

# Welding



**Workplace  
Program**



## DISCLAIMER

This Welding Workplace Program is a guide to help employers develop a safety plan to comply with the requirements of the Occupational Safety and Health Administration (OSHA). It contains helpful information and the basic elements to build a safety and health program. It is not meant to supersede OSHA requirements. Employers should review the OSHA standard for each specific worksite and customize the program accordingly.

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# INTRODUCTION



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Welding, cutting, and brazing are hazardous activities that pose a unique combination of safety and health risks to employees in many industries. Protecting employees when performing welding operations depends on understanding the hazards involved and the proper way to control them. Control of welding hazards includes avoiding eye injury, using respiratory protection, ventilating the work area, wearing protective clothing, and having safe equipment to use.

## Welding

Welding is a method for joining pieces of metal using heat, pressure, or both. There are more than 80 different types of welding and associated processes. Some of the most common types of welding include 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 oxyacetylene gas, electrical current, lasers, electron beams, friction, ultrasonic sound, chemical reactions, heat from fuel gas, and robots.

## Cutting

Cutting involves heating the metal with a flame and directing a stream of pure oxygen along the cut.

## Brazing or Soldering

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

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# 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 or the filler material
- coatings and paints on the metal or the electrode;
- shielding gases supplied from cylinders;
- chemical reactions that are the result of the action of ultraviolet light from the arc and heat;
- process and consumables used; and
- contaminants in the air, such as vapors from cleaners and degreasers.

The health effects of welding exposures vary widely because the fumes may contain many different substances that are known to be harmful, depending on the factors listed above. The individual components of welding smoke can affect many body parts, including lungs, heart, kidneys, and the 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- and long-term health effects

### Short-Term 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 4-12 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 fumes, such as cadmium, can be fatal in a short time. Secondary gases given off by the welding process can also be hazardous. For example, ultraviolet radiation given off by welding reacts with oxygen and nitrogen in the air to form ozone and nitrogen oxides. These gases can irritate the nose and throat and may cause serious lung disease. Some are deadly at high doses.
- Ultraviolet rays given off by welding can also react with chlorinated hydrocarbon solvents to form phosgene gas. Even a minimal amount of phosgene may be deadly. Early symptoms of exposure, such as dizziness, chills, and cough, usually take five or six hours to appear. Never perform arc welding within 200 feet of degreasing equipment or solvents.

## Long-Term Health Effects

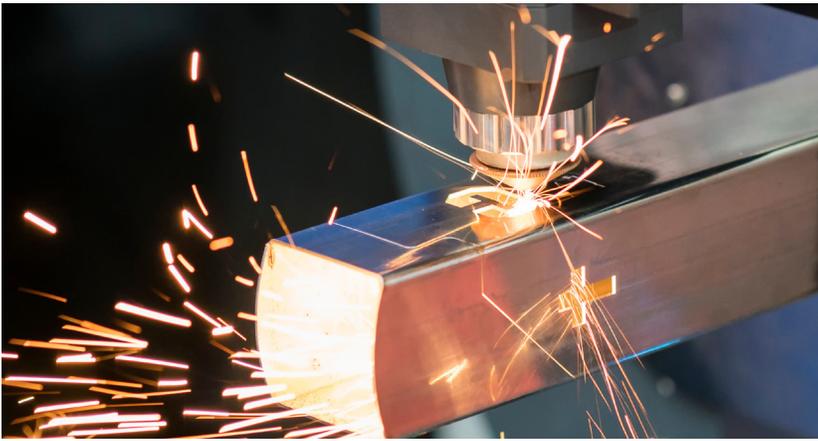
- Studies have shown that welders have an increased risk of lung cancer, and possibly cancer of the larynx (voice box) and urinary tract. These findings are not surprising given the large number of toxic substances in welding smoke, including cancer-causing agents, such as cadmium, nickel, beryllium, chromium, and arsenic.
- Welders may also experience a variety of chronic respiratory problems, including bronchitis, asthma, pneumonia, emphysema, pneumoconiosis referring 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, 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. Studies have shown that welding has had adverse effects on sperm quality, conception, and pregnancies among welders or their spouses. Possible causes include exposure to metals, such as aluminum, chromium, nickel, cadmium, iron, manganese, and copper; gases, such as nitrous gases and ozone; heat; and 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 protective equipment before welding near asbestos-containing material.

## Heat

- The intense heat of welding and sparks can cause burns. Contact with hot slag, metal chips, sparks, and hot electrodes can cause burns and eye injuries.
- Excessive exposure to heat can result in heat stress or heat stroke. Welders should be aware of symptoms, such as fatigue, dizziness, loss of appetite, nausea, abdominal pain, and irritability. Ventilation, shielding, rest breaks, and drinking plenty of cool water help protect workers against heat-related hazards.

## Light: Visible, 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 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 ultraviolet 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 material and burn nearby co-workers. About half of welding flash injuries involve 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 a sunburn and increase the welder’s risk of skin cancer.



## Laser & Electron Beams

- Laser welding uses a focused beam of light to achieve precise welds. The actual or reflected beam can cause blindness if it hits the eyes.
- Electron beam welding uses a focused beam of electrons to produce high-precision and deep-penetration welds, creating X-rays as a by-product. Long-term exposure to X-rays could cause cancer, and short-term exposure to high levels can cause radiation sickness (symptoms include nausea, weakness, hair loss, skin burns, or diminished organ function). The high voltages necessary also present an electrical hazard.

## 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 can make workers tired, nervous, and irritable.
- The Occupational Safety and Health Administration (OSHA) Noise Standard, 29 Code of Federal Regulations (CFR) 1910.95, requires your employer to test for noise levels to determine employee exposure. If average noise exposure exceeds 85 decibels for more than eight hours, employers must provide employees with a choice of free hearing protection or annual hearing tests.

## Musculoskeletal Injuries

Welders have a high prevalence of musculoskeletal complaints, including back injuries, shoulder pain, tendonitis, reduced muscle strength, carpal tunnel syndrome, vibration white finger (a form of Raynaud's syndrome), 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 following these proper techniques:

- do not work in one position for long periods;
- keep the work at a comfortable height;
- use a footrest when standing for long periods;
- store tools and materials in easily accessible locations; and
- minimize vibration.



# Safety Hazards of Welding

## Electrical Hazards

Even though welding generally uses low voltage, there is still a danger of electric shock. Environmental conditions, such as wet or cramped spaces, may increase the likelihood of a shock. 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 receiving the weld and all electrically-powered machine frames 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, wet gloves, or while standing on wet floors or grounded surfaces.

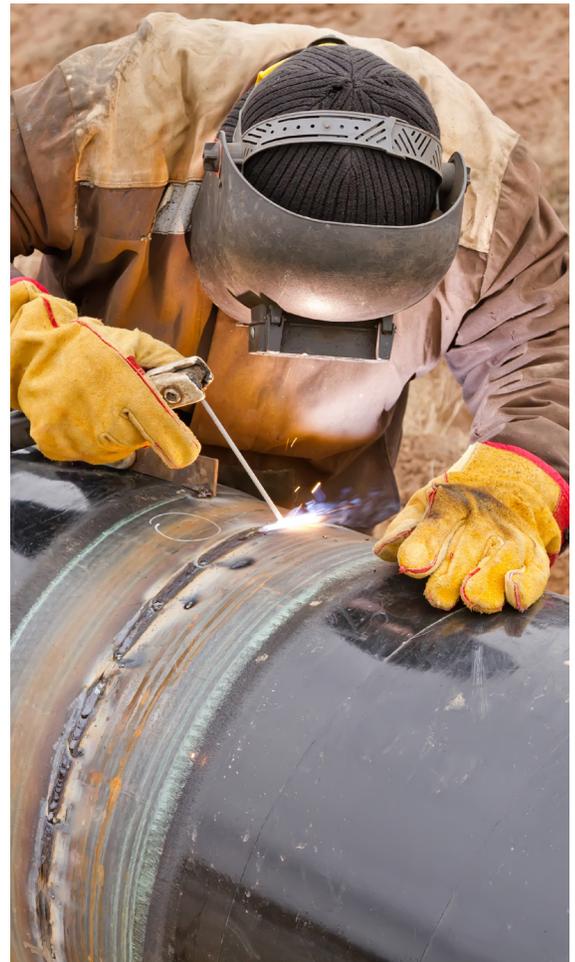
## Fires and Explosions

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

Perform welding or cutting only in areas free of combustible materials, such as trash, wood, paper, textiles, plastics, chemicals, flammable dusts, liquids, and gases. (Vapors can travel several hundred feet.) Cover those that cannot be removed with a tightfitting, flame-resistant material. Doorways, windows, cracks, and other openings should be covered.

Never attempt to weld 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. Assume containers with unknown contents are flammable or combustible.

Perform a fire inspection before leaving the work area and within 30 minutes after the operation completion. Fire extinguishers should be nearby.



## Dangerous Machinery

All machines in the area with moving parts must be guarded to prevent employees' hair, fingers, and clothing from getting caught.

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

# Confined Spaces

Welding in any small or crowded area with limited access and little or no airflow or ventilation is dangerous. 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 explosive. The following rules apply:



- Train all employees who may enter dangerous areas either regularly or in an emergency in rescue procedures, self-contained breathing apparatuses, safety equipment, and proper procedures for entering and exiting a confined space
- Equip the employee inside the confined space with a safety harness, a lifeline, and appropriate personal protective clothing, including a self-contained breathing apparatus. (Never use an air-purifying respirator.)
- Locate gas cylinders and welding power sources in a secure position outside of the confined space
- Station a trained monitor equipped with a fire extinguisher and personal protective equipment outside the confined space to assist or rescue the employee inside the confined space if necessary. If the monitor notices any indication of intoxication or decreased alertness from the employee inside

the confined space, the employee should be removed from the area immediately.

- Test all confined spaces before entering for toxic, flammable, or explosive gases or vapors, and oxygen level. Continuous air monitoring may be necessary during welding. No employee should enter a confined space where the percentage of oxygen is below 19.5 percent unless equipped with a supplied-air respirator.
- Never use oxygen for ventilation.
- Use continuous mechanical ventilation and a respirator whenever welding or performing 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 accidentally restart.
- Remove all unnecessary torches and other gas- or oxygen-supplied equipment from the confined space

# 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, or propane) supplied to the torch are stored in high-pressure cylinders.

The use of compressed-gas cylinders poses 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) burn or explode easily. Follow these rules when using compressed gases:



- Ensure all cylinders have caps or regulators.
  - Fit cylinders with pressure regulators designed for the gas in use.
  - Check all compressed gas cylinders, pressure relief valves, and lines before and during welding operations.
  - Keep blowpipes in good condition and cleaned at regular intervals.
  - Keep hoses and fittings in good condition and checked regularly.
  - Store cylinders upright.
  - Store oxygen and fuel cylinders separately,
- Shut off the blowpipe valves if a backfire occurs. Backfires usually occur because of defective or incorrectly operated equipment. Shut off the oxygen valve first, then the fuel gas cylinder valves. Cool the blowpipe with water and check the equipment, particularly the nozzle, for damage. To prevent flashbacks, use the correct lighting-up procedure. Ensure the blowpipe is fitted with spring-loaded, non-return valves to prevent a backflow of gas into the hoses. Use the correct gas pressure and nozzle size for the job and maintain the equipment in good condition.
  - 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 Welding Hazards

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

Ask for safety data sheets (SDSs) to identify the hazardous materials used in welding and cutting products, and the fumes these products generate. Employees should know what they are welding before they begin. Some fumes, such as those released from welding a cadmium-plated surface, can be fatal in a short time.

After identifying the hazard(s), implement appropriate control methods.

## Engineering Controls and Work Practices

Use less-hazardous materials, such as cadmium-free silver solders and asbestos-free electrodes, gloves, and hot pads.

Use ventilation to remove harmful fumes and gases. Local exhaust ventilation, which removes the fumes and gases at the source, is the most effective method. A partial enclosure, such as a ventilated workbench or hood positioned close to the weld point can provide adequate ventilation. Clean and maintain ventilation systems regularly. General ventilation uses roof vents, open doors, open windows, roof fans, or floor fans to move air through the work area. This method is not as effective as local exhaust ventilation and may spread chemicals around the workplace. General ventilation is often helpful, however, when used to supplement local ventilation.

Use an extracting gun as local exhaust for gas-shielded arc welding processes, which can reduce worker exposure to welding emissions by 70 percent.

Use hoods and ductwork 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.

Paint welding booths with a dull finish that does not reflect ultraviolet light, such as finishes that contain titanium dioxide or zinc oxide.

Use acoustic shields between the worker and the noise source to reduce noise levels. Alternatively, enclose the machinery or process.

Eliminate the hazards by modifying the process and following safe work practices:

- Remove all surface coatings before welding, if possible. Do not weld painted or coated parts.
- Use a water table under the plasma arc cutting to reduce fumes 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 maintained properly; for example, replace worn insulation and hoses.
- Welding areas should be kept free of equipment and machines that could cause trips or falls.
- You can 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.

All electron beam welding processes 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.

## Personal Protective Equipment (PPE)

PPE 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. Use special eye protection when laser welding and take precautions with any reflective surfaces. The original and reflected beams are hazardous

Welding helmets, goggles, or other eye protectors must contain special filter plates or lenses for employees exposed to arc welding or cutting processes, and to oxyfuel gas welding, brazing, or cutting. OSHA 29 CFR 1910, Subpart Q, requires that workers performing welding and cutting operations are protected with filter lenses or plates.

Use protective clothing made of flame-resistant wool or specially-treated cotton fabrics. Keep sleeves and collars buttoned and pants and shirts uncuffed. Capes and hard hats may also be required. Use welding helmets with appropriate filter lenses, not hand-held screens. When welding overhead, use extra protection, such as fire resistant shoulder covers, aprons, head covers, leggings, and suits. Wear earplugs when sparks or hot spatter may get in the ears.

Because welders work with highly toxic materials, provide lockers to store work clothes separately from street clothes.

Use hearing protectors such as earplugs or earmuffs during noisy operations, such as air arcing and grinding.

Respirators must be specific to the hazard and fitted, cleaned, stored, and maintained per OSHA's respirator standard. Also, workers must receive training in how to use respirators properly. The National Institute for Occupational Safety and Health (NIOSH) recommends welders wear respirators whenever a cancer-causing agent is present at any detectable concentration, or if any conditions might present an immediate danger to life or health. Wear a self-contained breathing apparatus when welding in confined spaces, because welding may reduce the oxygen concentration in the air.



## Protective Clothing

Protective clothing that should be worn during welding (by welders and nearby workers) includes:

- fire-resistant gauntlet gloves
- high-top, hard-toed shoes;
- leather apron;
- face shield;
- flame-retardant coveralls
- safety glasses;
- helmets; and
- leggings or high boots.

## Air Monitoring

Routine air monitoring should be conducted to determine the levels of hazardous materials and noise in the welding area. It is essential to reduce everyone's exposure to welding fumes, gases, and welding dust. Ambient air quality monitoring equipment includes gas detectors and portable instruments that monitor ambient air in the workplace to help detect the presence of toxic vapors and gases.

## Medical Monitoring

NIOSH recommends that all workers exposed to welding processes receive medical exams at least once a year, because of the hazards associated with welding. A doctor should examine the lungs, skin, eyes, heart, and hearing, and conduct any additional appropriate tests.



## Training

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



# OSHA Requirements

OSHA standards cover many aspects of welding, including welding safety, welding in confined spaces, handling of compressed gases, fire and electrical safety, ventilation, protective equipment, and employee training. Insist on safe working conditions before welding.

## 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 employee exposure to toxic fumes, gases, or dusts below the OSHA's 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's permissible exposure limits. NIOSH recommends reducing welding emissions to the lowest feasible concentrations using state-of-the-art engineering controls and work practices.

## Labels and Other Information

Under 29 CFR 1910.252 (c)(1)(iv)(A), all containers of filler metal, electrodes, and flux materials should carry warning labels alerting the welder that welding produces hazardous fumes and gases. Clearly label base metals coated in or containing toxic materials such as paints, lead, or mercury. Welding materials that contain cancer-causing agents must carry a warning label stating that gases from the material may cause cancer.

The employer must also keep SDSs for all hazardous materials, and make this information readily available to all exposed workers. The SDS 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 the use of signs to warn employees of hazards that may lead to accidental injury. Post signs in welding areas to warn employees of exposure hazards and serve as a reminder of the need for protective equipment. Signs should also notify all employees in the area that eye injury may occur from looking at the welding arc.

## Welding, Cutting, and Brazing Requirements

OSHA regulation 29 CFR 1910.252 covers specific requirements for assuring the safety of welding, cutting, and brazing operations. Below are some selected requirements of the standard:

- Keep compressed gas cylinders 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. Keep cylinders away from elevators, stairs, or other spaces where they can be knocked over or damaged.
  - Test piping systems to ensure each is gastight at 1.5 times the maximum operating pressure. Thoroughly purge with air before placing the piping system into service. Protect service piping systems with pressure-relief devices.
  - Repair or replace hoses showing leaks, burns, worn places, or other defects.
  - Train cutters and welders in the safe operation of their equipment and the process.
  - Enclose the welder in an individual booth or in non-combustible screens painted with a finish of low reflectivity, such as zinc oxide or lamp black, to absorb ultraviolet radiation.
- (continued)



- Protect bystanders by surrounding the weld area with noncombustible or flameproof screens, or require other people to wear appropriate goggles. The booths or screens should permit circulation of air at the floor level to ensure proper ventilation.
- Take all movable fire hazards in the vicinity of welding operations to a safe place. If unable to move all the fire hazards, guards must be used to contain the heat, sparks, and slag.
- Maintain suitable fire-extinguishing equipment and keep it ready for instant use.
- Require fire watchers whenever performing welding or cutting in a location where a fire might develop. Maintain a fire watch for at least 30 minutes after completion of welding or cutting operations to detect and extinguish possible smoldering fires
- Prohibit welding, cutting, or other hot work on used drums, barrels, tanks, or other containers until thoroughly cleaned. A purge with an inert gas is also recommended.
- Use eye protection during all arc welding, arc cutting, gas welding, oxygen cutting, resistance welding, or brazing operations. The proper shade number should be selected.
- Station an observer with a pre-planned rescue procedure outside a confined space when a welder must enter a manhole or other small opening.
- Require special ventilation or respirators in confined spaces when cleaning fluorine zinc, lead, beryllium, cadmium, and mercury compounds, and when cutting stainless steel.
- Require warning labels for all filler metals and fluxes containin fluorine compounds (fluorides