

## WELDING HAZARDS

**Welding** joins pieces of metal by the use of heat, pressure, or both.

**Brazing**, or **soldering**, involves a filler metal or alloy (a combination of metals) which has a lower melting point than the metal pieces to be joined. The filler materials (such as lead and cadmium) can be very toxic.

Metal **cutting** is done by heating the metal with a flame and directing a stream of pure oxygen along the line to be cut.

There are more than 80 different types of welding and associated processes. Some of the most common types of welding are: arc welding, which includes “stick,” or shielded metal arc welding (SMAW), the gas-shielded methods of metal inert gas (MIG) and tungsten inert gas (TIG), plasma arc welding (PAW) and submerged arc welding (SAW). Other welding processes may use oxy-acetylene gas, electrical current lasers, electron beams, friction, ultrasonic sound, chemical reactions, heat from fuel gas and robots.

### Health Hazards of Welding

#### Gases and Fumes

Welding “smoke” is a mixture of very fine particles (fumes) and gases. Many of the substances in welding smoke, such as **chromium, nickel, arsenic, asbestos, manganese, silica, beryllium, cadmium, nitrogen oxides, phosgene, acrolein, fluorine compounds, carbon monoxide, cobalt, copper, lead, ozone, selenium and zinc**, can be extremely toxic.

Generally, welding fumes and gases come from:

- the **base material** being welded or the **filler material** that is used;
- **coatings and paints** on the metal being welded, or coatings covering the electrode;
- **shielding gases** supplied from cylinders;
- **chemical reactions** which result by the action of ultraviolet light from the arc and heat;
- **process and consumables** used; and
- **contaminants in the air**, for example vapors from cleaners and degreasers.

The health effects of welding exposures are difficult to list, because the fumes may contain so many different substances that are known to be harmful. The individual components of welding smoke can affect any part of the body, including the lungs, heart, kidneys and central nervous system.

Welders who smoke may be at greater risk of health impairment than welders who do not smoke, although all welders are at risk.

Exposure to welding smoke may have short-term and long-term health effects. These effects are described below:

### **Short-Term (Acute) Health Effects**

Exposure to metal fumes (such as zinc, magnesium, copper, and copper oxide) can cause **metal fume fever**. Symptoms of metal fume fever may occur 4 to 12 hours after exposure, and include chills, thirst, fever, muscle ache, chest soreness, coughing, wheezing, fatigue, nausea and a metallic taste in the mouth.

Welding smoke can also irritate the eyes, nose, chest, and respiratory tract, and cause coughing, wheezing, shortness of breath, bronchitis, pulmonary edema (fluid in the lungs) and pneumonitis (inflammation of the lungs). Gastrointestinal effects, such as nausea, loss of appetite, vomiting, cramps, and slow digestion, have also been associated with welding.

Some components of welding fume, for example cadmium, can be fatal in a short time. Gases given off by the welding process can also be extremely dangerous. For example, ultraviolet radiation given off by welding reacts with oxygen and nitrogen in the air to form ozone and nitrogen oxides. These gases are deadly at high doses and can also cause irritation of the nose and throat and serious lung disease.

Ultraviolet rays given off by welding can react with chlorinated hydrocarbon solvents, such as 1, 1, 1-trichloroethane, trichloroethylene, methylene chloride, and perchloroethylene, to form phosgene gas. Even a very small amount of phosgene may be deadly, although early symptoms of exposure -- dizziness, chills, and cough -- usually take 5 or 6 hours to appear. **Arc** welding should never be performed within 200 feet of degreasing equipment or solvents.

### **Long-Term (Chronic) Health Effects**

Studies of welders, flame cutters, and burners have shown that welders have an increased risk of lung cancer, and, possibly cancer of the larynx (voice box) and urinary tract.

These findings are not surprising in view of the large quantity of toxic substances in welding smoke, including cancer-causing agents such as cadmium, nickel, beryllium, chromium, and arsenic.

Welders may also experience a variety of chronic respiratory (lung) problems, including bronchitis, asthma, pneumonia, emphysema, pneumoconiosis (refers to dust-related diseases), decreased lung capacity, silicosis (caused by silica exposure) and siderosis (a dust-related disease caused by iron oxide dust in the lungs).

Other health problems that appear to be related to welding include: heart disease, skin diseases, hearing loss and chronic gastritis (inflammation of the stomach), gastroduodenitis (inflammation of the stomach and small intestine) and ulcers of the stomach and small intestine. Welders exposed to heavy metals such as chromium and nickel have also experienced kidney damage.

Welding also poses reproductive risks to welders. A recent study found that welders, and especially welders who worked with stainless steel, had poorer sperm quality than men in other types of work. Several studies have shown an increase in either miscarriages or delayed conception among welders or their spouses. Possible causes include exposure to: (1) metals, such as aluminum, chromium, nickel, cadmium, iron, manganese, and copper, (2) gases, such as

nitrous gases and ozone, (3) heat and (4) ionizing radiation (used to check the welding seams). Welders who perform welding or cutting on surfaces covered with asbestos insulation are at risk of asbestosis, lung cancer, mesothelioma and other asbestos-related diseases. Employees should be trained and provided with the proper equipment before welding near materials that contain asbestos.

## **Other Health Hazards**

### **Heat**

The intense heat of welding and sparks can cause burns. Eye injuries have resulted from contact with hot slag, metal chips, sparks, and hot electrodes.

In addition, excessive exposure to heat can result in heat stress or heat stroke. Welders should be aware of the symptoms, such as fatigue, dizziness, loss of appetite, nausea, abdominal pain, and irritability. Ventilation, shielding, rest breaks, and staying hydrated will protect against heat related hazards.

### **Visible Light, and Ultraviolet and Infrared Radiation**

The intense light associated with arc welding can cause damage to the retina of the eye, while infrared radiation may damage the cornea and result in the formation of cataracts.

Invisible ultraviolet light (UV) from the arc can cause “arc eye” or “welder’s flash” after even a brief exposure (less than one minute). The symptoms of arc eye usually occur many hours after exposure to UV light, and include a feeling of sand or grit in the eye, blurred vision, intense pain, tearing, burning, and headache.

The arc can reflect off surrounding materials and burn co-workers who work nearby. About half of welder’s flash injuries occur in co-workers who are not welding. Welders and cutters who continually work around ultraviolet radiation without proper protection can suffer permanent eye damage.

Exposure to ultraviolet light can also cause skin burns similar to sunburn and increase the welder’s risk of skin cancer.

### **Noise**

Exposure to loud noise can permanently damage welders’ hearing. Noise also causes stress and increased blood pressure, and may contribute to heart disease. Working in a noisy environment for long periods of time can make workers tired, nervous, and irritable. If you work in a noisy area, the OSHA Noise Standard requires your employer to test for noise levels to determine your exposure. If your noise exposure exceeds 85 decibels averaged over 8 hours, your employer must provide you with free hearing protection and annual hearing tests.

### **Musculoskeletal Injuries**

Welders have a high prevalence of musculoskeletal complaints, including back injuries, shoulder pain, tendinitis, reduced muscle strength, carpal tunnel syndrome, white finger, and knee joint diseases. Work postures (especially welding overhead, vibration, and heavy lifting) can all contribute to these disorders. These problems can be prevented by:

- proper lifting;
- not working in one position for long periods of time;

- keeping the work at a comfortable height;
- using a foot rest when standing for long periods;
- locating tools and materials conveniently; and
- minimizing vibration.

## **Safety Hazards of Welding**

### **Electrical Hazards**

Even though welding generally uses low voltage, there is still a danger of electric shock. The environmental conditions of the welder (such as wet or cramped spaces) may make the likelihood of a shock greater. Falls and other accidents can result from even a small shock; brain damage and death can result from a large shock.

Dry gloves should always be worn to protect against electric shock. The welder should also wear rubber-soled shoes and use an insulating layer, such as a dry board or a rubber mat, for protection on surfaces that can conduct electricity.

The piece being welded and the frames of all electrically powered machines must be grounded. The insulation on electrode holders and electrical cables should be kept dry and in good condition. Electrodes should not be changed with bare hands, with wet gloves, or when standing on wet floors or grounded surfaces.

### **Fires and Explosions**

The intense heat and sparks produced by welding, or the welding flame, can cause fires or explosions if combustible or flammable materials are nearby.

Welding or cutting should be performed only in areas that are free of combustible materials, including trash, wood, paper, textiles, plastics, chemicals and flammable dusts, liquids and gases (vapors can travel several hundred feet). Those that cannot be removed should be covered with a tight-fitting flame-resistant material. Doorways, windows, cracks and other openings should be covered.

Never weld on containers that have held a flammable or combustible material unless the container is thoroughly cleaned or filled with an inert (non-reactive) gas. Explosions, fires, or release of toxic vapors may result. Containers with unknown contents should be assumed to be flammable or combustible.

A fire inspection should be performed before leaving the work area and for at least 30 minutes after the operation is completed. Fires extinguishers should be nearby.

### **Dangerous Machinery**

All machines with moving parts must be guarded to prevent workers' hair, fingers, clothing, etc. from getting caught.

When repairing machinery by welding or brazing, power must be disconnected, locked out, and tagged so that the machinery cannot start up accidentally.

## **Trips and Falls**

To prevent trips and falls, keep welding areas clear of equipment, machines, cables and hoses, and use safety lines or rails.

## **Hazards of Welding in Confined Spaces**

A confined space is a small or crowded area with limited access and little or no air flow or ventilation. Adequate ventilation is essential for working in confined spaces. Dangerous concentrations of toxic fumes and gases can build up very quickly in a small space. Unconsciousness or death from suffocation can occur rapidly because welding processes can use up or displace oxygen in the air. High concentrations of some fumes and gases can also be very explosive.

All workers who may enter dangerous areas, either on a regular basis or in an emergency situation, should be trained on rescue procedures, personal protective equipment, use of safety equipment, and proper procedures for entering and exiting a confined space.

- The worker inside the confined space should be equipped with a safety harness, a lifeline, and appropriate personal protective clothing, including a self-contained breathing apparatus. (Never use an air purifying respirator.)
- Gas cylinders and welding power sources should be located in a secure position outside of the confined space.
- A trained helper must be stationed outside of the confined space and equipped with appropriate gear (including a fire extinguisher and personal protective equipment), to assist or rescue the worker inside the confined space if necessary. If the standby person notices any indications of intoxication or decreased alertness from the “inside” worker, the inside worker should be removed from the area immediately.
- All confined spaces should be tested before entering for toxic, flammable, or explosive gases or vapors, and oxygen level. Continuous air monitoring may be necessary during welding. No worker should enter a confined space where the percentage of oxygen is below 19.5 percent unless he or she is equipped with a supplied-air respirator.
- Never use oxygen for ventilation.
- Use continuous mechanical ventilation and a respirator whenever you weld or perform thermal cutting in a confined space.
- All pipes, ducts, and power lines connected to the space, but not necessary to the operation, should be disconnected or shut off. All shutoff valves and switches should be tagged and locked out so they cannot be restarted accidentally.
- All unnecessary torches and other gas or oxygen-supplied equipment should be removed from the confined space.

## **Hazards of Compressed Gases**

Gas welding and flame cutting use a fuel gas and oxygen to produce heat for welding. For high-pressure gas welding, both the oxygen and the fuel gas (acetylene, hydrogen, propane, etc.) supplied to the torch are stored in cylinders at high pressure.

The use of compressed-gas cylinders poses some unique hazards to the welder. Acetylene is very explosive. It should be used only with adequate ventilation and a leak detection program.

Oxygen alone will not burn or explode. At high oxygen concentrations, however, many materials (even those that are difficult to burn in air, such as normal dust, grease, or oil) will burn or explode easily.

- All cylinders should have caps or regulators.
- Only pressure regulators designed for the gas in use should be fitted to cylinders.
- Compressed gas cylinders, all pressure relief valves and all lines should be checked before and during welding operations.
- Blowpipes must be kept in good condition and cleaned at regular intervals.
- Hoses and fittings should be kept in good condition and checked regularly.
- Cylinders must be stored upright so that they will not fall over.
- Oxygen and fuel cylinders must be stored separately, away from heat and sunlight, and only in a dry, well-ventilated, fire-resistant area that is at least 20 feet away from flammable materials such as paint, oil, or solvents.
- Be aware of backfires and flashbacks. These are danger signals and should prompt immediate corrective action.
- Close cylinder valves when work is finished. Put valve protection caps in place and release pressure in regulators and hose lines before cylinders are moved or placed in storage.

### **Reducing the Hazards of Welding**

Before beginning a welding job, it is important to identify the hazards for that particular welding operation. The hazards will depend on the type of welding, the materials (base metals, surface coatings, electrodes) to be welded, and the environmental conditions (outside or in a confined space).

Ask for material safety data sheets (MSDSs) to identify the hazardous materials used in welding and cutting products, and the fumes that may be generated. Make sure you know what you are welding before you start. Some fumes, such as those released from welding on a cadmium-plated surface, can be fatal in a short time.

After identifying the hazard, appropriate control methods can be implemented.

### **Engineering Controls and Work Practices**

**Substitute** hazardous materials for less hazardous materials.

- Use cadmium-free silver solders.
- Use asbestos-free electrodes, gloves, and hot pads.
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**Ventilation** should be used to remove harmful fumes and gases. **Local exhaust ventilation**, which removes the fumes and gases at their source, is the most effective method. This can be provided by a partial enclosure, such as a ventilated work bench, or by hoods positioned as close to the point of welding as possible. Ventilation systems should be cleaned and maintained regularly. **General ventilation** uses roof vents, open doors and windows, roof fans, or floor fans to move air through the entire work area. This is not as effective as local exhaust ventilation, and may simply spread chemicals around the workplace. General ventilation is often helpful, however, when used to supplement local ventilation.

- For gas-shielded arc welding processes, local exhaust can be provided by means of an extracting gun, which can reduce worker exposure to welding emissions by 70 percent.
- Hoods and ductwork should be constructed of fire-resistant materials.

Use **shielding** (barriers) to protect other people in the work area from the light of the welding arc, heat, and hot spatter.

- Welding booths should be painted with a dull finish that does not reflect ultraviolet light (such as finishes that contain titanium dioxide or zinc oxide).
- Acoustic shields between the worker and the noise source can be used to reduce noise levels. Alternatively, the machinery or process can be totally enclosed.

**Modify the process or follow safe work practices** so that hazards are eliminated. For example:

- Don't weld on painted or coated parts. If possible, remove all surface coatings before you weld.
- Use a water table under the plasma arc cutting to reduce fume and noise levels.
- Grind parts instead of air arcing.
- Use the sub arc process to minimize light and fumes created by a visible arc.
- Position yourself while welding or cutting so that your head is not in the fumes.
- Remove all nearby flammable or combustible materials before striking an arc or lighting a flame.
- Make sure that equipment is properly maintained. Replace worn insulation and hoses.
- Welding areas should be kept free of equipment and machines that could cause trips or falls.
- Minimize the production of welding fumes by using the lowest acceptable amperage and holding the electrode perpendicular and as close to the work surface and possible.
- Arc welding should never be performed within 200 feet of degreasing equipment or solvents.

### **Personal Protective Equipment (PPE)**

Personal protective equipment should always be used along with, but never instead of, engineering controls and safe work practices!

**Eye protection** should be used for all welding operations to protect the eyes from bright light, heat, ultraviolet light, and flying sparks. For the best protection, wear face shields or helmets and goggles. To keep slag and particles out of your eyes when removing your face shield, tip your head forward and keep your eyes closed.

Welding helmets, goggles, or other eye protectors must contain special filter plates or lenses for workers exposed to arc welding or cutting processes, oxyfuel gas welding, brazing, or cutting. The OSHA welding standard requires that employees performing welding and cutting operations shall be protected with filter lenses or plates conforming to the specifications in the table below:

<b>Filter Lens Shade Numbers for Protection Against Radiant Energy</b>	
<b>Welding Operation Number</b>	<b>Shade</b>
Shielded Metal-Arc Welding (SMAW) using 1/16-, 1/8-, and 5/32-inch diameter electrodes	10
Gas-Shielded Arc Welding (nonferrous) using 1/16-, 3/32-, 1/8-, and 5/32-inch D. electrodes	11
Gas-Shielded Arc Welding (ferrous) using 1/16-, 3/32-, 1/8-, and 5/32 -inch D. electrodes	12
Shielded Metal-Arc Welding (SMAW) using 3/16-, 7/32-, and 1/4-inch D. electrodes	12
5/16-, and 3/8-inch diameter electrodes.	14
Atomic Hydrogen Welding	10-14
Carbon-Arc Welding (CAW)	14
Soldering	2
Torch Brazing	3 or 4
Light cutting, up to 1-inch	3 or 4
Medium cutting, 1-inch to 6-inches	4 or 5
Heavy cutting, over 6 inches	5 or 6
Gas welding (light), up to 1/8-inch	4 or 5
Gas welding (medium), 1/8-inch to 1/2-inch	5 or 6
Gas welding (heavy), over 1/2-inch	6 or 8

**Protective clothing** which should be worn during welding (by welders and nearby workers) includes: fire-resistant gauntlet gloves, headcap, high-top, hard-toed shoes, leather apron, faceshield, flame-retardant coveralls, safety glasses, and helmets and leggings or high boots. Protective clothing should be made of wool, which does not ignite easily, or specially-treated cotton fabrics. Sleeves and collars should be kept buttoned, and pants and shirts should be uncuffed. Capes and hard hats may also be required. Workers should use welding helmets (with appropriate filter lenses), not hand-held screens. When welding overhead, extra protection should be used, such as fire-resistant shoulder covers, aprons, head covers, leggings and suits. Ear plugs should be worn when sparks or hot spatter may get in the ears.

Since welders work with highly toxic materials, lockers should be provided so that work clothes are stored separately from street clothes. Work clothes should be laundered by the employer. Showers and locker rooms should be provided so that workers can change into clean clothes at the end of the work shift.

**Hearing protection** (ear plugs or ear muffs) should be used during noisy operations such as air arcing and grinding.

**Respirators** must be specific to the hazard and fitted, cleaned, stored and maintained in accordance with OSHA's respirator standard. In addition, workers must receive training on how to use respirators properly. The National Institute for Occupational Safety and Health (NIOSH) recommends that respirators be worn whenever a carcinogen (cancer-causing agent) is present at any detectable concentration, or if any other conditions are present that might be immediately



dangerous to life or health. A self-contained breathing apparatus should be worn when welding in confined spaces because welding may reduce the oxygen concentration in the air.

### **Air Monitoring**

Routine air monitoring should be conducted to determine the levels of hazardous materials and noise in the welding area.

### **Medical Monitoring**

Because welding emissions are so hazardous, NIOSH recommends that all workers who may be exposed to welding processes receive medical exams at least annually. The doctor should examine your lungs, skin and eyes, heart, and hearing, in addition to any other tests that are appropriate.

### **Training**

All welders should receive training on the safe use of equipment and processes, safe work practices and emergency procedures.

### **The Law**

OSHA has standards that cover many aspects of welding work, including welding safety, welding in confined spaces, handling of compressed gases, fire and electrical safety, ventilation, protective equipment and worker training. The following is a brief summary of some of the regulations that can apply to welders. **INSIST ON SAFE WORKING CONDITIONS BEFORE YOU WELD!**

### **Workplace Exposure Limits**

There is no OSHA standard for total welding smoke, but OSHA does set standards for individual components of welding smoke. Local exhaust or general ventilation must be provided to keep your exposure to toxic fumes, gases, or dusts below the OSHA permissible exposure limit.

However, NIOSH has concluded that welders can be harmed by welding smoke even when the concentrations of the individual components are well below OSHA permissible exposure limits. NIOSH recommends that welding emissions be reduced to the lowest feasible concentrations using state-of-the-art engineering controls and work practices

### **Labels and Other Information**

Under OSHA's Hazard Communication Standard (29 CFR 1910.1200, also known as the "Right to Know Law"), all containers of filler metal, electrodes, and flux materials should carry warning labels alerting the welder that welding produces hazardous fumes and gases. Base metals that contain, or are coated with, toxic materials (such as paints, lead, or mercury) should also be clearly labeled. Welding materials that contain carcinogens (cancer-causing agents) must carry a warning label stating that gases from the material may cause cancer.

The employer must also keep Material Safety Data Sheets (MSDSs) for all hazardous materials, and make this information readily available to all exposed workers. The MSDS must contain information on chemical ingredients, hazardous decomposition products from welding, safe handling procedures, protective measures, first aid procedures and health effects of the welding material.

## Signs

OSHA's standard for signs and tags (29 CFR 1910.145) requires that signs be used to warn workers of hazards that may lead to accidental injury. Signs should be posted in welding areas to warn workers of exposure hazards, and serve as a reminder for the need for protective equipment. Signs should also notify all workers in the area that eye injury may occur from looking at the welding arc.

## OSHA's Welding Standard

Specific requirements for assuring the safety of welding, cutting, and brazing operations are covered under OSHA Standard 29 CFR 1910.252. Below are some selected requirements of the standard:

- Compressed gas cylinders must be kept away from radiators and other heat sources and stored upright in a well-ventilated, dry location at least 20 feet from highly combustible materials such as oil. Cylinders should be kept away from elevators, stairs, or other spaces where they can be knocked over or damaged.
- Piping systems must be tested and proved gastight at 1 1/2 times the maximum operating pressure, and shall be thoroughly purged with air before being placed in service. Service piping systems must be protected by pressure relief devices.
- Hoses showing leaks, burns, worn places, or other defects must be repaired or replaced.
- Cutters and welders must be suitably trained in the safe operation of their equipment and the safe use of the process.
- The welder should be enclosed in an individual booth, or by non-combustible screens, that are painted with a finish of low reflectivity such as zinc oxide or lamp black (to absorb ultraviolet radiation). People next to the welding area must be protected by noncombustible or flameproof screens or be required to wear appropriate goggles. The booths or screens should permit circulation of air at the floor level.
- All movable fire hazards in the vicinity of welding operations must be taken to a safe place. If all the fire hazards cannot be moved, guards must be used to contain the heat, sparks, and slag.
- Suitable fire extinguishing equipment must be maintained and ready for instant use.
- Fire watchers are required whenever welding or cutting is performed in a location where other than a minor fire might develop. A fire watch must be maintained for at least 1/2 hour after completion of welding or cutting operations to detect and extinguish possible smoldering fires.
- No welding, cutting, or other hot work shall be performed on used drums, barrels, tanks, or other containers until they have been thoroughly cleaned (a purge with an inert gas is also recommended).
- Eye protection with the proper shade number must be used during all arc welding or arc cutting operations, gas welding, oxygen cutting, resistance welding, or brazing operations.
- When a welder must enter a confined space through a manhole or other small opening,

an attendant with a pre-planned rescue procedure must be stationed outside to observe the welder at all times and to put the rescue operation into effect, if necessary.

- Special ventilation and/or respirators are required in confined spaces, for cleaning compounds, when fluorine compounds, zinc, lead, beryllium, cadmium, and mercury are encountered, and when cutting stainless steel.
- Warning labels are required for all filler metals, brazing filler metals containing cadmium, and fluxes containing fluorine compounds (fluorides).

## **New Welding Technologies**

New technologies in welding, such as the use of laser welding and electron beam welding, bring new hazards to the welder's environment. Special precautions must be taken when using these welding methods.

### **Laser Welding**

Laser welding uses a focused beam of light to achieve very precise welds. The major hazard of this powerful beam is to the eyes, which can be partially blinded when hit with the beam. Special eye protection must be used, and care must be taken with any reflective surfaces since both the original and reflected beam are extremely dangerous.

### **Electronic Beam Welding**

Electronic beam welding uses a focused beam of electrons to produce high precision and deep penetration welds. Since x-rays are produced as a by-product, the process should be enclosed and shielded with lead or other materials suitable for preventing x-ray exposure. All doors, ports, and other openings must have proper seals and should be checked periodically to prevent x-ray leakage.

Operators should wear film badges to detect accidental radiation exposure. The high voltages required also present an electrical hazard.

### **Robot Welders**

Many industries are beginning to use robot welders in place of workers on the assembly line. This removes workers from the hazard, but focuses on job elimination rather than workplace improvements. In addition, workers can be injured by industrial welding robots.

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For more information about protecting workers from workplace hazards, please contact the AFSCME Research & Collective Bargaining Department, Health and Safety Program at (202) 429-1215. You can also contact our office located at 1625 L Street, NW Washington, DC 20036.