



Welding Safety

Course Number: HS-02-301

PDH: 3

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**Replacement Welding Tips. STD 01-14-001
[STD 1-14.1], (1978, October 30)**

OSHA Instruction STD 1-14.1 October 30, 1978

February 22, 1973

OSHA PROGRAM DIRECTIVE #100-23

To: Field and National Offices

Subject: Replacement Welding Tips

1. Purpose. To clarify 29 CFR 1910.252(a)(1)(iii).
2. Background. Numerous requests for clarification have been received from employers and manufacturers concerned with the application of the term "approved apparatus" to replacement welding tips and convertor/adaptors (used for mounting tips). These inquiries were prompted by the fact that nationally recognized testing laboratories will not accept tips or convertor/adaptors for testing except as part of a completely assembled torch.
3. Interpretation. Use of replacement tips will not nullify the "approved apparatus" status of a torch, if such replacement tips are made to the same specifications as the original tip of the torch at the time of approval by the nationally recognized testing laboratory, or if the use of such tips in conjunction with convertor/adaptors results in the same specifications as the original tip at the time of approval by the nationally recognized testing laboratory.
4. Effective Date. This instruction is effective immediately and will remain in effect until canceled or superseded.

Director, Office of Standards

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**Welding, Cutting, or Heating of Metals Coated with Lead-Bearing Paint.
STD 03-08-001 STD 03-08-001
[STD 3-8.1], (1978, October 30)**

OSHA Instruction STD 3-8.1 OCT 30, 1978

OSHA PROGRAM DIRECTIVE #100-53

To: REGIONAL ADMINISTRATORS/OSHA

Subject: Welding, Cutting or Heating of Metals Coated with Lead-Bearing Paint

References: (a) 29 CFR 1926.353(c)(2)(i) (b) 29 CFR 1926.354(c)(1)

1. Purpose

This directive explains the requirements imposed by the referenced sections of 1926.353 and 1926.354 when welding, cutting or heating is performed in an enclosed space on metals coated with lead-bearing paint.

2. Documents Affected

None.

3. Explanation

In the Construction Industry, the referenced sections of 1926.353 and 1926.354 apply jointly when welding, cutting or hearing is performed in an enclosed space on metal coated with lead-bearing paint. Reference (a) requires employers to provide local exhaust ventilation or to protect employees with airline respirators. Reference (b) requires employers to ensure that the paint is stripped back at least 4 inches from the area of heat application or to protect the employees with airline respirators. A presentation on the dual impact of references (a) and (b) is in order.

4. Action

a. Sections 1926.353(c)(2)(i) and 1926.354(c)(1) have joint application when welding, cutting or heating is being performed in an enclosed space on metals coated with lead-bearing paint.

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b. There must be compliance with the following dual requirements:(1) At all times, the toxic preservative coating must be stripped back at least 4 inches from the area of heat application (1926.354(c)(1));(2) If the concentration of a substance in the breathing zone of the employee exceeds the threshold limit value (TLV) referenced in section 1926.55 (a), local exhaust ventilation must be provided in addition to the stripping back procedure (1926.353(c)(2)(i)).c. When conformity with these requirements fails to reduce concentrations below the TLV, or when the techniques are impossible to implement, then employees must be provided with airline respirators.(See 1926.103 (a)(1).) All possible paint-stripping and provision of local exhaust ventilation must be continued even though it is determined that airline respirators must be used.d. The area of heat application is interpreted to be the surface area that the

flame or arc contacts.e. In some instances it may be difficult to visually ascertain the edge of the area of heat application. In those instances where, because of this difficulty, it is uncertain from visual observations whether the lead-bearing paint is stripped back 4 inches from the area of heat application, the OSHA compliance officer shall mark the edge(s) of the stripped surface that is (are) distal from the center of heat application with temperature indicating crayons having a 500 deg. F melting point. Melting of the crayon markings shall be the criterion for affirming insufficient stripping of the lead-bearing paint.f. Temperature indicating crayons may be purchased locally from scientific equipment supply houses. If help in locating a supply source is needed, contact the National Office at the telephone number given at the end of this directive.

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5. Effective Date

This directive is effective immediately and shall be retained until further notice. Questions may be directed to Mr. Gail M. Brinkerhoff of the OSHA Washington, D.C. National Office - 523-8098.

Barry J. White Associate Assistant Secretary for Regional Programs

DISTRIBUTION:

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**29 CFR 1926.350(a)(9) Securing of Compressed Gas Cylinders.
STD 03-08-002 [STD 3-8.2], (1981, March 11)**

OSHA Instruction STD 3-8.2 March 11, 1981 Office of Compliance Programming

SUBJECT: 29 CFR 1926.350(a)(9) Securing of Compressed Gas Cylinders

A. Purpose. This instruction emphasizes that the OSHA standard, 29 CFR 1926.350(a)(9), applies to transporting, moving and storing compressed gas cylinders at construction sites only.

B. Scope. This instruction applies OSHA-wide.

C. Action. OSHA Regional Administrators and Area Directors shall assure that CSHO's do not apply 29 CFR 1926.350(a)(9) to the manufacturers and distributors of welding gases based on the following:

1. The construction standard, 29 CFR 1926.350(a) (9), or any comparable maritime standard, does not apply to welding gas supply manufacturers or distributors who do not secure compressed gas cylinders in an upright position on their premises. 2. The general industry standards, 29 CFR 1910, Subpart Q--Welding, Cutting, and Brazing, (Source Standard is in NFPA-51-1969) do not contain any standard comparable to the construction standard, 29 CFR 1926.350(a)(9). 3. 29 CFR 1910.101(b) references, through CGA Pamphlet P-1-1965 article 3.3.1, the source standard, NFPA No. 51-1969 paragraph 1023, which states: "This Standard does not apply to the manufacture of gases and the filling of cylinders."

OSHA Instruction STD 3-8.2 March 11, 1981 Office of Compliance Programming

D. Federal Program Change. This instruction describes a Federal program change which affects State programs. Each Regional Administrator shall:

1. Ensure that this change is forwarded to each State designee. 2. Explain the technical content of the change to the State designees as requested. 3. Ensure that the State designees are asked to acknowledge receipt of the Federal program change in writing, within 30 days of notification, to the Regional Administrator. This acknowledgment should include a description either of the State's plan to implement the change or of the reasons why the change should not apply to that State. 4. Review policies, instruction and guidelines issued by the State to determine that this change has been communicated to State program personnel. Routine monitoring activities (accompanied inspections and case file reviews) shall also be used to determine if this change has been implemented in actual performance.

E. Background. The National Welding Supply Association has brought to our attention that citations were issued to its manufacturer and distributor members in various parts of the country by compliance officers who are attempting to apply the standard, 29 CFR 1926.350(a)(9), to the activity of these manufacturers and distributors. The intent of the standard applies to gas welding or cutting on a construction site; it does not apply to the manufacturers and distributors of welding gases prior to delivery at the construction site. In addition, manufacturers and distributors have personnel experienced in the handling of the cylinders, who cap, carefully rack, and store the cylinders in an

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upright position. Continual chaining and unchaining, for example, of hundreds of cylinders as they are moved out of the plant and off the loading docks may produce other hazards.

Bruce Hillenbrand Deputy Director, Federal Compliance and State Programs

DISTRIBUTION: National, Regional and Area Offices All Compliance Officers State Designees
NIOSH Regional Program Directors

Welding, Cutting, and Compressed Gas Cylinder Safety **Course number: EOS 009**

GAS WELDING AND CUTTING

Transporting, Moving, and Storing Compressed Gas Cylinders

- Valve protection caps shall be in place and secured.
- When cylinders are hoisted, they shall be secured on a cradle, slingboard, or pallet. They shall not be hoisted or transported by means of magnets or choker slings.
- Cylinders shall be moved by tilting and rolling them on their bottom edges. They shall not be intentionally dropped, struck, or permitted to strike each other violently.
- When cylinders are transported by powered vehicles, they shall be secured in a vertical position.
- Valve protection caps shall not be used for lifting cylinders from one vertical position to another. Bars shall not be used under valves or valve protection caps to pry cylinders loose when frozen. Warm, not boiling, water shall be used to thaw cylinders loose.
- Unless cylinders are firmly secured on a special carrier intended for this purpose, regulators shall be removed and valve protection caps put in place before cylinders are moved.
- A suitable cylinder truck, chain, or other steadying device shall be used to keep cylinders from being knocked over while in use.



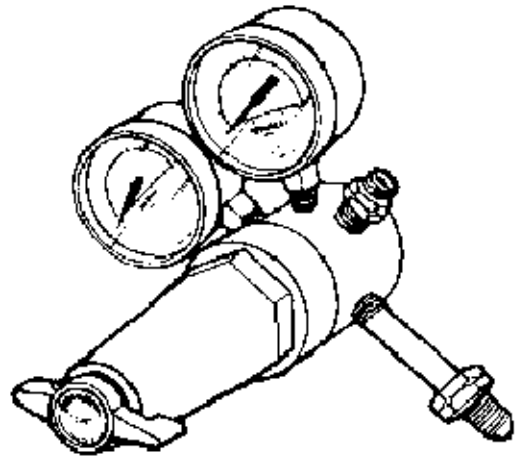
When work is finished, when cylinders are empty, or when cylinders are moved at any time, the cylinder

- valve shall be closed.
- Compressed gas cylinders shall be secured in an upright position at all times, if necessary, for short periods of time while cylinders are actually being hoisted or carried.

- Oxygen cylinders in storage shall be separated from fuel-gas cylinders or combustible materials (especially oil or grease), a minimum distance of 20 feet (6.1 m) or by a noncombustible barrier at least 5 feet (1.5 m) high having a fire-resistance rating of at least one-half hour.
- Inside of buildings, cylinders shall be stored in a well-protected, well-ventilated, dry location, at least 20 feet (6.1 m) from highly combustible materials such as oil or excelsior. cylinders should be stored in definitely assigned places away from elevators, stairs, or gangways. Assigned storage places shall be located where cylinders will not be knocked over or damaged by passing or falling objects, or subject to tampering.
- The in-plant handling, storage, and utilization of all compressed gases in cylinders, portable tanks, rail tank cars, or motor vehicle cargo tanks shall be in accordance with Compressed Gas Association Pamphlet P-1-1965.

Placing Cylinders

- Cylinders shall be kept far enough away from the actual welding or cutting operation so that sparks, hot slag, or flame will not reach them. When this is impractical, fire resistant shields shall be provided.
- Cylinders shall be placed where they cannot become part of an electrical circuit. Electrodes shall not be struck against a cylinder to strike an arc.
- Fuel gas cylinders shall be placed with **valve end up** whenever they are in use. They shall not be placed in a location where they would not be subject to open flame, hot metal, or other sources of artificial heat.
- Cylinders containing oxygen or acetylene or other fuel gas shall not be taken into confined spaces.



Treatment of Cylinders

- Cylinders, whether full or empty, shall not be used as rollers or supports.
- No person other than the gas supplier shall attempt to mix gases in a cylinder. No one except the owner of the cylinder or person authorized by him, shall refill a cylinder. No one shall use a cylinder's contents for purposes than those intended by the supplier. All cylinders used shall meet the Department of Transportation requirements published in 49 CFR Part 178, Subpart C, Specification for Cylinders.

- No damaged or defective cylinder shall be used.

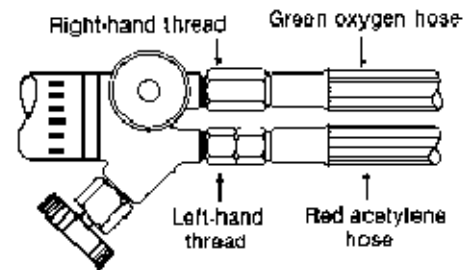
Use of Fuel Gas

The employer shall thoroughly instruct employees in the safe use of fuel gas, as follows:

- Fuel gas shall not be used from cylinders through torches or other devices which are equipped with shutoff valves without reducing the pressure through a suitable regulator attached to the cylinder valve or manifold.
- Before a regulator to a cylinder valve is connected, the valve shall be opened slightly and closed immediately. (This action is generally termed "cracking" and is intended to clear the valve of dust or dirt that might otherwise enter the regulator.) The person cracking the valve shall stand to one side of the outlet, not in front of it. The valve of a fuel gas cylinder shall not be cracked where the gas would reach welding work, sparks, flame, or other possible sources of ignition.
- The cylinder valve shall always be opened slowly to prevent damage to the regulator. For quick closing, valves of fuel gas cylinders shall not be opened more than 1½ turns. When a special wrench is required, it shall be left in position on the stem of the valve while the cylinder is in use so that the fuel gas flow can be shut off quickly in case of an emergency. In the case of manifold or coupled cylinders, at least one such wrench shall always be available for immediate use. Nothing shall be placed on top of a fuel gas cylinder, when in use, which may damage the safety device or interfere with the quick closing of the valve.
- Before a regulator is removed from a cylinder valve, the cylinder valve shall always be closed and the gas released from the regulator.
- If, when the valve on a fuel gas cylinder is opened, there is found to be a leak around the valve stem, the valve shall be closed and the gland nut tightened. If this action does not stop the leak, the use of the cylinder shall be discontinued, and it shall be properly tagged and removed from the work area. In the event that fuel gas should leak from the cylinder valve, rather than from the valve stem, and the gas cannot be shut off, the cylinder shall be properly tagged and removed from the work area. If a regulator attached to a cylinder valve will effectively stop a leak through the valve seat, the cylinder need not be removed from the work area.
- If a leak should develop at a fuse plug or other safety device, the cylinder shall be removed from the work area.
- **Fuel Gas and Oxygen Manifolds**

Fuel gas and oxygen manifolds shall bear the name of the substance they contain in letters at least 1-inch high which shall be either painted on the manifold or on a sign permanently attached to it. These manifolds shall be placed in safe, well ventilated, and accessible locations and not be located within enclosed spaces.

Manifold hose connections, including both ends of the supply hose that lead to the manifold, shall be such that the hose cannot be interchanged between fuel gas and oxygen manifolds and supply header connections. Adapters shall not be used to permit the interchange of hose. Hose connections shall be kept free of grease and oil.

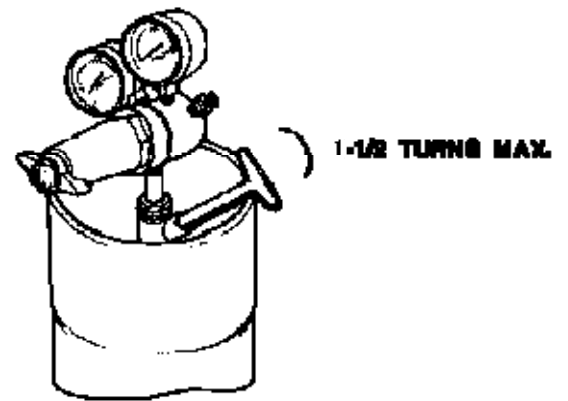


When not in use, manifold and header hose connections shall be capped.

Nothing shall be placed on top of a manifold, when in use, which will damage the manifold or interfere with the quick closing of the valves.

Hose

Fuel gas 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. Oxygen and fuel gas hoses shall not be interchangeable. (See accompanying figure for example.) A single hose having more than one gas passage shall not be used.



When parallel sections of oxygen and fuel gas hose are taped together, not more than 4 inches out of 12 inches shall be covered by tape.

All hose in use, carrying acetylene, oxygen, natural or manufactured fuel gas, or any gas or substance which may ignite or enter into combustion, or be in any way harmful to employees, shall be inspected at the beginning of each working shift. Defective hose shall be removed from service.

Hose which has been subject to flashback, or which shows evidence of severe wear or damage, shall be tested to twice the normal pressure to which it is subject, but in no case less than 300 psi. Defective hose, or hose in doubtful condition, shall not be used.

Hose couplings shall be of the type that cannot be unlocked or disconnected by

means of a straight pull without rotary motion.

Boxes used for the storage of gas hose shall be ventilated.

Hoses, cables, and other equipment shall be kept clear of passageways, ladders, and stairs.

Torches

Clogged torch tip openings shall be cleaned with suitable cleaning wires, drills, or other devices designed for such purpose.

Torches in use shall be inspected at the beginning of each working shift for leaking shutoff valves, hose couplings, and tip connections. Defective torches shall not be used.

Torches shall be lighted by friction lighters or other approved devices, and not by matches or from hot work.

Regulators and Gauges

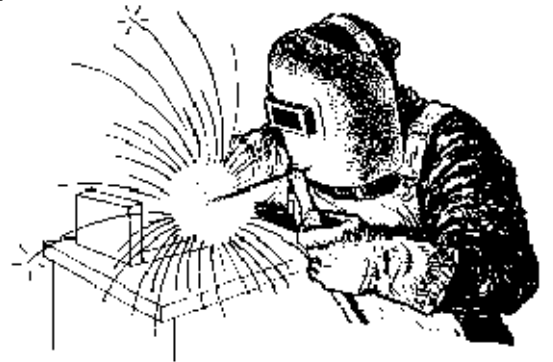
Oxygen and fuel gas pressure regulators, including their related gauges, shall be in proper working order while in use.

Oil and Grease Hazards

Oxygen cylinders and fittings shall be kept away from oil or grease. Cylinders, cylinder caps and valves, couplings, regulators, hose, and apparatus shall be kept free from oil or greasy substances and shall not be handled with oily hands or gloves. Oxygen shall not be directed at oily surfaces, greasy clothes, or within a fuel oil or other storage tank or vessel.

Additional Rules

For additional details not covered in this subpart, applicable technical portions of American National Standards Institute, Z49.1-1967, **Safety in Welding and Cutting**, shall apply.



ARC WELDING AND CUTTING

Manual Electrode Holders

Only manual electrode holders which are specifically designed for arc welding and cutting, and are of a capacity capable of safely handling the maximum rated current required by the electrodes, shall be used.

Any current-carrying parts passing through the portion of the holder which the arc welder or cutter grips in his hand, and the outer surfaces of the jaws of the holder, shall be fully insulated against the maximum voltage encountered to ground.

Welding Cables and Connectors

All arc welding and cutting cables shall be of the completely, insulated, flexible type, capable of handling the maximum current requirements of the work in progress, taking into account the duty cycle under which the arc welder or cutter is working.

Only cable free from repair or splices for a minimum distance of 10 feet from the cable end to which the electrode holder is connected shall be used, except that cables with standard insulated connectors or with splices whose insulating quality is equal to that of the cable are permitted.

Cables in need of repair shall not be used. When a cable, other than the cable lead referred to above, becomes worn to the extent of exposing bare conductors, the portion thus exposed shall be protected by means of rubber and friction tape or other equivalent insulation.

When it becomes necessary to connect or splice lengths of cable one to another, substantial insulated connectors of a capacity at least equivalent to that of the cable shall be used. If connections are effected by means of cable lugs, they shall be securely fastened together to give good electrical contact, and the exposed metal parts of the lugs shall be completely insulated.

Ground Returns and Machine Grounding

A ground return cable shall have a safe current-carrying capacity equal to or exceeding the specified maximum output capacity of the arc welding or cutting unit which it services. When a single ground return cable services more than one unit, its safe current-carrying shall exceed the total specified maximum output capacities of all the units which it services.

Pipelines containing gases or flammable liquids, or conduits containing electrical circuits, shall not be used as a ground return.

When a structure or pipeline is employed as a ground return circuit, it shall be determined that the required electrical contact exists at all joints. The generation of an arc, sparks, or heat at any point shall cause rejection of the structure as a ground circuit.

When a structure or pipeline is continuously employed as a ground return circuit,

all joints shall be bonded, and periodic inspections shall be conducted to ensure that no condition of electrolysis or fire hazard exists by virtue of such use.

The frames of all arc welding and cutting machines shall be grounded either through a third wire in the cable containing the circuit conductor or through a separate wire which is grounded at the source of the current. Grounding circuits, other than by means of the structure, shall be checked to ensure that the circuit between the ground and the grounded power conductor has resistance low enough to permit sufficient current to flow to cause the fuse or circuit breaker to interrupt the current.

All ground connections shall be inspected to ensure that they are mechanically strong and electrically adequate for the required current.

Operating Instructions

Employers shall instruct employees in the safe means of arc welding and cutting as follows:

- When electrode holders are to be left unattended, the electrodes shall be removed and the holders shall be

so placed or protected that they cannot make electrical contact with employees or conducting objects.
- Hot electrode holders shall not be dipped in water; to do so may expose the arc welder or cutter to electric shock.
- When the arc welder or cutter has occasion to leave his work or to stop work for any appreciable length of time, or when the arc welding or cutting machine is to be moved, the power supply switch to the equipment shall be opened.
- Any faulty or defective equipment shall be reported to the supervisor.
- A disconnecting means shall be provided in the supply circuit for each motor generated arc welder, and for each AC transformer and DC rectifier arc welder which is not equipped with a disconnect mounted as an integral part of the welder.
- A switch or circuit breaker shall be provided by which each resistance welder and its control equipment can be isolated from the supply circuit. The ampere rating of this disconnecting means shall not be less than the supply conductor ampacity.

Shielding

Whenever practicable, all arc welding and cutting operations shall be shielded

by noncombustible or flameproof screen which will protect employees and other persons working in the vicinity from the direct rays of the arc.

FIRE PREVENTION

When practical, objects to be welded, cut, or heated shall be moved to a designated safe location or, if these objects cannot be readily moved, all movable fire hazards in the vicinity shall be taken to a safe place, or otherwise protected. If these objects cannot be moved and if all the fire hazards cannot be removed, positive means shall be taken to confine the heat, sparks, and slag, and to protect the immovable fire hazards from them.

No welding, cutting or heating shall be done where the application of flammable paints, or the presence of other flammable compounds, or heavy dust concentrations creates a hazard.

Suitable fire extinguishing equipment shall be immediately available in the work area and shall be maintained in a state of readiness for instant use.

When the welding, cutting, or heating operation is such that normal fire prevention precautions are not sufficient, additional personnel shall be assigned to guard against fire while the actual welding, cutting, or heating operation is being performed, and for a sufficient period of time after completion of the work to ensure that no possibility of fire exists. Such personnel shall be instructed as to the specific anticipated fire hazards and how the firefighting equipment provided is to be used.

When welding, cutting, or heating is performed on walls, floors, and ceilings, since direct penetration of sparks or heat transfer may introduce a fire hazard to an adjacent area, the same precautions shall be taken on the opposite side as are taken on the side on which the welding is being performed.

Whenever practicable, all arc welding and cutting operations shall be shielded by noncombustible or flameproof screen which will protect employees and other persons working in the vicinity from the direct rays of the arc.

For the elimination of possible fire in enclosed spaces as a result of gas escaping through leaking or improperly closed torch valves, the gas supply to the torch shall be positively shut off at some point outside the enclosed space whenever the torch is not to be used or whenever the torch is left unattended for a substantial period of time, such as during the lunch period. Overnight and at the change of shifts, the torch and hose shall be removed from the confined space. Open end fuel gas and oxygen hoses shall be immediately removed from enclosed spaces when they are disconnected from the torch or other gas-

consuming device.

Except when the contents are being removed or transferred, drums, pails, and other containers which contain or have contained flammable liquids shall be kept closed. Empty containers shall be removed to a safe area apart from hot work operations or open flames.

Drums, containers, or hollow structures which have contained toxic or flammable substances shall, before welding, cutting, or heating is undertaken on them, either be filled with water or thoroughly cleaned of such substances and ventilated and tested.

Before heat is applied to a drum, container, or hollow structure, a vent or opening shall be provided for the release of any built-up pressure during the application of heat.

VENTILATION AND PROTECTION IN WELDING, CUTTING, AND HEATING

Mechanical Ventilation

Mechanical ventilation shall consist of either general mechanical ventilation systems or local exhaust systems.

Ventilation shall be deemed adequate if it is of sufficient capacity and so arranged as to remove fumes and smoke at the source and keep their concentration in the breathing zone within safe limits as defined in Subpart D of Part 1926, **Occupational Health and Environmental Controls**.

Contaminated air exhausted from a working space shall be discharged clear of the source of intake air.

All air replacing that withdrawn shall be clean and respirable. Oxygen shall not be used for ventilation purposes, comfort cooling, blowing dust from clothing, or for cleaning the work area.

Welding, Cutting, and Heating in Confined Spaces

Except where air line respirators are required or allowed as described below, adequate mechanical ventilation meeting the requirements described above shall be provided whenever welding, cutting, or heating is performed in a confined space.

When sufficient ventilation cannot be obtained without blocking the means of access, employees in the confined space shall be protected by air line respirators in accordance with the requirements of Subpart E of Part 1926, **Personal Protective and Life Saving Equipment**. An employee on the outside of the confined space shall be assigned to maintain communication with those working

within it and to aid them in an emergency.

Where a welder must enter a confined space through a small opening, means shall be provided for quickly removing him in case of emergency. When safety belts and lifelines are used for this purpose they shall be so attached to the welder's body that his body cannot be jammed in a small exit opening. An attendant with a pre-planned rescue procedure shall be stationed outside to observe the welder at all times and be capable of putting rescue operations into effect.

Welding, Cutting, or Heating of Metals of Toxic Significance

Welding, cutting, or heating in any enclosed spaces involving the following metals shall be performed with adequate mechanical ventilation as described above:

- Zinc-bearing base or filler metals or metals coated with zinc-bearing materials;
- Lead base metals;
- Cadmium-bearing filler materials;
- Chromium-bearing metals or metals coated with chromium-bearing materials.

Welding, cutting, or heating in any enclosed spaces involving the following metals shall be performed with adequate local exhaust ventilation as described above or employees shall be protected by air line respirators in accordance with the requirements of Subpart E:

- Metals containing lead, other than as an impurity, or metals coated with lead-bearing materials;
- Cadmium-bearing or cadmium-coated base metals;
- Metal coated with mercury-bearing metals;

Beryllium-containing base or filler metals. Because of its high toxicity, work involving beryllium shall be done with both local exhaust ventilation and air line respirators.

Employees performing such operations in the open air shall be protected by filter-type respirators in accordance with the requirements of Subpart E, except that employees performing such operations on beryllium-containing base or filler metals shall be protected by air line respirators in accordance with the requirements of Subpart E.

Other employees exposed to the same atmosphere as the welders or burners shall be protected in the same manner as the welder or burner.

Inert-Gas Metal-Arc Welding

Since the inert-gas metal-arc welding process involves the production of ultra-violet radiation of intensities of 5 to 30 times that produced during shielded metal-arc welding, the decomposition of chlorinated solvents by ultraviolet rays, and the liberation of toxic fumes and gases, employees shall not be permitted to engage in, or be exposed to the process until the following special precautions have been taken:

- The use of chlorinated solvents shall be kept at least 200 feet, unless shielded, from the exposed arc, and surfaces prepared with chlorinated solvents shall be thoroughly dry before welding is permitted on such surfaces.
- Employees in the area not protected from the arc by screening shall be protected by filter lenses meeting the requirements of Subpart E. When two or more welders are exposed to each other's arc, filter lens goggles of a suitable type, meeting the requirements of Subpart E, shall be worn under welding helmets. Hand shields to protect the welder against flashes and radiant energy shall be used when either the helmet is lifted or the shield is removed.
- Welders and other employees who are exposed to radiation shall be suitably protected so that the skin is covered completely to prevent burns and other damage by ultraviolet rays. Welding helmets and hand shields shall be free of leaks and openings, and highly reflective surfaces.
- When inert-gas metal-arc welding is being performed on stainless steel, adequate local exhaust ventilation as described above or air line respirators in accordance with the requirements of Subpart E shall be used to protect against dangerous concentrations of nitrogen dioxide.

General Welding, Cutting, and Heating

Welding, cutting, or heating not involving conditions or toxic materials described above may normally be done without mechanical ventilation or respiratory protective equipment. These protections shall be provided, however, where an unsafe accumulation of contaminants exists because of unusual physical or atmospheric conditions.

Employees performing any type of welding, cutting, or heating shall be protected by suitable eye protective equipment in accordance with the requirements of Subpart E.

WELDING, CUTTING, AND HEATING IN WAY OF PRESERVATIVE COATINGS

Before welding, cutting, or heating is commenced on any surface covered by a preservative coating whose flammability is not known, a test shall be made by a competent person to determine its flammability. Preservative coatings shall be considered to be highly flammable when scrapings burn with extreme rapidity.

When coatings are determined to be highly flammable, they shall be stripped from the area to be heated to prevent ignition.

Protection against toxic preservative coatings:

- In enclosed spaces, all surfaces covered with toxic preservatives shall be stripped of all toxic coatings for a distance of at least 4 inches from the area of heat application, or the employees shall be protected by air line respirators meeting the requirements of Subpart E.
- In the open air, employees shall be protected by a respirator, in accordance with the requirements of Subpart E.

The preservative coatings shall be removed a sufficient distance from the area to be heated to ensure that the temperature of the un-stripped metal will not be raised. Artificial cooling of the metal surrounding the heating area may be used to limit the size of the area required to be cleaned.

Welding Health Hazards

I. CHEMICAL AGENTS

ZINC

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

CADMIUM

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

BERYLLIUM

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

IRON OXIDE

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

MERCURY

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

LEAD

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

FLUORIDES

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

CHLORINATED HYDROCARBON SOLVENTS

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

PHOSGENE

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

CARBON MONOXIDE

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

OZONE

Ozone (O₃) is produced by ultraviolet light from the welding arc. Ozone is produced in greater quantities by gas metal arc welding (GMAW or short-arc), gas tungsten arc welding (GTAW or heli-arc), and plasma arc cutting. Ozone is a highly active form of oxygen and can cause great irritation to all mucous membranes. Symptoms of ozone exposure include headache, chest pain, and dryness of the upper respiratory tract. Excessive exposure can cause fluid in the lungs (pulmonary edema). Both nitrogen dioxide and ozone are thought to have long-term effects on the lungs.

NITROGEN OXIDES

The ultraviolet light of the arc can produce nitrogen oxides (NO, NO₂), from the nitrogen (N) and oxygen (O₂) in the air. Nitrogen oxides are produced by gas metal arc welding (GMAW or short-arc), gas tungsten arc welding (GTAW or heli-arc), and plasma arc cutting. Even greater quantities are formed if the shielding gas contains nitrogen. Nitrogen dioxide (NO₂), one of the oxides formed, has the greatest health effect. This gas is irritating to the eyes, nose and throat but dangerous concentrations can be inhaled without any immediate discomfort. High concentrations can cause shortness of breath, chest pain, and fluid in the lungs (pulmonary edema).

II. PHYSICAL AGENTS

ULTRAVIOLET RADIATION

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

INFRARED RADIATION

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

INTENSE VISIBLE LIGHT

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