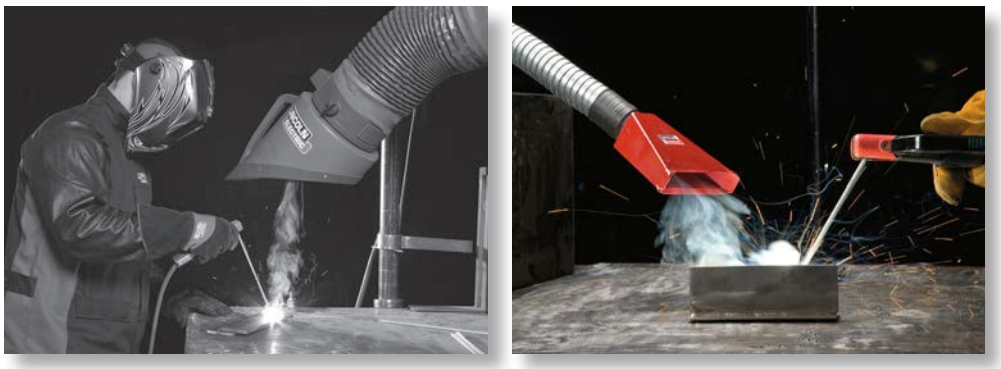


**Figure 5.1.** Fume extraction using (left) low-vacuum and (right) high-vacuum fume extraction.

Scene 6

# Personal Protective Equipment

**Figure 6.1.** If respiratory hazards are not controlled by ventilation, a NIOSH-approved respirator is required.

## Respiratory Protective Equipment

When respiratory hazards cannot be controlled by adequate ventilation, a National Institute of Occupational Safety and Health (NIOSH) approved respirator is required to protect from hazardous fumes, particulates, gases, or vapors (Figure 6.1).

The type of hazard determines the type of respirator needed:

- Filter respirator for fumes and other particulates
- Cartridge respirator for gases and vapors
- Powered air purifying respirator for gases and vapors
- Supplied airline respirator for high concentrations of hazards or oxygen deficient air (below 19.5% oxygen)
- Combination cartridge and filter respirators or supplied airline respirators are available when both fumes and gases are present.

Employers are required to provide the proper respirator for the type of hazard and also provide training in the fit and use of the respirator.

Employees are required to participate in annual fit testing and medical evaluations.

Other workers in the vicinity of the welder may need some level of respiratory protection depending on the exposure levels.

**Proper training is required before use of a respirator is allowed.**

**Safety glasses should be worn with the welding helmet.**

## Personal Protective Equipment

A welding helmet or hand shield with a filter lens must be used for eye protection whenever welding or cutting (Figure 6.2).

Arc rays, which contain harmful ultraviolet and infrared radiation, can burn the eyes and skin. Always wear all appropriate protective clothing and a helmet with the proper filter lens. Be sure any helmet used meets ANSI standards for welding eye protection.

It is very important to use the right filter shade for the type of welding or cutting that is being done (Tables 6.1 and 6.2). The correct filter shade also should be used when soldering and brazing. As a rule of thumb, start with a shade that is too dark, then go to a lighter shade which gives a sufficient view of the weld zone without going below the minimum shade number.

Filter shades range anywhere from #2–#14 (the higher the number, the darker the shade). There also are battery and solar-powered helmets that have an auto-darkening shade that will darken to the correct shade within $^{4}/_{10}$ of a millisecond on contact with intense visible or UV light.

Welding helmets with filter lenses are intended to protect from arc rays and from weld sparks and spatter. They are not intended to protect against slag chips or grinding fragments. Safety glasses with side shields or goggles should be worn also.


**Figure 6.2.** Welding helmets and safety glasses.

**Table 6.1** Welding Lens Shade Selection Guide—Arc Welding

| Operation | Electrode Size X/32 in. (mm) | Arc Current (AMP) | Minimum Shade # | Suggested Shade # (Comfort) |
|---|---|---|---|---|
| Shielded metal arc welding | Less than 3 (2.5) | Less than 60 | 7 | — |
| | 3-5 (2.5-4) | 60–160 | 8 | 10 |
| | 5-8 (4-6.4) | 160–250 | 10 | 12 |
| | More than 8 (6.4) | 250–550 | 11 | 14 |
| Gas metal arc welding and flux cored arc welding | | Less than 60 | 7 | - |
| | | 60–160 | 10 | 11 |
| | | 160–250 | 10 | 12 |
| | | 250–500 | 10 | 14 |
| Gas tungsten arc welding | | Less than 50 | 8 | 10 |
| | | 50–150 | 8 | 12 |
| | | 150–500 | 10 | 14 |
| Air carbon arc cutting | (Light) | Less than 500 | 10 | 12 |
| | (Heavy) | 500–1000 | 11 | 14 |
| Plasma arc welding | | Less than 20 | 6 | 6–8 |
| | | 20–100 | 8 | 10 |
| | | 100–400 | 10 | 12 |
| | | 400–800 | 11 | 14 |
| Plasma arc cutting | (Light) | Less than 300 | 8 | 9 |
| | (Medium) | 300–400 | 9 | 12 |
| | (Heavy) | 400-800 | 10 | 14 |
| Torch brazing | | — | — | 3 or 4 |
| Torch soldering | | — | — | 2 |
| Carbon arc welding | | — | — | 14 |

**Table 6.2** Welding Lens Shade Selection Guide—Oxy-Fuel Welding

| Operation | Plate Thickness | | Suggested Shade # (Comfort) |
|---|---|---|---|
| **Oxy-Fuel Gas Welding** | | | |
| Light | Under 1/8” | Under 3mm | 4 or 5 |
| Medium | 1/8” to 1/2” | 3mm–13mm | 5 or 6 |
| Heavy | Over 1/2” | Over 13mm | 6 or 8 |
| **Oxygen Cutting** | | | |
| Light | Over 1” | Under 35 mm | 3 or 4 |
| Medium | 1” to 6” | 25mm–50mm | 4 or 5 |
| Heavy | Over 6” | Over 150mm | 5 or 6 |

Data from ANSI Z49.1-2005

**Figure 6.3.** Flame-resistant gloves.

**Figure 6.4.**
Welder using PPE.

**Not all gloves are the same. For example, low-current GTAW gloves are not okay for high-current air carbon arc cutting.**

Proper clothing should be worn to protect from ignition burns, radiation burns, hot sparks, and electrical shock.

- All welders must wear appropriate flame-resistant leather or rubber gloves (Figure 6.3).
- Clothing should be either wool or chemically treated, fire-resistant, heavy cotton.
- Do not wear synthetics; they may melt and cause severe burns.
- Wear shirts with long sleeves and no front pockets. Do not wear collars open or sleeves unbuttoned or rolled up.
- Wear pants without cuffs and long enough to overlap shoe tops.
- High-top work boots with solid leather toes are recommended (no stitched toes).
- Leather aprons are recommended (Figure 6.4). Cape sleeves or shoulder covers with bibs made of leather may be necessary during overhead welding and cutting.
- Wear flame-resistant caps under helmets to prevent head burns.
- Wear properly fitted, flame-resistant earplugs or earmuffs to protect from overhead sparks and spatter.
- Wear earplugs or earmuffs when noise exceeds safe levels. Some arc-cutting processes can create noise levels in excess of 115 dBA which may exceed the Cal/OSHA permissible level of 90 dBA (time weighted average for an eight-hour workday).
- Do not carry butane lighters or other combustibles in pant pockets.
- If fall protection is required, wear a harness made of flame-resistant material.

## Protection for Other Workers

It is important to prevent other people from looking at the light generated from an arc welder. Where feasible, welding areas should be isolated from other work areas by partitions or curtains designed to absorb harmful welding rays (Figure 6.5). If it is not possible to shield the work area with partitions, use anti-flash goggles for eye protection when in the welding area. Appropriate signs should be posted.

Persons near the welding areas also must be protected from radiant energy and spatter from welding and cutting. This can be done by the use of flame-resistant shields or screens, or by providing proper eye and face protection and requiring the wearing of appropriate protective clothing.

**Protect other workers from the arc light, heat, and spatter.**

**Figure 6.5.** Welding area isolated by a tinted curtain, designed to absorb welding rays.

**Notes**

## Scene 7

# Working in Confined Spaces

When working in any confined space, the employer's confined space guidelines must be followed.

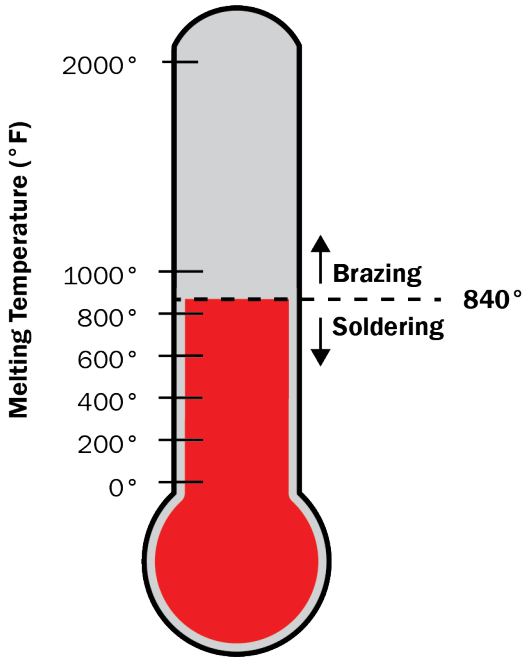
These guidelines may require testing of the air for hazards, providing adequate ventilation, and monitoring by a supervisor or a safety attendant. A hazardous atmosphere caused by the presence of hazardous gases or vapors or lack of oxygen is the leading cause of death in confined space accidents.

It is possible to create a hazardous atmosphere by the type of work performed in the confined space. Work with extreme caution when welding and cutting in a confined space.

- Get permission from the employer before welding in a confined space.
- Keep gas cylinders—oxygen, acetylene, or inert gases—outside of the confined space.
- Arc welding power sources should remain outside of the confined space.

**Check with the employer or safety department for confined space guidelines and training and permit requirements.**

**Notes**




## Scene 8

# Brazing and Soldering

Welding melts and mixes metal to join two parts into one single piece, most often using a welding rod or wire as a filler material.

Brazing differs from welding in that the base metal is not melted. Instead, the metal is bonded together using a filler metal that melts at a temperature lower than the melting point of the base metal.

Brazing is commonly used when joining dissimilar metals. When done properly, brazed joints are often stronger than the two metals being bonded together.

Soldering is similar to the brazing process, but the filler metal melts at a much lower temperature than in brazing. Due to the lower temperature, a soldered joint is not as strong as a brazed one.

**Do not breathe fumes from brazing or soldering.**

## Melting Points

- If the melting point of the filler metal is above 840° F, the term **brazing** is used.
- If the melting point of the filler metal is below 840° F, the term **soldering** is used.

## Safety Precautions

The same safety precautions used for welding and cutting should be followed when brazing or soldering, including fire prevention procedures, protection from health and physical hazards, use of proper ventilation, and use of the appropriate PPE.

# Scene 9
# Summary

Before doing any welding or cutting always protect, inspect, ask.

## Protect

- Protect yourself and others at all times when welding or cutting.
- Protect yourself from arc rays and heat rays that can injure the eyes and burn the skin.
- Wear the proper PPE to protect the body, eyes, ears, and lungs.
- Do not breathe hazardous fumes and gases.
- Wear the correct type of respirator for the hazard.
- Use proper ventilation or exhaust to keep fumes and gases out of the breathing zone.
- Read the SDS for the metals, solders, fluxes, rods, wires, and gases used.
- Do not touch live electrical parts or metal energized by the arc.
- Remove regulators, close valves, and keep valve caps on compressed gas cylinders when not in use.
- Read and follow manufacturer's instructions.

**Contact a supervisor or the safety department for guidance.**

## Inspect

- Inspect equipment before each use.
- Confirm that the arc welder is grounded properly and working properly before beginning work.
- Check the regulator and pressure gauge, and confirm both are correct for the gas being used.

## Ask

- Has training been completed for the equipment and the type of welding or cutting to be done?
- Has anyone contacted the employer's safety department for specific safety guidelines?
- Is a hot-work permit or a fire watch needed?
- Is the welding area fire safe?
- Are the employer's safety procedures followed at all times?

By following all safety regulations and guidelines, the risks associated with welding and cutting are reduced.

**Remember**…each welding and cutting procedure has the possibility of creating unique work situations where additional regulations may apply and other safeguards may be required.

## Appendix A

# Regulations

Listed below are some of the safety standards that are applicable to welding and cutting.

### California Code of Regulations – Title 8

#### General Industry Safety Orders

§3382. Eye and Face Protection.

§4649. Construction and Marking of Cylinders.

§4650. Storage, Handling, and Use of Cylinders.

§4794. Purpose.

§4795. Definitions.

§4797. Approval and Markings.

§4799. Training of Operators and Instruction.

§4838. Pressure Regulators.

§4839. Hose.

§4845. General Precautions.

§4848. Fire Prevention and Suppression Procedure.

§4850. General. Electrical Welding, Cutting, and Heating.

§4851. Arc Welding and Cutting.

§4852. Resistance Welding.

§4853. Inert-Gas Metal-Arc Welding.

§5150. Ventilation and Personal Protective Equipment Requirements for Welding, Brazing and Cutting.

§5166. Cleaning, Repairing, or Altering Containers.

§5550. Repairs to Equipment. Hot Work.

#### Construction Safety Orders:

§1536. Ventilation Requirements for Welding, Brazing, and Cutting.

§1537. Welding, Cutting, and Heating of Coated Metals.

§1740. Storage and Use of Cylinders.

§1741. Pressure Regulators.

§1742. Hose and Connections.

§1743. General Precautions. Oxygen, Acetylene, and Fuel Gas.

**Electrical Safety Orders:**

§2563.22. Overcurrent Protection.

§2563.23. Disconnecting Means–Arc Welding.

§2563.33. Disconnecting Means–Resistance Welding.

## Federal OSHA Regulations

29 CFR 1910 Subpart Q – Welding, Cutting, and Brazing

29 CFR §1910.251 – Definitions.

29 CFR §1910.252 – General requirements.

29 CFR §1910.253 – Oxygen-fuel gas welding and cutting.

29 CFR §1910.254 – Arc welding and cutting.

29 CFR §1910.255 – Resistance welding

29 CFR 1926 Subpart J – Welding and Cutting

29 CFR §1926.350 – Gas welding and cutting.

29 CFR §1926.351 – Arc welding and cutting.

29 CFR §1926.352 – Fire prevention.

29 CFR §1926.353 – Ventilation and protection in welding, cutting, and heating.

29 CFR §1926.354 – Welding, cutting, and heating in way of preservative coatings

49 CFR Part 178 Subpart C – Specifications for Cylinders

## ANSI Z49.1

Safety in Welding, Cutting, and Allied Processes

## Appendix B

# Lincoln Electric Arc Welding Safety

**SUPPLEMENT 4**

## ⚠ WARNING

**⚠ CALIFORNIA PROPOSITION 65 WARNINGS ⚠**

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

The Above For Diesel Engines

The engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm.

The Above For Gasoline Engines

**ARC WELDING CAN BE HAZARDOUS. PROTECT YOURSELF AND OTHERS FROM POSSIBLE SERIOUS INJURY OR DEATH. KEEP CHILDREN AWAY. PACEMAKER WEARERS SHOULD CONSULT WITH THEIR DOCTOR BEFORE OPERATING.**

Read and understand the following safety highlights. For additional safety information, it is strongly recommended that you purchase a copy of "Safety in Welding & Cutting - ANSI Standard Z49.1" from the American Welding Society, P.O. Box 351040, Miami, Florida 33135 or CSA Standard W117.2-1974. A Free copy of "Arc Welding Safety" booklet E205 is available from the Lincoln Electric Company, 22801 St. Clair Avenue, Cleveland, Ohio 44117-1199.

**BE SURE THAT ALL INSTALLATION, OPERATION, MAINTENANCE AND REPAIR PROCEDURES ARE PERFORMED ONLY BY QUALIFIED INDIVIDUALS.**

### FOR ENGINE powered equipment.

1.a. Turn the engine off before troubleshooting and maintenance work unless the maintenance work requires it to be running.

1.b. Operate engines in open, well-ventilated areas or vent the engine exhaust fumes outdoors.

1.c. Do not add the fuel near an open flame welding arc or when the engine is running. Stop the engine and allow it to cool before refueling to prevent spilled fuel from vaporizing on contact with hot engine parts and igniting. Do not spill fuel when filling tank. If fuel is spilled, wipe it up and do not start engine until fumes have been eliminated.

1.d. Keep all equipment safety guards, covers and devices in position and in good repair.Keep hands, hair, clothing and tools away from V-belts, gears, fans and all other moving parts when starting, operating or repairing equipment.

1.e. In some cases it may be necessary to remove safety guards to perform required maintenance. Remove guards only when necessary and replace them when the maintenance requiring their removal is complete. Always use the greatest care when working near moving parts.

1.f. Do not put your hands near the engine fan. Do not attempt to override the governor or idler by pushing on the throttle control rods while the engine is running.

1.g. To prevent accidentally starting gasoline engines while turning the engine or welding generator during maintenance work, disconnect the spark plug wires, distributor cap or magneto wire as appropriate.

1.h. To avoid scalding, do not remove the radiator pressure cap when the engine is hot.

### ELECTRIC AND MAGNETIC FIELDS may be dangerous

2.a. Electric current flowing through any conductor causes localized Electric and Magnetic Fields (EMF). Welding current creates EMF fields around welding cables and welding machines

2.b. EMF fields may interfere with some pacemakers, and welders having a pacemaker should consult their physician before welding.

2.c. Exposure to EMF fields in welding may have other health effects which are now not known.

2.d. All welders should use the following procedures in order to minimize exposure to EMF fields from the welding circuit:

2.d.1. Route the electrode and work cables together - Secure them with tape when possible.

2.d.2. Never coil the electrode lead around your body.

2.d.3. Do not place your body between the electrode and work cables. If the electrode cable is on your right side, the work cable should also be on your right side.

2.d.4. Connect the work cable to the workpiece as close as possible to the area being welded.

2.d.5. Do not work next to welding power source.

## ELECTRIC SHOCK can kill.

3.a. The electrode and work (or ground) circuits are electrically "hot" when the welder is on. Do not touch these "hot" parts with your bare skin or wet clothing. Wear dry, hole-free gloves to insulate hands.

3.b. Insulate yourself from work and ground using dry insulation. Make certain the insulation is large enough to cover your full area of physical contact with work and ground.

**In addition to the normal safety precautions, if welding must be performed under electrically hazardous conditions (in damp locations or while wearing wet clothing; on metal structures such as floors, gratings or scaffolds; when in cramped positions such as sitting, kneeling or lying, if there is a high risk of unavoidable or accidental contact with the workpiece or ground) use the following equipment:**

- **Semiautomatic DC Constant Voltage (Wire) Welder.**
- **DC Manual (Stick) Welder.**
- **AC Welder with Reduced Voltage Control.**

3.c. In semiautomatic or automatic wire welding, the electrode, electrode reel, welding head, nozzle or semiautomatic welding gun are also electrically "hot".

3.d. Always be sure the work cable makes a good electrical connection with the metal being welded. The connection should be as close as possible to the area being welded.

3.e. Ground the work or metal to be welded to a good electrical (earth) ground.

3.f. Maintain the electrode holder, work clamp, welding cable and welding machine in good, safe operating condition. Replace damaged insulation.

3.g. Never dip the electrode in water for cooling.

3.h. Never simultaneously touch electrically "hot" parts of electrode holders connected to two welders because voltage between the two can be the total of the open circuit voltage of both welders.

3.i. When working above floor level, use a safety belt to protect yourself from a fall should you get a shock.

3.j. Also see Items 6.c. and 8.

## ARC RAYS can burn.

4.a. Use a shield with the proper filter and cover plates to protect your eyes from sparks and the rays of the arc when welding or observing open arc welding. Headshield and filter lens should conform to ANSI Z87. I standards.

4.b. Use suitable clothing made from durable flame-resistant material to protect your skin and that of your helpers from the arc rays.

4.c. Protect other nearby personnel with suitable, non-flammable screening and/or warn them not to watch the arc nor expose themselves to the arc rays or to hot spatter or metal.

## FUMES AND GASES can be dangerous.

5.a. Welding may produce fumes and gases hazardous to health. Avoid breathing these fumes and gases. When welding, keep your head out of the fume. Use enough ventilation and/or exhaust at the arc to keep fumes and gases away from the breathing zone. **When welding with electrodes which require special ventilation such as stainless or hard facing (see instructions on container or MSDS) or on lead or cadmium plated steel and other metals or coatings which produce highly toxic fumes, keep exposure as low as possible and below Threshold Limit Values (TLV) using local exhaust or mechanical ventilation. In confined spaces or in some circumstances, outdoors, a respirator may be required. Additional precautions are also required when welding on galvanized steel.**

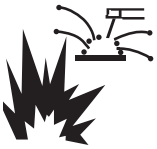
5. b. The operation of welding fume control equipment is affected by various factors including proper use and positioning of the equipment, maintenance of the equipment and the specific welding procedure and application involved. Worker exposure level should be checked upon installation and periodically thereafter to be certain it is within applicable OSHA PEL and ACGIH TLV limits.

5.c. Do not weld in locations near chlorinated hydrocarbon vapors coming from degreasing, cleaning or spraying operations. The heat and rays of the arc can react with solvent vapors to form phosgene, a highly toxic gas, and other irritating products.

5.d. Shielding gases used for arc welding can displace air and cause injury or death. Always use enough ventilation, especially in confined areas, to insure breathing air is safe.

5.e. Read and understand the manufacturer's instructions for this equipment and the consumables to be used, including the material safety data sheet (MSDS) and follow your employer's safety practices. MSDS forms are available from your welding distributor or from the manufacturer.

5.f. Also see item 1.b.



## WELDING and CUTTING SPARKS can cause fire or explosion.

6.a. Remove fire hazards from the welding area. If this is not possible, cover them to prevent the welding sparks from starting a fire. Remember that welding sparks and hot materials from welding can easily go through small cracks and openings to adjacent areas. Avoid welding near hydraulic lines. Have a fire extinguisher readily available.

6.b. Where compressed gases are to be used at the job site, special precautions should be used to prevent hazardous situations. Refer to "Safety in Welding and Cutting" (ANSI Standard Z49.1) and the operating information for the equipment being used.

6.c. When not welding, make certain no part of the electrode circuit is touching the work or ground. Accidental contact can cause overheating and create a fire hazard.

6.d. Do not heat, cut or weld tanks, drums or containers until the proper steps have been taken to insure that such procedures will not cause flammable or toxic vapors from substances inside. They can cause an explosion even though they have been "cleaned". For information, purchase "Recommended Safe Practices for the Preparation for Welding and Cutting of Containers and Piping That Have Held Hazardous Substances", AWS F4.1 from the American Welding Society (see address above).

6.e. Vent hollow castings or containers before heating, cutting or welding. They may explode.

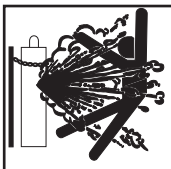
6.f. Sparks and spatter are thrown from the welding arc. Wear oil free protective garments such as leather gloves, heavy shirt, cuffless trousers, high shoes and a cap over your hair. Wear ear plugs when welding out of position or in confined places. Always wear safety glasses with side shields when in a welding area.

6.g. Connect the work cable to the work as close to the welding area as practical. Work cables connected to the building framework or other locations away from the welding area increase the possibility of the welding current passing through lifting chains, crane cables or other alternate circuits. This can create fire hazards or overheat lifting chains or cables until they fail.

6.h. Also see item 1.c.

6.I. Read and folllow NFPA 51B " Standard for Fire Prevention During Welding, Cutting and Other Hot Work", available from NFPA, 1 Batterymarch Park,PO box 9101, Quincy, Ma 022690-9101.

6.j. Do not use a welding power source for pipe thawing.



## CYLINDER may explode if damaged.

7.a. Use only compressed gas cylinders containing the correct shielding gas for the process used and properly operating regulators designed for the gas and pressure used. All hoses, fittings, etc. should be suitable for the application and maintained in good condition.

7.b. Always keep cylinders in an upright position securely chained to an undercarriage or fixed support.

7.c. Cylinders should be located:

- Away from areas where they may be struck or subjected to physical damage.
- A safe distance from arc welding or cutting operations and any other source of heat, sparks, or flame.

7.d. Never allow the electrode, electrode holder or any other electrically "hot" parts to touch a cylinder.

7.e. Keep your head and face away from the cylinder valve outlet when opening the cylinder valve.

7.f. Valve protection caps should always be in place and hand tight except when the cylinder is in use or connected for use.

7.g. Read and follow the instructions on compressed gas cylinders, associated equipment, and CGA publication P-l, "Precautions for Safe Handling of Compressed Gases in Cylinders," available from the Compressed Gas Association 1235 Jefferson Davis Highway, Arlington, VA 22202.

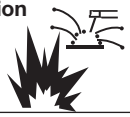
## FOR ELECTRICALLY powered equipment.

8.a. Turn off input power using the disconnect switch at the fuse box before working on the equipment.

8.b. Install equipment in accordance with the U.S. National Electrical Code, all local codes and the manufacturer's recommendations.

8.c. Ground the equipment in accordance with the U.S. National Electrical Code and the manufacturer's recommendations.

## Supplement 7: Welding Safety Checklist

| *WELDING SAFETY CHECKLIST* | | |
|---|---|---|
| **HAZARD** | **FACTORS TO CONSIDER** | **PRECAUTION SUMMARY** |
| **Electric shock can kill**  | • **Wetness**<br>• **Welder in or on workpiece**<br>• **Confined space**<br>• **Electrode holder and cable insulation** | • Insulate welder from workpiece and ground using *dry* insulation. Rubber mat or dry wood.<br>• Wear *dry, hole-free* gloves. (Change as necessary to keep dry.)<br>• Do not touch electrically "hot" parts or electrode with bare skin or wet clothing.<br>• If wet area and welder cannot be insulated from workpiece with dry insulation, use a semiautomatic, constant-voltage welder or stick welder with voltage reducing device.<br>• Keep electrode holder and cable insulation in good condition. Do not use if insulation damaged or missing. |
| **Fumes and gases can be dangerous**  | • **Confined area**<br>• **Positioning of welder's head**<br>• **Lack of general ventilation**<br>• **Electrode types, i.e., manganese, chromium, etc. See MSDS**<br>• **Base metal coatings, galvanize, paint** | • Use ventilation or exhaust to keep air breathing zone clear, comfortable.<br>• Use helmet and positioning of head to minimize fume in breathing zone.<br>• Read warnings on electrode container and material safety data sheet (MSDS) for electrode,<br>• Provide additional ventilation/exhaust where special ventilation requirements exist.<br>• Use special care when welding in a confined area.<br>• Do not weld unless ventilation is adequate. |
| **Welding sparks can cause fire or explosion**  | • **Containers which have held combustibles**<br>• **Flammable materials** | • Do not weld on containers which have held combustible materials (unless strict AWS F4.1 procedures are followed). Check before welding.<br>• Remove flammable materials from welding area or shield from sparks, heat.<br>• Keep a fire watch in area during and after welding.<br>• Keep a fire extinguisher in the welding area.<br>• Wear fire retardant clothing and hat. Use earplugs when welding overhead. |
| **Arc rays can burn eyes and skin**  | • **Process: gas-shielded arc most severe** | • Select a filter lens which is comfortable for you while welding.<br>• Always use helmet when welding.<br>• Provide non-flammable shielding to protect others.<br>• Wear clothing which protects skin while welding. |
| **Confined space**  | • **Metal enclosure**<br>• **Wetness**<br>• **Restricted entry**<br>• **Heavier than air gas**<br>• **Welder inside or on workpiece** | • Carefully evaluate adequacy of ventilation especially where electrode requires special ventilation or where gas may displace breathing air.<br>• If basic electric shock precautions cannot be followed to insulate welder from work and electrode, use semiautomatic, constant-voltage equipment with cold electrode or stick welder with voltage reducing device.<br>• Provide welder helper and method of welder retrieval from outside enclosure. |
| **General work area hazards**    | • **Cluttered area** | • Keep cables, materials, tools neatly organized. |
| | • **Indirect work (welding ground) connection** | • Connect work cable as close as possible to area where welding is being performed. Do *not* allow alternate circuits through scaffold cables, hoist chains, ground leads. |
| | • **Electrical equipment** | • Use only double insulated or properly grounded equipment.<br>• Always disconnect power to equipment before servicing. |
| | • **Engine-driven equipment** | • Use in only open, well ventilated areas.<br>• Keep enclosure complete and guards in place.<br>• See Lincoln service shop if guards are missing.<br>• Refuel with engine off.<br>• If using auxiliary power, OSHA may require GFI protection or assured grounding program (or isolated windings if less than 5KW). |
| | • **Gas cylinders** | • Never touch cylinder with the electrode.<br>• Never lift a machine with cylinder attached.<br>• Keep cylinder upright and chained to support. |

# Industry Safety Resources

## Safety Bulletins

Safety Bulletins are researched, written, and distributed by the Industry Wide Labor-Management Safety Committee for use by the motion picture and television industry. The Industry Wide Labor-Management Safety Committee is composed of Guild, Union, and Management representatives active in industry safety and health programs.

These Safety Bulletins are guidelines recommended by the Safety Committee. They are not binding laws or regulations. State, federal, and/or local regulations, where applicable, override these guidelines. Modifications in these guidelines should be made, as circumstances warrant, to ensure the safety of the cast and crew.

The Committee and these Safety Bulletins are representative of the commitment of both Labor and Management to safe practices in the motion picture and television industry. The members of the Committee and all those who contributed to its work have devoted a great deal of time and effort to these guidelines because of the importance of safety to our industry.

Current safety bulletins are available on the CSATF website:

**http://www.csatf.org/bulletintro.shtml**

## 24-Hour Industry Safety Hotline

The 24-hour industry safety hotline number directs callers to an automated system that will assist them in reaching the desired Studio Safety Hotline.

**888-7-SAFELY**

A list of the Studio Safety Hotlines can also be found on the CSATF website:

**http://www.csatf.org/studio_safety_hotlines.pdf**

**Safety is everyone's responsibility.**