American Welding Society

Safety & Health Fact Sheets

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The free PDF documents below provide clear help in addressing common safety and health concerns. For more detailed information, refer to the free ANSI Z49.1 standard.

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Fumes and Gases

INTRODUCTION

Many welding, cutting, and allied processes produce fumes and gases, which may be harmful to your health.

- Fumes are solid particles which originate from welding consumables, the base metal, and any coatings present on the base metal.
- In addition to shielding gases that may be used, gases are produced during the welding process or may be produced by the effects of process radiation on the surrounding environment.
- Acquaint yourself with the effects of these fumes and gases by reading the Safety Data Sheets (SDSs) for all materials used (consumables, base metals, coatings, and cleaners).
- For help, consult a recognized specialist in Industrial Hygiene or Environmental Services.
- The amount and composition of these fumes and gases depend upon the composition of the filler metal and base material, welding process, current level, arc length, and other factors.

POSSIBLE EFFECTS OF OVER-EXPOSURE

- Depending on the material involved, the effects range from irritation of eyes, skin, and respiratory system to more severe complications.
- Effects may occur immediately or at some later time.
- Fumes can cause symptoms such as nausea, headaches, dizziness, and metal fume fever.
- The possibility of more serious health effects exists when highly toxic materials are involved. For example, manganese overexposure can affect the central nervous system resulting in impaired speech and movement.
- In confined spaces the gases might displace breathing air and cause asphyxiation.

HOW TO AVOID OVEREXPOSURE

- Keep your head out of the fumes.
- Do not breathe the fumes.

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- Use enough ventilation or exhaust at the arc, or both, to keep fumes and gases from your breathing zone and general area.

- In some cases, natural air movement provides enough ventilation and fresh air

- Where ventilation is questionable, use air sampling to determine the need for corrective measures.

- Use mechanical ventilation to improve air quality.

- If engineering controls are not feasible, use an approved respirator.

- Whenever the following materials are identified as other than trace constituents in welding, brazing, or cutting operations, and unless breathing zone sampling under the most adverse conditions has established that the level of hazardous constituents is below the allowable limits specified by the authority having jurisdiction, special ventilation precautions shall be taken: Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Cobalt, Copper, Lead, Manganese, Mercury, Nickel, Ozone, Selenium, Silver, Vanadium. See section 5.5, Special Ventilation Concerns, ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes.*

- Work in a confined space only if it is well ventilated, or while wearing an air-supplied respirator. Fumes from Welding or cutting and oxygen depletion can alter air quality causing injury or death. Be sure the breathing air is safe.

- Follow OSHA guidelines for permissible exposure limits (PELs) for various fumes.

- Follow the American Conference of Governmental Industrial Hygienists recommendations for threshold limit values (TLVs) for fumes and gases.

- Have a recognized specialist in Industrial Hygiene or Environmental Services check the operation and air quality and make recommendations for the specific welding or cutting situation.

INFORMATION SOURCES

Occupational Safety and Health Administration (OSHA). *Code of Federal Regulations,* Title 29 Labor, Parts 1910.1 to 1910.1450, available from the U.S. Government Printing Office, 732 North Capital Street NW, Washington, DC 20401 (telephone: 800-321-6742; Web site: www.osha.gov).

American Conference of Governmental Industrial Hygienists (ACGIH). *Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices,* available from ACGIH, 1330 Kemper Meadow Drive, Cincinnati, OH 45240-1634 (telephone: 513-742-2020; Web site: www.acgih.org).

American Welding Society (AWS). *Fumes and Gases in the Welding Environment* and other welding related safety and health publications, published by the American Welding Society, 8669 Doral Blvd., Doral,

FL 33166; telephone 800-443-9353; Web site: www.aws.org.

Mine Safety and Health Administration (MSHA). *Code of Federal Regulations,* Title 30 Mineral Resources, Parts 1 to 199, available from the U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401; telephone: 202-693-9400; Web site: www.msha.gov.

American National Standards Institute (ANSI). *Safety in Welding, Cutting, and Allied Processes* (ANSI Z49.1), published by the American Welding Society, 8669 Doral Blvd., Doral, FL 33166; telephone 800-443-9353; Web site: www.aws.org.

For specific information, refer to the applicable Safety Data Sheet (SDS) available from the manufacturer, distributor, or supplier.

Radiation

INTRODUCTION

Most arc welding and cutting processes, laser welding, and torch welding, cutting, and brazing, or soldering may produce quantities of radiation requiring precautionary measures. Some processes, such as resistance welding and cold pressure welding, ordinarily produce negligible quantities of radiant energy.

DEFINITION

Radiation is electromagnetic energy given off by the arc or flame that can injure eyes and burn skin. An operator sees visible light radiation. However, he does not see ultraviolet or infrared radiation. Radiation is often silent and undetected, yet injury occurs. Have all users learn about the effects of radiation.

EFFECTS OF RADIATION

The effects of radiation depend on the wavelength, intensity, and length of time one is exposed to the radiant energy. Although a variety of effects is possible, the following two injuries are most common:

- Skin burns.
- Eye damage.

TYPES OF RADIATION

There are two types of radiation associated with welding operations:

- Ionizing (such as X-rays).
- Nonionizing (such as ultraviolet, visible light, or infrared).

IONIZING RADIATION

- Produced by the electron beam welding process. Controlled within acceptable limits by using suitable shielding around the electron beam welding area.
- Dust produced during grinding (pointing) of thoriated tungsten electrodes for Gas Tungsten Arc Welding (GTAW) process is radioactive. Controlled by using local exhaust and, if necessary, an approved respirator.

NONIONIZING RADIATION

- Intensity and wavelength of energy produced depend on the process, welding parameters, electrode and base metal composition, fluxes, and any coatings or plating on the base material.

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- Ultraviolet radiation increases approximately as the square of the welding current.

- Visible brightness (luminance) of the arc increases at a much lower rate. Processes using argon produce larger amounts of ultraviolet radiation than those using most other shielding gases.

HOW TO PROTECT AGAINST IONIZING RADIATION

- Required protection varies with time of exposure, distance from source, and shielding used.

- Follow recommended procedures in AWS F2.1.

- Use thorium-free electrodes whenever possible. When grinding (pointing) thoriated tungsten electrodes, use dust collecting grinders. Always use local exhaust and, if necessary, respiratory protection to prevent inhalation of dust.

HOW TO PROTECT AGAINST NON-IONIZING RADIATION

- Use welding helmet with correct shade of filter plate according to ANSI Z87.1.

  Note: Transparent welding curtains are not intended as welding filter plates, but rather are intended to protect passersby from incidental exposure.

- Protect exposed skin with adequate gloves and clothing according to ANSI Z49.1.

- Be aware of reflections from welding arcs, and protect all persons from intense reflections.

  Note: Paints using titanium dioxide or zinc oxide as major pigmentation media have a low reflectance for ultraviolet radiation.

- Locate welding operations so that other workers are not exposed to either direct or reflected radiation. Use screens, curtains, or adequate distances from other work stations, aisles, or walkways to avoid exposure.

- Wear safety glasses with UV protective side shields in addition to a proper welding helmet with filter plate. The side shields provide needed protection from reflected radiation.

- Have all persons wear safety glasses with UV protective side shields anytime near welding or cutting areas.

- Choose safety glasses according to ANSI Z87.1.

INFORMATION SOURCES ON NONIONIZING RADIATION

American Welding Society (AWS). *Recommended Practices for Electron Beam Welding* (AWS C7.1), published by the American Welding Society, 8669 Doral Blvd., Doral, FL 33166; telephone 800-443-9353; Web site: www.aws.org.

Manufacturers' Product Information Literature

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American National Standards Institute (ANSI). *Practice for Occupational and Educational Eye and Face Protection* (ANSI Z87.1), available from ANSI, 25 West 43rd Street, New York, NY 10036 (telephone: 212-642-4900; web site: www.ansi.org).

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National Technical Information Service (NTIS). *Evaluation of the Potential Hazards from Actinic Ultraviolet Radiation Generated by Electric Welding and Cutting Arcs,* Nonionizing Radiation Protection Special Study No. 42-0053-77, NTIS, Springfield, VA (telephone: 703-605-6000; web site: www.ntis.gov).

National Technical Information Service (NTIS). *Evaluation of the Potential Retinal Hazards from Optical Radiation Generated by Electric Welding and Cutting Arcs,* Nonionizing Radiation Protection Special Study No. 42-0312-77, NTIS, Springfield, VA (telephone: 703-605-6000; web site: www.ntis.gov).

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Naidoff, M. A. and Sliney, D. H. *Retinal Injury from a Welding Arc,* American Journal of Ophthalmology, Vol. 77, No. 5, pp. 663-668, May 1974.

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American Welding Society (AWS). *Ultraviolet Reflectance of Paint*, published by the American Welding Society, 8669 Doral Blvd., Doral, FL 33166; telephone 800-443-9353; Web site: www.aws.org.

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Noise

INTRODUCTION

In welding, cutting, and allied operations, noise may result from the process, the power source, or other equipment. Air carbon arc cutting and plasma arc cutting are examples of processes which are frequently noisy. Engine-driven generators may also be quite noisy. Excessive noise is a known health hazard.

DEFINITION

Scientifically, noise is composed of several frequencies and involves random changes in frequency or amplitude. Sound waves are produced when the air is mechanically disturbed. Sound is measured by its frequency (pitch-high or low) and intensity (loudness). Practically, noise is unwanted or unpleasant sound. It can get in the way of the sounds we would rather hear and often need to hear for safety reasons.

EFFECTS OF OVEREXPOSURE TO NOISE

- Loss of hearing that may be either full or partial and either temporary or permanent.
- Hearing loss may be a temporary threshold shift from which the ears may recover if removed from the noise source.
- The time required to develop permanent hearing loss depends on individual susceptibility, noise level, and exposure duration.
- There is evidence that excessive noise affects other bodily functions and behavior as well.

HOW TO PROTECT AGAINST NOISE

- Reduce the intensity of the source.
- Shield the source where practical.
- Use engineering control methods, such as room acoustics, to control noise.
- If engineering methods fail to reduce noise to acceptable levels, wear approved personal protective devices such as ear muffs or ear plugs appropriate for the situation.
- Follow OSHA regulations which require a Hearing Conservation Program if noise levels reach 85 dB on an 8-hour, Time Weighted Average (TWA) basis.
- If noise level is questionable, have a certified safety specialist or Industrial Hygienist take measurements and make recommendations.

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INFORMATION SOURCES

Occupational Safety and Health Administration (OSHA). Code of Federal Regulations, Title 29 Labor, Parts 1910 and 1926, available from the U.S. Government Printing Office, Washington, DC 20401; telephone: 800-321-6742; web site: www.osha.gov.

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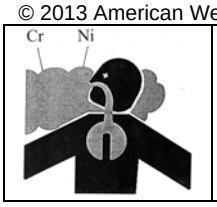

Chromium and Nickel in Welding Fume

INTRODUCTION

The fume from welding processes may contain compounds of chromium, including hexavalent chromium, and of nickel. The composition of the base metals, the welding materials used, and the welding processes affect the specific compounds and concentrations found in the welding fume.

IMMEDIATE EFFECTS OF OVER-EXPOSURE TO FUMES CONTAINING CHROMIUM AND NICKEL

- Similar to the effects produced by fumes from other metals.
- Cause symptoms such as nausea, headaches, dizziness, and respiratory irritation.
- Some persons may develop a sensitivity to chromium or nickel which can result in dermatitis or skin rash.

CHRONIC (LONG TERM) EFFECTS OF EXPOSURE TO FUMES CONTAINING CHROMIUM AND NICKEL

- Conclusions from the National Institute for Occupational Safety and Health (NIOSH): some forms of hexavalent chromium and nickel and their inorganic compounds should be considered occupational carcinogens (cancer-causing agents).
- Definite effects are not yet determined.
- NIOSH Criteria Documents 76–129 and 77–164 (listed below) contain these conclusions based on data from the chromate producing industry and from nickel ore-refining processes.
- Conclusions from the International Agency for Research on Cancer (IARC): (1) there is limited evidence in humans for the carcinogenicity of welding fumes and gases, and (2) there is inadequate evidence in experimental animals for the carcinogenicity of welding fumes.

OVERALL EVALUATION

- Welding fumes are possibly carcinogenic to humans (IARC Group 2B).
- No determination has yet been made concerning the health effects on welders or users of chromium- or nickel-containing alloys.
- Nevertheless, give consideration to the NIOSH and IARC conclusions.

HOW TO PROTECT AGAINST OVER-EXPOSURE

- Do not breathe fumes and gases. Keep your head out of the fumes.

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- Use enough ventilation or exhaust at the arc or both to keep fumes and gases from your breathing zone and general area.

- If ventilation is questionable, use air sampling to determine the need for corrective measures.

- Keep exposure as low as possible.

INFORMATION SOURCES

National Institute for Occupational Safety and Health (NIOSH). *Criteria for a Recommended Standard: Occupational Exposure to Chromium (VI),* NIOSH Publication No. 76-129. Cincinnati, OH (telephone: 800-356-4674; web site: http://www.cdc.gov/niosh/homepage.html).

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National Institute for Occupational Safety and Health (NIOSH). *Safety and Health in Arc Welding and Gas Welding and Cutting,* NIOSH Publication No. 78-138. Cincinnati,OH (telephone: 800-356-4674; web site: http://www.cdc.gov/niosh).

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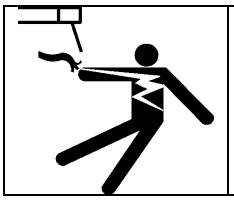

Electrical Hazards

INTRODUCTION

Electric shock from welding and cutting equipment can result in death or severe burns. Additionally, serious injury can occur if the welder falls as a result of the shock.

All of the following are electrically energized when the power is “on”: the welding circuit (including the electrode and workpiece), input power and machine internal circuits, the wire, reel of wire, drive rolls, and all other metal parts touching the energized electrode. Additionally, incorrectly installed or improperly grounded equipment is a hazard.

HOW TO AVOID ELECTRIC SHOCKS

Use proper precautionary measures and recommended safe practices at all times. Train all personnel using welding and cutting equipment to reduce the risk of injuries, fatalities, and electrical accidents, by following these instructions:

- Read all instructions, labels, and installation manuals before installing, operating, or servicing the equipment.
- Train all personnel involved in welding operations to observe safe electrical work practices according to OSHA 1910.332.
- Do not touch live electrical parts.
- Have all installation, operation, maintenance, and repair work performed only by qualified people.
- Properly install and ground the equipment in accordance with the instruction manual and national, state, and local codes.
- Frequently inspect input power cord for damage or bare wiring – replace cord immediately if damaged – bare wiring can kill.
- Do not work alone where there are electrically hazardous conditions.
- Wear dry, hole-free, insulating gloves in good condition and protective clothing. Do not touch the electrode with a bare hand.
- Insulate yourself from the workpiece and ground using dry insulating mats or covers big enough to prevent any physical contact with the work or ground, or wear properly designed and approved rubber-soled boots in good condition.

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- Use fully insulated electrode holders. Never dip the holder into water to cool it or lay it on conductive surfaces or the work surface.

- Do not touch electrode holders connected to two welding machines at the same time since double open-circuit voltage can be present.

- Do not allow the electrode holder or electrode to come in contact with any other person or any grounded object.

- Do not use worn, damaged, undersized, or poorly spliced cables, welding gun cables, or torch cables. Make sure all connections are tight, clean, and dry.

- Do not wrap cables carrying electric current around any part of your body.

- When required by ANSI Z49.1 or other codes, ground the workpiece to a good electrical earth ground. The work lead is not a ground lead. Do not use the work lead as a ground lead. Use a separate connection to ground the workpiece to earth.

- Do not touch an energized electrode while you are in contact with the work circuit.

When using auxiliary power from welding generators, it is recommended that you use a circuit protected by a ground fault circuit interrupter (GFCI) such as receptacles in boxes, extension cords, and the like. Use of an assured grounding system is also acceptable and is equivalent to use of a GFCI protected circuit. (see AWS Safety and Health Fact Sheet No. 29, Grounding of Portable and Vehicle Mounted Welding Generators, for information about assured grounding systems).

Additional safety precautions are required when welding is performed under any of the following electrically hazardous conditions: in damp locations or while wearing wet clothing; on metal floors, gratings, scaffolds, or other metal structures; in cramped positions such as sitting, kneeling, or lying; or when there is a high risk of unavoidable or accidental contact with the workpiece or ground. Where these conditions are present, use one of the following types of equipment presented in order of preference: (1) a semiautomatic DC constant voltage metal electrode (wire) welder, (2) a DC manual covered electrode (stick) welder, or (3) an AC welder with reduced open-circuit voltage. In most situations, use of a DC, constant voltage wire welder is recommended. And, do not work alone!

- Wear a safety harness to prevent falling if working above floor level.

- Turn off all equipment when not in use. Disconnect the power to equipment that will be left unattended or out of service.

Disconnect the input power or stop the engine before installing or servicing the equipment. Lock the input disconnect switch in the “open” (Off) position, or remove the fuses, so that power cannot be turned on accidentally. Follow lockout/tagout procedures (see AWS Safety and Health Fact Sheet No. 18, Lockout/Tagout).

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- Use only well maintained equipment. Frequently inspect welding equipment and repair or replace all damaged parts before further use.

- Keep all covers and panels securely in place.

WEARERS OF PACEMAKERS

The technology of heart pacemakers and other electronic devices changes frequently and this may change the way these devices are affected by other electrical devices including welding equipment. Wearers of pacemakers or other electronic devices vital to life should be instructed to check with their doctor and with the device manufacturer to determine if any hazard exists when near welding or cutting operations. See AWS Fact Sheet No. 16, Pacemakers and Welding, for additional information about pacemakers and welding.

PROCEDURES FOR ELECTRIC SHOCK

- Turn off the electric power.

- Use nonconducting material, such as dry wood, to free the victim from contact with live parts or wires.

- If the victim is not breathing, call for emergency services. Administer cardiopulmonary resuscitation (CPR) immediately after breaking contact with the electrical source. Continue CPR until breathing starts or until help arrives.

- Where an automatic electronic defibrillator (AED) is available, use according to instructions.

- Treat an electrical burn as a thermal burn by applying clean, cold (iced) compresses. Prevent contamination, and cover with a clean, dry dressing.

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American National Standards Institute (ANSI). *Safety in Welding, Cutting, and Allied Processes* (ANSI Z49.1), published by the American Welding Society, 8669 Doral Blvd., Doral, FL 33166; telephone 800-443-9353; Web site: www.aws.org.

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National Fire Protection Association (NFPA). *Standard for Fire Prevention During Welding, Cutting and Other Hot Work* (NFPA 51B), available from National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101; telephone: 800-344-3555; Web site: www.nfpa.org.

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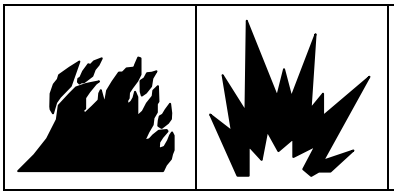

Fire and Explosion Prevention

INTRODUCTION

Welding, cutting, and allied processes produce molten metal, sparks, spatter, slag, and hot work surfaces. These can cause fire or explosion if precautionary measures are not followed.

NATURE OF THE HAZARDS

Flying sparks, spatter and molten metal are the main cause of fires and explosions in welding and cutting. They can travel up to 35 feet (10.7 meters) from the work area. They can travel greater distances when falling, or with some processes, they can pass through or become lodged in cracks, clothing, pipe holes, and other openings in floors, walls, or partitions. Heat can be transferred through walls and surfaces.

Typical combustible materials inside buildings include: wood, paper, rags, clothing, plastics, chemicals, flammable liquids and gases, dusts, and trash. Parts of buildings such as floors, partitions, and roofs may also be combustible.

Typical combustible materials outside buildings include dry leaves, grass, brush, and trash.

Welding and cutting can cause explosions in spaces containing flammable gases, vapors, liquids, or dusts. Special precautions are needed for any work on containers (see AWS F4.1).

HOW TO AVOID THE HAZARD

- Develop adequate procedures, and use proper equipment to do the job safely.
- When required obtain a Hot-Work Permit (See NFPA 51B).
- Remove combustible materials from a sphere with a minimum radius of 35 feet (10.7 meters) around the work area or move the work to a location well away from combustible materials.
- If relocation is not possible, protect combustibles with fire resistant covers.
- If possible, enclose the work area with portable, fire-resistant screens.
- Cover or block all openings within the 35 foot radius, such as doorways, windows, cracks, or other openings with fire resistant material.

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- Do not weld on or cut material having a combustible coating or internal structure, such as in walls or ceilings, without an appropriate method for eliminating the hazard.

- When needed, have a qualified firewatcher in the work area during and for at least 30 minutes after the job is finished

- After welding or cutting, make a thorough examination of the area for evidence of fire. Remember that easily visible smoke or flame may not be present for some time after the fire has started. Be alert, combustibles such as wood dust can smolder for extended periods of time (days).

- Do not dispose of hot slag in containers holding combustible material.

- Keep appropriate fire extinguishing equipment nearby, and know how to use it.

- Make sure all electrical equipment and wiring are installed properly and have recommended circuit protection.

- Do not overload or improperly size input conductors and/or weld output conductors to prevent fire hazards.

- Connect the work cable to the work as close to the welding zone as practical to avoid stray current paths.

- Do not weld or cut in atmospheres containing reactive, toxic, or flammable gases, vapors, liquids, or dust.

- Do not create dust clouds. Some dust clouds can explode.

- Do not apply heat to a workpiece covered by an unknown substance or coating that can produce flammable, toxic, or reactive vapors when heated.

- Do not apply heat to a container that has held an unknown substance or a combustible material unless container is made or declared safe. (see AWS F4.1).

- Provide adequate ventilation in work areas to prevent accumulation of flammable gases, vapors, or dusts.

SUMMARY

Remember that sparks can travel in all directions up to a distance of 35 feet (10.7 meters) from the work and pass through or become lodged in all kinds of openings and cause fires where least expected. Recognize that sparks can travel well beyond the 35 foot (10.7 meters) radius when falling or during plasma arc cutting and air carbon arc cutting or gouging. Remove combustible materials and prevent flammable gases, vapors, and dusts from accumulating in the work area to reduce the possibility of a fire or explosion. Always have appropriate fire extinguishing equipment nearby, and know how to use it.

Fires and explosions can be prevented by being aware of your surroundings, minimizing the combustibles in them, and taking the appropriate protective precautions.

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INFORMATION SOURCES

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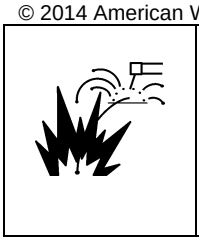
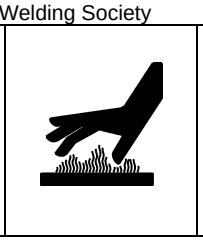

Burn Protection

NATURE OF THE HAZARD

Sparks and spatter fly off from the welding arc. Hot metal and sparks blow out from the cutting flame. The workpiece and equipment get hot. The flying sparks and hot metal, slag, spatter, hot workpiece, and hot equipment can cause burns. Additionally, arc rays can cause radiation burns (see Fact Sheet No. 2).

HOW TO PREVENT BURNS

- Use approved helmets or hand shields that provide protection for the face, neck, and ears, and wear a head covering.
- Wear approved safety goggles or safety glasses with side shields, even under your helmet.
- Wear dry, hole-free insulating gloves.
- Wear flame-resistant ear plugs or ear muffs to keep sparks out of ears when welding or cutting overhead or in confined spaces.
- Wear oil-free protective garments such as leather gloves, heavy shirt, cuffless pants, high shoes, and a cap.
- Wear leather leggings and fire-resistant boots, as needed.
- In cold climates heavy clothing may prevent awareness of clothing fires.
- Use dry, hole-free aprons, cape-sleeves, leggings, shoulder covers, and bibs approved for welding and cutting service.
- Remove any combustibles, such as a butane lighter or matches, from your person before doing any welding or cutting.
- Touching hot equipment such as electrode holders, gun tips, and nozzles can cause burns. Always wear dry, insulating gloves. Allow a cooling period before touching these and other parts of equipment that are near the actual welding or cutting operation.
- Do not wear pants with cuffs, shirts with open pockets, or any clothing that can trap molten metal or sparks.
- Keep clothing free of grease, oil, solvents, or any flammable substances.
- If combustible substances spill on protective clothing, change to clean clothing before doing any welding or cutting.
- Use sheet metal screens for extra protection when unusually heavy welding or cutting is involved.

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- For highly hazardous processes or jobs, consider automation.

- Do not attempt to repair or disconnect electrical equipment under load. Disconnecting under load produces arcing of the contacts and may cause burns or shocks.

HOW TO PROTECT OTHERS FROM BURNS

- Use noncombustible screens or barriers to protect nearby persons or watchers.

- Mark hot work pieces to alert others of the burn and fire hazards.

- If the job requires several persons, have all wear proper protective gear and follow all required procedures.

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American National Standards Institute (ANSI). *Safety in Welding, Cutting, and Allied Processes* (ANSI Z49.1), published by the American Welding Society, 8669 Doral Blvd., Doral, FL 33166; telephone 800-443-9353; Web site: www.aws.org.

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Mechanical Hazards

NATURE OF THE HAZARD

Like other technologies that work with metals, welding and cutting seldom work in isolation. Other equipment and tools are normally used and kept nearby. The use of, or the closeness to, mechanical equipment can present hazards to the welder. Knowledge of the proper use of power tools, such as grinders, chippers, drills, and various hand tools, is important to welder safety. Know and understand the safe limits and proper use of cranes, positioners, and other material handling equipment. Use appropriate guards and personal protective equipment. Some safety recommendations follow.

PERSONAL SAFETY

- Wear proper head, eye and hand protection.
- Use face shields, safety glasses, and goggles as appropriate.
- Wear dry, hole-free insulating gloves when welding or cutting.
- Avoid wearing loose items such as earrings, rings, necklaces, bracelets, loose clothing, neckties, and scarves.
- Watch out for sharp objects, pinch points, and moving objects.
- Protect long hair and beards.

GINDING WHEEL SAFETY

- Follow grinding wheel speed limitations according to manufacturer's instructions.
- Do not grind on the side of a wheel unless designed for such service.
- When starting a new wheel, stand to the side until it reaches speed, and correct any abnormalities noted.
- Be sure guards are in place.

TOOL SAFETY

- Use the right tool for the job. Use good quality tools. Use them for the job they were intended to perform.
  For example, it is often tempting to use a screwdriver for a chisel or a pair of pliers for a wrench. Avoid such practices. The right tool will do the job faster and safer.
- Inspect tools before use.
- Never use a tool that is in poor or faulty condition.
- Keep all tools in good condition.

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- Keep a firm grip on tools to prevent them from slipping away.

- Do not overload or force a tool beyond its capabilities.

- Foresee results of unexpected occurrences such as tools getting away, binding, or coming loose from their handles.

- Check any tool that has become jammed, or otherwise overstressed, for damage before reuse.

- Anticipate the reactive force from tools.

- Anticipate what might happen to a component that is to be loosened or unbolted from its working position.

- When using tools that involve weights and spring tension, be certain that all pressures are applied and released in a safe manner.

- Follow lockout/tagout procedures for equipment and tools as required.

- Do not bypass safety interlocks on equipment. Bypassing defeats the safety device and creates a possibly serious hazard.

- Store tools in a safe place. Many accidents are caused by tools falling off ladders, shelves, or scaffolds. Each tool should have a designated place in a tool box or pouch.

- For additional information of the safe operation and guarding of mechanical equipment, refer to the manufacturers' safe operating procedures.

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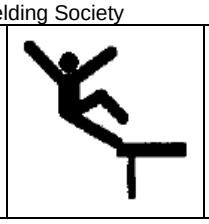

Tripping and Falling

NATURE OF THE HAZARD

Welding, cutting and associated processes take place in a wide variety of locations under many different conditions. Welding and cutting occurs in shops and factories on the floor level, on high steel in skyscraper construction, in pits, vats, mines, tanks, ship compartments, and everywhere metals are joined or cut.

SOME CAUSES OF TRIPS AND FALLS

- Poor housekeeping of materials, equipment, hoses, and tools.
- Scattered parts and pieces either left over or waiting for use.
- Failure to use or correctly use a fall protection system.
- Sudden loud noises or shouts.
- Inadequate or improperly used safety equipment such as ladders, guardrails, scaffolds, and nets.
- Failure to use proper personal protective equipment such as skid-resistant soles on shoes to meet job needs.
- Horseplay or unsafe actions, such as tossing tools to each other or bumping someone in a precarious position.
- Electric shock from faulty equipment.
- Restricted vision caused by needed safety gear such as welding helmets and safety goggles.
- Failure to fully understand the hazards, such as toxic fumes, when entering a pit, tank, or compartment.

HOW TO PREVENT TRIPPING AND FALLING

- Be alert, aware, and focused on the job and the work area; notice any changing conditions.
- Wear and use only the correct, approved equipment for the specific job; be sure it is properly installed and used.
- Do not carry things that obstruct your view or that upset your balance.
- Prohibit horseplay on the job.
- Follow all standard safe practices required by your employer.
- Keep the work area clean and neat – ask your supervisor for help if needed.

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- Do not take chances or unnecessary risks – such actions cause accidents.

INFORMATION SOURCES

American National Standards Institute (ANSI). *Safety in Welding, Cutting, and Allied Processes* (ANSI Z49.1), published by the American Welding Society, 8669 Doral Blvd., Doral, FL 33166; telephone 800-443-9353; Web site: www.aws.org.

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Protecting Against Falling Objects

NATURE OF THE HAZARD

Welding, cutting and associated processes often take place in areas where falling objects may be present. Falling objects may seriously injure or kill. Falling objects are common problems on construction and demolition sites, from buildings to bridges, and are often a problem during maintenance work. Even sparks, spatter, and cut-off pieces can fall.

HOW TO PROTECT AGAINST FALLING OBJECTS

- Wear approved head and foot protection (see Information Sources).
- Be alert and aware of your total work environment and any possible overhead objects before you start working.
- Place a safety net or equivalent below overhead work.
- Follow safe work practices when working below overhead activities.
- Notify others of overhead work and any changing job conditions.
- Remember, a welding helmet or goggles restricts vision and may prevent taking the action necessary to avoid falling objects.
- Post areas where falling objects are a hazard.
- Practice safe hot work procedures.

HOW TO PREVENT FALLING OBJECTS

- Be certain that material being welded or cut is secured from falling.
- Do not permit loose objects near the edge of overhead structures.
- Appropriately cover floor and wall openings. Floor hole covers must effectively support two times the weight of employees, equipment, and materials that may be imposed on the covers at any one time.
- Use toe boards with guardrails where work takes place near unprotected edges where materials could fall.
- Do not kick, throw, or push anything off overhead structures – this includes electrode stubs and scrap metal.
- Do not create falling objects for others – be alert to your actions.
- Use fire blankets to prevent, or catch, falling sparks, spatter, and hot pieces.

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Hot Work in Confined Spaces

NATURE OF THE HAZARD

Many different places require welding, cutting, and other hot 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.

EXAMPLES OF CONFINED SPACES

Small rooms	Process vessels
Pits	Tunnels
Vats	Furnaces
Storage tanks	Pipelines
Sewers	Silos
Degreasers	Boilers
Reactor vessels	Utility vaults
Compartments of ships	Ventilation ducts
Unventilated room areas	Conveyers

REASONS FOR DEATHS AND SERIOUS INJURIES FROM HOT WORK IN CONFINED SPACES

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

ACTIONS REQUIRED BEFORE APPROVING HOT WORK IN A CONFINED SPACE

- Determine if special training or a permit is required to enter the space.
- Open all covers and secure them from closing.
- Test atmosphere for:
  (1) suitable oxygen content
  (2) combustibles or reactives
  (3) toxics

  Note: The testing requires special equipment and training.
- Isolate lines by capping or double blocking and bleeding. Keep vents open and valves leak-free.
- Lock out/tagout all systems not required during hot work.
- 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 hazardous when exposed to hot work.

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REQUIRED ACTIONS DURING HOT WORK IN A CONFINED SPACE

- Continuously ventilate and monitor air to ensure fumes and gases do not exceed safe exposure limits.

- 29 CFR 1910.252(c) and 1926.353(c) require the use of local exhaust ventilation or supplied air respiratory protection when hot work is performed in a confined space where there is a potential for exposure to fluorine compounds (fluxes and rod coatings), zinc, lead, cadmium, or mercury. When beryllium is present, use both local exhaust and a supplied-air respirator.

- 29 CFR 1926.353(c) requires the use of local exhaust ventilation or supplied air respiratory protection when hot work is performed in a confined space where there is a potential for exposure to chromium or when Gas Metal Arc Welding is performed on stainless steel.

- Use NIOSH/MSHA (National Institute for Occupational Safety and Health/Mine Safety and Health Administration) approved breathing device when required by code.

- Keep unnecessary persons and equipment out of, and away from, the confined space.

- Do not allow equipment to block exit or rescue efforts. Place as much equipment as possible outside the confined space.

- Do not enter a confined space unless a watchperson, properly equipped and trained for rescue, is outside. Maintain continuous communications with the worker inside.

- When possible, provide means for readily turning off power, gases, and fuel from inside the confined space, even if outside turn-off means are provided.

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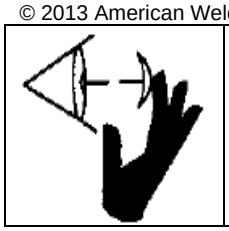

Contact Lens Wear

INTRODUCTION

For many years, the American Welding Society has received reports concerning welders who claimed to have had contact lenses fused to their eyes, either by the heat of the arc or by optical radiation. None of these reports has been substantiated. Safety bulletins issued by the Occupational Safety and Health Administration (OSHA), the Food and Drug Administration (FDA), and the National Safety Council (NSC) have refuted such claims.

The American Optometric Association (AOA) has stated that contact lenses may be worn safely under a variety of environmental situations and that evidence refutes the claims that contact lenses negate the protection provided by safety equipment or make the cornea more susceptible to damage by optical radiation, in particular arc flashes.

- Workplace policies limiting the wearing of contact lenses in any given circumstance must be scientifically defensible.

- Restrictions on the wearing of contact lenses by welders may be unreasonable and discriminatory. Restrictions should not be based on perceived hazards, random experiences, isolated unverified case histories or unsubstantiated personal opinions.

GUIDELINES FOR CONTACT LENS USE

The following recommendations are adapted from the statement on contact lens use in eye-hazardous environments by the American College of Occupational and Environmental Medicine (ACOEM):

- Establish a written policy documenting general safety requirements for the wearing of contact lenses.

- Conduct an eye hazard evaluation in the workplace that includes an assessment of eye-hazardous environments and appropriate eye and face protection for contact lens wearers.

- Provide training on the employer policies on contact lens use and the first aid for contact lens wearers with a chemical exposure. Routinely train medical and first aid personnel in the removal of contact lenses and encourage workers to routinely inspect their contact lenses for damage.

- Provide personal protective equipment including eye and face protection for all workers exposed to eye injury hazards, regardless of contact lens wear.

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- Notify visitors and employees of any area where contact lenses are restricted without appropriate eye and face protection.

- Notify supervisors, first aid responders and EMS responders of the contact lens use by workers in eye hazardous environments.

INFORMATION SOURCES

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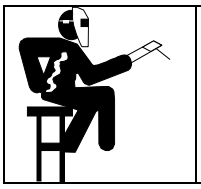

Ergonomics in the Welding Environment

INTRODUCTION

Ergonomics is the science of arranging or designing things for efficient use. Ergonomics is also called Human Factors Engineering. It involves making the workplace fit the needs of workers. It does not try to make workers adjust to the workplace. When a workplace is designed properly, the worker feels comfortable. Quality and production increase. Everyone benefits.

NATURE OF THE HAZARD

Welding introduces many ergonomic challenges. These challenges are starting to be recognized and addressed. Welding often requires awkward body positions. Body position and time are key factors in causing injuries.

OBJECTIVES OF ERGONOMICS

- Reduce injuries and disorders
- Ensure worker safety
- Ensure worker health
- Ensure worker productivity
- Reduce compensation costs
- Reduce absenteeism
- Comply with regulations

Ergonomics focuses on changing things (tools, equipment, facilities, etc.), not changing people.

PROBLEMS FROM POOR ERGONOMICS

- Musculoskeletal Disorders (MSDs)
- Repetitive Motion Injury
- Lower productivity
- Lower quality
- Worker dissatisfaction
- Increased absenteeism
- Increased compensation costs
- Increased turnover rate
- Decreased compliance with regulations
- Increased insurance costs

CAUSES OF THE PROBLEMS

- Reaching
- Bending
- Heavy lifting
- Using continuous force
- Working with vibrating equipment
- Repetitive motions
- Awkward postures
- Temperature

SYMPTOMS OF MSDs

- Less gripping strength
- Less range of motion
- Loss of muscle function
- Painful joints
- Pain, tingling, or numbness

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- Shooting or stabbing pains
- Swelling or inflammation
- Stiffness or burning sensation

POSSIBLE SOLUTIONS TO PROBLEMS

- Recognize that often Repetitive Motion Injury is mistakenly felt to be a type of short-term weakness or fatigue. Actually it is the start of potentially more serious injuries.
- Address complaints in a timely manner.
- Get employee input.
- Interact with the worker. Discuss possible solutions. Give the employee ownership of any new plans. Promote employee acceptance of solutions.
- Redesign the workstation with the employees' help. Employees should feel part of the process.
- Utilize gravity when it can help move material to the work area or station. This helps to prevent unnecessary material handling.

PRACTICAL SOLUTIONS—HOW TO AVOID THE HAZARDS

- Avoid fixed work positions. They reduce the blood supply to muscles.
- Keep elbows close to the body.
- Avoid positions where arms are raised above shoulder level.
- Use lighter hand tools.
- Suspend tools.
- Support your elbows.
- Provide sufficient rest.
- Utilize jigs and fixtures.

WORKSTATION DESIGN FACTORS

- Position of the work
- Physical ability of the worker
- Design and weight of the tools
- Body mechanics of the operation
- Type of protective equipment used
- Workspace / environment (size, lighting, temperature, noise, vibration, etc.)
- Physical requirements of the job (lifting, turning, reaching, etc,)
- Mental requirements (motivation, alertness, concentration)
- Strength and size of the workers

SUMMARY

Consider ergonomic solutions for all welding situations. Many can be improved. Evaluate and apply ergonomic principles. Use suggested PRACTICAL SOLUTIONS to avoid the hazards.

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GRAPHIC SYMBOLS FOR PRECAUTIONARY LABELS

INTRODUCTION

Existing standards, such as American National Standards Institute (ANSI) Z49.1, ANSI Z535.4, and National Electrical Manufacturer's Association (NEMA) EW6, thoroughly present guidelines for the minimum required information, method of presentation, signal words, color use, and label format.

DEFINITION

Graphic symbols are pictures sometimes called pictographs, pictograms, or pictorials used in place of, or as a supplement to, written words. These symbols provide non-verbal communication about the possible hazard. They represent or symbolize the hazard.

RATIONALE FOR GRAPHIC SYMBOLS

Pictures may convey information better than words. Graphic symbols can show the major welding or cutting hazards. The use of symbols on precautionary labels is optional and is recommended for the following reasons:

- Symbols may show and help to explain the hazards quickly – fast concept transfer – and use visual (not verbal) recognition.
- Symbols address nonreaders as well as readers.
- Symbols may be multilingual and usually translate directly into all languages.

RATIONALE FOR STANDARDIZED SYMBOLS

The welding and cutting industry needs standardized symbols and uniform methods of use to avoid user confusion and to supplement and reinforce the written message.

NEMA EW6 standard provides a list of symbols and minimum symbol size for labels along with complete information regarding their use and application.

HOW TO USE THE SYMBOLS

- Use the symbols to show the associated hazard.
- Take standard symbols from NEMA EW6.
- Follow a building block approach.
- Select a primary hazard symbol, often it is used alone, such as the fire symbol.

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- Choose additional symbol element(s) to fully show the hazard.

- Combine the chosen symbol element(s), such as the covered electrode symbol, with the base symbol, such as fumes and gases.

- Follow the design methods and standard way of incorporating symbols onto the safety label according to EW6.

INFORMATION SOURCES

National Electrical Manufacturer's Association (NEMA). Guidelines For Precautionary Labeling For Arc Welding And Cutting Products, Arc Welding Section (NEMA EW6). Published by the National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1752, Rosslyn, Virginia 22209; telephone: (703) 841-3200; web site: www.nema.org.

American National Standards Institute (ANSI). Safety in Welding, Cutting, and Allied Processes (ANSI Z49.1), published by the American Welding Society, 8669 Doral Blvd., Doral, FL 33166; telephone 800-443-9353; web site: www.aws.org.

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American Welding Society (AWS). Safety and Health Fact Sheets, published by the American Welding Society, 8669 Doral Blvd., Doral, FL 33166; telephone 800-443-9353; web site: www.aws.org.

EXAMPLES FROM NEMA EW6

HAZARD	SOURCE OF HAZARD	SYMBOL
Electric Shock	Welding Electrode	
Electric Shock	Wiring	
Electric Shock	Welding Electrode and Wiring	
Fumes and Gases	Any Source	
Fumes and Gases	Welding Fumes and Gases	
Arc Rays	Welding Arc	
Fire	Engine Fuel	

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STYLE GUIDELINES FOR SAFETY AND HEALTH DOCUMENTS

INTRODUCTION

Style for welding and cutting documents means two things: matter and manner, otherwise known as content and form or subject and format. Style refers not only to what is said, but also how it is stated and presented to the reader.

BACKGROUND OF CURRENT STYLE

The recommended writing style evolves from precautionary labeling practices. It also arises from the obligation to users found in standards and codes, as well as from an industry-wide concern for the well-being of its customers. The text needs to **warn and instruct** the reader about the **normal use and reasonably foreseeable misuse and abuse** of a product or process. The instruction literature which accompanies a product, or process, is considered as part of that practice.

- The **warn** part of the requirement is met by a statement of the hazard and consequences of the failure to act as specified.

- The **instruct** part of the requirement is met by explaining how to avoid the hazard and consequences.

- It is not mandatory to have a particular order to the statements. It can be **warn and instruct** or **instruct and warn**. Either sequence is satisfactory, though **warn and instruct** is preferred.

- This order preference is based on current precautionary labeling practices which warn first and instruct second.

- For all safety and health information published by the American Welding Society, try to follow the **warn and instruct** requirements for the **normal use** as well as for the **foreseeable misuse and abuse** of the product or process.

STYLE METHODS AND FEATURES

The matter and manner for welding and cutting documents have evolved with time. It is recommended that documents state the hazards and include the consequences as well as how to avoid them. The stylistic features are as follows:

- Use the active voice.

- Use strong, clear, action verbs in the imperative mood.

- Use short, direct sentences.

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- Use a checklist. Do not skip any items. Omitting steps can cause personal injury or equipment damage.

- Use quality control procedures to meet intended performance requirements and to minimize costs.

USE OF PRECAUTIONARY SIGNAL WORDS

There are three signal words used to identify the levels of hazard in ANSI Z535.4. These are: DANGER, WARNING, and CAUTION. Wherever possible, reserve these words for use on labels and collateral materials only. Avoid the use of signal words in prose. Use the word "precautionary" or other such words instead of signal words for text.

FORMAT SUGGESTIONS

Several formats satisfy these requirements. The two of the most popular are:

- Put all information in one or two simple sentences.

- Use a hazard statement containing the precautionary statement (description of hazard and its consequences) followed by a list of simple instructions telling how to avoid the hazard. The following example is adapted from NEMA EW 6:

WARNING: ELECTRIC SHOCK can kill: FUMES AND GASES can be hazardous; ARC RAYS can injure eyes and burn skin.

- Do not touch live electrical parts.
- Keep your head out of the fumes.
- Wear dry insulating gloves and clothing.
- Use enough ventilation or exhaust at the arc to keep fumes and gases from your breathing zone, and the general area.
- Wear correct eye, ear, and body protection.
- Read and follow the manufacturer's instructions, employer's safety practices, and Safety Data Sheets (SDSs).

SUMMARY

Read and understand all instructions, especially those containing safety or health information.

- Quickly get to the point to keep the reader's attention and save time.

- Be clear, direct, and simple in communicating with the reader.

- Use easy-to-read short instructions.

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National Electrical Manufacturer's Association (NEMA). *Guidelines For Precautionary Labeling For Arc Welding And Cutting Products,* Arc Welding Section (NEMA EW6). Published by the National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1752, Rosslyn, Virginia 22209; telephone: (703) 841-3200; web site: www.nema.org.

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Implantable Medical Devices and Arc Welding/Cutting

INTRODUCTION

An implantable medical device is any medical device which is intended to be totally or partially introduced, surgically or medically, into the human body or by medical intervention into a natural orifice, and which is intended to remain after the procedure.

Implantable medical devices are classified as active or passive. Typical active implants rely on electrical energy to function. Passive implants perform their function without the use of electronic power.

Examples of active medical implants:

- Pacemakers
- Cardiac defibrillators
- Cochlear implants
- Diaphragm stimulators
- Insulin pumps
- Nerve stimulators

Examples of passive medical implants:

- Artificial hip and knee implants
- Spinal fusion hardware
- Screws for bone fracture repair
- Intra-uterine devices
- Coronary stents
- Artificial eye lenses

NATURE OF THE HAZARD

Electric arc welding and cutting processes produce intense electric and magnetic (electromagnetic) fields. Active medical implants are electrical in operation and their ability to function can be affected by strong electromagnetic fields. Passive medical implants are typically not affected by electromagnetic fields.

Implanted medical devices might experience electromagnetic interference from the electromagnetic waves generated from arc welding equipment and this could cause the implanted devices to not function properly.

HOW TO REDUCE EXPOSURE

(Adapted from the Medtronic Patient Services Electromagnetic Compatibility Guide for Implantable Cardiac Devices)

- Limit welding to currents less than 160 amps.
- Work in a dry area with dry gloves and shoes.
- If possible, maintain at least a 2-foot (60 centimeter) distance between the welding arc and implanted device.
- Keep the welding cables close together and as far away as possible from your implanted device.

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- Place the welding machine at least 5 feet from the work area.
- Connect the work clamp to the workpiece/metal as close to the point of welding as possible.
- Arrange the work so the welding torch or gun and electrode will not contact the metal being welded if they are accidentally dropped.
- Wait several seconds between attempts when having difficulty starting a weld.
- Work in an area that offers firm footing and plenty of room for movement.
- If you feel sick, immediately stop welding and seek medical attention.

TALK TO THE DOCTOR

If you are getting an implanted medical device and will be working with or around welding, talk with your doctor. Inform the doctor of your occupation and discuss your work. Implanted medical devices differ, and your doctor can select one that is less likely to be affected by interference.

INFORMATION SOURCES

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Boston Scientific Corporation, 300 Boston Scientific Way, Marlborough, MA 01752; Phone: 800 227.3422; web site: www.bostonscientific.com

American Heart Association, 7272 Greenville Ave., Dallas, TX 75231; Phone: 800-242-8721; web site: www.heart.org

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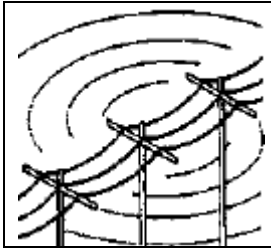

ELECTRIC AND MAGNETIC FIELDS (EMF) IN WELDING

INTRODUCTION

Electric and magnetic fields are often referred to as "electromagnetic fields," or EMF. There is concern that EMF may affect your health. All electric welding processes create EMF.

IS EMF HARMFUL?

Many scientific tests have been and are still being conducted by governmental and private agencies to determine if EMF is harmful to our health. Studies to date indicate that there is no evidence of health problems from EMF.

HOW DO I MINIMIZE EXPOSURE?

- Do not place your body between the welding electrode and work cables. Route cables on the same side of your body.
- Route the welding cables close together. Secure them together with tape or cable ties.
- Connect the work cable to the workpiece as close to the weld zone as practical.
- Keep the welding power source and cables as far away from you as practical.
- Never coil a welding cable around your body.

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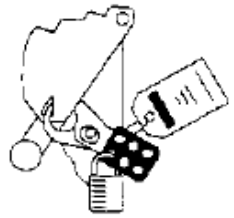

LOCKOUT/TAGOUT

INTRODUCTION

Sometimes welding or its allied processes must be performed on equipment, pipelines, and machinery. These may contain moving parts, pressurized gases or liquids, electrical energy, or other potential hazards. These may cause an injury or death. Employers must train employees to take steps, such as lockout/tagout, to isolate harmful energy sources before starting work. Lockout/tagout is sometimes abbreviated as LOTO.

DEFINITIONS

"Lockout" means to install a lockable device that keeps the switch, valve, or other mechanism from being turned on or energized. "Tagout" means to put a tag on the locking device. The tag indicates DANGER or WARNING, and a brief alert message. It also has a place to put information, like the date and responsible person's name; that way the person may be easily found or notified. When more than one person may be exposed to hazards a lockout/tagout device can allow multiple persons to install their locks.

NATURE OF THE HAZARD

- The sudden release of energy results in about 120 fatalities and 50,000 injuries annually in the U.S. These could be prevented by following proper lockout/tagout procedures, according to the Occupational Safety & Health Administration (OSHA).

- The types of energy most often found are: electrical, pneumatic (pressurized air), hydraulic, gases and liquids, as well as mechanical energy and moving parts.

- Working with or around energy sources without isolating them from the work activity can result in serious injury or even death.

HOW TO AVOID THE HAZARD

- Employers must develop a written lockout/tagout program and procedure.

- Employees must be trained in these procedures, as well as the purpose and methods of lockout/tagout.

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The basic steps to lockout/tagout usually involve:

- Inform affected supervisors and employees how to lockout and tagout the equipment.
- Shut down the equipment involved in the work. Then place locks, tags or other isolation devices according to the written procedure.
- Before lockout/tagout work begins, try to start the equipment or open the valves.
- If the equipment operates, do not begin work. All work employees must verify where the locks should be placed. If needed, place additional locks to ensure that equipment or valves are not operable. Recheck the equipment or valves for operation.
- Complete assigned work.
- Remove all tools and equipment.
- Ensure all employees are clear of the hazard
- Remove locks and tags according to the written procedure and verify that all employees are clear.
- Test the equipment for normal, safe start-up. Notify other employees when it is safe to operate the equipment.

Note: If more than one person performs work on the equipment, it is recommended that they each have their own locks and tags on the lockout devices and/or use a lock-box device.

- If the shift ends before the work is completed, the general practice is for the workers on the initial shift to remove their locks and to ensure that the next shift's employees install their locks and tags before continuing the work. This should be done before the previous shift's employee's locks and tags are removed.
- For specific information on recommended lockout procedures for equipment, machinery, and valves, consult the employer's written program and procedures. In some cases, it may also be advisable to contact the equipment manufacturer.

INFORMATION SOURCES

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LASER WELDING AND CUTTING SAFETY

INTRODUCTION

A laser is a device which produces an intense, coherent, directional beam of light. The term LASER is an acronym for Light Amplification by Stimulated Emission of Radiation. Lasers can be designed to deliver a large amount of energy to a very small area. In welding and cutting operations, this energy can heat metals quickly to very high temperatures. Much of the radiation that strikes the workpiece is reflected into the environment, creating hazards. Some laser light used in laser welding equipment is invisible, so the hazard may not be readily apparent.

HOW LASERS WORK

Typical lasers use electricity to create the unique coherent light that is very different from ordinary non-coherent light, such as that from a light bulb. Coherent light can be tightly focused and is not diffused or scattered like ordinary light. This coherent light beam is parallel and can be focused to cut or weld metals. Laser light can be different colors of the visible light spectrum, or can be invisible when the light is ultraviolet or infrared. Lasers used for welding and cutting may be infrared, and therefore the beam may be invisible. It is very difficult to take precautions against things one cannot see. It is even more difficult to convince others to take precautions against hazards they cannot see and may not understand.

POTENTIAL HAZARDS

- RADIATION - Both visible and invisible light radiation are produced when welding or cutting. Due to the interaction with the workpiece, high levels of hazardous blue light and ultraviolet radiation (secondary radiation) are produced. This light radiation is often reflected from the workpiece into the work area. Radiation from these processes can seriously burn eyes and skin quickly and permanently. These hazards are addressed in the American National Standards Institute Z136.1 standard.

- FIRE - Since the laser system produces a very small spot size with high energy, the hazard of fire is present if the beam hits flammable material. Keep flammables away from the welding or cutting area. Be sure to cover and protect anything flammable in the area, since reflected radiation could start fires in unexpected places. Protect the work area.

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- FUMES AND MISTS - Lasers easily vaporize metals. In doing so, fumes and mists are created which can present a respiratory hazard. Often the fumes and mists cannot be seen, yet they can pose a serious health hazard. Always use adequate ventilation.

- MECHANICAL - The optical device on the robotic arm or other beam manipulator can malfunction and send the laser beam in unintended directions. Therefore, it is essential that the work cell be shielded in conformance with standards for the laser type and class.

- ELECTRIC SHOCK - Since most lasers require a large amount of electrical power to accomplish specific tasks, electrical hazards are present. Conventional hazards associated with any electrical industrial power source are present. These require standard and common electrical safe practices as found in ANSI Z49.1 and in AWS Safety and Health Fact Sheet No. 5. Additionally, there are the unique electrical hazards common to lasers in general and the hazard of the individual application. Usually, the best source of safety information is provided in the instruction manual from the manufacturer of the laser system. Always read, understand, and follow the manufacturer's recommended safety procedures.

- EYE AND SKIN DAMAGE - Laser system eye and skin hazards are addressed in the ANSI Z136.1 standard. In many use situations, special laser eye protective devices are required. According to the ANSI Z136.1 standard, this eyewear must be labeled with both the optical density (protective factor) and wavelength(s) for which the protection is afforded. The protective eyewear must be compatible with the manufacturer's specifications for the laser system in use, to ensure that the eyewear is suitable. In addition to the primary hazard of the laser beam, there may be a considerable eye hazard from high levels of secondary radiation. The ANSI Z136.1 standard requires that the eyes be protected from this secondary radiation in addition to the primary laser beam. A precaution must be added here--standard safety glasses alone do not provide protection. Any laser eyewear, plain or prescription, <u>must</u> be labeled with the wavelength(s) of protection and the optical density at that wavelength(s). In some laser systems, ultraviolet light may be leaked into the workplace. Thus the eyewear should provide primary beam protection, secondary radiation protection, and also ultraviolet protection.

SAFETY NEEDS

All laser welding and cutting installations are required to have a laser safety officer (LSO). The LSO is responsible for personnel protection, laser cell class conformance, and enforcement of all laser safety regulations. Be certain to follow recommendations from the laser system manufacturer. In addition, provide certified laser protective eyewear, clothing, and shields where required.

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THERMAL SPRAYING SAFETY

INTRODUCTION

Thermal spraying processes use electric arc, plasma, and combustion energy sources to produce a high temperature and high velocity gas stream. Powder or wire material is introduced to this gas stream. Particles of this material are heated and propelled onto a surface to produce a coating. The noise, heat, dust, fumes, and mechanical operations of the spraying processes create a unique set of safety hazards for the operator and those nearby.

DEFINITIONS/PROCESS DESCRIPTIONS

According to ANSI/AWS A3.0, *Standard Welding Terms and Definitions*, Thermal Spraying is a group of processes that deposit molten metallic or non-metallic surfacing materials onto a prepared substrate.
All thermal spraying processes introduce a feedstock (usually a powder or wire) into a spraying device (combustion or electrical).

The spraying device is generally referred to as a thermal spray gun. At the gun the material is heated, blended into a hot gas stream, and sprayed onto a prepared substrate. The heated particles strike the surface where they flatten and adhere to the surface. As this process continues a coating is formed from the spray material. The coating process is stopped when the desired thickness of coating is formed.

Thermal spray processes include:

- Combustion processes
  - LVOF: Low-Velocity Oxyfuel
  - HVOF: High Velocity Oxyfuel
- Electrical processes:
  - Arc (twin-wire)
  - Plasma Arc

Typical operating conditions for the various processes are shown in the table below.

	LVOF	HVOF	Arc	Plasma Arc
Temperature	To 5000°F	To 6000°F	4000 – 15,000°F	4000 – 15,000°F
Velocity	200 – 700 ft/sec (<Mach 1)	2500 – 4000 ft/sec (to Mach 5)	800 – 1800 ft/sec (to Mach 2)	800 – 1800 ft/sec (to Mach 2)
dBA (Sound Level)	110	150	115	132
Spray Distance	4 – 10“	6 – 18“	2-1/2 – 6”	2-1/2 – 6”

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POTENTIAL HAZARDS AND HAZARDOUS EFFECTS

- **Dust** – The finely divided airborne dust and fume should be treated as an explosion and inhalation hazard. Adequate ventilation, proper electrical system design, and appropriately designed dry collection systems should be provided.

- **Fumes, Vapors, And Gases** – Use ventilation and safe practices according to ANSI Z49.1, the material supplier's Safety Data Sheet (SDS), and AWS Safety and Health Fact Sheet No. 1. Most spray and abrasive blasting operations require the operator to use an approved respirator that complies with requirements of ANSI Z88.2. Also, precautions should be taken to avoid the presence of chlorinated hydrocarbon solvent vapor in the area of the arc or plasma spraying. Hazardous phosgene gas can be produced when hydrocarbon vapors are exposed to ultra-violet radiation from these processes.

- **Noise** – Thermal spray processes generate noise levels that require hearing protection by the operator. Earmuffs and noise control procedures should be provided to conform to the standard limits of OSHA 29 CFR 1910.95.

- **Radiation** - Intense ultraviolet (UV) and infrared (IR) radiation occurs with these processes. They require total protection of the eyes and all exposed skin to avoid eye damage and burns.

- Eye shades of No. 3-6 for combustion and 9-12 for electrical processes are recommended. See AWS Safety and Health Fact Sheet No. 2.

- **Electric Shock** - Arc, Plasma Arc, and Plasma Induction Spraying utilize electrical voltages in excess of 100 volts. Take precautionary measures according to ANSI Z49.1 and AWS Safety and Health Fact Sheet No. 5.

- **Fire** – The gas stream from a thermal spray gun is in excess of 3,000°F. Use care when handling thermal spray guns during operation to avoid personal injury or fire (see AWS Safety and Health Fact Sheet No. 6).

- **Mechanical Hazards** - The substrate surface preparation, spraying, finishing, and post-treatment operations involved with thermal spraying processes present a variety of mechanical hazards. Consult the equipment manufacturer's manuals and material supplier's MSDS for their recommended safe practices.

- **Compressed Gases** – Use and handle compressed gases as specified in ANSI-Z49.1.

INFORMATION SOURCES

American National Standards Institute (ANSI). *Safety in Welding, Cutting, and Allied Processes* (ANSI Z49.1), published by the American Welding Society, 8669 Doral Blvd., Doral, Florida 33166; telephone 800-443-9353; web site: www.aws.org.

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American National Standards Institute (ANSI). *Practice for Occupational and Educational Eye and Face Protection* (ANSI Z87.1), available from ANSI, 11 West 42nd Street, New York, NY 10036-8002; telephone: 212-642-4900; web site: www.ansi.org.

American National Standards Institute (ANSI). *Safe Practices For Respiratory Protection* (ANSI Z88.2), available from ANSI, 11 West 42nd Street, New York, NY 10036-8002; telephone: 212-642-4900; web site: www.ansi.org.

American National Standards Institute (ANSI). *Safety Requirements For Industrial Head Protection* (ANSI Z89.1), available from ANSI, 11 West 42nd Street, New York, NY 10036-8002; telephone: 212-642-4900; web site: www.ansi.org.

Occupational Safety And Health Administration (OSHA). *Code Of Federal Regulations*, Title 29 Labor, Parts 1901.1 to 1910.1450, available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 02402.

National Fire Protection Association (NFPA). *Standard for Fire Prevention During Welding, Cutting and Other Hot Work* (NFPA 51B), available from the National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101; telephone: 800-344-3555; Web site: www.nfpa.org.

National Fire Protection Association (NFPA). *National Electric Code* (NFPA 70), available from National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101; telephone: 800-344-3555; Web site: www.nfpa.org.

Compressed Gas Association (CGA). *Safe Handling of Compressed Gases in Cylinders*, CGA Pamphlet P-1 (and V-1), from Compressed Gas Association, 1735 Jefferson Davis Highway, Suite 1004, Arlington, VA 22202-4102 (telephone: 703-412-0900, web site: www.cganet. com).

Robotic Industries Association (RIA). *Safety Requirements for Industrial Robots and Robot Systems* (RIA R15.06), available from the Robotic Industries Association, P.O. Box 3724, 900 Victors Way, Ann Arbor, MI 48106; telephone: 734.994.6088; web site: www.robotics.org.

American Welding Society (AWS). *Thermal Spraying: Practice, Theory, And Application*, available from American Welding Society, 8669 Doral Blvd., Doral, FL 33166; telephone 800-443-9353; web site: www.aws.org.

National Fire Protection Association (NFPA). *Standard for the Design of Oxygen-Fuel Gas Systems for Welding and Cutting and Allied Process* (NFPA 51), available from National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101; telephone: 800-344-3555; Web site: www.nfpa.org.

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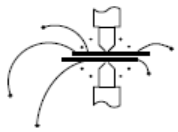

RESISTANCE SPOT WELDING

INTRODUCTION

Resistance Spot Welding is one of the oldest of the electric welding processes in use by industry. The weld is made by a combination of heat, pressure, and time. As the name implies, it is the material's resistance to current flow that causes a localized melting in the part. Pressure is exerted by the electrodes and tips. Time needed is determined by material thickness and type, amount of current, and cross-sectional area of the welding tips and contact surfaces.

HOW THE PROCESS WORKS

Fundamentally, Resistance Spot Welding occurs when current flows through the tips and the separate pieces of metal to be joined. The resistance of the base metal to the electrical current causes localized heating, and the weld is made. The weld is unique because the weld nugget is formed internally with relation to the surface of the base metal. An arc spot weld, on the other hand, starts at the surface of one piece and penetrates into the second piece to form the weld nugget. The arc weld is made from one side only. The resistance spot weld is normally made with electrodes that press both sides of the workpieces.

SAFETY HAZARDS

Resistance Spot Welding is not an open-arc process. The weld is made inside the workpieces. Consequently there are unique hazards to consider. Here are the major ones:

- Flying sparks can cause fire and explosion.
- Flying sparks and spatter can burn or injure eyes and skin.
- Electric shock from live electrical parts is a possible hazard.
- Hot metal and parts can cause burns.
- Moving electrode parts, such as tongs, tips, and linkages, can injure fingers and hands.
- Fumes from spot welding parts coated with cleaners, paints, or platings can be hazardous.

HOW TO AVOID THE HAZARDS

- Wear safety goggles or a face shield. Wear long sleeved shirts. Do not weld near flammables – move them away. Keep a fire extinguisher nearby, and know how to use it.

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- Wear dry insulating gloves. Install and ground unit according to electrical codes. Disconnect input power before servicing. Do not put hands between tips. Keep away from linkages and pinch points. Keep all guards and panels in place.

- Do not breathe the fumes. Use proper ventilation. Read Material Safety Data Sheets (MSDSs) for metals, coatings, and cleaners.

- Do not touch hot workpiece, tips, or tongs with bare hands. Allow tongs and tips to cool before touching. Wear proper insulating gloves when handling hot work or parts is necessary.

INFORMATION SOURCES

Occupational Safety And Health Administration (OSHA). *Code of Federal Regulations*, Title 29 Labor, Parts 1901.1 to 1910.1450, available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 02402.

American National Standards Institute (ANSI). *Safety in Welding, Cutting, and Allied Processes* (ANSI Z49.1), published by the American Welding Society, 8669 Doral Blvd., Doral, Florida 33166; telephone 800-443-9353; web site: www.aws.org.

National Fire Protection Association (NFPA). *National Electric Code* (NFPA 70), available from National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101; telephone: 800-344-3555; Web site: www.nfpa.org.

Canadian Standards Association (CSA). *Safety in Welding, Cutting and Allied Processes* (Standard W117.2), available from Canadian Standards Association, Standards Sales, 5060 Spectrum Way, Suite 100, Mississauga, Ontario, Canada L4W 5N6; telephone 800-463-6727; web site: www.csa.ca .

American National Standards Institute (ANSI). *Practice for Occupational and Educational Eye and Face Protection* (ANSI Z87.1), available from ANSI, 11 West 42nd Street, New York, NY 10036-8002; telephone: 212-642-4900; web site: www.ansi.org.

National Fire Protection Association (NFPA). *Standard for Fire Prevention During Welding, Cutting and Other Hot Work* (NFPA 51B), available from National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101; telephone: 800-344-3555; Web site: www.nfpa.org.

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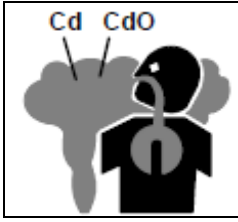

Cadmium Exposure from Welding and Allied Processes

INTRODUCTION

Fumes are poisonous and can kill. Overexposure may cause death. Some fume and dust from welding processes (including brazing, soldering, and thermal spraying) may contain cadmium or cadmium oxide compounds. The specific form and concentration of cadmium present in the fume and dust are dependent on the composition of the filler metal, base metals, metal coatings, atmosphere, flux, and the welding process.

ACUTE (SHORT TERM) EFFECTS OF OVEREXPOSURE TO CADMIUM

- Similar, but much more severe, to the effects produced by fume and dust from other metals.
- Inhalation exposure to high concentrations of fume may cause symptoms such as nausea, headaches, dizziness, nervousness, lung complications, and death.

CHRONIC (LONG TERM) EFFECTS OF OVEREXPOSURE TO CADMIUM

- Long term exposure to cadmium oxide fume and dust has caused severe chronic effects, kidney failure, and may, with longer exposure and/or higher concentrations lead to severe respiratory disease and death.
- Inhalation of cadmium by smokers may accelerate the development of respiratory diseases.
- There is evidence that long term exposure to cadmium may cause lung cancer. OSHA has defined cadmium as a carcinogen with no further categorization. Observations are difficult to interpret because of inadequate data and confounding factors.
- Conclusions from the International Agency for Research on Cancer (IARC Group 2B):
  (1) there is limited evidence in humans for the carcinogenicity of welding fumes, and
  (2) there is inadequate evidence in experimental animals for the carcinogenicity of welding fumes. (The IARC classification 2B means that the agent is possibly carcinogenic to humans. By contrast, a 2A designation would mean that the agent is probably carcinogenic to humans.)

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OVERALL EVALUATION

- Overexposure to cadmium may cause death.
- Cadmium exposure is possibly carcinogenic to humans (IARC Group 2B).

HOW TO PROTECT AGAINST OVEREXPOSURE

- Comply with OSHA regulations for cadmium.
- Identify composition of all base metals, coatings, and consumables; substitute non–cadmium containing materials wherever possible.
- Read and follow the Safety Data Sheets (SDSs) for cadmium containing products.
- Do not breathe fumes and gases. Avoid even brief exposure to high concentrations.
- Keep your head out of the fumes.
- Use enough ventilation, exhaust at the arc, or both, to keep fumes and gases from your breathing zone and the general area.
- If ventilation is questionable, use air sampling to determine the need for corrective measures—air supplied respirators may be required.
- Avoid ingestion. Do not eat or smoke in areas containing cadmium fume or dust.
- Keep exposure as low as possible.

INFORMATION SOURCES

Agency for Toxic Substances and Disease Registry (ATSDR), *Toxicological Profile for Cadmium—1998*, available from the Agency for Toxic Substances and Disease Registry, Dept. of Health and Human Services—Div. of Toxicology, 1600 Clifton Road, N.E.– M.S.E–29, Atlanta, GA 30333; Web site: www.astdr.cdc.gov.

National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161; Web site: www.ntis.gov.

International Programme on Chemical Safety(IPCS*) Environmental Health Criteria 134–Cadmium*, available from INCHEM; Web site: www.inchem.org/.

Organization for Economic Cooperation and Development (OECD), Risk Reduction Monograph No. 5: Cadmium—OECD 1994, available from the Organization for Economic Cooperation and Development, Environmental Health and Safety Division, Zrue André–Pascal, 75775 Paris Cedex 16, France; Web site: www.oecd.org.

National Institute for Occupational Safety and Health (NIOSH). Registry of Toxic Effects of Chemical Substances, and IDLHs. Cincinnati, Ohio: National Institute for Occupational Safety and Health, Taft Labs, 4676 Columbia Pkwy, Cincinnati, OH45226; Web site: www.cdc.gov/niosh.

American Welding Society (AWS) Study. Fumes and Gases in the Welding Environment, available from American Welding Society, 8669 Doral Blvd., Doral, FL 33166; Web site: www.aws.org.

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International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk to Humans— Cadmium and Cadmium Compounds, Supplement 7 and Vols. 43–61 (1990). Oxford University Press, New York, NY 10016; Web site: www.iarc.fr.

American Conference of Governmental Industrial Hygienists, Documentation of the Threshold Limit Values and Biological Exposure Indices, and Guide to Occupational Exposure Values, available from American Conference of Governmental Industrial Hygienists (ACGIH), 1330 Kemper Meadow Drive, Cincinnati, OH 45240; Web site: www.acgih.org.

Occupational Safety and Health Administration (OSHA). Code of Federal Regulations, Title 29 Labor, Part 1910.1027 Cadmium, available from the U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401; telephone: 800-321-6742; Web site: www.osha.gov.

Environmental Protection Agency (EPA). Integrated Risk Information System (IRIS) database; Web site: www.epa.gov/iris.

The following references include the specific precautionary methods used to protect against exposure to fumes and gases:

American National Standards Institute (ANSI). Safety in Welding, Cutting, and Allied Processes, Z49.1, available from American Welding Society, 8669 Doral Blvd., Doral, FL 33166; Web site: www.aws.org.

National Institute for Occupational Safety and Health (NIOSH). Safety and Health in Arc Welding and Gas Welding and Cutting, NIOSH Publication No. 78–138. Cincinnati, Ohio: National Institute for Occupational Safety and Health; Web site: www.cdc.gov/niosh.

Mine Safety and Health Administration (MSHA). Code Of Federal Regulations, Title 30 Mineral Resources, Parts 1-199, , available from the U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401; telephone: 800-321-6742; Web site: www.msha.gov.

Occupational Safety and Health Administration (OSHA). Code of Federal Regulations, Title 29 Labor, Part 1910, available from the U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401; telephone: 800-321-6742; Web site: www.osha.gov.

International Cadmium Association (ICdA). Using Cadmium Safely, available from International Cadmium Association, P.O. Box 924, Great Falls, VA 22066–0924; Web site: www.cadmium.org.

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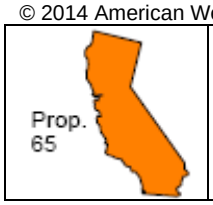

California Proposition 65

WHAT IS PROPOSITION 65?

In November 1986, California voters approved an initiative to address growing concern about exposures to toxic chemicals. That initiative became *The Safe Drinking Water and Toxic Enforcement Act of 1986,* better known as Proposition 65. Proposition 65 appears in California Law as Health and Safety Code Sections 25249.5 through 25249.13. The spirit of the law is to prevent contamination of the water sources, to help consumers make informed choices about products, and to enable residents or workers to protect themselves from exposures to the listed harmful chemicals.

WHAT DOES PROPOSITION 65 REQUIRE?

The "Governor's List." Proposition 65 requires the Governor to publish a list of chemicals that are "known to the State of California" to cause cancer, birth defects, or other reproductive harm. This list must be updated at least once a year. Over 820 chemicals had been listed as of December 19, 2008. Always review the current list of chemicals to be sure you have the latest information and up-to-date details. Only those chemicals that are on the list are regulated under this law. Businesses that produce, use, release, or otherwise engage in activities involving those chemicals must comply with the following:

Clear and reasonable warnings*. A business is required to warn a person before "knowingly and intentionally" exposing that person to a listed chemical. The warning given must be "clear and reasonable." This means that the warning must: (1) clearly make known that the chemical involved is known to cause cancer, birth defects, or other reproductive harm; and (2) be given in such a way that it will effectively reach the person before he or she is exposed.

Prohibition from discharges into drinking water. A business must not knowingly discharge or release a listed chemical into water or onto land where it passes or probably will pass into a source of drinking water.

WHAT KIND OF CHEMICALS ARE ON THE LIST?

A chemical is listed if the "state's qualified experts" or a recognized "authoritative" organization finds that the chemical has been clearly shown to cause cancer, birth defects, or other reproductive harm. A chemical can also be listed if it is required to be labeled or identified as a carcinogen or as a reproductive toxicant by an agency of the state (of California) or federal government. The California list contains a wide range of chemicals, including dyes,

*This term is not used consistent with ANSI Z535 guidelines.

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solvents, pesticides, drugs, food additives, and by–products of certain processes such as welding and cutting. Some of the chemicals are ingredients of common household products, while others are specialty chemicals used in very specific industrial applications. For a complete list of chemicals, see the list at www.oehha.org/ prop65 provided on the Proposition 65 website.

ARE THERE ANY EXEMPTIONS?

Yes, there are several exemptions to the law as follows:

- Government agencies and public water utilities
- Businesses with nine or fewer employees.
- Exposures that pose no significant risk of cancer.
- Exposures that will produce no observable reproductive effects at 1,000 times the level in question.
- Discharges that do not result in a "significant amount" of the listed chemical entering into any source of drinking water. A "significant amount" means any detectable amount, except an amount that would meet the "no significant risk" or "no observable effect" test if a person were exposed to such an amount in drinking water.
- Federally preempted – Proposition 65 may be preempted to the extent it is regulated by Federal Law, including OSHA and the Hazard Communication Act.

HOW IS PROPOSITION 65 ENFORCED?

Enforcement is carried out through civil lawsuits. These lawsuits may be brought by the Attorney General, any district attorney, or certain city attorneys (those in cities with a population exceeding 750,000). Lawsuits may also be brought by private parties acting in the public interest, but only after providing notice of the alleged violation to the Attorney General, the appropriate district attorney and city attorney, and the business accused of the violation. The notice must provide adequate information to allow the recipient to assess the nature of the alleged violation. A notice must comply with the information and procedural requirements specified in California regulations.

WHAT HAPPENS TO VIOLATORS?

A business found to be in violation of Proposition 65 is subject to civil penalties of up to $2,500 per day for each violation. In addition, the business may be ordered by a court of law to stop committing the violation. In most cases a settlement is reached in which the alleged violators must stop violating, pay a civil penalty, and pay the attorney fees.

WHO CAN I CONTACT FOR FURTHER INFORMATION?

By phone, contact the Office of Environmental Health Hazard Assessment's Proposition 65 Implementation Office at 916-445-6900. Or go to their website at: www.oehha.ca.gov/prop65.html.

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WHAT DOES THIS MEAN FOR THE WELDING AND CUTTING INDUSTRIES?

Many welding and cutting manufacturers have committed to label their products in a uniform way and to label certain types of equipment and consumables that are for sale in California. The label may be on the product or carton – most manufacturers choose to put it on the carton. The product manuals are also required to carry the precautionary wording. There are three different label wordings depending on the product, process, or chemical involved as follows:

1. *WARNING: This product contains or produces a chemical known to the State of California to cause cancer (California Health and Safety Code Section 25249.5 et seq.).*

This warning is used for chemicals such as dichloromethane (methylene chloride).

2. *WARNING: This product contains or produces a chemical known to the State of California to cause cancer and birth defects (or other reproductive harm) (California Health and Safety Code Section 25249.5 et seq.).*

This warning is used for all products (consumables) with stainless steel, thorium, chromium, nickel, cobalt, cadmium, antimony, carbon black, and submerged-arc fluxes with crystalline silica of respirable size (any bonded fluxes).

3. *WARNING: This product, when used for welding or cutting, produces fumes or gases which contain chemicals known to the State of California to cause birth defects and, in some cases, cancer (California Health and Safety Code Section 25249.5 et seq.).*

This warning is used for all welding and cutting equipment, plasma equipment, oxyfuel equipment, and all other consumables.

NOTE: The Material Safety Data Sheets (MSDSs) are also required to carry parallel CALIFORNIA WARNING language for each product that is intended for distribution and sale in California.

INFORMATION SOURCES

California Health and Safety Code, Section 25249.4 through 25249.13.

The California Office of Environmental Health Hazard Assessment, 301 Capitol Mall, Sacramento, CA 95814; telephone 916-445-6900.

California Proposition 65 website: www.oehha.ca.gov/prop65.html.

American National Standards Institute (ANSI). *Product Safety Signs And Labels* (ANSI Z535.4), available from ANSI, 25 West 43rd Street, New York, NY 10036; telephone: 212-642-4900; web site: www.ansi.org.

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FLUXES FOR ARC WELDING AND BRAZING: SAFE HANDLING AND USE

INTRODUCTION

Fluxes are used in various arc welding processes, such as Submerged–Arc Welding (SAW) and Electroslag Welding (ESW). Fluxes are also used in most brazing applications. Fluxes are available in various forms such as granules, powder, paste, or liquid. There are hazards when dealing with fluxes.

HAZARD OVERVIEW

The possible hazards associated with handling and using fluxes include the following:

- Inhaling toxic or corrosive flux dust
- Breathing welding fumes and gases
- Getting flux on the skin and in the eyes
- Swallowing toxic or corrosive flux or dust
- Breathing and swallowing flux particles during recovering and grinding.

The makeup and amount of these hazardous materials varies depending on the flux and the process. Individuals with pre-existing physical conditions, such as allergies or lung diseases, may react to levels below allowable exposure limits and have symptoms that normal, healthy adults do not experience.

ACUTE (SHORT TERM) EFFECTS OF OVEREXPOSURE

Overexposure to flux may cause the following symptoms:

- General overexposure may cause irritation, burning, and bleeding of the exposed tissue, headache, dizziness, and shortness of breath.
- Dust, fumes and gases may irritate the skin, eyes, and respiratory system.
- Toxic, corrosive, or oxygen–depleting gases can cause fluid in the lungs, suffocation, and death.
- Fumes containing chromium or nickel compounds may irritate the skin and respiration tract and cause Metal Fume Fever (see Fact Sheet Number 25).
- Flux products containing both fluoride and hydrogen compounds may produce corrosive and toxic hydrofluoric acid which can cause irritation to skin, eyes, and the nose and throat.
- Swallowing or breathing barium oxide dust or fume can result in abdominal pain, vomiting, paralysis, and death.

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CHRONIC (LONG TERM) EFFECTS OF OVEREXPOSURE

Long term overexposure to inhalable welding fumes may lead to their accumulation in the body. The effect is cumulative, depending on concentration and time of exposure. The accumulation, evident from x-ray examination, may or may not result in reduced lung function or disease. Smoking or other non-welding exposure to hazardous particles may cause or aggravate this type of lung accumulation condition. Chronic fluoride absorption can cause calcium loss from the bones and can discolor or spot the teeth. Prolonged exposure to manganese oxides may affect the central nervous system, causing tiredness, fatigue, sleepiness, muscular weakness, emotional disturbances, walking (muscle spasms). Chronic overexposure to respirable crystalline silica may result in silicosis, a disabling lung disease, and also a suspected carcinogen to the lungs. Nickel and chromium VI compounds, when present, and when inhaled over long periods, are carcinogenic. Nickel fumes may also cause fibrous masses and fluid in the lungs.

OVERALL EVALUATION OF POTENTIAL HAZARDS

Fluxes are safe and useful when handled and used properly and when recommended safety procedures are followed. The major hazards to avoid are overexposure by breathing, swallowing, or inhaling the dust or fumes and gases, especially those containing respirable crystalline silica and fluorides. If the application recovers used flux, as is common in Submerged–Arc Welding (SAW), and then reuses or grinds the flux for reuse, overexposure to dust happens quickly if precautions are not taken.

Some submerged arc welding fluxes may contain very small quantities of naturally occurring radioactive material (NORM). Flux materials containing sufficiently low concentrations of NORM are not subject to federal radiation control regulations. These fluxes do not present an environmental or health hazard. Contact the flux manufacturer for further information.

HOW TO PROTECT AGAINST OVEREXPOSURE

- Wear proper hand, face, and body protection when handling or when otherwise exposed to fluxes and their dust, fumes and gases—this means protective (leather, rubber) gloves, goggles, and full clothing with long sleeves and long pants (not shorts).

- Avoid breathing the dust or fumes and gases. Keep your head out of the fumes, dust, and gases. Use enough ventilation, exhaust at the arc, or both, to keep fumes, dust, and gases from your breathing zone and the general area. When necessary, wear an approved mask or respirator.

- Do not consume food or beverages in areas where flux dust or fumes or gases may be generated or may be present.

- During brazing, do not overheat the fluxes. Follow the manufacturer's recommended procedures. Overheating results in the generation of, and potential exposure to, excessive fumes and gases.

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INFORMATION SOURCES

American Welding Society (AWS) Study. Fumes and Gases in the Welding Environment, available from American Welding Society, 8669 Doral Blvd., Doral, FL 33166; Web site: www.aws.org.

Occupational Safety and Health Administration (OSHA). Code of Federal Regulations, Title 29 Labor, Part 1910, available from the U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401; telephone: 800-321-6742; Web site: www.osha.gov.

American Conference of Governmental Industrial Hygienists, *Threshold Limit Values (TLV®) for Chemical Substances and Physical Agents in the Workroom Environment*, available from American Conference of Governmental Industrial Hygienists (ACGIH), 1330 Kemper Meadow Drive, Cincinnati, OH 45240; Web site: www.acgih.org.

American National Standards Institute (ANSI). Safety in Welding, Cutting, and Allied Processes, Z49.1, available from American Welding Society, 8669 Doral Blvd., Doral, FL 33166; Web site: www.aws.org.

National Institute for Occupational Safety and Health (NIOSH). *Criteria for a Recommended Standard: Welding, Brazing, and Thermal Cutting,* NIOSH Publication No. 88-110.Cincinnati, Ohio: National Institute for Occupational Safety and Health; Web site: www.cdc.gov/niosh.

American Welding Society (AWS). Safety And Health Fact Sheet No. 1, *Fumes And Gases,* available from American Welding Society, 8669 Doral Blvd., Doral, FL 33166; Web site: www.aws.org.

American Welding Society (AWS). Safety And Health Fact Sheet No. 25, *Metal Fume Fever,* available from American Welding Society, 8669 Doral Blvd., Doral, FL 33166; Web site: www.aws.org.

For specific information, refer to the applicable Safety Data Sheet (SDS) available from the manufacturer, distributor, or supplier of the specific flux.

American Welding Society (AWS). *A Sampling Strategy Guide for Evaluating Contaminants in the Welding Environment* (AWS F1.3), available from American Welding Society, 8669 Doral Blvd., Doral, FL 33166; Web site: www.aws.org.

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METAL FUME FEVER

OVERVIEW

Metal Fume Fever is the name for an illness that is caused primarily by exposure to zinc oxide fume (ZnO) in the workplace. The main cause of this exposure is usually breathing the fumes from welding, cutting, or brazing on galvanized metal. Metal Fume Fever is an acute allergic condition experienced by many welders during their occupational lifetimes. Studies indicate that the most common cause of metal fume fever is overexposure to zinc fumes from welding, burning, or brazing galvanized steel. Since galvanized steel is more and more common in industry, the chances of welders having to work on it are occurring more frequently all the time. Other elements, such as copper and magnesium, may cause similar effects.

EFFECTS OF OVEREXPOSURE

Zinc oxide fumes cause a flu–like illness called Metal Fume Fever. Symptoms of Metal Fume Fever include headache, fever, chills, muscle aches, thirst, nausea, vomiting, chest soreness, fatigue, gastrointestinal pain, weakness, and tiredness. The symptoms usually start several hours after exposure; the attack may last 6 to 24 hours. Complete recovery generally occurs without intervention within 24 to 48 hours. Metal Fume Fever is more likely to occur after a period away from the job (after weekends or vacations). High levels of exposure may cause a metallic or sweet taste in the mouth, dry and irritated throat, thirst, and coughing at the time of the exposure. Several hours after exposure, a low–grade fever occurs (seldom higher than 102_ F or 39_ C). This is followed by sweating and chills before temperature returns to normal in 1 to 4 hours. If you encounter these symptoms, contact a physician and have a medical examination / evaluation. There is no information in the literature regarding the effects of long–term exposure to zinc oxide fumes.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for zinc oxide fume is 5 milligrams of zinc oxide fume per cubic meter of air (mg/m^3) averaged over an eight–hour work shift. NIOSH recommends that the permissible exposure limit be changed to 5 mg/m3 averaged over a work shift of up to 10 hours per day, 40 hours per week, with a Short–Term Exposure Limit (STEL) of 10 mg/m3 averaged over a 15–minute period. Consult the NIOSH standard, *Criteria Document for Zinc Oxide,* listed in the Information Sources for more detailed information.

HOW TO AVOID THE HAZARD

- Keep your head out of the fumes.
- Do not breathe fumes.

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- Use enough ventilation, exhaust at the arc, or both, to keep fumes and gases from your breathing zone and the general area.

- If adequacy of the ventilation or exhaust is uncertain, have your exposure measured and compared to the Threshold Limit Values (TLV) in the Safety Data Sheet (SDS) for the galvanized material.

- Never take chances with welding fumes. If none of this is adequate or practical, wear an approved respirator, air–supplied or otherwise, that adequately removes the fumes from your breathing zone.

RESPIRATORS

Good safe practices recommend using engineering controls, such as local exhaust and/or general ventilation, to reduce the exposure level to zinc oxide fumes. However, there are times when such practices and controls are not feasible, or are in the process of being installed, or are down during periods of failure. Then respirators are needed. Respirators are often used for operations in confined spaces, such as tanks or closed vessels, and in emergency situations. Always use only respirators that are approved by the Mine Safety and Health Administration (MSHA) or by the National Institute for Occupational Safety and Health (NIOSH).

MONITORING AND MEASUREMENT PROCEDURES

- **Eight–Hour Exposure Evaluation**

Exposure measurements are best taken so the eight–hour exposure is based on a single eight–hour sample or on two four–hour samples. Several short–time interval samples (up to 30 minutes) may be used, but are not preferred. The air samples should be taken by a qualified person using approved collection methods and devices. Take the samples in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

INFORMATION SOURCES

National Institute for Occupational Safety and Health. *Criteria for a Recommended Standard – Occupational Exposure to Zinc Oxide,* DHEW, NIOSH Publication No. 76–104; NTIS Publication No. PB–246–693, available from National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161; Web site: www.ntis.gov.

American Welding Society (AWS) Study. Fumes and Gases in the Welding Environment, available from American Welding Society, 8669 Doral Blvd., Doral, FL 33166; Web site: www.aws.org.

American Conference of Governmental Industrial Hygienists, Threshold Limit Values (TLV®) for Chemical Substances and Physical Agents in the Workroom Environment, available from American Conference of Governmental Industrial Hygienists (ACGIH), 1330 Kemper Meadow Drive, Cincinnati, OH 45240; Web site: www.acgih.org.

Occupational Safety and Health Administration (OSHA). Code of Federal Regulations, Title 29 Labor, Part 1910, available from the U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401; telephone: 800-321-6742; Web site: www.osha.gov.

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American Conference of Governmental Industrial Hygienists, Documentation of the Threshold Limit Values and Biological Exposure Indices, and Guide to Occupational Exposure Values, available from American Conference of Governmental Industrial Hygienists (ACGIH), 1330 Kemper Meadow Drive, Cincinnati, OH 45240; Web site: www.acgih.org.

The following references include the specific precautionary methods used to protect against exposure to fumes and gases:

American National Standards Institute (ANSI). Safety in Welding, Cutting, and Allied Processes, Z49.1, available from American Welding Society, 8669 Doral Blvd., Doral, FL 33166; Web site: www.aws.org.

National Institute for Occupational Safety and Health (NIOSH). Safety and Health in Arc Welding and Gas Welding and Cutting, NIOSH Publication No. 78–138. Cincinnati, Ohio: National Institute for Occupational Safety and Health; Web site: www.cdc.gov/niosh.

American Welding Society (AWS). *A Methods for Sampling Airborne Particulates Generated by Welding and Allied Processes* (AWS F1.1), available from American Welding Society, 8669 Doral Blvd., Doral, FL 33166; Web site: www.aws.org.

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Arc Viewing Distance

PREFACE

This Fact Sheet is the AWS Labeling and Safe Practices Subcommittee's response to requests for information on hazard distances from the arc for skin and corneal exposures. Our committee decided to present the work of Mr. Terry Lyon, a physicist with the U.S. Army Laser/Optical Radiation Program, U.S. Army Center for Health Promotion and Preventive Medicine.

These hazard distances are for actinic ultraviolet radiation exposure to the skin and cornea. These are not safe viewing distances for viewing a bright light source. Brief viewing of an arc, limited by natural aversion or the blink response, do not exceed personnel exposure limits for the retina. Staring at the arc should never be permitted without appropriate eye protection.

Mr. Lyon published his work in an article in the AWS *Welding Journal* (December 2002). With Mr. Lyon's permission, we decided to include his entire article as the substance of this Fact Sheet. His complete article appears on the following pages..

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KNOWING THE DANGERS of Actinic Ultraviolet Emissions

Those who work around electric arc welding and cutting operations should be aware of the potential health hazards caused by these electromagnetic waves

BY TERRY L. LYON

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While open arc welding operations are common worldwide, the general population is largely unaware of the potential hazards. Before the mid 1970s, measures of optical radiation hazards and protection were largely empirically determined, even for welders and their helpers.

Today, we know serious potential hazards can exist wherever there are lines of sight to open arcs created by invisible emissions called "actinic ultraviolet radiation (UVR)." These UVR emissions are simply electromagnetic waves, like light, that travel in straight lines at the speed of light. A summary of the actinic UVR hazards to persons working around electric arc welding and cutting operations is contained in Table 1.

Table 1 — Distances[(a)] to Common Electric Arc Welding or Cutting Processes[(b)] at which the Actinic Ultraviolet Radiation (UVR)[(c)] Is Below the U.S. Daily Threshold Limit Value (TLV)[(d)] for Various Exposure Times[(e)].

Arc Welding/Cutting Process	Base Metal	Shielding Gas	Arc Current in Amperes	Distance in m for 1 min	Distance in m for 10 min	Distance in m for 8 h
Shielded Metal Arc (Stick)	Mild steel	None	100–200	3.2	10	71
GMAW	Mild steel	CO_2	90	0.95	3.0	21
			200	2.2	7.0	48
			350	4.0	13	87
	Mild steel	CO_2	175	1.1	3.6	25
			350	2.3	7.3	51
		95% Ar + 5% O_2	150	2.9	9.3	65
			350	6.7	21	150
	Al	Ar	150	3.2	10	70
			300	5.0	16	110
		He	150	1.6	5.0	34
			300	3.2	10	69
GTAW	Mild steel	Ar	50	0.32	1.0	6.9
			150	0.90	2.8	20
			300	1.7	5.5	38
	Mild steel	He	250	3.0	9.5	66
	Al	Ar	50 AC	0.32	1.0	6.9
			150 AC	0.85	2.7	19
			250 AC	1.6	5.0	35
	Al	He	150 AC	0.94	3.0	21
PAW	Mild steel	Ar	200–260	1.5	4.9	34
		85% Ar + 15% H_2	100–275	1.7	5.5	38
		He	100	3.0	9.4	65
PAC (dry)	Mild steel	65% Ar + 35% H_2	400	1.4	4.4	31
			1000	2.4	7.5	52
PAC (H_2O)	Mild steel	N_2	300	3.3	10	72
			750	1.7	5.5	38

(a) These distances are approximate. To convert to feet, multiply the distance in meters by 3.3.
(b) The distances are based upon the worst-case exposure conditions; maximum UVR for exposure angle, arc gap, and electrode diameter.
(c) Invisible actinic UVR poses a potential hazard to cornea (called welder's flash) and skin (much like sunburn) and exposure is cumulative with each exposure over an 8-h workday per 24-h period.
(d) TLVs are published by the ACGIH, Cincinnati, Ohio.
(e) These distances were based upon data from Lyon, T. L. et al, 1976. *Evaluation of the Potential Hazards for Actinic Ultraviolet Radiation Generated by Electric Welding and Cutting Arcs.* U.S. Army Environmental Hygiene Agency.

Exposure Effects

Since the beginning of arc welding, welders have known welding and cutting operations can cause acute effects such as severe "sunburn" (erythema) of the skin and painful "welder's flash" (photokeratitis) of the cornea of the eye. Consequently, early welders empirically selected protective clothing and eyewear for comfortable viewing. Also, the U.S. Army adopted a measure to prevent eye injuries in industrial areas. Ordinary safety glasses were prescribed for all Army personnel, including welders and their helpers. As a by-product of physical injury prevention, the eyewear resulted in a dramatic drop in the incidence of welder's flash. Any stray invisible actinic UVR was also blocked by the transparent lenses.

Exposure Limits

The first actinic UVR exposure guidelines were published by the American Conference of Governmental Industrial Hygienists (ACGIH) in 1972 (Ref. 1). These guidelines were intended to prevent the acute effects of actinic UVR. The International Non-Ionizing Radiation Committee (INIRC) of the International Radiation Protection Association (IRPA) (Ref. 2) proposed similar guidelines in 1985. After considerable review, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) (Ref. 3) revalidated and endorsed those limits. Besides being concerned about acute effects, these standards have also been shown to minimize any adverse effects and pose an extremely small risk for delayed effects.

Instrumentation

By the early 1970s, several instruments were available to measure actinic UVR but many simpler instruments presented significant measurement errors primarily from a flaw called "stray light." The actinic UVR resulting in an acute injury followed a narrow range of wavelengths (from around 200–315 nm) with a varying "action spectrum" (peaking sharply at 270 nm). Producing an instrument with this wavelength response was difficult with known filters at that time. The better instruments were the traditional ultraviolet spectrometers that could manually scan UVR wavelengths, weigh the results against the exposure standard for each wavelength, then sum them for the net result.

Joint Effort

In 1974, a joint effort was planned to determine the optical radiation hazards from electric arc welding and cutting operations. Testing was planned for six processes: gas tungsten arc welding (GTAW), gas metal arc welding (GMAW), flux cored arc welding (FCAW), plasma arc cutting (PAC), plasma arc welding (PAW), and shielded metal arc welding (SMAW). Organizations that provided personnel and equipment for the effort included Union Carbide Corp., the American Welding Society (AWS), Battelle Memorial Institute, National Institute of Occupational Safety and Health (NIOSH), and the U.S. Army Environmental Hygiene Agency (USAEHA, now U.S. Army Center for Health Promotion and Preventive Medicine [USACHPPM]).

In 1974 a joint effort was undertaken by various public and private organizations to determine the optical radiation hazards of electric arc welding and cutting operations.

Joint Effort Results

Arc measurements were conducted in 1975 at Union Carbide Corp. in Florence, S.C., and later at Plasma in Lebanon, N.H., and Caterpillar in Peoria, Ill. A variety of detectors were employed but the final results of the first study were based upon traditional UVR spectrometer results. The arc location and root opening were stabilized for measurements by employing a rotating pipe fixture, and all measurements were made at a measurement distance of one meter and at the worst-case angle for emissions. The results of that study were published as a USAEHA report (Ref. 4) in 1976 employing the ACGIH threshold limit value. That study contained results for more than 100 different conditions and processes and yielded the relationships between arc current, arc length, shielding gas, base metal, and actinic UVR that resulted in the derivation of formulas for those relationships.

Table Summary

A summary of actinic UVR hazards posed to persons working around electric arc welding and cutting operations are contained in Table 1 and are summarized as follows.

- **Hazardous Exposure.** The level of hazardous exposure affecting welders' helpers and other personnel (forklift and overhead crane operators, for example) located in the vicinity of open arc welding and cutting operations can now be determined. The intensity and wavelengths of nonionizing radiant energy produced depend on many factors such as the process type, welding parameters, electrode and base metal composition, fluxes, and any coating or plating on the base material. Some processes such as resistance welding, cold-pressure welding, and submerged arc cutting ordinarily produce negligible quantities of radiant energy. Later, Europeans conducted UVR measurements on pulsed welding.
- **Exposure Time.** Exposure to actinic UVR is considered to be cumulative with each exposure over an 8-h workday and within a 24-h period. Therefore, two 5-min exposures during a workday could be considered as a single 10-min exposure.
- **Reflections.** Actinic UVR can reflect significantly from some common surfaces and these reflections might also create potentially harmful exposure to unprotected personnel. Unpainted metals (particularly aluminum) and concrete floors readily reflect actinic UVR. On the other hand, lightly colored paints often use pigments of zinc oxide or titanium oxide and have a low reflectance of actinic UVR. Therefore, even lightly pigmented paints are good absorbers of actinic ultraviolet radiation (Ref. 5).
- **Safety Information.** Welders, welders' helpers, and their supervisors should periodically include a discussion of actinic UVR hazards in normal safety reviews and within written safety procedures. Concern for actinic UVR is especially important to discuss with new employees and personnel who work in the vicinity of open arcs.
- **Nearby Persons.** Persons in the vicinity of welding operations can be protected from exposure to actinic UVR by use of screens, curtains, or adequate distance from aisles, walkways, etc. Welders' helpers, overhead crane operators, and forklift operators who have a line of sight to any open arcs should consider wearing appropriate safety equipment such as safety glasses with sideshields or even a clear, full-face shield and long-sleeved shirts.
- **Skin Protection.** While standards exist for welders and their helpers, skin protection has not been uniformly prescribed for other personnel who work in the vicinity of open arcs. Fabric measurements have shown that natural materials (leather, cotton, wool) are better for absorbing actinic ultraviolet radiation than synthetic materials (polyester, nylon) (Ref. 6). Incidental personnel should consider wearing a long-sleeved shirt.
- **Warning Signs.** Warning signs are useful when persons unfamiliar with actinic UVR and other welding hazards are nearby. Such warnings are especially important to have on portable welding screens that can be used at field sites near the general population. A suitable sign could simply state "Danger" or "Warning" and be posted conspicuously at entry points or doors to welding areas. Such signs might also include the warning "Avoid Exposure of Eye and Skin to Arc and Harmful Ultraviolet Emissions."

Retinal Exposure

In addition to actinic UVR measurements, another study was published as a USAEHA report (Ref. 7) in 1977 containing an evaluation of potential retinal exposure hazards. The eye can focus an open arc onto the retina where an injury might result that was photochemical or thermal in nature. Photochemical injury is the result of exposure to intense blue light sources, whereas thermal injury can result from all visible and some near-infrared radiation, which is largely invisible. Measurements of blue light and other retinal-thermal emissions suggest momentary viewing of electric welding and cutting arcs does not exceed retinal exposure limits; however, staring at an open arc can readily exceed these standards. While staring at the arc should never be permitted, actual retinal injuries are rare (Ref. 8) and would likely result only from chronic staring.

References

1. American Conference of Governmental Industrial Hygienists (ACGIH). 2001. *TLVs and BEIs, Threshold Limit Values for Chemical Substances and Physical Agents*. Cincinnati, Ohio: ACGIH.
2. International Commission on Non-Ionizing Radiation Protection (ICNIRP). 1996. Guidelines on UV radiation exposure limits. *Health Phys.* 71(6): 978.
3. Sliney, D. H. 2000. Ultraviolet radiation exposure criteria. *Radiation Protection Dosimetry* 91(1–3): 213–222.
4. Report No. 42-0053-77/ADA033768, *Evaluation of Potential Hazards from Actinic Ultraviolet Radiation Generated by Electric Welding and Cutting Arcs*, Dec. 1975–Sept. 1976. U.S. Army Environmental Hygiene Agency.
5. Sliney, D. H., and Wolbarsht, M. L. 1980. *Safety with Lasers and Other Optical Sources*. New York, N.Y.: Plenum Press.
6. Sliney, D. H., Benton, R. E., et. al. 1987. Transmission of potentially hazardous actinic ultraviolet radiation through fabrics. *Applied Industrial Hygiene* 2(1): 36–44.
7. Report No. 42-0312-77/ADA043023, *Evaluation of the Potential Retinal Hazards from Optical Radiation Generated by Electric Welding and Cutting Arcs*, Dec. 1975–Apr. 1977. U.S. Army Environmental Hygiene Agency.
8. Naidoff, M. A., and Sliney, D. H. 1974. Retinal injury from a welding arc. *American Journal of Ophthalmology* 77(5): 663–668.

Thoriated Tungsten Electrodes

INTRODUCTION

Thoriated tungsten electrodes contain thorium, a radioactive material that can pose health and environmental risks at elevated exposure levels. The use of these electrodes is exempt from Nuclear Regulatory Commission (NRC) regulations.

Effective August 27, 2014, electrode manufacturers and importers will need to possess a specific NRC license to distribute these electrodes. The license will impose requirements for labeling, quality control, reporting, and record keeping.

All persons shipping thoriated tungsten electrodes in the United States need to comply with Department of Transportation (DOT) regulations. DOT requires the thoriated tungsten electrodes to be properly packaged and labeled. The surface of the package must be monitored for radioactivity. For example, the US Postal Service requires the following label on the address side of the package:

> "This package conforms to the conditions and limitations specified in 49 CFR 173.426 for radioactive material, excepted package–articles manufactured from natural uranium (or natural thorium), UN2909 and is within Postal Service activity limits for mailing."

NATURE OF THE HAZARD

Thorium is a low-level radioactive material that primarily emits alpha particles as well as some beta and gamma radiation. These electrodes are normally sharpened by grinding as part of the standard procedure while preparing to perform gas tungsten arc welding (GTAW). Dust particles from this grinding process can cause internal radiation exposure if the dust is accidentally ingested or inhaled, so precaution is necessary. Concern regarding radiation exposure to the external body from these electrodes is minimal.

The risk of internal exposure during welding is negligible in most circumstances since the thoriated electrode is consumed at a very slow rate.

During the grinding of the thoriated tungsten electrodes, radioactive dust is created, posing the potential hazard of internal radiation exposure by inhalation or ingestion unless care is taken to control the dust.

HOW TO REDUCE EXPOSURE

- Choose thorium-free tungsten electrodes such as those containing cerium, lanthanum, yttrium, or zirconium.

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- Read, understand, and follow all information in the Safety Data Sheet (SDS) for the selected tungsten electrode.

- Use a high-efficiency dust collection system to capture particles created during the grinding of electrodes or disturbed during housekeeping.

- Evaluate the ventilation system before acceptance and periodically thereafter to minimize personnel and environmental contamination.

- Develop and implement standard operating procedures for the use of thoriated tungsten electrodes, including proper procedures for storage, grinding, use, housekeeping and disposal.

- Provide training in the operation of the welding and grinding equipment, personal hygiene, and safety.

WHAT TO DO WITH THE COLLECTED DUST PARTICLES

- Regularly remove the dust generated by grinding.

- Properly dispose of the dust and spent electrodes in accordance with federal, state, and local regulations.

SUMMARY

Several of the information sources listed indicate that the risk of occupational exposure to radiation during storage, handling, and welding with thoriated tungsten electrodes is negligible where simple precautions are taken. Special care should be taken to control and collect dust from grinding these electrodes in order to prevent a potential ingestion and inhalation exposure to radioactive dust particles resulting from this operation.

INFORMATION SOURCES

Nuclear Regulatory Commission (NRC). Code of Federal Regulations, Title 10 Energy, Part 40.13, available from the U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401; telephone: 800-368-5642; web site: www.nrc.gov.

Department of Transportation (DOT), 49 Code of Federal Regulations, Title 49 Transportation, Part 173, available from the U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401; telephone: 855-368-4200; web site: www.dot.gov.

United States Postal Service (USPS). Publication 52, Hazardous, Restricted, and Perishable Mail, Instruction 7A, Radioactive Materials, available from the USPS web site: www.usps.com.

Jankovic, J. T., W. S. Underwood, and G. M. Goodwin. 1999. Exposures from Thorium Contained in Thoriated Tungsten Electrodes. *American Industrial Hygiene Journal* 60: 384 – 389.

Oak Ridge National Laboratory (ORNL): Estimated Radiation Doses from Thorium and Daughters Contained in Thoriated Welding Electrodes, by L. M. McDowell-Boyer (ORNL/NUREG/TM-344). Oak Ridge, TN: ORNL, 1979.

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Oxyfuel Safety: Check Valves and Flashback Arrestors

INTRODUCTION

Check Valves and Flashback Arrestors are safety devices for protecting workers using oxyfuel cutting and welding equipment. A check valve is a device that is designed to prevent the unintentional backflow of gases. A flashback (flame) arrestor is a device that prevents the propagation of a flame upstream. Note that these devices reduce the volume of gases available at the tip/nozzle.

NATURE OF THE HAZARD

Always be sure there is enough fuel in both cylinders to complete the operation before starting a job. Reverse flow of a gas generally happens when one cylinder goes empty during operation, creating an imbalance of pressure in the system. A clogged or blocked tip can also cause a backflow. An extremely hazardous situation can develop when oxygen and fuel gases are mixed inside the hoses. Reverse flow check valves alone will not stop a flashback in the system. When conducting oxy-fuel cutting and welding operations, operators can experience backfires or flashbacks.

A backfire is defined as the momentary recession of the flame into the torch, potentially causing a flashback or sustained backfire. It is usually signaled by a popping sound, after which the flame may either extinguish or reignite at the end of the tip. The user hears a “pop” and the flame is extinguished. This can happen at high gas exit velocities at the nozzle/tip or if the nozzle/tip gets too close to the work piece. The flame may re-ignite automatically or the use of an igniter may be necessary. This is not normally a safety concern and, in fact, many manufacturers induce backfires during design and production tests to insure flame integrity of torches and tips.

A sustained backfire is defined as the recession of the flame into the torch body with continued burning characterized by an initial popping sound followed by a squealing or hissing sound, potentially burning through the torch body.

A flashback is defined as the recession of the flame through the torch and into the hose, regulator, and/or cylinder, potentially causing an explosion. This is a potentially hazardous situation, particularly if the flame reaches the hoses where an explosion will result causing a rupture or separation of the hose. A flashback is generally caused by the reverse flow of gases upstream into the hoses or other equipment. This reverse flow is usually the result of 1) improper shutdown and/or startup procedures or 2) by allowing cylinder pressures to become too low or 3) by a check valve that is not working properly.

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As with any cutting or welding operation, workers need to be aware of their surroundings where work is performed. Always have approved fire extinguishers nearby and have all personnel trained in their proper use. Flashbacks can damage equipment and cause injury to nearby workers and equipment. Proper workplace precautions such as barriers and other protections should be utilized to minimize fire hazards and injury.

HOW TO AVOID THE HAZARD

- Equipment with integrated check valves and/or flashback arrestors is available.
- Check valves and/or flashback arrestors can be added to existing equipment. Properly maintained and operated systems are safe.
- Inspect the entire system before use, and repair or replace defective or damaged parts.
- Have only qualified people make any needed repairs.
- Be sure that there is enough gas in both cylinders to complete the job.
- Follow the manufacturers recommended procedures for proper start-up and shut-down of the equipment used.
- Don't allow the tip to touch the work.

SUMMARY

Flashback arrestors and check valves are not intended to replace proper practices for safe operation. They can provide an increased level of protection in addition to the manufacturers recommended operating procedures. Check valves and flashback arrestors should be installed at the location specified by the manufacturer. Manufacturers' have begun incorporating flashback arrestors and check valves as a standard item with all of their torches sold.

INFORMATION SOURCES

American National Standards Institute (ANSI). *Safety in Welding, Cutting, and Allied Processes*, Z49.1, published by the American Welding Society, 8669 Doral Blvd., Doral, FL 33166; telephone 800-443-9353; web site: www.aws.org.

National Fire Protection Association (NFPA), *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, NFPA 51B, published by the National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101; Phone: 617-770-3000; Web site: www.nfpa.org.

CGA TB-3, *Hose Line Flashback Arrestors,* Compressed Gas Association, Inc., 4221 Walney Road, 5th Floor, Chantilly, VA 20151; Phone 703-788-2700; Web site: www.cganet.com.

CGA E-5, *Torch Standard,* Compressed Gas Association, Inc., 4221 Walney Road, 5th Floor, Chantilly, VA 20151; Phone 703-788-2700; Web site: www.cganet.com.

CGA P1, *Safe Handling of Compressed Gases in Containers,* Compressed Gas Association, Inc., 4221 Walney Road, 5th Floor, Chantilly, VA 20151; Phone 703-788-2700; Web site: www.cganet.com.

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Occupational Safety and Health Administration (OSHA). Code Of Federal Regulations,Title 29 Labor, Chapter XVII, Parts 1901.1 to 1910.1450, Order No. 869-019-00111-5, U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401; Phone: 800-321-6742; Web site: www.osha.gov.

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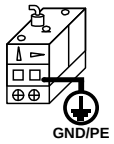

Grounding of Portable and Vehicle Mounted Welding Generators

INTRODUCTION

Proper grounding and bonding of portable and vehicle mounted welding generators that also supply 115 or 230 volts AC auxiliary power is an on-going topic among welders. This Fact Sheet will help you determine the requirements for bonding and grounding welding generators. Additionally, it will give definitions and present necessary electrical concepts to clarify the requirements for bonding and grounding.

TERMS

Sources: ANSI Z49.1, hereafter termed Z49.1, AWS A3.0, and NEC--National Electrical Code, hereafter termed NEC. See Information Sources Section at end for details.

Bonding—The permanent joining of metallic parts to form an electrically conductive path that will ensure electrical continuity and the capacity to conduct safely any current likely to be imposed.

Ground—The electrical potential of the earth's surface; a conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

Ground Connection—An electrical connection of the welding machine frame to the earth for safety.

Grounded—Connected to earth or to some conducting body that serves in place of the earth.

Grounded, effectively—Intentionally connected to earth through a ground connection of sufficiently low resistance and with adequate current-carrying capacity to prevent the buildup of voltage that may be hazardous to connected equipment or to persons.

Grounding—The process of bonding one or more conductive objects to the ground, so that all objects are at zero (O) electrical potential; also referred to as "earthing."

Grounding Conductor—A conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes [ground rod(s) or metal water pipe].

Ground Rod—A metal rod, typically copper, not less than eight feet in length and 1/2 inch in diameter, driven into the earth such that at least eight feet of length is in contact with the soil, to function as a suitable connection point to earth. NOTE: Since different diameters are required for different rod materials and the driven length and number of rods used depends

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on the special soil conditions and applications, consult the NEC for the specific data for the correct ground rod and method of use for each particular situation.

Hard Wired—Connected by separate conductors to a junction point or box—not to receptacles.

Metal Water Pipe—Typically an underground metal water pipe that supplies water to a building or premises or faucet /outlet and that is in contact with the earth for a specified distance. NOTE: Since the metal water pipe has several key requirements that must be met before it complies with regulations, consult the NEC for specific information before selecting any pipe for a ground connection.

Portable—Capable of being carried or moved about; designed for ready movement and use in field locations.

Separately Derived System--A premises wiring system whose power is derived from a battery, a solar photovoltaic system, or from a generator, transformer, or converter windings, and that has no direct electrical connection, including a solidly connected grounded circuit conductor, to supply conductors originating in another system.

Vehicle Mounted—Equipment installed in a truck, trailer, or similar wheeled vehicle.

Work—The workpiece or metal upon which the welder welds and is normally grounded independently of the welding leads to a good electrical ground unless a qualified person assures it is safe to work on an ungrounded workpiece.

Work Lead—The electric conductor between the source of arc welding current and the work. The work lead should not be referred to as the ground lead. It is preferable to connect the work lead directly to the work. Unless a separate grounding conductor is used (to connect the workpiece to an earth ground), the work lead will not be grounded.

NATURE OF THE HAZARD

Some basics:

- When the generator is running, current can pass through a wire, a ladder, a hoist, your body, or any other conductor.
- If you become part of an electrical circuit, current can pass through your body causing a shock.

Why Grounding is Important: Grounding the frame of electrical equipment ensures the following:

- Generators are grounded to prevent the buildup of voltages that may result in undue hazards to persons or equipment.
- When no voltage difference exists between the grounded generator frame and earth, no electric current can flow. Therefore, the shock hazard is reduced.
- Since it is the flow of electric current through the human body that is hazardous, proper grounding is one of the best ways to prevent unintended electric shock

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If we don't ground the generator and should have, the results can be hazardous—here's why:

- If the auxiliary power circuit has a fault condition (such as a short caused by bare wires), and there is no safety ground connection to protect the user, the result can be an electric shock.

- Additionally, grounding helps prevent possible fire or explosion when fueling by reducing the chances for static electricity sparks from the fuel nozzle to the tank.

CONDITIONS WHERE GROUNDING THE GENERATOR FRAME TO A METAL WATER PIPE OR GROUND ROD IS REQUIRED BY THE NEC:

1. The welding generator is not part of a separately derived system, **OR**

2. It has its neutral conductor solidly interconnected to a service-supplied system neutral, **OR**

3. It supplies auxiliary power output (115 volts AC / 230 volts AC) by means other than cord-and-plug connection through receptacles mounted on the generator, such as connections to internal terminals on the generator—hard wired (see equipment Owner's Manual for grounding instructions).

When **ANY** of these conditions are met, grounding is required.

CONDITIONS WHERE GROUNDING THE GENERATOR FRAME TO A METAL WATER PIPE OR GROUND ROD IS NOT REQUIRED BY THE NEC:

1. The welding generator has auxiliary power output (115 volts AC or 230 volts AC) and the generator receptacles have a ground pin outlet available for the equipment that plugs into the receptacle, **AND**

2. The generator is portable or mounted on a truck or trailer, **AND**

3. The auxiliary power is used by cord-and-plug-connection means through receptacles mounted on the generator, **AND**

4. The generator is mounted on a vehicle and the generator frame is bonded to the vehicle frame.

HOW TO AVOID THE HAZARDS

- Follow the manufacturer's recommended procedures for grounding the welding generator.

- Watch out for bed liners in trucks—securely connect the welding generator frame to the frame of the vehicle or trailer by a ground wire or bolted metal-to-metal contact.

- Bond the generator to the vehicle frame or earth.

- When grounding a generator sitting directly on the earth, use a driven ground rod to ensure the earth connection.

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- Keep the fuel nozzle in contact with the tank when fueling to prevent static sparks and fire

SUMMARY

- Proper grounding of the welding generator frame can help prevent electric shock.

- If your generator is in a truck or trailer, and you use power directly from the receptacles via plugs, connect (bond) the generator frame to the vehicle frame—be sure there is a good metal-to-metal connection.

- If you hard wire the generator auxiliary power to a project or building electrical system, then you must connect the generator frame to a driven ground rod or metal water pipe.

- **The decision is based on what you do with your auxiliary power:** If you just plug equipment into the receptacles, connection to the vehicle frame is fine. If you hard wire the auxiliary power into another electrical system, then you must connect the generator frame to a driven ground rod or metal water pipe.

- **Remember:** The objective is to keep the frame of the generator at zero (or earth) voltage.

- In simplest terms, grounding the welding generator frame provides an electrical path to ground instead of a possible electrical shock hazard to the user.

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National Fire Protection Association (NFPA). *National Electrical Code* (NFPA 70), available from National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269–9101; telephone: 800–344–3555; Web site: www.nfpa.org.

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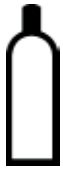

Cylinders: Safe Storage, Handling, and Use

INTRODUCTION

To use compressed gas cylinders safely, it is important that they are stored properly, handled correctly, used with the correct equipment, and that the properties of the gases they contain are fully understood.

OVERVIEW OF CYLINDER PHYSICAL HAZARDS

Physical Damage: Cylinders, with their high internal pressure [up to 2,500 pounds per square inch gauge (psig)], are very hazardous when exposed to damage from falling over or tipping, heat, electric circuits, motion, or vibration – anything that can cause a weakness or crack in the cylinder wall or shell. Such damage can cause the cylinder to rupture and explode sending sharp metal pieces, like shrapnel, blasting through the area.

Valve Hazard: The CGA (in Pamphlet V-1) has established a 0.300 inch (7.62 mm) maximum valve inlet diameter as a requirement to minimize the propulsion effect in case the valve is severed. This standard has the exception of valves used in liquefied gas services and fire control systems. Special design requirements and unique applications such as fire control systems, which require a “high blow down flow”, may dictate greater diameters. The actual outcome of a broken off valve depends on the design and pressure of the valve and cylinder. If the valve is broken off and the valve inlet opening meets the Compressed Gas Association (CGA) requirements, the cylinder will rapidly release all its gas (which could be a health and/or flammability concern), cause a whistling sound, and possibly spin uncontrollably. If the valve inlet opening is different from the standard hole size used in most welding gases, such as those used for propane or butane and fire protection system cylinders, the cylinders may take off and become airborne. You can check this size matter by being sure the cylinder meets all V-1 requirements.

Tipping and Falling: The most common major hazard is having a cylinder tip over or fall on you or another nearby worker. Since cylinders are heavy and awkward to handle, they require special care and equipment in handling and securing so they don’t fall or tip over and cause injury.

Valve Leakage: Cylinder valves can leak, causing their contents to discharge. To minimize hazards from leaks, use proper ventilation and storage.

OVERVIEW OF CYLINDER CONTENTS HAZARDS

Read, understand, and follow the markings on the cylinder, the label(s) on the cylinder, and the safety data sheet (SDS). Each compressed gas cylinder has unique

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hazards based on contents. Some are filled with inert gases – especially those used in arc welding. Many gases are flammable, explosive, toxic, or a combination. Common compressed gases include acetylene, carbon dioxide, argon, hydrogen, nitrogen, air, propane, and oxygen.

HOW TO STORE CYLINDERS

- Store cylinders upright and secure them with a chain, strap, or cable to a stationary building support or to a proper cylinder cart to prevent them from tipping or falling.
- Completely close the valves, and keep the valve protection devices, such as caps or guards, securely in place.
- Store cylinders in a dry, well-ventilated area at least 20 feet from combustible materials. Do not keep cylinders in lockers. If they leak, a buildup of flammable or other types of gases can occur inside the locker.
- Mark the storage area with proper precautionary signs, such as flammable, oxidizer, or toxic.
- Place them in a location where they will not be subject to mechanical or physical damage, heat, or electrical circuits to prevent possible explosion or fire. Keep cylinders away from vehicle traffic.
- Store empty cylinders separate from full ones.
- Keep oxygen cylinders 20 feet away from fuel-gas cylinders, such as acetylene, or separate them with a non-combustible barrier (such as a wall) at least 5 feet high with a fire-resistance rating of at least one-half hour.

HOW TO TRANSPORT CYLINDERS

- Most accidents or injuries involving cylinders happen when moving or handling the gas cylinders.
- Use the right equipment, correct procedures, and sufficient number of persons to lift and move cylinders to avoid personal injury and cylinder damage.
- Wear protective footwear, safety glasses, and heavy gloves.
- Securely install the valve protection devices, such as caps or guards.
- Secure cylinders upright to a proper hand truck or cylinder cart designed for the purpose.
- Don't drag or roll them – use a properly designed cart or hand truck.
- When using a crane, be sure to use proper cradles, nets, boats, or special platforms designed for this purpose to prevent cylinders from falling.
- Prevent damage – handle carefully – avoid dropping or banging them.
- Do not lift by the protective cap/guard or use magnets or slings to lift or move them since valves may be damaged or sheared off.

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HOW TO USE CYLINDERS

- Follow the instructions in the Compressed Gas Association (CGA) publication P-1, “Safe Handling of Compressed Gases in Cylinders.” (The phone number and web site of the CGA are located at the end of this sheet in the Information Sources Section.) Don't tamper with safety devices.

- Keep cylinders upright and away from heat, sparks, fire, physical damage, or electrical circuits to avoid rupture.

- Use in a well-ventilated area to avoid gas accumulation.

- Do not bring cylinders into a confined space to avoid inhaling the gas and possible suffocation from the accumulation of flammable, toxic, or reactive gases.

- Read, understand, and follow all cylinder markings and labels to avoid misuse.

- Before connecting a regulator, stand to one side, and momentarily open the valve and then close it immediately. This procedure, called “cracking” the valve, is done to clear the valve of dust or dirt that could enter the regulator.

- Open valves slowly by hand to avoid gauge damage. If a specific tool is required to open the valve, leave it in position so that the flow of gas can be stopped quickly in an emergency.

- Lift and move cylinders properly.

- Close the gas cylinder valves when not in use such as during breaks, lunch, or end-of-shift to avoid leaks.

- Avoid getting any oil or grease on the cylinders or regulators/gauges, particularly those containing oxygen, to avoid fire or explosion.

- Storage is not required for single cylinders of fuel gas and oxygen ready for use with regulators attached secured to a proper cart.

HOW TO MAINTAIN THEM

- Protect the markings on cylinders that identify the contents, and mark the full/empty status on cylinders (do not use color to identify contents). Mark all empty cylinders (some companies use "MT").

- Don't use the recessed top of the cylinder as a storage area for tools or material.

- If cylinders are leaking, isolate them outdoors and away from sparks or heat. Call your gas supplier to send qualified people to take care of the problem – don’t try any repairs yourself. Tag leaking cylinders.

- Never mix gases in a cylinder or try to refill a cylinder – always contact your gas supplier.

SUMMARY

Even though high-pressure, compressed gas cylinders are near or part of most welding and cutting operations, they are used safely everyday by many people throughout the world. To prevent injury,

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always store, handle, use, and maintain them properly. Treat them with the respect they deserve.

INFORMATION SOURCES

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Eye and Face Protection for Welding and Cutting Operations

INTRODUCTION

U.S. government agencies estimate that there are about 2,000 eye injuries each day in American workplaces. Most injuries are caused by not wearing eye protection or wearing the wrong kind of eye protection needed for the job. Additionally, nearly 70 percent of eye injuries are caused by flying particles.

NATURE OF THE HAZARD

The major eye and face hazards during welding and cutting include arc and heat rays, flying metal, slag from chipping, dirt, and particles from grinding. Because these hazards are so common in welding and cutting environments, proper selection and consistent use of eye and face protection are vital to avoid injury and blindness.

Note: This fact sheet does not address eye protection for welding operations involving lasers.

HOW TO AVOID EYE AND FACE INJURIES

- Select the proper protection for the job - including other work going on nearby. Eye and face protectors for welding and related tasks, such as grinding and chipping, should comply with the requirements of ANSI Z87.1. Look for labels or markings indicating compliance. Depending on the specific work task, appropriate eye/face protection may include safety glasses with side protection (side shields or wrap-around frames), goggles, face shields, welding helmets, curtains, or combinations of the above.

- Always wear safety glasses with top and side protection under your welding helmet.

- Keep eye and face protectors in place whenever the hazards are present. Not using them is the main cause of eye injury.

- Use the correct shade of filter in your welding helmet or goggles.

- Be sure eye protection devices are not damaged or missing parts, and be sure they fit properly.

- Whenever radiation or flying particles and spatter are a hazard, welding helmets should be selected that protect the face, forehead, neck, and ears. Additional protection may be needed for overhead welding, where spatter and rays can bounce back from nearby surfaces, and where hazards are created by nearby workers.

- Where feasible, welding areas should be isolated from other work areas by

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partitions or curtains designed to absorb harmful welding rays.

SELECTING PROTECTIVE EYEWEAR FOR ARC PROCESSES

For all types of electric arc processes, a welding helmet complying with ANSI Z87.1, equipped with the correct shade filter, is required. See the chart at the end of this Fact Sheet for shade selection. In recent years welders have been able to choose between traditional “fixed-shade” welding filters and the newer "auto-darkening" filters. Following are some safety considerations for each type of filter.

SAFETY CONSIDERATIONS FOR FIXED-SHADE FILTERS

- Fixed-shade filters provide reliable protection as long as they are worn and in the down position.

- Welders must raise the helmet to see whenever there is no arc, to start a new weld, or to inspect a completed weld. This increases the possibility of eye and face injuries from flying metal fragments and “arc flash” or “welder’s eye”, where the surface of the eyeball is burned by arc or heat rays. These limitations can also cause welders to keep their helmet up until the arc is started, further increasing the chances of arc flash.

- Increased potential for neck injury or muscle strain from continual “snapping” or "nodding" the helmet up or down.

- Inability to see the precise location of the arc start accurately causing out-of-position starts.

- No light or dark shaded areas when looking through the filter.

SAFETY CONSIDERATIONS FOR AUTO-DARKENING FILTERS (ADFs)

- ADFs allow continuous visibility of the work piece and arc zone before, during, and after striking an arc, and without raising the helmet.

- The need for “snapping” or "nodding" the helmet up or down is eliminated, reducing strain and possible neck injury.

- Keeping the helmet down more means less chance for eye injuries from flying particles or arc rays--particularly when welding in groups or near other workers.

- Higher accuracy in starting welds.

- ADFs include a special filter that blocks harmful radiation even if the main switching element fails.

- Blocked light sensors, dead batteries, improper sensitivity settings, or using ADFs in very cold temperatures can prevent switching to the dark shade when an arc is struck, resulting in temporary "blind spots," similar to the effects of a camera flash.

SELECTING PROTECTIVE EYEWEAR FOR OXY-FUEL PROCESSES

- Always wear safety glasses with side shields or goggles with the correct filter shade.

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- Choose goggles/safety glasses appropriate for the work area—dust, dirt, and some airborne vapors require specific goggle types—see ANSI Z87.1 for the complete details.

- If goggles are used, they should be vented to prevent fogging.

- When full-face protection is needed, such as when working overhead or during cutting, use of a full-face shield or helmet over safety glasses of the correct filter shade is recommended.

- Be sure the selected glasses or goggles meet the impact, heat, and filtering requirements specified in ANSI Z87.1— look for a label on the carton and product stating compliance.

SUMMARY

- Always choose welding helmets and eyewear that meets the requirements of ANSI Z87.1 to ensure proper vision protection. Filter lens and ADFs should be marked with the manufacturers name or logo, the desired shade number (or shade range for variable ADFs), and "Z87.1."

- Maintain welding helmets and eyewear in good condition—inspect them regularly and replace parts as needed.

- Clean eyewear as needed according to the manufacturer's recommendations, and after use by others.

- Always read, understand, and follow the manufacturer's instructions.

Remember: The eyewear you choose and wear is your first line of defense in preventing eye injury and blindness.

INFORMATION SOURCES

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This chart provides minimum suggested protective lens shades and suggested comfort lens shades for a variety of commonly used welding and cutting processes. It is adapted from the 2001 Edition of ANSI F2.2.

LENS SHADE SELECTOR

Shade numbers are given as a guide only and may be varied to suit individual needs.

Process	Electrode Size in. (mm)	Arc Current (Amperes)	Minimum Protective Shade	Suggested* Shade No. (Comfort)
Shielded Metal Arc Welding (SMAW)	Less than 3/32 (2.4)	Less than 60	7	-
	3/32-5/32 (2.4-4.0)	60-160	8	10
	5/32-1/4 (4.0-6.4)	160-250	10	12
	More than 1/4 (6.4)	250-550	11	14
Gas Metal Arc Welding (GMAW) and Flux Cored Arc Welding (FCAW)		Less than 60	7	-
		60-160	10	11
		160-250	10	12
		250-500	10	14
Gas Tungsten Arc Welding (GTAW)		Less than 50	8	10
		50-150	8	12
		150-500	10	14
Air Carbon Arc Cutting (CAC-A) **(Light)**		Less than 500	10	12
(Heavy)		500-1000	11	14
Plasma Arc Welding (PAW)		Less than 20	6	6 to 8
		20-100	8	10
		100-400	10	12
		400-800	11	14
Plasma Arc Cutting (PAC)		Less than 20	4	4
		20-40	5	5
		40-60	6	6
		60-80	8	8
		80-300	8	9
		300-400	9	12
		400-800	10	14
Torch Brazing (TB)		-	-	3 or 4
Torch Soldering (TS)		-	-	2
Carbon Arc Welding (CAW)		-	-	14

	Plate Thickness in.	Plate Thickness mm	Suggested* Shade No. (Comfort)
Oxyfuel Gas Welding (OFW)			
Light	Under 1/8	Under 3	4 or 5
Medium	1/8 to 1/2	3 to 13	5 or 6
Heavy	Over 1/2	Over 13	6 or 8
Oxygen Cutting (OC)			
Light	Under 1	Under 25	3 or 4
Medium	1 to 6	25 to 150	4 or 5
Heavy	Over 6	Over 150	5 or 6

*As a rule of thumb, start with a shade that is too dark to see the weld zone. Then go to a lighter shade which gives sufficient view of the weld zone without going below the minimum. In oxyfuel gas welding, cutting, or brazing where the torch and/or the flux produces a high yellow light, it is desirable to use a filter lens that absorbs the yellow or sodium line of the visible light spectrum.

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Personal Protective Equipment (PPE) for Welding and Cutting

INTRODUCTION

Like other jobs or careers, welders must wear suitable protective equipment. In general, Personal Protective Equipment (PPE) must protect against hazards such as burns, sparks, spatter, electric shock, and radiation. The use of PPE is a good safe practice and may be required by regulatory agencies. For example, OSHA requires the use of PPE when engineering and administrative controls are not feasible or effective.

NATURE OF THE HAZARD

Welding and cutting can produce hazards such as sparks, spatter, radiation (infrared, ultraviolet, and blue light), slag, heat, hot metal, fumes and gases, and even electric shock. Since these hazards may cause burns, injury, or death, it is important to wear proper PPE at all times.

EYE AND FACE PROTECTION

- Wear a helmet with filter lens and cover plate that complies with ANSI Z87.1 for protection from radiant energy, flying sparks, and spatter.

- According to ANSI Z49.1 and OSHA 29 CFR 1910.252, "Helmets and hand shields shall protect the face, forehead, neck, and ears to a vertical line in back of the ears, from the direct radiant energy from the arc and from direct weld spatter."

- Helmets shall be made of material that complies with ANSI Z49.1.

- Filter lenses and cover plates must meet the tests prescribed in ANSI Z87.1.

- Wear approved safety glasses with side shields (or goggles) under your helmet.

- The safety glasses with side shields (or goggles) are used to protect against flying metal, slag chips, grinding fragments, wire wheel bristles, and similar hazards, which can ricochet under the helmet.

- Choose a filter lens shade according to the Lens Shade Selector Chart in ANSI Z49.1 or AWS F2.2. *Lens Shade Selector.*

- Consult AWS Fact Sheet 31, *Eye and Face Protection for Welding and Cutting Operations.*

HEAD AND EAR PROTECTION

- Wear a fire-resistant welder's cap or other head covering under your helmet. It will protect your head and hair from

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flying sparks, spatter, burns, and radiation.

- When working out of position, such as overhead, wear approved ear-plugs or muffs. They prevent sparks, spatter, and hot metal from entering your ears and causing burns.

- If loud noise is present, wear approved earplugs or muffs to protect your hearing and prevent hearing loss.

FOOT PROTECTION

- Select boots that meet the requirements of ASTM F2412 and ASTM F2413 (or the older ANSI Z41 which has been withdrawn). Look for a compliance mark inside your boot.

- Wear leather, steel-toed, high-topped boots in good condition. They will help protect your feet and ankles from injury.

- In heavy spark or slag areas, use fire-resistant boot protectors or leather spats strapped around your pant legs and boot tops to prevent injury and burns.

- Do not wear pants with cuffs. Wear the bottoms of your pants over the tops of your boots to keep out sparks and flying metal. Do not tuck pant legs into your boots.

HAND PROTECTION

- Always wear dry, hole-free, insulated welding gloves in good condition. They will help protect your hands from burns, sparks, heat, cuts, scratches, and electric shock.

- ANSI Z49.1 requires all welders to wear protective flame-resistant gloves, such as leather welder's gloves. They should provide the heat resistance and general hand protection needed for welding.

BODY PROTECTION

- Wear oil-free protective clothing made of wool or heavy cotton. Heavier materials work best. They are harder to ignite and resist wear and damage.

- Choose clothing that allows freedom of movement and covers all areas of exposed skin. Wear long sleeved shirts (no t-shirts), and button the cuffs, pockets, and collar. They will protect your arms and neck from radiation exposure and skin burns (caused by ultraviolet radiation from the arc).

- Wear heavy, durable, long pants (no shorts) without cuffs that overlap the tops of your boots.

- Keep clothing dry. Change it when needed (this reduces the possibility of electric shock).

- Be aware that any cuffs or open pockets can catch flying sparks and start on fire easily. Unroll cuffs and button pockets to prevent spark entry.

- Keep clothing clean (free of oil, grease, or solvents which may catch fire and burn easily). Keep it in good repair (no holes, tears, or frayed edges). Always follow the manufacturer's directions for their use, care, and maintenance.

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- Remove all flammables and matches and cigarette lighters from your pockets.

- Do not wear synthetic (man-made) fabrics because they may burn easily, melt, stick to your skin, and cause serious burns.

- Wear leather aprons, leggings, capes and sleeves as needed for the application. Leather protects better than most materials.

Read ANSI Z49.1. It gives a full explanation of the protective clothing needed when welding or cutting. In brief, Z49.1 states that "Clothing shall provide sufficient coverage, and be made of suitable materials, to minimize skin burns caused by sparks, spatter, or radiation." Full details are in the document.

RESPIRATORY PROTECTIVE EQUIPMENT

For information on respirators, see ANSI Z49.1 and Fact Sheet 37. Also see OSHA and NIOSH regulations.

SUMMARY

Protect all areas of your body from injury during welding or cutting by wearing the proper protective clothing and equipment. Do not weld or cut unless wearing the necessary PPE as specified in this Fact Sheet and in ANSI Z49.1.

INFORMATION SOURCES

American National Standards Institute (ANSI). Safety in Welding, Cutting, and Allied Processes, Z49.1, available from American Welding Society, 8669 Doral Blvd., Doral, FL 33166; Web site: www.aws.org.

American National Standards Institute (ANSI). *Practice for Occupational and Educational Eye and Face Protection* (ANSI Z87.1), available from ANSI, 11 West 42nd Street, New York, NY 10036-8002; Web site: www.ansi.org.

Occupational Safety and Health Administration (OSHA). Code of Federal Regulations, Title 29 Labor, Part 1910, available from the U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401; Web site: www.osha.gov.

National Fire Protection Association (NFPA). *Standard for Fire Prevention during Welding, Cutting, and Other Hot Work* (NFPA 51B), available from National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269–9101; Web site: www.nfpa.org.

American Welding Society (AWS). Safety and Health Fact Sheet No. 31, *Eye and Face Protection for Welding and Cutting Operations,* available from American Welding Society, 8669 Doral Blvd., Doral, FL 33166; Web site: www.aws.org.

ASTM International Standards, F2412, *Test Methods for Foot Protection*, and F2413, *Specification for Performance Requirements for Protective Footwear*, available from ASTM International, 100 Bar Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2559; Web site: www.astm.org.

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Coated Steels: Welding and Cutting Safety Concerns

INTRODUCTION

Steels are coated to provide a protective covering or a decorative finish. Protective coatings are designed to prevent rusting or to shield the steel from chemical attack.

Coatings found on steels can become airborne or give off fumes, smoke, or dust, during joining and cutting. Some of the coating's dusts, fumes or gases can harm you and their exposure limits should not be exceeded. Exposure limits include:

- Permissible Exposure Limit (PEL): The PEL is set by the Occupational Safety and Health Administration (OSHA) and is a legal employee exposure limit in the U.S.

- Threshold Limit Value (TLV®): The TLV® is published by the American Conference of Governmental Industrial Hygienists (ACGIH) and is a guideline for employers to consider in controlling employee exposures.

OVERVIEW OF HEALTH HAZARDS

Employers need to know which chemical may be released into the air that may injure welders. Welders must be trained in how to do each process the correct way, and they shall cut or weld *only* after proper safety precautions have been taken.

Coatings may give off fumes and gases when welding or cutting is performed. A health hazard may be created when its dusts, fumes or gases get into the air in large enough amounts that safe levels are exceeded.

Protective coatings on steels can contain chromium, lead, tin, zinc or other materials. It is always good for the welder to understand the coating types for the materials he works with. If not, the welder should get this information from his supervisor or employer.

Paints are made up of compounds that may release hazardous materials into the air when heated. Paints are usually used on a "phosphated" and passivated (often with chromium) metal surface. The heat from the arc can cause paints to give off unsafe amounts of gases like carbon monoxide and carbon dioxide. These also increase the risk of suffocation in confined work areas, or those with poor air movement.

Steels coated with plastic materials should not be cut or welded unless proper precautions are taken. It is best to remove coating to a distance away from the weld or cut where the temperature won't go above the point where the material starts to break down.

For additional information, see AWS Fact Sheet 1, *Fumes and Gases.*

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HOW TO AVOID HEALTH HAZARDS FROM OVEREXPOSURE

The welder should make sure he or she knows what a coating might give off when heated or burned:

- Obtain the Safety Data Sheets (SDSs) for all materials used.
- Read and understand the specification for coating type and coating weights.
- Find out what hazardous materials are present or might be given off by the coating when it is exposed to the arc or high temperatures.
- Use adequate ventilation whenever an airborne fume gas or dust must be controlled. Use enough ventilation, exhaust, or both to keep the air the welder breathes below recommended safe levels such as the PEL and TLV®.
- Have air monitoring done as necessary to test for exposure levels in the breathing zone of the welder and other persons working nearby.
- Use a respirator when required.
- Orient the work so the welder's head is kept out of the fume plume.
- See AWS Fact Sheet 1, *Fumes and Gases.*
- See AWS Fact Sheet 11, *Hot Work in Confined Spaces.*
- See AWS Fact Sheet 25, *Metal Fume Fever.*

SUMMARY

Coatings on steels may be a source of exposure to fumes and gases during welding, brazing and cutting. Steel coatings and paints contain materials that can cause harmful overexposure when breathed. This is why coatings must also be looked at in order to remove hazards from welding and cutting. The joining of some coated steels requires special types of ventilation. In some cases, the welder must wear a respirator to keep safe.

INFORMATION SOURCES

American National Standards Institute (ANSI). Safety in Welding, Cutting, and Allied Processes, Z49.1, available from American Welding Society, 8669 Doral Blvd., Doral, FL 33166; Web site: www.aws.org.

Occupational Safety and Health Administration (OSHA). Code of Federal Regulations, Title 29 Labor, Part 1910, available from the U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401; Web site: www.osha.gov.

American Welding Society (AWS). Safety and Health Fact Sheets, available from American Welding Society, 8669 Doral Blvd., Doral, FL 33166; Web site: www.aws.org.

ISO15011-5, Health and safety in welding and allied processes — Laboratory method for sampling fume and gases — Part 5: Identification of thermal-degradation products generated when welding or cutting through products composed wholly or partly of organic materials using pyrolysis-gas chromatography-mass spectrometry.

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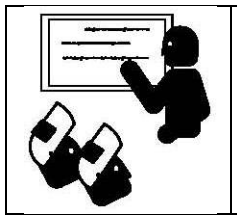

WELDING SAFETY IN EDUCATION AND SCHOOLS

INTRODUCTION

You may be a student who is new to the field of welding or a seasoned, experienced, welding educator. In either case, you will encounter welding hazards while involved in welding education. Following correct safety measures ensures the safety of welding students and educators.

WHERE TO FIND INFORMATION

Four main resources are available to provide you with detailed welding safety information:

1. Regulations, Laws and Standards
2. Manufacturer's Instructions
3. Safety Labels On Equipment and Materials
4. Safety Data Sheets (SDSs)

In the United States, the provisions of the Occupational Safety and Health Act (OSHA) are the law. It makes many voluntary consensus standards enforceable. One of the most important welding standards is ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes.*

All tested and certified welding equipment is provided with safety labels and an owner's manual with safety information.

SDSs must be provided by the suppliers of welding consumables such as electrodes, fluxes, and gases and kept on file. They must be readily available in the work area. A safety training program must be in place for the educators, students, and anyone who regularly visits the weld training area.

POTENTIAL HAZARDS

The safety resources listed describe the potential hazards related to welding, such as:

- Electric Shock
- Fumes and Gases
- Arc Radiation
- Fire or Explosion
- Hot Parts
- Flying Sparks, Spatter, Metal or Dirt
- Electric and Magnetic Fields (EMF)
- Noise
- Gas Cylinders
- Moving Parts

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- Falling Equipment
- Surface Coatings and Contaminants

WHO IS RESPONSIBLE

The school administration and educators have the following responsibilities:

- Ensure the students are trained on the welding hazards, safety rules, regulations and laws.

- Ensure the students follow the safety rules, safe practices, regulations and laws.

The students have the following responsibilities:

- Be informed and trained to detect when hazards are present and how to protect themselves.

- Learn and use safe practices.

- Obey safety rules and regulations.

- Properly use the equipment.

SUMMARY

Remember, hazards are present in the welding area. These hazards include (but are not limited to) electric shock, fumes and gases, arc radiation, fire, hot parts, flying sparks, spatter, metal or dirt, EMF, noise, gas cylinders, moving parts and falling equipment. Safety and health information resources include Laws, Regulations, Standards, Owner's Manuals, Safety Labels, and SDSs.

As a welding educator or student your primary concern should be to follow correct safety measures. This will ensure a welding education that results in a long, healthy, productive and enjoyable career.

INFORMATION SOURCES

American National Standards Institute (ANSI). *Safety in Welding, Cutting, and Allied Processes* (ANSI Z49.1), published by the American Welding Society, 8669 Doral Blvd., Doral, FL 33166; telephone 800-443-9353; web site: www.aws.org.

Occupational Safety And Health Administration (OSHA). Code Of Federal Regulations, Title 29 Labor, Parts 1901, 1910, 1915 and 1926, available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 02402.

National Fire Protection Association (NFPA). *Standard for Fire Prevention During Welding, Cutting and Other Hot Work* (NFPA 51B), available from National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101; telephone: 800-344-3555; Web site: www.nfpa.org.

American Welding Society (AWS). *Safety and Health Fact Sheets,* published by the American Welding Society, 8669 Doral Blvd., Doral, FL 33166; telephone 800-443-9353; web site: www.aws.org.

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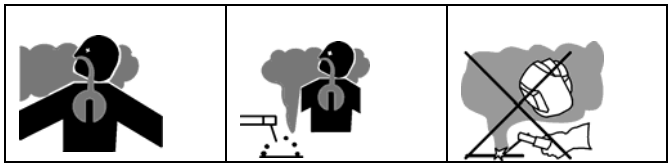
Ventilation for Welding and Cutting

INTRODUCTION

Ventilation is used to control overexposures to the fumes and gases during welding and cutting. Adequate ventilation will keep the fumes and gases from the welder's breathing zone.

NOTE: This safety and health fact sheet does not address ventilation in confined spaces. Also, the term "welding" includes "cutting."



NATURE OF THE HAZARD— THE FUME PLUME

The heat of the arc or flame creates fumes and gases (fume plume). Fumes contain respirable particles. Gases include the shielding gas, and combustion products. The heat from the arc or flame causes the fume plume to rise.

Fumes contain hazardous substances. Overexposure to them may cause acute (short term) or chronic (long term) health effects. Fumes and gases may be produced at toxic levels and they can displace oxygen in the air causing asphyxiation. Overexposure to welding fumes and gases can cause dizziness, illness, and even unconsciousness and death.

HOW TO AVOID THE HAZARD — VENTILATION

Keep your head out of the fumes. Reposition the work, your head, or both to keep from breathing the fumes.

Use ventilation to control the fumes and gases produced from cutting and welding. Adequate ventilation keeps exposures to airborne contaminants below allowable limits. Have a technically qualified person evaluate the exposure to determine if the ventilation is adequate. Wear an approved respirator when ventilation is not adequate or practical.

Adequate ventilation depends on:

- Size and shape of the workplace
- Number and type of operations
- Contents of the fume plume
- Position of the worker's and welder's head
- Type and effectiveness of the ventilation

Adequate ventilation can be obtained through natural or mechanical means or both.

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Natural Ventilation – is the movement of air through a workplace by natural forces. Roof vents, open doors and windows provide natural ventilation. The size and layout of the area/building can affect the amount of airflow in the welding area. Natural ventilation can be acceptable for welding operations if the contaminants are kept below the allowable limits.

	**<u>Natural Ventilation</u>: Using airflow from open windows, doors, and roof vents may be adequate.**

Mechanical Ventilation – is the movement of air through a workplace by a mechanical device such as a fan. Mechanical Ventilation is reliable. It can be more effective than natural ventilation. Local exhaust, local forced air, and general ventilation are examples of mechanical ventilation.

<u>Local exhaust ventilation</u> systems include a capture device, ducting and a fan. The capture devices remove fumes and gases at their source. Fixed or moveable capture devices are placed near or around the work. They can keep contaminants below allowable limits.

One or more of the following capture devices are recommended:

- Vacuum nozzle at the arc
- Fume Hoods
- Gun mounted fume extractor

Some systems filter the airflow before exhausting it. Properly filtered airflow may be recirculated.

	**<u>Local Exhaust Ventilation</u>: Use enough local exhaust at the arc to remove the fumes and gases from your breathing area.**

<u>Local forced air ventilation</u> is a local air moving system. A fan moves fresh air horizontally across the welder's face. A wall fan is an example of Local Forced Air Ventilation.

When using localized ventilation, remember:

- Locate the hood as close as possible to the work.
- Position the hood to draw the plume away from the breathing zone.
- Curtains may be used to direct airflow.
- Some toxic materials or chemicals may require increased airflows.
- Velocities above 100 feet per minute at the arc or flame may disturb the process or shielding gas.
- The capture device can depend on the type of job.

SUMMARY

Adequate ventilation removes the fumes and gases from the welder's breathing zone and general area. It prevents overexposure to contaminants. Approved respirators may be required when ventilation is not adequate.

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To minimize worker overexposure to fumes and gases:

- Keep your head out of the fumes, and do not breathe the fumes.
- Reposition the work and your head to avoid the fumes.
- Choose the correct ventilation method(s) for the specific operation.
- Use enough ventilation, exhaust at the arc, or both, to keep fumes and gases from your breathing zone and the general area.
- Understand what is in the fumes.
- Have a technically qualified person sample your breathing air and make recommendations.
- Keep hazardous air contaminants below allowable limits.
- Wear the proper respirator when necessary.

INFORMATION SOURCES

American National Standards Institute (ANSI). Safety in Welding, Cutting, and Allied Processes, Z49.1, available from American Welding Society, 8669 Doral Blvd., Doral, FL 33166; Web site: www.aws.org.

Occupational Safety and Health Administration (OSHA). Code of Federal Regulations, Title 29 Labor, Part 1910, available from the U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401; Web site: www.osha.gov.

National Fire Protection Association (NFPA). *Standard for Fire Prevention during Welding, Cutting, and Other Hot Work,* NFPA 51B, available from National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269–9101; Web site: www.nfpa.org.

American Conference of Governmental Industrial Hygienists (ACGIH), *Industrial Ventilation – A Manual of Recommended Practice*, available from ACGIH, 6500 Glenway Avenue, Building D-7, Cincinnati, OH 45211-4438; Web site: www.acgih.org.

American Welding Society (AWS). *Ventilation Guide for Weld Fume* (AWS F3.2), available from American Welding Society, 8669 Doral Blvd., Doral, FL 33166; Web site: www.aws.org.

Edison Welding Institute (EWI). *Reduction of Worker Exposure and Environmental Release of Welding Emissions* (NSRP report No. 43149GTH, November 30, 2003), available from the Edison Welding Institute, 1250 Arthur E. Adams Drive, Columbus, OH 43221; Web site: www.ewi.org.

Occupational Safety and Health Administration (OSHA). *OSHA Technical Manual* (OTM), Section III Health Hazards, Chapter 3 Ventilation Investigation, available from OSHA, Room N3655, 200 Constitution Ave., N.W., Washington, DC 20210; Web site: www.osha.gov.

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Selecting Gloves for Welding and Cutting

INTRODUCTION

Welding gloves can protect you from electric shock, flames, hot parts, sharp or flying metal, and arc rays. Proper gloves are the first line of defense against the hand hazards of welding and cutting. ANSI Standard Z49.1 (see Information Sources) requires that all welders and cutters wear protective gloves while working. Different processes may use different gloves. Here are some guidelines for selecting proper gloves for welding and cutting.

NATURE OF THE HAZARD

- Mechanical hazards that cause cuts, scrapes, tears, and punctures.
- Thermal hazards such as heat, flames, hot parts, arc rays, fire, molten metal, spatter, slag, and sparks.
- Electrical hazards due to gloves that are wet, torn, damaged, or have insulation failure.

GLOVE REQUIREMENTS

Gloves should be:

- Dry and moisture resistant.
- In good condition, no holes or tears.
- Flame resistant.
- Comfortable--proper fit and size.
- Electrically and thermally insulated to suit the process.
- Flexible--allow easy movement and full range of motion.
- Made with materials, seams, and edges that do not affect the health or safety of the user.
- Durable, tough, and long lasting.
- Cut, scrape, tear, and puncture resistant.

GLOVE MATERIALS

Many materials are available. Each has properties affecting its performance and use. Here is a list of typical materials and their useful characteristics:

- Cowhide—tough, durable, flame and heat resistant, with good electrical resistance when dry.
- Calfskin—better dexterity than cowhide but not as tough.
- Pigskin—flexible, oil resistant, quick drying.
- Rubber— moisture proof, electrical insulation.
- Treated Cotton—absorbent, lightweight, flexible.
- Aluminized—heat resistant, reflects heat radiation.
- Goatskin—light weight, comfortable, superior dexterity, durable.
- Deerskin—good touch sensitivity.

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GLOVE DESIGN RECOMMENDATIONS

There are many different styles of gloves. Some protect only the fingers and palms. Others protect the entire hand. Still others protect the wrist and forearm as well. Some gloves have combinations of material, such as cowhide palms and pigskin backs. One pair of gloves may not be suitable for all processes. For example, gloves that are proper for low current Gas Tungsten Arc Welding (GTAW) (thin and flexible) would not be proper for high-current Air Carbon Arc Cutting (CAC-A) (insulated, tough, and durable).

Always use gloves as recommended by the manufacturer. Follow the provided instructions. Improper use may lead to injury if the gloves do not provide the needed protection. Check with your Safety Supervisor or Supplier. Be sure you have the right gloves for the job.

SUMMARY: HOW TO PICK THE RIGHT GLOVES FOR THE JOB

- Know the job.
- Know the process.
- Review the equipment.
- Determine the specific hazards.
- Match the gloves to the needs and hazards of the work.
- For help, ask your supervisor or supplier.

INFORMATION SOURCES

American National Standards Institute (ANSI). Safety in Welding, Cutting, and Allied Processes, Z49.1, available from American Welding Society, 8669 Doral Blvd., Doral, FL 33166; Web site: www.aws.org.

Occupational Safety and Health Administration (OSHA). Code of Federal Regulations, Title 29 Labor, Part 1910, available from the U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401; Web site: www.osha.gov.

National Fire Protection Association (NFPA). *Standard for Fire Prevention during Welding, Cutting, and Other Hot Work,* NFPA 51B, available from National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269–9101; Web site: www.nfpa.org.

NOTE: All the following European Standards are available from the British Standards Institution (BSI), 389 Chiswick High Road, London, England W4 4AL; Web site: www.bsi-global.com.

EN 388: 2003. *Protective Gloves against Mechanical Risks.*

EN 407: 2004. *Protective Gloves against Thermal Risks.*

EN 420:2003. *Protective Gloves—General Requirements and Test Methods.*

EN 12477: 2001. *Protective Gloves for Welders.*

EN 60903: 2003. *Live Working - Gloves of Insulating Material.*

EN 702: 1994. *Protective Clothing—Protection against Heat and Flame.*

EN 1149-2: 1997. *Protective Clothing—Electrostatic Properties.*

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Safety and Health
Fact Sheet No. 38 September 2013

Respiratory Protection Basics for Welding Operations

RESPIRATORY HAZARDS

Welding fume is a complex mixture of very small particles of metal oxides and other compounds that are released during the welding process. Fume ingredients depend on the make-up of the electrode (stick, wire or filler rod), the base metal, surface coatings and contaminants. The type of shielding used (flux vs. gas) is also important. In addition, when electrode coatings, fluxes, shielding gases and surface coatings are burned or exposed to arc radiation, they may give off gases that could be harmful, such as carbon monoxide, ozone, nitrogen oxides, gaseous fluoride and phosgene.

What are the Hazards from Overexposure?

It is claimed that overexposed welders have a greater chance of developing bronchitis, airway irritation, lung function changes, lung infections (pneumonia), and lung cancer when compared to the general working population. Welding and its allied processes can result in overexposures to some forms of manganese in fumes from specific types of welding consumables. Some of these have been reported to cause a neurological impairment known as manganism.

How Can Welders Be Protected from Overexposure?

- **Understand Exposures:** To protect welders it is necessary to understand their actual exposures. The amount of welding fume and other contaminants given off is influenced by many variables. For example, the fume given off increases as current or electrode feed rate increases. Also, fume generation is typically much higher for flux-shielded processes than for gas-shielded processes. The amount of fume being given off is only one factor affecting the amount of fume a welder might inhale. Because so many things are involved, it is difficult to estimate the exposure level for welders. Therefore, when adequate ventilation is in doubt, exposure tests should be conducted to measure actual representative exposures during welding operations. Exposure tests typically involve the collection of air samples by a qualified safety specialist, such as a Certified Industrial Hygienist. Because each component of welding fume has unique

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effects and exposure limits, the exposure level of each component must be measured separately. For example, exposure tests for stainless steel welders usually focus on chromium and nickel. (More information on welding fume and exposure assessment is listed at the end of this document.)

- **Exposure Limits:** Once the exposure is measured and understood, it can be compared to exposure limits set up to protect workers. Occupational exposure limits are typically given as a time-weighted average concentration over a normal eight-hour workday (8-hour TWA). In the USA, OSHA's published Permissible Exposure Limits (PELs) are the legally enforceable standard. However, many choose to follow more current advisory standards such as Threshold Limit Values (TLVs®) published by the American Conference of Governmental Industrial Hygienists (ACGIH). Each contaminant measured must be compared to its exposure limits to judge if exposure levels pose a risk or not.

- **Ventilation and Engineering Controls:** Normally, ventilation, or exhaust, or both can be used to keep fumes and gases from the breathing zone and general area. When this doesn't work and exposure limits are exceeded, it is necessary to take additional steps. These could include the use of: fume exhaust guns, additional ventilation devices, fans or even simple adjustments relative to the natural air flow.

- **Keep Away from the Plume (fume):** One important factor is the position of the welder's head relative to the rising smoke/plume and how well the ventilation keeps the plume away from the welder's breathing zone and general area. Take care to position the work and/or ventilation device to maintain protection at all times.

When to Use Respiratory Protection?

Whenever possible, ventilation systems or other controls should be used to remove harmful fumes and gases. However, these may not reduce exposure levels enough. Then in this case another option may be to use a respirator. Various respirators exist that offer their own benefits and limitations. A summary of common welding respirator categories is shown in Table 2.

How is the Correct Filter Selected?

Particulate (Dust) Filters: Fume can only be captured with particulate filters. Table 1 lists particle filter classifications defined by the National Institute for Occupational Safety and Health (NIOSH). Always look for the NIOSH mark and classification code when choosing a particulate filter.

Table 1

Efficiency	Resistance to oil mist		
	N-Series (not resistant)	R-Series (medium resistance)	P-Series (high resistance)
95%	**N95**	**R95**	**P95**
99%	**N99**	**R99**	**P99**
99.97%	**N100**	**R100**	**P100**

The first letter refers to the filter's resistance to liquid oil mist. The number

Table 2					
	Disposable Half Facepiece	Elastomeric Half Facepiece	Powered-Air, Loose-Fitting Headpiece	Powered-Air, Helmet (Hard Hat)	Supplied-Air, (Loose-Fitting or Helmet)
Description					
APF	10	10	25	25 / 1000 *	25 or 1000
Benefits	No maintenance Low unit cost Fits under any welding helmet Light weight	More filter options More size options Moderate unit cost Light weight	Reduced stuffiness Cooling effect No breathing resistance No fit testing Hard hat options Accommodates limited facial hair	Same as Loose-Fitting Headpiece plus: Hard hat included Higher protection factor Better neck protection Accommodates facial hair including some beards	Maximum contaminant versatility Chilled or heated air No breathing resistance No filters to change No batteries to charge
Limitations	Not compatible with facial hair For particles only Increase heat retention and stuffiness Fit-test required	Not compatible with facial hair May not fit all welding helmets Increase heat retention and stuffiness Fit-test required	Increased weight Higher unit cost Increased maintenance Increased user training	Same as Loose-Fitting Headpiece	Attachment to airline Increased weight Higher unit cost Requires compressor

*APF refers to Assigned Protection Factor which is *the minimum anticipated level of protection provided by each type of respirator worn in accordance with an adequate respiratory protection program. For example, an APF of 10 means that the respirator should reduce the airborne concentration of a particulate by a factor of 10 (or to 10% of the workplace concentration).* August 2006 OSHA amended 29 CFR 1910.134 by *adding requirements for APF's. For Powered Air Purifying (PAPR) helmets, the manufacturer must have a Workplace Protection Factor(WPF) or Simulated Workplace Protection Factor (SWPF) study data to substantiate APF of 1000. Refer to OSHA Final Rule: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=FEDERAL_REGISTER&p_id=18846*

that follows refers to the filter's efficiency in laboratory tests. N95 class filters are recommended for most welding applications because welding fume is relatively easy to filter and oil mist is seldom a factor. There is no harm in using a higher class filter, provided the worker is fit-tested for the device and medically cleared. When high hazard compounds, such as lead or cadmium are involved, special regulations require the use of P100 class filters. Particulate filters must be replaced when they become soiled, damaged or difficult to breathe through.

Gas and Vapor Cartridges: Gases and vapors cannot be removed by particulate (dust) filters. They must be removed by adsorption in a bed of activated carbon or other media, depending on the gas or vapor species. Certain vapors must be changed before they can be captured. This is accomplished by treating activated carbon with catalysts. Therefore, it is important to select a cartridge that is approved by NIOSH for the vapors present. The approved contaminants will

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be listed on each cartridge label. The most common cartridges used in welding are organic vapor (black label), acid gas (white label) and organic vapor/acid gas (yellow label). The service life (how long it lasts) of gas and vapor cartridges depends on the chemicals removed and their concentration. Gas and vapor cartridges do not clog like particle filters. They simply become used up and allow contaminants to flow through. In some cases, harmful levels can be exceeded without being detected. Therefore, it is critical that a service life estimate be calculated for each situation. Establish a schedule that tells when to change filters. Respirator manufacturers can help with figuring this schedule.

Powered Air Purifying Respirators (PAPRs): Battery powered respirators use a motor to pull air through filters and/or cartridges to purify the air. The blowers are usually belt-mounted and push filtered air through a headpiece breathing tube. Because the filtered air is under pressure, leakage of contaminants into the helmet is greatly reduced. This increases the level of protection. The movement of air helps keep the welder cool and comfortable.

Supplied Air Respirators: Some gases and vapors cannot really be filtered. In these cases, a supplied-air respirator may be needed. Supplied-air respirators require a compressor, located in a clean area, to pump clean air into the respirator. The main disadvantage of supplied-air respirators is that the airline makes it difficult for the wearer to move. An important advantage of supplied-air is the ability to cool the air. This is a popular feature in hot welding environments. (Supplied-air must come from a device or system that can supply what is known as "Grade D" breathing air. General shop compressed air often contains contaminants and should not be used.)

Other Factors

- Individual comfort is important. An uncomfortable respirator will be worn less consistently. Removal of the respirator, even for short periods of time, dramatically reduces the protection.

- Welders with facial hair must shave or use a particular type of powered or supplied air respirator. Even one-day stubble can cause tight fitting respirators to leak significantly.

- Not all respirators are flame and spark resistant. Select a respirator recommended for welding.

Respirator Program

Before respirators can be used in a workplace, the employer must have a written OSHA Respiratory Protection Program in place. Key Elements of the Program Include:

- **Training:** Training must include instruction on respirator use, maintenance, cleaning and storage. Users must be trained prior to use and at least annually thereafter.

- **Medical Evaluation:** Certain lung or heart conditions can make respirator use dangerous. Medical clearance must be obtained before using a respirator.

- **Fit Testing:** The OSHA standard requires fit testing for all tight-fitting

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respirator models. Whether you select a maintenance-free or a reusable respirator, the wearer must obtain a satisfactory fit. Fit tests must be repeated for each model and when any changes occur that could affect the fit.

- **Respirator Selection:** Describes how a respirator was selected for each task.

- **Program Evaluation:** A process for regularly evaluating the effectiveness of the program.

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Occupational Safety And Health Administration (OSHA). Code Of Federal Regulations, Title 29 Labor, Chapter XVII, Parts 1901,.1 to 1910.1450, Order No. 869-019-00111-5, available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 02402.

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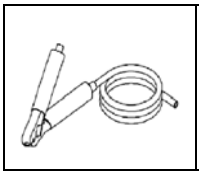

Welding Cables

INTRODUCTION

Cables deliver current from the welding power source to the welding or cutting arc. Welding cable size, length, connections, placement, and care are all important to welder safety. Know and understand the safe limits and proper use of welding cables to reduce potential hazards.

POTENTIAL WELDING CABLE HAZARDS

TRIPPING can cause falls and injuries.

- Relocate cables to prevent tripping.

ENTANGLEMENT can pull cables loose, and cause arcs and sparks.

- Keep cables out of the way. Protect them from damage.

ARCS and SPARKS can injure and start fires.

- Keep connections clean and tight.

INCORRECT CABLE SIZE can cause cables to overheat, damage insulation and cause burns and fires.

- Use the correct cable size/gauge. Follow the welding power source and cable manufacturers recommendations.
- Use proper connectors and splices.
- Use correct cable length for the job.
- Do not leave cables coiled while in use as this can cause spot overheating.
- Electromagnetic Fields - See AWS Safety & Health Fact Sheet No. 17, Electric and Magnetic Fields (EMF) in Welding.
- Examine before, during, and after use for damage.
- Repair or remove damaged cables.
- Do not use worn, damaged, undersized, or poorly spliced cables.

SOME CABLE FACTS

- To ensure the correct power is delivered to the arc, follow the welding power source and cable manufacturers recommendations. These recommendations maintain a 4 volt drop or less at a specific current and cable length. The maximum 4 volt drop helps maintain proper arc characteristics. It is not primarily meant to protect the cable, although longer cables will stay cooler than with a higher voltage drop.

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Recommended Sizes of Copper Welding Cables

Amp	Distance in Feet from Welding Machine*											
	50	75	100	125	150	175	200	225	250	300	350	400
100	2	2	2	2	1	1/0	1/0	2/0	2/0	3/0	4/0	4/0
150	2	2	1	1/0	2/0	3/0	3/0	4/0	4/0			
200	2	1	1/0	2/0	3/0	4/0	4/0					
250	2	1/0	2/0	3/0	4/0							
300	1	2/0	3/0	4/0								
350	1/0	3/0	4/0									
400	1/0	3/0	4/0									
450	2/0	4/0										
500	2/0	4/0										
550	3/0											
600	3/0											

* Based on direct current and 4-v drop. Double the distance for total length

- American Wire Gage (A.W.G.) cable size numbers get smaller as the cable diameter gets bigger. For example, No.16 gage is about 0.05 inches in diameter, and No. 4 gage is about 0.20 inches in diameter.

- After No. 1 gage the next bigger cable is “one naught” (1/0 or 0) (sometimes called “one aught”). Bigger cables are 2/0, 3/0, and 4/0 (00, 000, 0000). A.W.G. was formerly “Brown & Sharp Gage” and is sometimes referred to as “B & S Gage”.

- Metric wire gages are based on the actual diameter, in millimeters (mm) multiplied by 10. For example, a 5.00 mm diameter wire is a 50 gage metric wire.

- Metric cable sizes may not directly correspond to AWG cable sizes. Use a metric cable size at least as large as the recommended AWG cable size.

- With A.W.G. cables a change of 3 number sizes doubles or halves the actual size. For example, if you go from 1/0 to 4/0, the cable has twice as much copper. Therefore, it will have half the resistance and half the voltage drop. You can then use cable twice as long before you a reach a 4 volt drop.

INFORMATION SOURCES

Manz, August. “How to Pick the Right-Sized Welding Cable” Welding Journal, March 2012, pages 91 and 92. Web site: www.aws.org. The article is included here in its entirety for your convenience.

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How to Pick the Right-Sized Welding Cable

Here are a formula and tables that will help you to choose a safe-sized cable every time

BY AUGUST F. MANZ

AUGUST F. MANZ is a Fellow of the American Welding Society.

What size welding cable do you need to be safe when you are using XX amperes and are about YY feet from the power supply?

Most welders know that the use of the wrong cable size can lead to cable overheating, insulation failure, electric shock, and even fires. The wrong size can even affect the welding condition.

Picking a Safe Cable Size

To answer the question above, you need to know the welding current and the distance from the power supply. The safe American Wire Gauge (AWG) size is based on a 4-V cable loss, due to the welding current flowing through the cable resistance. (Note: Years ago, it was agreed that a 4-V cable loss, due to welding current, would be acceptable. A 4-V drop does not have too much effect on the arc system or the system efficiency.) Table 1 shows that at 250 A and 150 ft from the power supply, the correct size is a 4/0 AWG cable, which is the same as the #0000 AWG in Table 2.

Another Method

You can also pick a safe cable size by using the formula below, and Table 2, for copper cables. First, calculate the safe circular mil size needed. Circular mil (CM) is engineering measure of the cable cross-section area.

CM = 10.37 A (total cable length, ft)/4 V

Now, use the calculated CM value and the AWG sizes in Table 2 to select a cable (the 10.37 value is only good for copper cables). Always pick an AWG cable size with a CM value larger than the calculated value. Do not pick an AWG size smaller than #2 because of needed mechanical strength. The following is an example CM calculation: To determine the safe AWG size cable needed for 250 A and a total cable length of 300 ft [150 ft · 2 (from the power supply to the arc and return)], you use the following formula:

CM = 10.37 (250)(300)/4 = 194,438 cm

In Table 2, the next larger CM is 211,600 cm, for #0000 AWG cable. This is the same 4/0 size you found in Table 1. The actual voltage drop in the cable can be calculated as follows: From Table 2, for #0000 AWG, at 20°C (the estimated room temperature) there are 0.04901 ohms per 1000 ft. Using Ohm's Law as follows:

Volts = (ohms) (amperes)
= (0.04901 ohms/1000 ft)(300ft)(250 A)
= 3.68 V

The calculated 3.68-V loss is smaller than the acceptable 4-V loss agreed upon, and is okay. Calculations like this were used to generate the data in Table 1.

The Bottom Line

With the tables and information in this article, you can choose a safe cable size every time.

Table 1 — Recommended Sizes of Copper Welding Leads *

Amps	Distance in Feet from Welding Machine											
	50	75	100	125	150	175	200	225	250	300	350	400
100	2	2	2	2	1	1/0	1/0	2/0	2/0	3/0	4/0	4/0
150	2	2	1	1/0	2/0	3/0	3/0	4/0	4/0			
200	2	1	1/0	2/0	3/0	4/0	4/0					
250	2	1/0	2/0	3/0	4/0							
300	1	2/0	3/0	4/0								
350	1/0	3/0	4/0									
400	1/0	3/0	4/0									
450	2/0	4/0										
550	3/0	4/0										
600	3/0											

*Based on direct current and 4-V drop. Double the distance for total length.

Table 2 — Wire Table, Standard Annealed Copper American Wire Gauge

Gauge No.	Dia. in Mils at 20°C	Cross Section 20°C Circular Mils	Square Inch	Pounds 1000 ft	Ohms per 1000 ft 0°C (32°F)	20°C (68°F)	50°C (122°F)
0000	460.0	211,600	0.1662	640.5	0.04516	0.04901	0.05479
000	409.6	167,800	0.1318	507.9	0.05695	0.06180	0.06909
00	364.8	133,100	0.1045	402.8	0.07181	0.07793	0.08712
0	324.9	105,500	0.08289	319.5	0.09055	0.09827	0.1099
1	289.3	83,690	0.06573	253.3	0.1142	0.1239	0.1385
2	257.6	66,370	0.05213	200.9	0.1440	0.1563	0.1747
3	229.4	52,640	0.04134	159.3	0.1816	0.1970	0.2203
4	204.3	41,740	0.03278	126.4	0.2289	0.2485	0.2778

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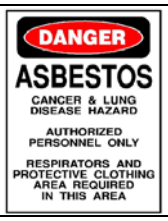

ASBESTOS HAZARDS ENCOUNTERED IN THE WELDING AND CUTTING ENVIRONMENT

INTRODUCTION

Asbestos is a fibrous mineral that was once widely used because of its heat and chemical resistance. Most uses of asbestos have been discontinued, but large amounts of asbestos are still in the workplace. Asbestos fibers can be long enough to make into cloth or paper, but most are too small to see with the naked eye. These very small fibers are a respiratory hazard when they become airborne. Overexposure can cause lung disease, lung cancer, and other cancers.

During construction or maintenance welders or cutters can be exposed to asbestos. Workers can be exposed when disturbing asbestos themselves, or simply by being present in the general work area. There are specific regulations that specify how work must be done if asbestos may be present. These regulations are to keep personnel safe from asbestos hazards.

Asbestos is found in many different materials, including the following:

- Thermal systems insulation on ducts, pipes, tanks, boilers, furnaces, etc.
- Refractory – fireproof brick, mortar and cement
- Roofing and siding – shingles, boards, coatings, cements and paints
- Floor coverings and leveling compounds
- Wall and ceiling finishes – plaster, tiles, spray-on, sheetrock
- Fire protection systems – gaskets, dampers, “firestop” compounds

NATURE OF THE HAZARD—ASBESTOS TYPES

Overexposure to asbestos fibers by inhalation can cause asbestosis (scarring of the lungs). This results in loss of lung function. It often progresses to disability and to death. It can also cause mesothelioma (cancer affecting the membranes lining the lungs and abdomen); lung cancer; and cancers of the esophagus, stomach, colon, and rectum. Common types of asbestos are: chrysotile (white asbestos), amosite (brown asbestos), and crocidolite (blue asbestos). White asbestos is the most common. Brown and blue asbestos can be the most harmful. They are usually found in high temperature thermal system insulation.

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HOW TO AVOID THE HAZARD—ASBESTOS

The Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA) regulate work involving asbestos. Employers must conduct surveys to identify all asbestos-containing materials. They must inform workers of asbestos materials they may contact. Also, workers that may disturb or work around asbestos must be trained to recognize which materials contain asbestos, and how to avoid hazards.

Only specially trained workers may touch, disturb and/or dispose of asbestos containing materials.

SUMMARY

- Asbestos is a mineral that was widely used due to its heat and chemical resistant properties. Asbestos can give off fibers if disturbed. Fibers are a severe inhalation hazard. Inhalation can lead to lung disease, lung cancer, and other types of cancers.

- Do not disturb materials that may contain asbestos. Only use properly trained workers, directed by authorized supervision. Typical materials are: pipe and thermal system insulation, transite wall board, floor and ceiling tile, spray-on insulation, structural coatings, galbestos siding, roofing materials and mastics.

- Asbestos work is regulated by OSHA and the EPA. Only those trained and authorized may disturb asbestos materials.

- Employers and building owners are required to identify and label asbestos-containing materials. Make employees aware of the location and presence of these materials. Use effective training and communications.

- Special work practices are required for handling or disturbing asbestos. These include isolation with a negative pressure enclosure, disposable garments and other hygiene controls and facilities.

- Engineering controls must be used to prevent the release of asbestos fibers. Respirators must also be worn when there is a possibility of overexposure.

INFORMATION SOURCES

Two pamphlets summarizing OSHA rules dealing with asbestos are available: (in single copies) "Asbestos Standard for General Industry" and "Asbestos Standard for Construction Industry." These can be obtained by sending a self-addressed mailing label to the OSHA Publications Office, Room N-3101, Washington, D.C. 20210, telephone 202-219-4667 or from any local OSHA office.

EPA basic information is available at the following website:
www.epa.gov/asbestos/pubs/help.html

NIOSH information is available at the following website:
www.cdc.gov/Niosh/topics/Asbestos

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COMBUSTIBLE DUST HAZARDS IN THE WELDING AND CUTTING ENVIRONMENT

INTRODUCTION

Combustible dusts are a serious workplace hazard. Airborne clouds of these dusts are easily ignited, resulting in the rapid, violent spread of fire, or "deflagration." If confined inside a structure, the pressure can build up creating an explosion. Deflagration or explosion can cause loss of life and property damage. Welding and other hot work operations initiate many workplace combustible dust explosions. Dust trails on surfaces can act as a fuse to serve as a source of ignition in other areas. Therefore, welders should understand the factors that contribute to combustible dust hazards.

Industries that process or generate combustible dusts include: metallurgical, textile, mining, plastics, rubber, pharmaceutical, lumber, food processing and agriculture, and a wide range of manufacturing processes. During processing of combustible solids and powdered materials, dusts can become airborne when conveyed, dumped, mixed and transferred. These dusts may also collect on surfaces and present a potential hazard if released into the air. Process controls should be used to collect these dusts to prevent them from escaping into the work environment. Dust control equipment must be designed to avoid creating dust explosion or deflagration hazards. Housekeeping practices must be sufficient to prevent fugitive dust accumulation on surfaces.

NATURE OF THE HAZARD—COMBUSTIBLE DUSTS

Not all dust is combustible. In fact, limestone dust is used in coal mines to reduce explosion hazards. However, materials which can burn or corrode in contact with oxygen can form combustible dusts. These "reactive" materials include: metals, plastics, coal and other carbonaceous materials, grains, wood and paper, and many organic compounds such as additives, solid food products and pharmaceuticals. Dusts vary in their potential for combustion and in how violent their airborne dust deflagrations may be.

For a dust deflagration to happen, it takes a big enough and dense enough cloud of the dust to become airborne at one time and then contact an energy source strong enough to cause ignition. For some dusts it may take only a static spark to ignite a dense cloud, while others might require an open flame or contact with a hot surface. Understanding how dense is a dust cloud and what kinds of energy sources are needed to make an ignition hazard can only be learned though specialized lab testing.

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A small explosion or other shock will stir up settled dust into the air. This makes a big cloud, which is often ignited by the heat of the first explosion.

It is also important to understand that finer dust particles become airborne more easily - and also ignite more easily.

HOW TO AVOID THE HAZARD— WHAT TO LOOK FOR

If dusts or powders are processed or handled in a workplace, or if dusts are visible in the air or on surfaces, find out what is in the dust. Ask for Safety Data Sheets (SDSs), and look them over for flammability and combustibility data. Find out if the dust is reactive or combustible. Combustible dusts should not be allowed to collect on surfaces to depths > 1/32". Compressed air or steam should never be used to clean such dust deposits on surfaces. Proper housekeeping requires special tools like explosion proof vacuums.

Dusts contained inside processing equipment and/or ventilation systems can deposit in ducts, and become concentrated in collection devices like bag houses. Equipment used to store, collect or handle combustible dusts requires special design features to reduce the risk of deflagration.

PRECAUTIONS:

- Always understand the materials that may be present in the environment, and check when you are not sure.
- Never use compressed air for cleaning powdered materials and dusts.
- Never weld or do other hot work where combustible dusts are present on surfaces or where they might become airborne. Check adjacent and concealed spaces for dust. Consult with your supervisor or safety professional if you are unsure about the risks or safety requirements.
- Never work on equipment that handles or collects combustible dusts unless you are authorized to do so and have the required training.
- Always be extra careful about electrical safety, including static charge buildup.
- Always follow all safety precautions, hot work procedures and other steps designed to prevent dust explosions.

SUMMARY

It is important to understand the materials present in the work environment and if any of their dusts might be flammable or combustible, or have other hazards. The dusts or powdered forms of certain types of solid materials can be ignited by a sufficient energy source if enough of it gets airborne at one time. This makes it doubly important for those who conduct welding and its allied processes to know if this hazard is present and to take the appropriate steps to prevent potentially devastating dust explosions.

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