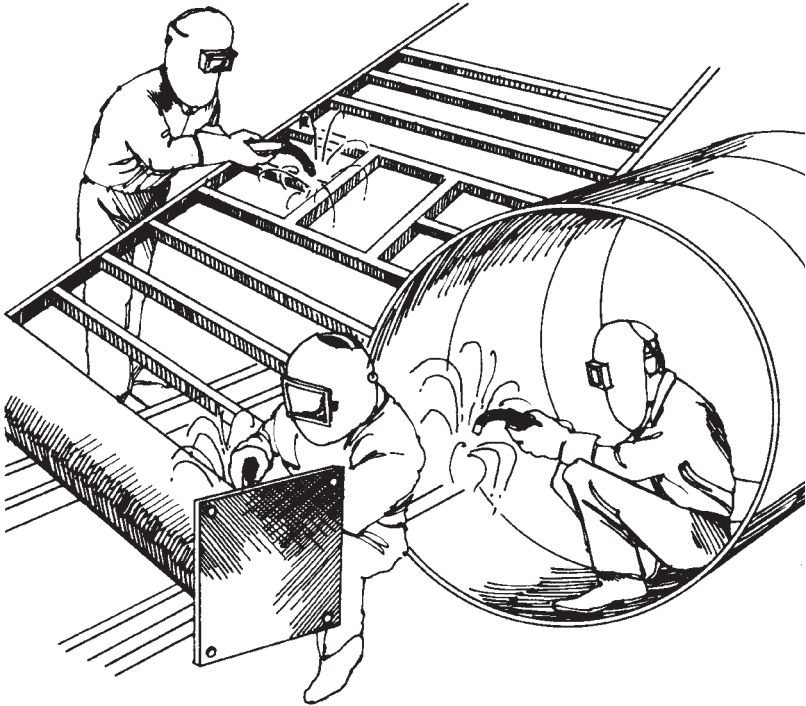




WARNING

**Protect yourself and others.
Read and understand this booklet.**

**F-52-529
December, 2009**



**Precautions and Safe Practices
for**

ARC WELDING, CUTTING & GOUGING

Be sure this information reaches the operator.

Keep this booklet available for reference at all times. You can get extra copies through your supplier.



ESAB Welding &
Cutting Products

FOREWORD

The "Occupational Safety and Health Act of 1970" (OSHA) was enacted "to assure safe and healthful working conditions for working men and women..."

As duties under Section 5 of this Act, each employer shall;

1. Furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees.
2. Comply with occupational safety and health standards promulgated under this act.

Each **employee** shall comply with occupational safety and health standards and all rules, regulations, and orders issued pursuant to this Act which are applicable to his own actions and conduct.

This booklet provides employers and employees with safety and health information on electric welding products and processes. If an employee has language difficulties or cannot be expected to read and understand this booklet, the employer should provide additional training and help to the individual.

Precautions and safe practices outlined in this booklet cover arc welding and cutting processes such as the following:






1. Gas metal arc welding (GMAW), commonly known as "MIG" welding
2. Gas tungsten arc welding (GTAW), commonly referred to as "TIG" welding
3. Shielded metal arc welding (SMAW), commonly called "stick" welding
4. Submerged arc welding (SAW)
5. Air carbon arc gouging and cutting (AAC)
6. Flux cored wire welding (FCAW)
7. Plasma arc welding (PAW)
8. Plasma arc cutting (PAC)
9. Plasma arc gouging (PAG)

This booklet contains guidelines on the safe handling and operation of electric welding and cutting equipment. The American Welding Society and the American National Standards Institute also publish specifications and standards on welding and cutting safety. You should be familiar with the information in this booklet as well as "Safety in Welding and Cutting" - ANSI Z49.1, which is published by the American Welding Society, P.O. Box 351040, Miami, Florida, 33135. Material Safety Data Sheets (MSDS's) on various products, such as rods, wires, and fluxes also provide helpful safety and health information.

In addition, you should also read the manufacturers' operating instructions for the apparatus you use. You should be familiar with the proper operation of all equipment before you start to work. ALWAYS READ AND UNDERSTAND THE MANUFACTURER'S OPERATING INSTRUCTIONS AND YOUR EMPLOYER'S SAFETY PRACTICES BEFORE OPERATING AND MAINTAINING ELECTRIC WELDING AND CUTTING EQUIPMENT.

-Also-

ALWAYS READ AND UNDERSTAND ALL PRECAUTIONARY LABELS AND INSTRUCTIONS BEFORE USING EQUIPMENT OR MATERIALS. A typical precautionary label is shown below. This booklet supplements information on the label.

PROTECT YOURSELF AND OTHERS.	⚠ WARNING ⚠	DO NOT REMOVE, DESTROY OR COVER THIS LABEL.
ARC WELDING AND CUTTING can be hazardous. <ul style="list-style-type: none"> ● Read and understand this label and the instruction manual before installing and operating this unit. 	<ul style="list-style-type: none"> ● Only qualified persons are to install, use or service this equipment according to applicable codes and safety practices. ● Keep children away. ● Pacemaker wearers keep away. 	
 ELECTRIC SHOCK can kill. <ul style="list-style-type: none"> ● Always wear dry insulating gloves. ● Insulate yourself from work and ground. ● Connect work lead to workpiece. ● Do NOT touch live electrical parts. ● Disconnect input power before servicing unit. ● Keep all panels and covers securely in place. ● Replace all damaged insulating parts. ● Turn off power source before working on torch. ● Welding wire and drive parts may be at welding voltage. 	 FUMES AND GASES can be hazardous to your health. <ul style="list-style-type: none"> ● Keep your head out of the fumes. ● Ventilate area or use breathing device. ● Read Material Safety Data Sheet (MSDS) and manufacturer's instructions for material used. 	
 WELDING OR CUTTING can cause fire or explosion. <ul style="list-style-type: none"> ● Do NOT weld or cut near flammable material. ● Watch for fire; keep extinguisher nearby. ● Do NOT weld or cut on closed containers. ● Do NOT place unit on combustible surface. 	 ARC RAYS can burn eyes and skin; NOISE can damage hearing. <ul style="list-style-type: none"> ● Wear welding helmet with correct filter. ● Wear eye, ear and body protection. 	
	 ARC CUTTING can cause injury. <ul style="list-style-type: none"> ● Keep away from torch tip. ● Keep away from cutting path. ● Turn off power source before working on torch. ● Install shield cup before operating torch. ● Use torch(es) specified in instruction manual. 	
<small>Follow your employer's safety practices and read American National Standard Z49.1, "Safety in Welding and Cutting", from American Welding Society, 550 N.W. LaJunction Rd., Miami, FL 33126; OSHA Safety and Health Standards, 29 CFR 1910, from U.S. Government Printing Office, Washington, D.C. 20462; Canadian Standards Association W117.2 "Code for Safety in Welding and Cutting".</small>		
PROTEJASE UD Y PROTEJA A LOS DEMAS.	⚠ ADVERTENCIA ⚠	NO REMUEVA, DESTRUYA, O CUBRA ESTA CALCOMANIA.
<ul style="list-style-type: none"> ● La soldadura y corte pueden ser perjudiciales. ● Las descargas electricas pueden matar. ● La soldadura y corte pueden causar fuego y explosiones. 	<ul style="list-style-type: none"> ● Gases y humo son perjudiciales a la salud. ● Los rayos del arco pueden quemar los ojos y la piel, el ruido puede causar problemas de audicion. ● El corte con arco puede causar dafio a su persona. 	
SOUDAGE A L'ARC peut etre hasardeux.	⚠ AVERTISSEMENT ⚠	COUPAGE A L'ARC PLASMA peut etre hasardeux.
<ul style="list-style-type: none"> ● Lire le manuel d'instructions avant utilisation. ● Ne pas installer sur une surface combustible. ● Les fils de soudage et pieces conductrices peuvent etre a la tension de soudage. ● Couper l'alimentation avant la depose du chalumeau. 	<ul style="list-style-type: none"> ● Utiliser les torches specifiees dans le manuel d'instructions. ● Avant d'utiliser le chalumeau s'assurer que l'ecran de protection est en place. ● Installation et raccordement de cette machine doivent etre conformes a tous les codes pertinents. 	<small>P/N 2091514-L 11/84</small>

This booklet is intended for beginners and skilled operators. The Appendix, which discusses the health hazards, is intended for use by persons trained in first aid, as well as medical professionals. It will help you do the best job possible. Additional copies of this booklet (F-52-529) may be obtained from your nearest distributor.

For safety and health information covering oxy-fuel gas operations, obtain a copy of Form 2035, "Precautions and Safe Practices for Gas Welding, Cutting, and Heating".

Additional safety information, including material on video cassettes, is developed from time to time as well.

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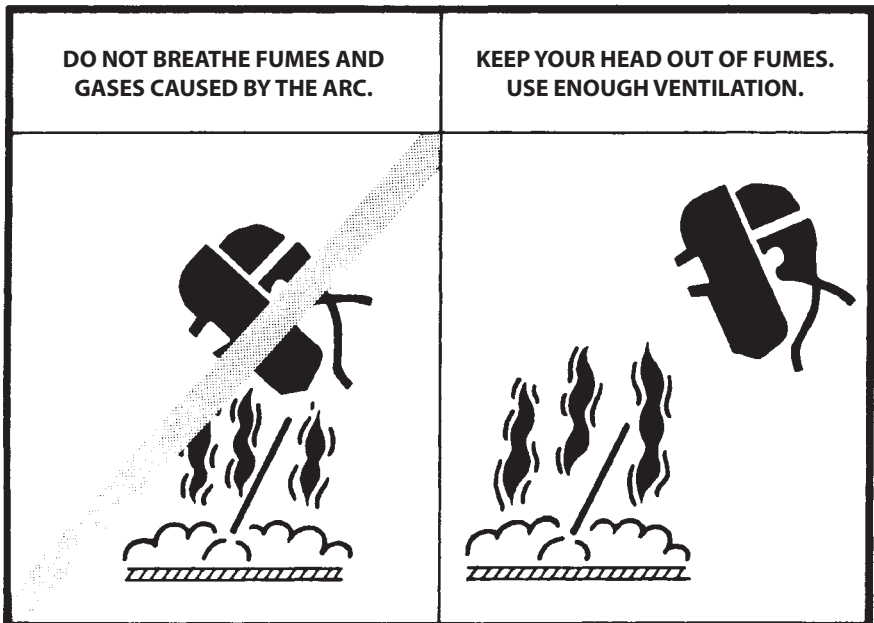
DESCRIPTION OF MAJOR HAZARDS AND PRECAUTIONS



FUMES and GASES can be hazardous to your health.

Keep your head out of the fumes. Do not breathe fumes and gases caused by the arc. Use enough ventilation. The type and the amount of fumes and gases depend on the equipment and supplies used. Air samples can be used to find out what respiratory protection is needed.

Provide enough ventilation wherever welding and cutting are performed. Proper ventilation will protect the operator from the evolving noxious fumes and gases. The degree and type of ventilation will depend on the specific welding and cutting operation. It varies with the size of work area; on the number of operators; and on the types of materials to be welded or cut. Potentially hazardous materials may exist in certain fluxes, coatings, and filler metals. They can be released into (lie atmosphere during welding and cutting. In some cases, general natural-draft ventilation may be adequate. Other operations may require forced-draft ventilation, local exhaust hoods or booths, or personal filter respirators or air-supplied masks. Welding inside tanks, boilers, or other confined spaces require special procedures, such as the use of an air supplied hood or hose mask.



Check the welding atmosphere and ventilation system if workers develop unusual symptoms or complaints. Measurements may be needed to determine whether adequate ventilation is being provided. A qualified person, such as an industrial hygienist, should survey the welding operations and environment. Follow their recommendations for improving the ventilation of the work area.

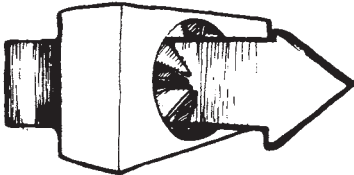
Do not weld on dirty plate or plate contaminated with unknown material. The fumes and gases which are formed could be hazardous to your health. Remove all paint and galvanized coatings before welding. All fumes and gases should be considered as potentially hazardous.

Do not weld near vapor degreasers or on metal that has been just degreased. The decomposition of chlorinated hydrocarbons used in vapor degreasers can form into a poisonous gas.

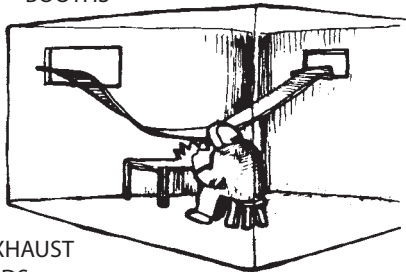
Additional information on various fumes and gases that can harm your health is located in the Appendix of this booklet. More complete information on health protection and ventilation recommendations for general welding and cutting can be found in the American National Standard Z49.1, "Safety in Welding and Cutting".

TYPICAL METHODS FOR VENTILATION AND RESPIRATORY PROTECTION.

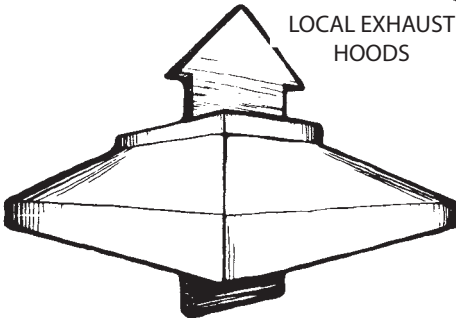
FORCED DRAFT VENTILATION



BOOTHS



LOCAL EXHAUST HOODS



AIR SUPPLIED MASK





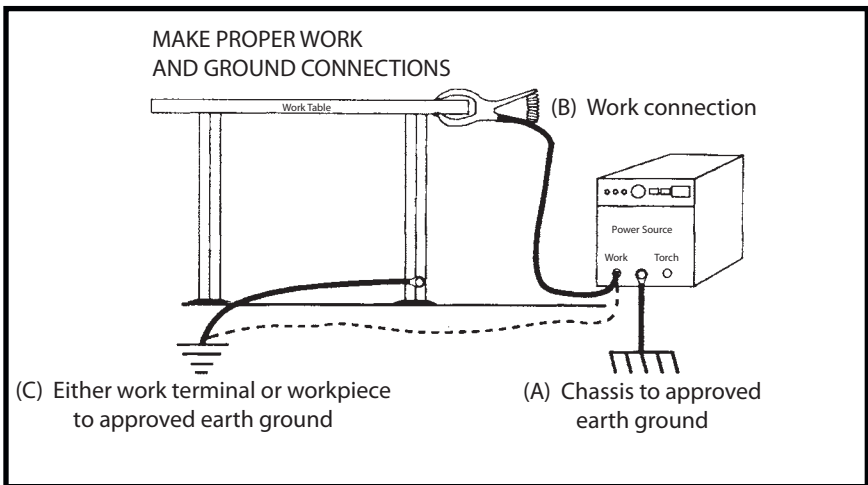
ELECTRIC SHOCK can kill you.

Do not touch live electrical parts.

Live electrical parts can include the power supply, the power and work cables, the torch and the work itself (if the work is not connected to earth ground.)

Electric shock can be avoided. Follow the recommended practices listed below. Faulty installation, improper grounding, and incorrect operation and maintenance of electrical equipment are always sources of danger.

1. **Connect electrical equipment and workpiece correctly.** Prevent electrical shock. (A.) Connect power supply and control cabinet chassis to approved earth ground. (B.) Connect workpiece to “work” output connection of power supply. (C.) Connect workpiece (as illustrated below) OR power supply work terminal (but not both) to approved earth ground. “Double-grounding” can cause welding/cutting current to occur in conductors intended only for safety grounding and can result in destruction of the safety ground. **NOTE: The work lead is NOT a ground lead; the work lead is to be used only to complete the welding circuit.**



2. **Make good electrical connections of the work lead to the power supply work terminal and to the workpiece.** A missing or poorly-connected work lead can cause a fatal shock. Make sure the work lead is always in good condition.
3. **Use the correct cable size.** Sustained overloading will cause cable failure and result in possible electrical shock or fire hazard. Work cable should be the same rating as the torch cable.

4. **Make sure all electrical connections are tight, clean, and dry.** Poor electrical connections can heat up, and even melt. They can also cause bad welds and produce dangerous arcs and sparks. Do not try to make an electrical connection through paint. Do not allow water, grease, or dirt to accumulate on plugs, sockets, or electrical units.
5. **Insulate yourself from workpiece and ground.** Moisture and water can conduct electricity. To prevent shock, it is advisable to keep work areas, equipment, and clothing dry at all times. Fix water leaks immediately. Keep hoses from touching hot metal. Do not exceed recommended water pressures. Make sure that you are well insulated. Wear dry insulated gloves, rubber-soled shoes, or stand on a dry board or platform.
6. **Use only the proper equipment if welding must be done in electrically-hazardous conditions.** Such conditions include damp or warm locations, wet clothing, metal structures such as floors or scaffolds, cramped positions or wherever there is a high risk of contact with workpiece or ground. In any of these situations use:
 - * DC MIG welding
 - * DC manual (stick electrode) welding
 - * AC welder with reduced open-circuit voltage control
7. **Keep cables and connectors in good condition.** Improper or worn electrical connections can increase the chance of an electrical shock. Do not use worn, damaged or bare cables.
8. **Avoid open-circuit voltage.** Open circuit voltage of welding, cutting and gouging power supplies can cause electric shock. When several welders are working with arcs of different polarities, or when using multiple alternating current machines, the open-circuit voltages can be additive. The added voltages increase the severity of the shock hazard.
9. **Remove metal jewelry.** It is recommended that rings, watches, necklaces, and other metallic items be removed before welding or cutting. Accidental contact of jewelry with welding power can cause metal to become hot or even melt. It can also increase the possibility of a fatal shock.
10. **Follow recognized safety standards.** Follow the recommendations in American National Standard Z49.1, "Safety in Welding and Cutting," available from the American Welding Society, P. O. Box 351040, Miami, FL 33135, and also the National Electrical Code, NFPA No. 70, which is available from the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.



ARC RAYS and SPATTER can injure eyes and burn skin.

Wear correct eye, ear, and body protection.

Electric arcs emit both ultraviolet and infrared rays. They can bum eyes and skin the same way as strong sunlight. However, it can happen a lot faster and with greater intensity. Operators and others in the welding area may receive eye and skin bums after brief exposures to arc rays. Reddening of the skin by ultraviolet rays becomes apparent seven or eight hours later. Long exposures may cause severe skin bum. Eyes may be severely burned by both ultraviolet and infrared rays. Hot welding spatter can cause painful skin bums and permanent eye damage.

To be sure you are fully protected from arc radiation and spatter, follow these precautions:

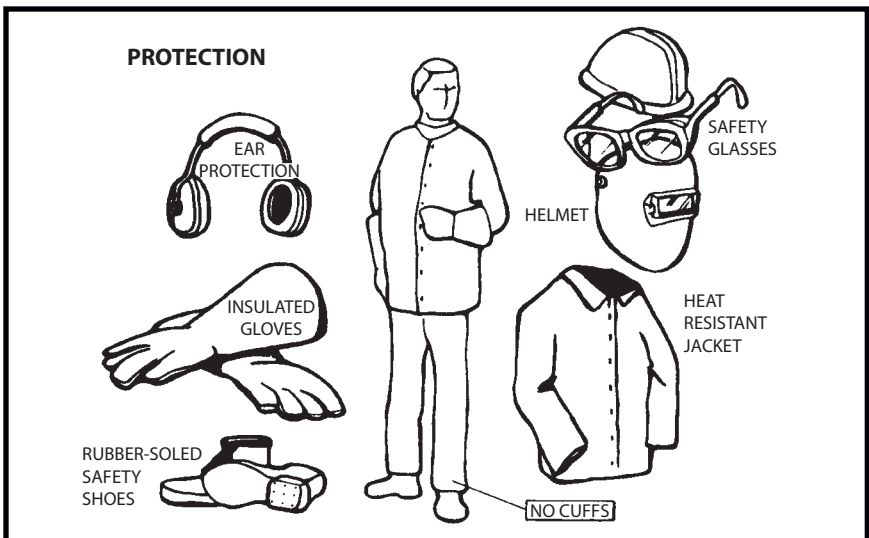
1. **Cover all skin surfaces and wear safety glasses with side shields for protection from arc burns and burns from sparks or spatter.** Keep sleeves rolled down and wear gloves. Wear a helmet over safety glasses. Use correct lens shade to prevent eye injury. Choose the correct shade from the table below. Observers should also use proper protection. Be aware that arc gouging spatter can spray a long distance.

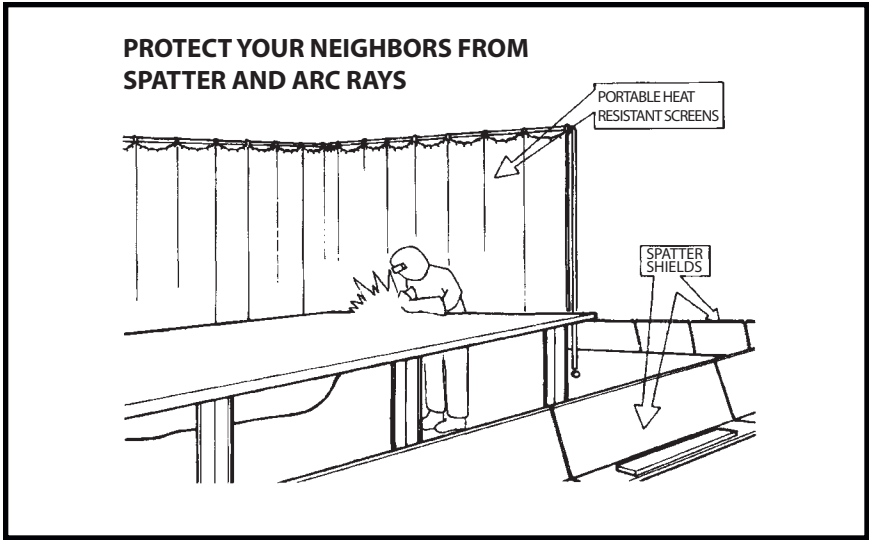
FILTER RECOMMENDATIONS (adapted from ANSI Safety Standard Z49.1)

Application	Lens Shade No.*
Mig (Gas Metal and Fluxed Cored Arc)	
60 to 160 amps	11
160 to 250 amps	12
250 to 500 amps	14
Tig (Gas Tungsten Arc)	
up to 50 amps	10
50 to 150 amps	12
150 to 500 amps	14
Arc Gouging and Pad Washing	
less than 500 amps	12
500 to 1000 amps	14
Plasma Arc Welding	
up to 100 amps	10
100 to 400 amps	12
400 to 800 amps	14
Plasma Arc Cutting	
up to 300 amps	9
300 to 400 amps	12
400 to 800 amps	14
Stick (Shielded Metal Arc)	
under 5'32-in. (under 4 mm) electrodes, up to 160 amps	10
5-'32- to 1 4-in. (4 to 6 mm) electrodes, 160 to 250 amps	12
Over 1 4-in. (over 6 mm) electrodes, 250 to 550 amps	14

* As a rule of thumb, start with a shade that is too dark to see the arc zone. Then go to a lighter shade which gives sufficient view of the arc zone without exerting a strain on your eyes.

2. **Protect against arc flashes, mechanical injury, or other mishaps.** Wear spectacles or goggles with No. 2 shade filter lens and side shields inside the welding helmet or hand shield. Helpers and observers should wear similar protection-Be sure "lift front" welding helmet has plastic plate inside and safety glass cover on the outside.
3. **Wear protective clothing such as heat resistant jackets, aprons, and leggings.** Exposure to prolonged or intense arc radiation can cause injury. Thin cotton clothing is inadequate protection. Cotton deteriorates with this type of radiation.
4. **Wear high, snug fitting shoes.** Avoid wearing low or loose shoes which would allow hot spatter to get inside.
5. **Wear cuffless pants.** By wearing pants with no cuffs, you eliminate a dangerous spark and spatter trap- Pants legs should overlap shoe tops to prevent spatter from getting into your shoes.
6. **Wear clean clothes.** Do not wear clothing that has been stained with oil and grease. It may burn if ignited by the heat of the arc.
7. **Wear ear protection,** not only where there is noise, but where there is a chance that spatter or sparks could get into your ears.
8. **Wear a leather cap** or other protection to protect the head from sparks or spatter.
9. **Protect neighboring workers from exposure to arc radiation.** Shield your station with metal or heat resistant shields. If your station cannot be shielded, everyone within about 75 ft. should wear eye protection when welding or cutting is in progress.
10. **Keep your pockets, sleeves and collars buttoned.** Sparks may lodge in them and cause fires or burns. Be sure your pockets are emptied of combustibles such as matches and other flammables.





NOISE can damage hearing.

Wear correct ear protection.

Wear ear protective devices or earplugs when plasma arc cutting, plasma arc gouging or air carbon arc gouging is being performed, or in noisy welding areas. In addition, ear protection can prevent hot spatter from entering the ear. Warn others in area of possible noise hazards.



ELECTRIC AND MAGNETIC FIELDS-May be dangerous. Electric current flowing through any conductor causes localized Electric and Magnetic Fields (EMF). Welding and cutting current creates EMF around welding cables and welding machines. Therefore:

1. Welders having pacemakers should consult their physician before welding. EMF may interfere with some pacemakers.
2. Exposure to EMF may have other health effects which are unknown.
3. Welders should use the following procedures to minimize exposure to EMF:
 - A. Route the electrode and work cables together. Secure them with tape when possible.
 - B. Never coil the torch or work cable around your body.
 - C. Do not place your body between the torch and work cables. Route cables on the same side of your body.
 - D. Connect the work cable to the workpiece as close as possible to the area being welded.
 - E. Keep welding power source and cables as far away from your body as possible.

OTHER PRECAUTIONARY MEASURES



PREVENT FIRES.

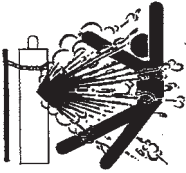
Hot slag, sparks, and the arc can act as a source of ignition.

Every worker should be familiar with the following fire-prevention and fire-protection measures:

1. **Maintain a safe workplace.** If possible, move the material to be welded or cut to a safe location designated specifically for welding and cutting.
2. **Keep fire hazards away.** Areas for welding and cutting must be kept clear and free of flammable liquids, such as gasoline, paints, and solvents; combustible solids, such as paper, packing material, and wood; and flammable gases, such as oxygen, acetylene and hydrogen.
3. **Provide fire barriers.** If welding or cutting cannot be performed in a designated location or away from combustible materials, provide metal sheets or fire-resistant blankets to prevent heat, sparks, and slag from reaching these materials.
4. **Be alert for cracks or crevices.** Sparks and slag can travel long distances. They can start a fire at a location not apparent to the welder. Look for holes or openings in the floor, crevices around pipes, and other openings which can hide a smoldering fire.
5. **Provide fire extinguishing equipment.** Be prepared to put out fires. Serviceable fire extinguishers, fire hoses, or sand buckets should be on hand. Their use depends on the quantity and type of combustible material which may be present.
6. **Consider the need for a fire watcher.** Welders may not become aware of a fire starting while welding. Their vision is seriously hampered by the welding helmet and dark lenses. Depending upon the circumstances of welding location, it may be advisable to have a fire watcher to man an extinguisher and sound a fire alarm in case of a fire.
7. **Know the local fire codes for welding and cutting.** Follow the information on fire protection during welding or cutting operations in National Fire Protection Association Standard NFPA No. 51B, "Fire Protection in Use of Cutting and Welding Processes."
8. **Inspect work area after completing operation.** Make sure there are no hot sparks or hot metal which could start a fire later.

9. Use a “Hot Work” authorization system. Before welding or cutting begins in a new or unauthorized location you should have the location inspected. The inspector should authorize the work before you begin.

WELDING AND CUTTING OF CONTAINERS



Containers can explode by heat of welding, cutting, or gouging unless properly cleaned and vented. Toxic fumes can be formed when welding or cutting metal which has been in contact with an unknown material. Do not weld or cut containers unless they are cleaned by qualified personnel.

The welding or cutting of containers which previously held flammable or toxic material or any unknown substance is extremely dangerous unless they are first properly cleaned. Enough combustible or potentially toxic material may remain to be an explosion, fire, or poison hazard when the material is vaporized by heat from the electric arc. Some non toxic materials may form toxic gases due to the action of the arc.

Make sure surrounding pipelines or containers are protected before striking an arc.

Refer to the list of Recommended References for additional information on welding and cutting containers.

SHIELDING GASES



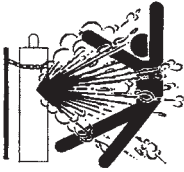
Shielding Gases can cause suffocation without warning.

Argon, helium, carbon dioxide, and nitrogen are commonly used shielding gases in electric welding and cutting processes. These inert, colorless, odorless and tasteless gases cannot be detected by the human senses. They can displace the oxygen required for normal breathing. An atmosphere with less than 18% oxygen can cause dizziness, unconsciousness, or even death. This can happen without any warning signs. Therefore, be aware of the following precautions:

1. **Make sure a confined area is well ventilated before entering.** If there is doubt, check area with an oxygen analyzer to be sure it contains a life supporting atmosphere. Otherwise wear an air supplied respirator. A second person, similarly equipped, should be standing by. Even if the amount of oxygen is sufficient at the start of welding, shielding gases formed during welding may displace enough oxygen to create a dangerous situation. Monitor oxygen level throughout welding.
2. **Do not bring cylinders of shielding gas into confined areas.**
3. **Do not leave shielding gas equipment in confined areas when not in use.**
4. **Treat pits, tank bottoms, ceilings, etc., as confined areas.** Shielding gases are heavier or lighter than air and may displace breathing air in those areas.
5. **Hydrogen is a flammable gas. A mixture of this gas with oxygen or air in a confined area will explode if ignited by a spark.** Hydrogen is also a colorless, odorless and tasteless gas which can act as a asphyxiant. Being lighter than air, hydrogen can accumulate in upper portions of confined areas.

For more safety information on these gases, contact your gas supplier.

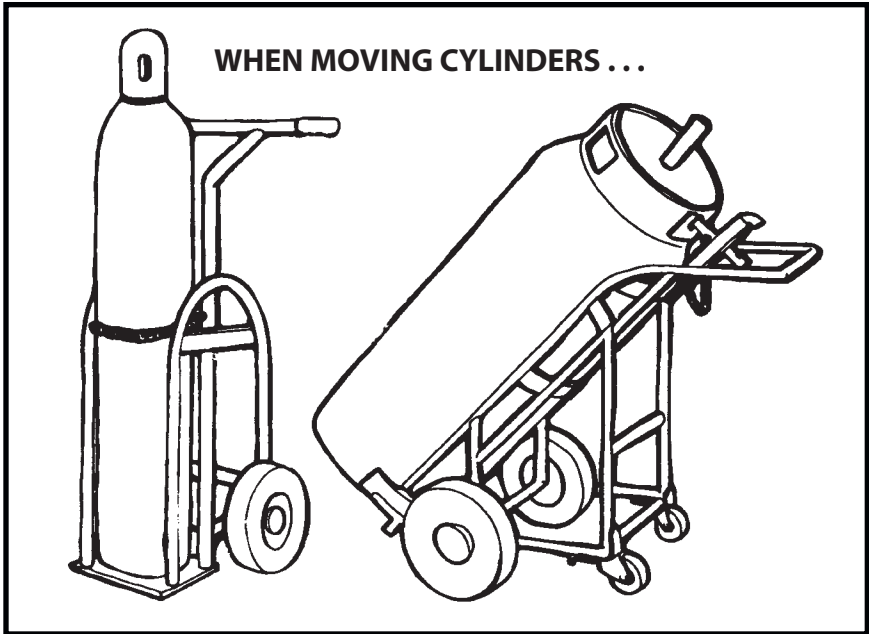
HANDLING, STORAGE, AND USE OF CYLINDERS



Cylinders, if mishandled, can rupture and violently release gas. Handle all cylinders with care.

Gas cylinders are constructed and maintained in accordance with the regulations of the Federal Department of Transportation (DOT). Gases are compressed to 2000 to 5500 psig in high pressure cylinders. Liquefied gases can be as cold as -450°F (-267°C). Sudden rupture of cylinder, valve, or relief device can injure or kill and can cause property damage. If gas is combustible an explosion hazard can exist. Therefore, be sure to understand all of the following precautions.

1. **Always read the cylinder label.** Cylinders are clearly labeled with the name of the gas to identify the contents. The cylinder contents may have their own unique hazards. Know and follow the information on the cylinder label. If the cylinder does not bear a gas label, or if the label is not legible, **DO NOT USE THE CYLINDER**. Do not assume the identity of the gas by the cylinder paint color or other means. Return the cylinder to the gas supplier for gas identification or cylinder replacement.
2. **Handle, store, and use cylinders in an upright and secured position.** Secure cylinders by chain or strap to suitable cylinder carts, benches, wall, post, or racks. If transporting cylinders in vehicles such as pick-up trucks, secure other cargo as well so it cannot roll or slide and damage the cylinders. Transport with the cylinder valve closed and cap in place. Never transport cylinders in the trunk of a car. Do not store cylinders in confined unventilated spaces such as closets, drawers, cabinets or work boxes.
3. **Use suitable hand trucks or racks for moving cylinders.** Properly capped, cylinders may be moved for short distances by rolling them on their base. Care must be taken to prevent the cylinder from rolling or sliding out of control. Avoid rough handling. Do not slide or drag cylinders. Do not bump cylinders. Do not allow cylinders to drop or tip over. Do not roll cylinders on a wet or steel dock plate.
4. **Unless in use, cylinder valves should be kept closed at all times.**
5. **When manually lifting cylinders, do not raise them by the valve-protection cap.** The cap may accidentally and suddenly come loose.
6. **Never use slings or electro-magnets for lifting and transporting cylinders.** Use a cradle or suitable platform when transporting by crane or derrick.



7. **Never tamper with safety-relief devices on gas cylinders.** They are provided to vent the contents to relieve excessive pressure within the cylinders if the cylinders are exposed to fire or excess temperatures.
8. **Never use any gas from cylinder except through an approved pressure-reducing regulator.** A regulator is designed for reducing the high pressure compressed contents in the cylinder to a constant, controllable working pressure for the equipment in use. A single approved regulator may, however, be connected to the outlet of manifolded cylinders supplying one or more use points. Do not adapt a regulator to use it with a gas for which it was not designed. A regulator must be approved for the particular gas being handled. Use the proper gas pressures recommended for the equipment as furnished by the equipment manufacturer.
9. **Never transfer any gas from one cylinder to another or attempt to mix any gases in a cylinder.** Any attempt to transfer or mix gases could result in a cylinder rupture or explosion.
10. **Cylinders should not be placed where they might become part of an electrical circuit.** They must never be used as a grounding connection. Accidental arcing could cause a brittle local defect (arc-bum) which could lead to eventual cylinder rupture. Refer to the following section that covers arc-burn preventions.
11. **Store high-pressure and liquefied-gas cylinders in a separate, dry, well-ventilated room.** Do not let full or empty cylinders stand around and clutter up work areas. They may interfere with operations, and they may be subjected to arc-burn or other damage.

12. **Full and empty cylinders should be stored separately.** Storage location should be arranged so that the old stock of cylinders can be removed first. Cylinders should not be exposed to continuous dampness. They should not be stored near salt water or corrosive chemicals or fumes. Corrosion can weaken the cylinder. This can eventually lead to a sudden rupture or explosion.
13. **Store cylinders away from welding and cutting work.** They should not be exposed to falling objects, moving machinery, and vehicular traffic. Storage areas should be located where cylinders will not likely get knocked over. Cylinders should be secured by suitable means such as chains or straps.
14. **Store cylinders at least 20 feet from any combustible materials, and where the cylinders will not be subjected to temperatures above approximately 125° F (52°C).** Flammable-gas cylinder storage areas should be heated by indirect means, and meet the design requirements of National Fire Protection Association NFPA Standard 51 or 58. Smoking, open flames, and other sources of ignition must be prohibited in areas where flammable gases are stored.
15. **Cylinders should be grouped by types of gas.** Where gases of different types are stored at the same location, oxygen cylinders should be separated from flammable-gas cylinders a minimum distance of 20 feet or by a non-combustible barrier at least 5 feet high having a fire-resistance rating of at least 1 1/2 hour. (Refer to NFPA Standard 51.)
16. **Cylinders used in public areas or at construction sites should be located where they cannot be tampered with by unauthorized persons.** Store cylinders in accordance with state and local regulations and in accordance with appropriate standards of the Occupational Safety and Health Administration.

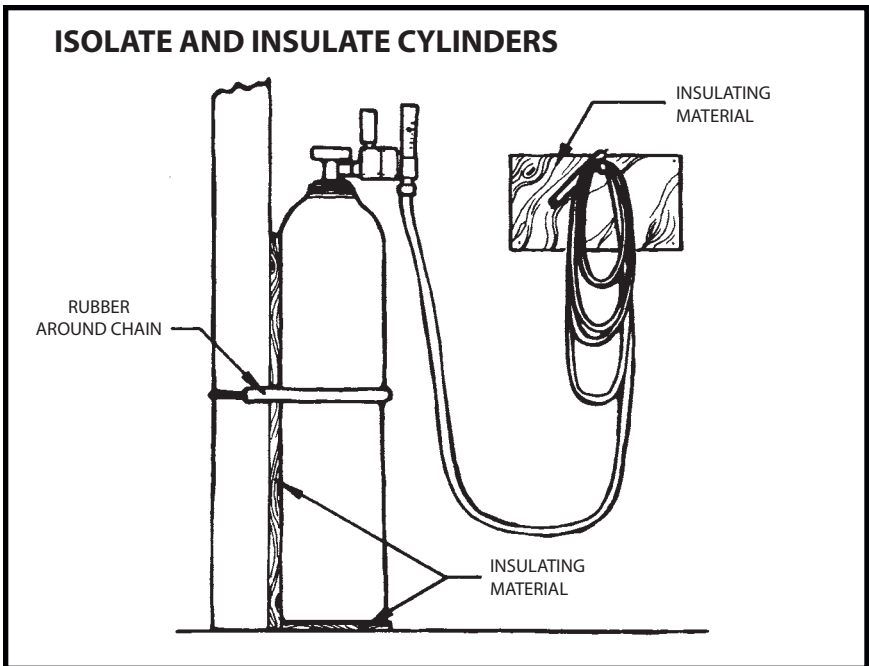
PREVENT ARC-BURNS ON CYLINDERS

Electric-arc burns on cylinders are potentially dangerous. The arc-burn causes higher stresses and might lead to cylinder rupture. Arc-burns can be caused by arc current passing through a grounded cylinder. They can happen quickly, and in a number of ways. The basic thing to remember is to keep the torch, arc, and any source of current away from compressed gas cylinders. With a little care while operating, arc-burn damage to cylinders can be eliminated by the following these precautionary steps.:

Never strike an arc on a cylinder. When you want to test the system operation, use a piece of grounded scrap metal.

Be sure that shielding-gas cylinders are never grounded. Cylinders, fittings, and supports should be electrically insulated from metallic building structures or fixtures to which they are secured.

3. **Do not fasten cylinders to work tables and fixtures.** They may become part of the work circuit. Use insulating shields to electrically isolate cylinders that cannot be removed. (See below)
4. **Be careful of where and how the work is grounded** so that the ground connections will never touch the cylinder.
5. **Do not hang the torch or any electrode holder on the cylinder.** Use a nearby hook; not the regulator or flowmeter. This will help keep arcs away from the cylinder at all times.
6. **Remove empty cylinders from working areas.** Return them to a designated storage area as soon as possible.
7. **Make sure all electrical wiring is in good condition.** Repair or replace defective, frayed or exposed sections immediately.

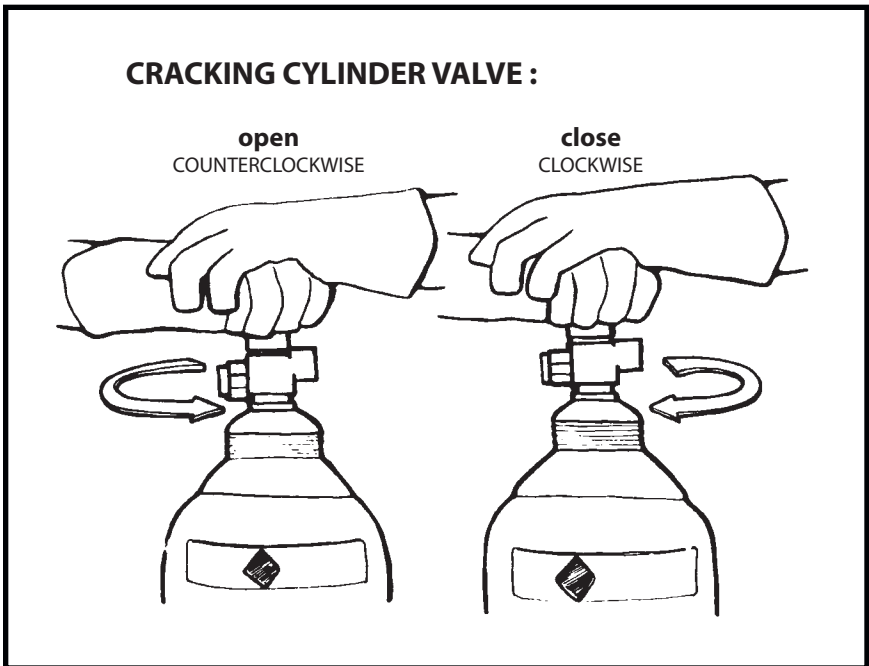


CONNECTING AND ADJUSTING SHIELDING GAS SUPPLY

Here is a list of steps and important things to check when hooking up cylinders. They are intended to help prevent possible injury or death to you and your fellow workers as well as prevent possible equipment and property damage.

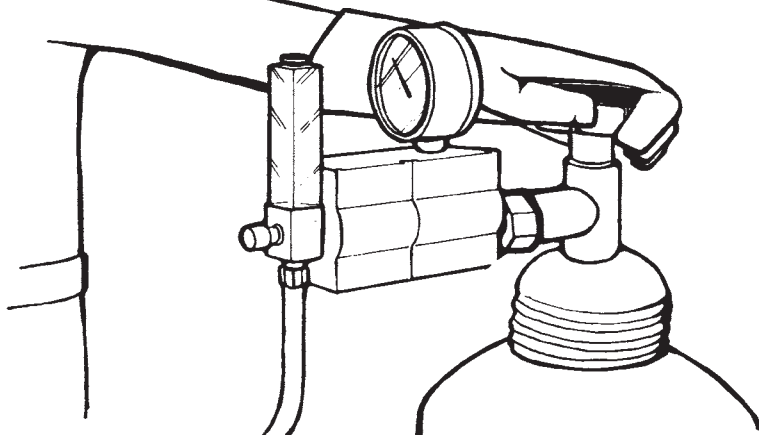
1. **Fasten the cylinders to be used in an upright position.** If cylinders are not on a suitable cylinder cart, they should be securely chained or strapped to a workbench, wall, or post so that they cannot be accidentally knocked or pulled over.
2. **“Crack” the cylinder valve.** Stand at one side or rear of the cylinder outlet. Open the cylinder valve slightly for an instant, and then close it. This will clean the valve of dust or dirt which may have accumulated during storage. Dirt can damage critical parts of a regulator.

NOTE: Valves on flammable-gas cylinders should NOT be “cracked” near welding or cutting work in progress, or near sparks, flame, or other possible sources of ignition.



3. **Always attach a regulator to the gas supply (and a flowmeter when required).** When a single cylinder is used, a pressure-reducing regulator must be connected at the cylinder valve. Normally in electric welding and cutting, a combination regulator-flowmeter is used. Make certain that the regulator is proper for the particular gas, service pressure, and flow requirements. If the shielding gas is supplied at the proper working pressure through a piping system that is regulated from a large storage unit or bank of manifolded cylinders, a flowmeter may be connected at the work station.
4. **Do not use adaptors unless you follow the instructions of a manufacturer.** The various Compressed Gas Association (CGA) designated connections are designed for your protection. Refer to CGA pamphlet V-1.
5. **Never force connections that do not fit properly.** This can strip the threads on fittings and result in leaky connections. To prevent leakage, be sure the regulator nut is pulled up wrench-tight, not merely handtight. Do not tighten the connections excessively.
6. **Do not use lubricants or pipe fitting compound for making connections.** Connections in apparatus are designed so that they can be made up clean and leak tight. Oil or grease in lubricants and compounds tends to gum up regulating equipment and torches. Lubricants and compounds can also contaminate the shielding gas, and in the case of oxygen service they can contribute to a catastrophic fire and personal injury.
7. **Make sure the regulator pressure-adjusting screw is released by rotating it counterclockwise until it turns freely.** This closes the regulator valve and prevents a sudden surge of pressure from possibly damaging components in the system. If regulator is equipped with a flowmeter, be certain the flow control valve is closed by turning the knob all the way in (clockwise).
8. **Stand to one side of the regulator or regulator/flowmeter away from gauge face.** SLOWLY open the cylinder valve. NEVER open a cylinder valve suddenly. Sudden surge of high pressure gas can weaken or damage critical components in the regulator.
9. **Check all connections and joints for leaks.** After making all connections, close torch or downstream valve and then turn in the regulator pressure-adjusting screw to the desired operating pressure (or just open the flowmeter valve). Using a suitable leak test solution, check every connection and joint from cylinder to torch for leaks. Correct any leakage before starting operations.
10. **Never tighten a leaky connection between a regulator and cylinder when under pressure.** Close the cylinder valve; allow the trapped gas to leak out; and then tighten the connection.

SLOWLY OPEN CYLINDER VALVE . . .



11. **Use correct pressure and gas flow.** Always be sure you are using the correct gas pressure. Refer to the manufacturer's instructions for the torch or apparatus being used. If operating properly, the regulator maintains pressure as set. The required flow rate will of course vary according to the type of job. Once set at the desired rate, a flowmeter will give an accurate measurement of flow at all times.
12. **As soon as you have finished working, or if you are going to disconnect the regulator or regulator-flowmeter combination, do the following:**
 - a. Close the cylinder valve.
 - b. Open the flowmeter and torch valves to release all pressure from the hose and regulator.
 - c. When the gauge pressure drops to zero, close the flowmeter valve.

This will prevent the occurrence of an accident caused by someone removing the regulator with the cylinder valve open. Double check by observing the inlet gauge.

CONFINED SPACES

1. Introduction/Definition

Many different places require welding, cutting, and heating work. Some of these places lack room and become “confined spaces.” Confined spaces have the following characteristics:

- Limited space, entry, or exit
- Poor ventilation - lack of safe breathing air and possible buildup of hazardous gases, fumes, and particles

2. Examples of Confined Spaces

- Small rooms
- Process vessels
- Pits
- Tunnels
- Vats
- Reactor vessels
- Underground utility vaults
- Unventilated corners of a room
- Furnaces
- Storage tanks
- Pipelines
- Sewers
- Silos
- Degreasers
- Boilers
- Compartments of ships
- Ventilation and exhaust ducts

3. Reasons For Deaths and Serious Injuries From Welding In Confined Spaces

- Fire
- Electric shock
- Exposure to hazardous air contaminants
- Explosion
- Asphyxiation

4. Actions Required Before Approving Start of Work In A Confined Space

- Open all covers and secure them from closing.
- Test confined space atmosphere for (1) suitable oxygen content, (2) no combustibles or reactives, (3) no toxics.
Note: The testing requires special equipment and training.
- Isolate lines by capping or double valving and venting, if feasible-keep vents open and valves leak-free.
- Lock out all systems not required during welding, cutting, or heating.
- Provide means for readily turning off power, gas, and other supplies from outside the confined space.
- Protect or remove any hazardous materials or materials which may become a physical or health risk when heated or exposed to an arc.

5. Required Actions During Work In A Confined Space

- Continuously ventilate and monitor confined space to ensure that fumes and gases do not exceed safe exposure limits as found in OSHA (Occupational Safety and Health Administration) regulations Title 29, CFR Part 1910, 1000.

- Use NIOSH/MSHA (National Institute for Occupational Safety and Health/Mine Safety and Health Administration) approved breathing device when required by code, instruction, or good practice.
- Keep unnecessary persons and equipment out of and away from the confined space.
- Do not allow equipment to block exit or possible rescue efforts.
- Place as much equipment as possible outside the confined space.
- Do not go into a confined space unless a watchperson, properly equipped and trained for rescue, is outside and maintaining continuous communications with worker inside.
- Provide means for turning off power, gases, and fuel from inside the confined space, if feasible, especially if outside turn-off means are not provided, feasible, or certain.

6. **Information Sources**

National Institute for Occupational Safety and Health. Criteria For A Recommended Standard - Working In Confined Spaces, NIOSH Publication No. 80-106. Cincinnati, Ohio: National Institute for Occupational Safety and Health.

Occupational Safety and Health Administration. Code Of Federal Regulations, Title 29 Labor, Chapter XVII, Part 1910. Washington, DC: U.S. Government Printing Office.

De Reamer, R. Modern Safety And Health Technology, New York, New York: John Wiley & Sons.

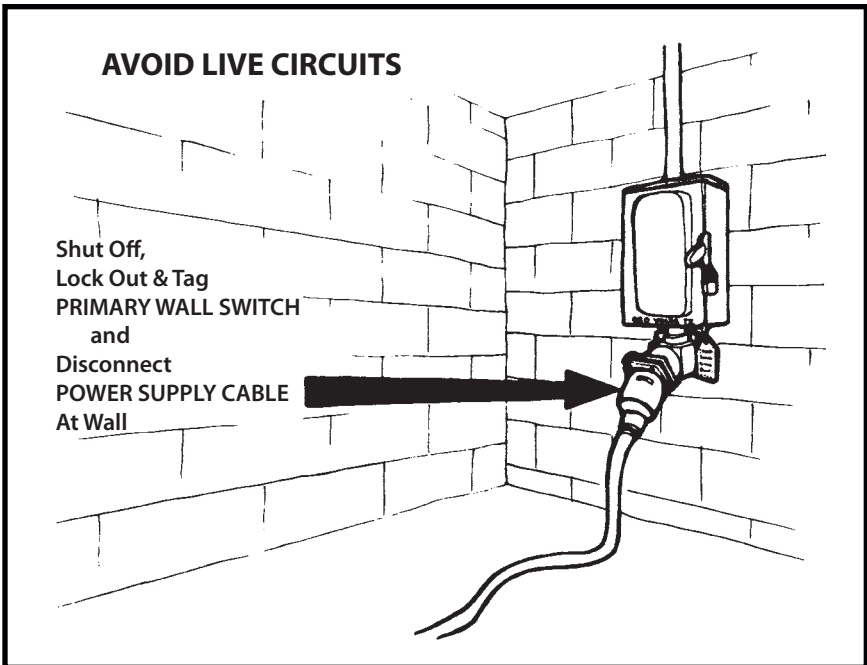
American National Standards Institute. Safety Requirements For Working In Tanks And Other Confined spaces, ANSI Z1 17.1 New York: American National Standards Institute.

Mine Safety And Health Administration (MSHA)..Code Of Federal Regulations, Title 30 Mineral Resources. Washington, DC: U.S. Government Printing Office.

MAINTENANCE AND TROUBLESHOOTING PRECAUTIONS

Faulty or improperly maintained equipment can cause property damage, physical injury, or possibly death by fire or electrical shock. Here is a list of some important items to check when troubleshooting or maintaining equipment.

1. **Stop operating IMMEDIATELY if equipment is malfunctioning.** Notify your supervisor of the malfunction. Do not perform any further operations until the problem is corrected.
2. **Do not perform any maintenance unless you are qualified to perform such work.** Only qualified personnel should install, maintain, and repair the equipment.
3. **Avoid live circuits.** Disconnect the equipment from the main electrical power source before working on the inside of the equipment. Just turning off the equipment power switch does not shut off the power going to the equipment. If external 115-volt power is used to energize a power supply contactor, disconnect it as well. Use disconnect/lockout/tag procedures where possible.



4. **Make test readings carefully.** If necessary to take testmeter readings on live electrical equipment, be sure to wear insulating gloves, use properly insulated test probes, and apply input voltage momentarily to obtain the readings.
5. **Maintain cables, grounding wire, connections, power cord, and power supply in safe working order.** Do not operate equipment in faulty condition. Replace damaged cables.
6. **Do not abuse the equipment.** Protect the equipment from heat, excessive wet conditions, oil or grease, corrosive atmospheres, and inclement weather.
7. **Replace parts only with manufacturer's recommended replacement parts.** Do not substitute, modify, or use unauthorized parts. Use fuses of proper rating as specified in the manufacturer's manual. Read and understand the operating instructions provided by the manufacturer of the equipment before attempting repairs.
8. **Keep all protective devices and covers in position.** They are designed to protect personnel and equipment.

APPENDIX

CHEMICAL SUBSTANCES AND POTENTIAL HEALTH HAZARDS IN THE ELECTRIC WELDING AND CUTTING ENVIRONMENT.

INTRODUCTION

The information in this appendix is directed toward the health and medical professional. It is intended to instruct, as well as alert, the health and medical professional about potential health hazards in the electric welding and cutting environment.

When electric welding and cutting are used as recommended and according to recognized and accepted sound industrial hygiene standards, as set forth in OSHA regulations and in American National Standard Z49.1 "Safety in Welding and Cutting", minimal or no adverse health effects should be expected.

Fumes, gases, radiation, and noise are created as by-products of most welding processes. The type of welding process is a major factor in determining the concentration of metal fumes and gases, and the intensity of radiation which may be produced. The composition of the welding fumes is dependent on the alloy being welded and the process and electrodes used. The health hazard potential depends on the concentration and toxicity of the materials involved (types of metals, fluxes, coatings, etc.), length of exposure, the relationship of the welder's head with respect to the fumes, and the effectiveness of control measures, such as ventilation and personal protective equipment.

Table 1 lists some common chemical and physical agents which may be produced as by-products in some welding and cutting applications.

DESCRIPTION OF MAJOR HEALTH HAZARDS

1. Respiratory System

Acute — Gases, fumes, and dusts may cause irritation to the eyes, lungs, nose, and throat. Some toxic gases associated with welding may cause pulmonary edema (accumulation of fluid in the air spaces of the lungs), asphyxiation, and death. Acute overexposure may include signs and symptoms such as watery eyes, nose and throat irritation, headache, dizziness, difficulty breathing, frequent coughing, or chest pains.

Chronic — Prolonged inhalation of air contaminants may lead to their accumulation in the lungs, a condition which may be seen as dense areas on chest x-rays. The severity of change is proportional to the length of exposure. The changes

Fumes* and Gases

Aluminum	Carbon Dioxide
Barium	Carbon Monoxide
Beryllium	Nitrogen Oxides
Cadmium	Ozone
Calcium	Phosgene
Chromium	
Copper	
Fluorides	
Iron	
Lead	
Magnesium	
Manganese	
Nickel	
Potassium	
Silica	
Silicate	
Sodium	
Titanium	
Vanadium	
Zinc	

Radiant Energy

Ultraviolet
Visible
Infrared

Other Agents

Noise Heat
Electric Fields
Magnetic Fields
Hot Spatter

* Including the metals and their oxides. Some of the fumes and gases listed are covered in detail on pages 25 through 27.

seen are not necessarily associated with symptoms or signs of reduced lung function or disease. In addition, the changes on x-rays may be caused by non-work related factors such as smoking, etc.

2. Eye

Eye injury may be caused by flying particles. Ultraviolet and infrared rays are emitted by the welding arc. "Arc Eye" is an acute, self-limited, irritation and inflammation of the superficial structures of the eye caused by ultraviolet radiation. The signs and symptoms disappear 24 to 48 hours after the exposure usually without permanent injury. Infrared radiation penetrates the interior of the eye and can cause burns on the retina.

3. Skin

Exposed skin is susceptible to cuts, scrapes and burns (electrical and thermal). Ultraviolet rays from the arc may cause redness of the skin similar to sunburn. Persons being treated with certain drugs, such as tetracycline, may react unduly to ultraviolet rays. Skin contact with certain metal dusts, such as chromium and nickel, may cause a dermatitis characterized by dry, red, cracked itchy skin on the hands, forearms, and face. Passage of an electrical current into living tissues may cause electrical burns or fatal shock. Clinical manifestations usually depend on the amount of current that passes through the body. Respiratory paralysis or ventricular fibrillation, or both, may result.

4. **Cardiovascular Disease**

Carbon monoxide may be generated from carbon dioxide in gas shielded welding processes. Small amounts are produced during shielded metal arc welding. Carbon monoxide combines avidly with hemoglobin, reducing the oxygen-carrying capacity of the blood. Exposure to carbon monoxide may present an added health risk to workers with heart disease.

5. **Noise**

Exposure to high noise levels may result in hearing loss. Exposed workers should wear properly fitted ear protection.

6. **Carcinogenicity**

Carcinogenicity depends upon many factors, including the properties of the materials of exposure, the adequacy of protective equipment used, the individual's susceptibility, and other factors. Certain metals, such as chromium VI compounds and nickel, have been reported to cause cancer. The possible confounding roles of cigarette smoking, environmental agents, and other non-work related factors must be considered.

7. **Other Factors**

In addition to any direct effects, heat and stress may also increase the workers susceptibility to the effects of other agents. Workers using pacemakers or similar equipment should check with physicians to verify its suitability to the work area. Workers who hold a torch above shoulder height for prolonged periods may experience shoulder pain and/or cumulative trauma disorder.

COMMON CHEMICAL SUBSTANCES AND THEIR POTENTIAL HEALTH HAZARDS

The following are brief descriptions of materials which may be found in some welding and cutting operations:

Beryllium - Beryllium and its compounds are highly toxic. They can cause serious injury or death. Exposure is capable of producing chronic lung changes which are permanent in nature. Suspected human carcinogen.

Cadmium - Cadmium fumes or fine dust are capable of causing serious injury or death when inhaled. It is easy to mistake cadmium-plated steel for galvanized steel. However, when heated, cadmium leaves an olive-drab color as it oxidizes. Always know the metal you are working with. Cadmium oxide fumes often cause no symptoms until a few hours after exposure. Cadmium is a confirmed human carcinogen.

Carbon Monoxide - Carbon monoxide may cause illness or death. If carbon dioxide is used as a shielding gas, carbon monoxide can form in hazardous concentrations. It is an odorless, colorless, and toxic gas. Exposure to low concentrations of carbon monoxide may cause headache, mental dullness, and generalized fatigue. The toxic effects of carbon monoxide are similar to those of oxygen deficiency. Loss of consciousness occurs at only very high concentrations.

Chromium - Acute exposures to chromium dust or fumes may cause coughing and wheezing, headache, shortness of breath, pain on deep inspiration, and fever. Other symptoms may include irritation of the conjunctivae, nasal itch and soreness, ulceration and perforation of the nasal septum, chronic bronchitis, and discoloration of the skin. Certain forms of chromium (VI) have been found to cause increased respiratory cancer among workers.

Copper - The fumes and dust cause irritation of the upper respiratory tract, metallic taste in the mouth, nausea, metal fume fever, and in some instances, discoloration of the skin and hair. Copper dust can act as an irritant to skin causing itching, redness, and dermatitis. It may also cause conjunctivitis and small ulcers of the cornea.

Fluorides - Fluoride fumes can be very irritating to eyes, nose, and throat. Some fluorine compounds can cause death. Chronic fluorine absorption can cause sclerosis of the bones and mottled teeth. Fluorides may be formed when welding with self-shielded and T-5 type flux cored electrodes and with fluoride containing covered electrodes, and with some fluxes used in submerged arc and electroslag welding.

Iron Oxide — Inhalation of these fumes and dust may cause “metal fume fever” (an influenza-like illness lasting 24 to 48 hours), and may also cause a benign pneumoconiosis (siderosis). Pure iron oxide probably does not cause fibrotic pulmonary changes, whereas inhalation of iron oxide plus certain other substances may cause lung injury.

Lead - Lead fumes or fine dust, when inhaled, can cause lead poisoning, anemia, muscle weakness, nausea, vomiting, colic, or death. Be careful to guard against lead poisoning when welding or cutting materials such as lead-coated steel (“terneplate”) containers and metals which have been painted with lead-containing paint. In all such cases, lead produces toxic fumes.

Manganese - Manganese dust and fumes are irritants to the eye and mucous membranes of the respiratory tract. Early recognition of chronic manganese poisoning is difficult. Progression of disease manifestations can vary widely among individuals. Signs and symptoms may include apathy, irritability, loss of appetite, headache, weakness of the muscles in the legs, and joint aches. Speech disturbances are common. Chronic manganese poisoning, although disabling, is usually not fatal.

Nickel — Skin sensitization or “nickel itch” is a commonly seen toxic reaction to nickel dusts. Nickel dust and fumes may also irritate the conjunctivae of the eye and the mucous membranes of the upper respiratory tract. Nickel and its compounds have been reported to produce an increased incidence of cancer of the lung and nasal passages.

Nitrogen Oxides — Nitrogen oxides may irritate the eyes and mucous membranes. High concentrations may produce severe pulmonary irritation and methemoglobinemia. Acute exposure to high concentrations may produce immediate fatigue, cyanosis (“blue lips and skin”), cough, shortness of breath, chills, fever, headache, nausea and vomiting. Collapse and death may occur if the exposure is sufficiently high. Survivors may develop severe and increasing shortness of breath due to chronic lung disease.

Ozone - Ozone is a form of gaseous oxygen. It is produced by the action of the electric arc on oxygen in the surrounding atmosphere. Consequently processes which produce a very intense arc and low levels of particulate in the fume (such as gas metal arc welding of aluminum) will result in greater concentration of ozone. It has a noticeable odor and exposure may produce irritations of the eye, nose, and throat. Overexposure may cause death.

Phosgene - This highly toxic gas is formed when the ultraviolet rays from an electric arc contact chlorinated solvents, such as trichloroethylene. Material or equipment which has been degreased by chlorinated solvents should not be welded or cut until it has been thoroughly dried to remove the solvent. Welding or cutting should not be done near degreasing tanks containing chlorinated solvents. To avoid the formation of this hazardous gas, solvents should be stored and used in a separate room from welding operations. Do not leave chlorinated solvents lying around in open buckets or tanks. Keep solvent containers tightly covered when they are not in use. Inhalation of high concentrations of phosgene may produce pulmonary edema frequently preceded by a latent period of several hours' duration. There is little immediate irritating effect of the gas and consequently there may be no immediate warning that dangerous concentrations are being inhaled.

Silica - The crystalline forms of silica are responsible for producing silicosis. Respirable crystalline silica is a suspected carcinogen. However, attempts to locate crystalline phases of silica in welding fumes have far been unsuccessful. Silica is a common ingredient in submerged arc fluxes, so care should be taken to minimize dust generation during handling.

Zinc - Do not inhale fumes from welding or cutting galvanized sheet, brass, or other zinc alloys. Zinc can cause metal fume fever, commonly called "zinc chills" or "galo". The symptoms usually occur a few hours after exposure and include metallic taste in mouth, dryness of nose and throat, weakness, fatigue, muscle and joint pains, fever, chills, and nausea.

MEDICAL PRECAUTIONARY MEASURES

1. Periodic health examinations are recommended. The potential health effects of nonwork related factors, such as smoking, must be considered.
2. An effective educational, training, and industrial hygiene program should be instituted. The program should cover the following: (a) the nature and potential hazards of welding, cutting and gouging; (b) proper and safe use of equipment; and (c) emergency and first aid procedures.
3. Medical personnel should be available on-site or by phone for advice and consultation. Emergency phone numbers should be posted near the telephones. At least one person on each shift should be trained in first aid, as well as qualified to administer oxygen and cardiopulmonary resuscitation (CPR).
4. The following should be readily available: (a) first aid supplies approved by a physician; (b) stretchers and blankets for transportation; (c) oxygen inhalation equipment; and (d) approved instant acting eye washes and showers.

5. Good personal hygiene practices are very important. Employees should wash their face and hands before eating, and it is recommended they not be permitted to eat, drink, or smoke in the work area. Food and beverages should not be stored in the work area. Contaminated clothing should be changed.
6. Protection against skin conditions, such as chemical burns, rashes, and dermatitis can be provided by appropriate protective clothing and equipment, as well as the use of protective creams or lotions.
7. All employees should be protected from ultraviolet rays. Noncombustible or flame proof screens or shields, appropriate eye protection, and other protective equipment should be used.
8. Respirators may be needed where engineering and administrative controls do not provide adequate protection. If respirators are used, they should be approved by NIOSH, MSHA or other approving agency.
9. Emergency and first aid procedures are given on the back cover of this booklet.

Threshold limit values (TLV) for materials may be found in the American Conference of Governmental Industrial Hygienists publication entitled "Threshold Limit Values and Biological Exposure Indices", (published annually, address given in the References section of this booklet). A selection of typical values for a variety of materials used in welding and cutting is listed in Table 2, which summarizes some of the health hazards which may be found in the welding environment. (These values are subject to change; therefore, refer to its latest publication.)

HEALTH HAZARDS REFERENCES

Some authoritative sources on health hazard effects include the following:

1. "Guide to Occupational Exposure Values" (latest edition), American Conference of Governmental Industrial Hygienists, 1330 Kemper Meadow Dr., Cincinnati, OH 45240-4148 (www.acgih.org)
2. "AWS Fumes and Gases in the Welding Environment" (1979), American Welding Society, 550 N.W. LaJeune Rd., Miami, FL 33126 (www.acs.org)
3. "Encyclopedia of Occupational Health and Safety", Vols. I & II, J. M. Stellman, Fourth Edition (1998), International Labour Office, Geneva, Switzerland (www.ilo.org/public/english/protection/safework/cis/products/dbs.htm)
4. "Patty's Industrial Hygiene and Toxicology", Fifth Edition (2000), John Wiley & Sons, New York
5. "Safety & Health in Arc Welding and Gas Welding & Cutting", NIOSH Publication No. 78-138, (1978) U.S. Department of Health, Education and Welfare, Public Health Service, Center for Disease Control, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (www.ntis.gov/search/index.aspx Use Product Code: PB83174920)
6. "Dangerous Properties of Industrial Materials", N. Irving Sax, Eleventh Edition (2004), John Wiley & Son. New York
7. "Documentation of the Threshold Limit Values for Substances and Biological Exposure Indices With Other Worldwide Occupational Exposure Values", (latest edition), American Conference of Governmental Industrial Hygienists, 1330 Kemper Meadow Dr., Cincinnati, OH 45240-4148 (www.acgih.org)

Chemical Substance	(1) TLV-TWA	OSHA PELs-TWA	Potential Health Hazard
Aluminum, Metal and insoluble compounds	⁽²⁾ 1 mg/m ³ R -----	15 mg/m ³ (Total dust) 5 mg/m ³ (Respirable fraction)	Acute: Irritant to eyes, skin, and respiratory tract. Chronic: Unknown-possible pneumoconiosis. Possible neurological effects.
Aluminum, Welding fumes, as Al			
Antimony & compounds, as Sb	0.5 mg/m ³	0.5 mg/m ³ (NIOSH REL)	Acute: Skin and upper respiratory tract irritation. Chronic: Animal carcinogen via inhalation.
Arsenic & inorganic compounds, (except arsine), as As	0.01 mg/m ³	0.5 mg/m ³ (Organic compounds) 0.01 mg/m ³ (Inorganic compounds)	Acute: Irritation of skin and mucous membranes. Chronic: Carcinogenic.
Asbestos, All forms	⁽³⁾ 0.1 f/cc (F)	0.1 f/cc ⁽⁴⁾ C 1 f/cc (30 min.)	Chronic: Fibrosis of lungs and reduced lung function; Carcinogenic.
Barium and soluble compounds, as Ba	0.5 mg/m ³	0.5 mg/m ³	Acute: Irritant to eyes, skin, and respiratory tract. Chronic: Muscular stimulation.
Beryllium and compounds, as Be	⁽⁴⁾ 0.00005 mg/m ³ I	0.002 mg/m ³ ⁽⁵⁾ C 0.005 mg/m ³	Acute: Lung inflammation which may be fatal. Chronic: Pneumonitis which may be fatal. Suspected human carcinogen. Chronic beryllium disease.
Cadmium and compounds, as Cd	0.01 mg/m ³ ⁽²⁾ 0.002 mg/m ³ R	0.005 mg/m ³	Acute: Lung edema which may be fatal. Chronic: Kidney and lung damage. May have latent interval and be progressive. Carcinogenic.
Carbon Black	3.5 mg/m ³	3.5 mg/m ³	No demonstrated health hazard. Chronic: Animal carcinogen although no human evidence.
Carbon Dioxide	5,000 ppm	5,000 ppm	Acute: Mild to severe asphyxia. Toxic in high concentrations.
Carbon Monoxide	25 ppm	50 ppm	Acute: Mild to severe asphyxia. Can be fatal if inhaled causing carboxyhemoglobin formation. Chronic: None known.
Chlorinated Hydrocarbon Solvent	See "Health Hazards References" 1, for specific compound.	See "Health Hazards References" 1, for specific compound.	Acute: Narcotic. Chronic: Liver & kidney damage.
Chromium metal	0.5 mg/m ³	1 mg/m ³	Acute: Allergen to skin. Irritant to skin, eyes, mucous membranes and lungs. Nose bleeds, ulceration and perforation of nasal septum. Chronic: Carcinogenic.
Chromium inorganic compounds, as Cr Hexavalent, water soluble Hexavalent, certain water insoluble Trivalent	0.05 mg/m ³ , as Cr 0.01 mg/m ³ , as Cr 0.5 mg/m ³	0.005 mg/m ³ , as Cr(VI) 0.005 mg/m ³ , as Cr(VI) 0.5 mg/m ³	

Chemical Substance	(1) TLV-TWA	OSHA PELs-TWA	Potential Health Hazard
Cobalt and inorganic compounds, as Co	0.02 mg/m ³	0.1 mg/m ³ (Metal dust & fume, as Co)	Acute: Allergic dermatitis and asthma. Chronic: Lung inflammation, heart effects (myocardial)
Copper, Fume, as Cu	0.2 mg/m ³	0.1 mg/m ³	Acute: Irritant to eyes, skin, and mucous membranes. Metal fume fever. Chronic: Only in those with Wilson's disease.
Fluorides, as F	2.5 mg/m ³	2.5 mg/m ³	Acute: Irritation of skin and mucous membranes. Increased bone density. Chronic: Bone damage, fluorosis.
Iron Oxide (Fe ₂ O ₃)	(6) 5 mg/m ³ R	10 mg/m ³ (Fume)	Acute: Metal fume fever. Chronic: Benign pneumoconiosis.
Lead and inorganic compounds	0.05 mg/m ³ , as Pb	0.05 mg/m ³ See 29 CFR 1910.1025	Acute: Systemic lead poisoning. Chronic: Neurological and blood effects. Animal carcinogen. May also affect the reproductive system.
Manganese and inorganic compounds, as Mn	(6) (2) 0.2 mg/m ³ (6) (4) NIC-0.02 mg/m ³ R (7) NIC-A4	(6) C 5 mg/m ³	Acute: Minor irritant. Chronic: Irreversible damage to the central nervous system, including the brain, symptoms of which may include slurred speech, lethargy, tremor, muscular weakness, psychological disturbances and spastic gait.
Manganese, Fume, as Mn	0.2 mg/m ³	(6) C 5 mg/m ³	
Mercury, Inorganic compounds, as Hg	0.025 mg/m ³	(6) C 0.1 mg/m ³	Acute: Injury to respiratory, digestive, renal, and cardiovascular system. May be fatal. Chronic: Damage to central nervous system, gasiro intestinal, renal, respiratory system, and skin.
Molybdenum Insoluble compounds, as Mo	(4) 10 mg/m ³ I (2) 3 mg/m ³ R	15 mg/m ³ (Total dust)	Acute: Mild irritant to mucous membranes. Chronic: Lower respiratory tract irritation.
Soluble compounds, as Mo	(2) 0.5 mg/m ³ R	5 mg/m ³	
Nickel, Inorganic compounds Insoluble compounds, as Ni Soluble compounds, as Ni	(4) 0.2 mg/m ³ I (4) 0.1 mg/m ³ I	1 mg/m ³ 1 mg/m ³	Local: Skin sensitizer. Systemic: Suspect carcinogen.
Nitrogen Dioxide	3 ppm	(6) C 5 ppm	Acute: Severe irritant to eyes and mucous membranes. Difficulty in breathing. Chronic: Lung dysfunction.

Chemical Substance	(1) TLV-TWA	OSHA PELs-TWA	Potential Health Hazard
Ozone	0.05 ppm (Heavy Work) 0.1 ppm (Light Work)	0.2 mg/m ³	Acute: Severe irritant to eyes and mucous membranes. Difficulty in breathing. Chronic: Lung fibrosis.
Phosgene	0.4 mg/m ³ (0.1 ppm)	0.4 mg/m ³ (0.1 ppm)	Acute: Lung damage may be fatal. Fibrosis and lung damage.
Phosphine	0.42 mg/m ³ (0.3 ppm)	0.4 mg/m ³ (0.3 ppm)	Acute: Irritation of lungs, liver damage, and central nervous System (CNS) depression. CNS impairment.
Sodium Fluoride-see Fluorides	2.5 mg/m ³ (as F)	2.5 mg/m ³ (as F)	Acute: Irritant to eyes, skin, mucous membranes, and lungs. Chronic: Nose bleeds and sinusitis.
Silica (Silicon Dioxide) – Crystalline, alpha-Quartz	⁽²⁾ 0.025 mg/m ³ R	Use "Quartz" formulas in "Health Hazards References" 1.	Chronic: Can cause silicosis and may cause cancer. Pulmonary fibrosis.
Titanium Dioxide	10 mg/m ³	15 mg/m ³ (Total dust)	Acute: Combined with chlorine, lung injury can occur. Chronic: Possibly carcinogenic (animal carcinogen).
Welding fumes (Not otherwise specified)	Withdrawn. (Previously 5 mg/m ³)	-----	Acute: Respiratory irritation. Chronic: Possible human carcinogen.
Zinc Oxide, Fume	-----	5 mg/m ³	Acute: Irritant to skin. Metal fume fever.
Zinc Oxide	⁽²⁾ 2 mg/m ³ R	15 mg/m ³ (Total dust) 5 mg/m ³ (Respirable fraction)	

(1) Threshold Limit Values-Time Weighted Average (2009 ACGIH Guide to Occupational Exposure Limits)

(2) "R" - Measured as respirable fraction of the aerosol.

(3) "(F)" - Respirable fibers: length > 5µ, aspect ratio > or = 3:1, as determined by the membrane filter method at 400-450x magnification (4-mm objective), using phase-contrast illumination.

(4) "I" - Measured as Inhalable fraction of the aerosol.

(5) "C" - Threshold Limit Ceiling Value -- The concentration that should not be exceeded even instantaneously.

(6) "NIC" - Notice of Intended Change

(7) "NIC-A4" - Notice of Intended Change--Not Classifiable as a Human Carcinogen"

RECOMMENDED REFERENCES

The following sources on safety in welding, cutting and gouging operations are periodically updated and are recommended to the reader. These publications are prepared for the protection of persons from injury and illness and the protection of property from damage by fire and other causes arising from welding, cutting and gouging.

- A. A. Publications available from the American Welding Society, P.O. Box 351040, Miami, FL 33135:
 - 1. "Welding Safety and Health Information Packet" - SHP.
 - 2. "Safety in Welding and Cutting"-ANSI/AWSZ49.1.
 - 3. "Recommended Safe Practices for the Preparation for Welding and Cutting of Containers and Piping That Have Held Hazardous Substances"-AWSF4.1.
 - 4. "Recommended Practices for Plasma Arc Cutting" - AWS C5.2.
 - 5. "Method for Sampling Airborne Particulates Generated by Welding and Allied Processes" - ANSI/AWS F1.1
 - 6. "Guide for Welding Fume Control", AWS F3.1.
 - 7. "Arc Welding and Cutting Noise" - AWN.
 - 8. "Fumes and Gases in the Welding Environment." - FGW

- B. Publications available from the National Fire Protection Association, 1 Battery-march Park, P.O. Box 9101, Quincy, MA 02269:
 - 1. "Cutting and Welding Processes" - NFPA 51 B.
 - 2. "Oxygen - Fuel Gas Systems for Welding, Cutting and Allied Processes"-NFPA 51.
 - 3. "National Electrical Code" - NFPA 70.
 - 4. "National Electrical Code Handbook".

- C. Publications available from the Compressed Gas Association, Inc., 1235 Jefferson Davis Highway, Arlington, VA 22202:
 - 1. "Safe Handling of Compressed Gases in Cylinders" - CGA P-1.
 - 2. "Compressed Gas Cylinder Valve Outlet and Inlet Connections" - CGA V-1.

D. Safety information available from your welding products supplier:

1. Material Safety Data Sheets.
2. "Precautions and Safe Practices for Welding, Cutting, and Heating with Oxygen-Fuel Gas Equipment, Form 2035.
3. Oxy-Fuel Safety Composite, VHS videocassette, Part No. F7217. Includes "Safe Welding and Cutting with Oxy-Fuel Equipment," "Multiflame Heating Heads," "Protect Yourself Against Dangerous Flashbacks" and "Protect Yourself Against Oxygen Regulator Explosions."
4. "Safe Brazing, Soldering and Cutting", VHS videocassette, Part No. 7103.
5. "Protect Yourself Against Dangerous Flashbacks", VHS Videocassette, Part No. 7167.

E. Other Publications:

1. "Safe Practices for Occupation and Educational Eye and Face Protection" - ANSI Z87.1, American National Standards Institute, 11 West 42nd Street, New York, NY 10036.
2. "Occupational Safety and Health Standards" - 29 CFR 1910, U.S. Department of Labor, Occupational Safety and Health Administration, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

EMERGENCY & FIRST-AID PROCEDURES

First aid is immediate, temporary treatment given in the event of accident or illness. Immediate first aid (within four minutes) may be the difference between complete recovery, permanent impairment, or death.

INHALATION -Workers with symptoms of exposure to fumes and gases should go to an uncontaminated area and inhale fresh air or oxygen. If victim is unconscious, rescuer must clear the area of poisonous or asphyxiant gases or wear proper breathing apparatus before entering area. Then, immediately remove victim to an uncontaminated area and call a physician. Administer oxygen by mask if the person is breathing. If breathing has stopped, administer cardiopulmonary resuscitation (CPR), preferably with simultaneous administration of oxygen. Call for emergency assistance. Keep the victim warm and at rest.

EYE - Contact lenses, if worn, should be removed. Irrigate the eyes immediately with large amounts of water for 15 minutes. Occasionally hold the eyelids apart to insure complete irrigation. Apply a dry protective dressing. Call for emergency medical assistance.

Don't remove dust from the eyes yourself. Get medical assistance.

For "flash burns" cover the eye with cold (preferably iced) compresses for 5 to 10 minutes; then repeat. Apply a dry protective dressing. Call a physician. Don't rub the eye. Don't use ointments or drops unless prescribed by a physician.

SKIN - For skin contact with irritants, flush the areas with large amounts of water, and then wash with soap and water. Remove contaminated clothing. If mucous membranes are irritated, flush with water. Wash cuts and scrapes with mild soap and water. Avoid contamination. Apply a dry sterile dressing.

For thermal burns, cold water is an effective first aid measure. If skin is not broken, immerse burn part in clean cold water or apply clean ice to relieve pain. Do not disturb or open blisters. Prevent contamination. Bandage loosely with a clean dry dressing. Call for emergency medical assistance.

ELECTRICAL SHOCK AND ELECTRICAL BURNS - Disconnect and turn off power. Remove victim from contact. Use nonconducting materials if the rescuer must resort to pulling the victim from the live contact. The rescuer must first protect himself by use of insulated materials such as gloves. If not breathing, administer CPR as soon as electrical contact is broken. Call for emergency medical assistance. Continue CPR until spontaneous breathing has been restored or until a physician arrives. Administer oxygen. Keep comfortably warm. Keep horizontal until there is no further evidence of shock. Treat electrical burns as thermal burns. For electrical burns apply clean, cold (iced) compresses. Prevent contamination. Cover with a clean, dry dressing. Call for emergency medical assistance.

