Welding, Cutting, and Brazing Safety

OSHAcademy
Occupational Safety & Health Training

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OSHAcademy Course 745 Study Guide

Welding, Cutting, and Brazing Safety

This study guide is designed to be reviewed off-line as a tool for preparation to successfully complete OSHAcademy Course 745.

Read each module, answer the quiz questions, and submit the quiz questions online through the course webpage. You can print the post-quiz response screen which will contain the correct answers to the questions.

The final exam will consist of questions developed from the course content and module quizzes.

We hope you enjoy the course and if you have any questions, feel free to email or call:

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Revised: March 31, 2017

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Course Introduction

Welding, cutting, and brazing are hazardous activities which pose a unique combination of both chemical and physical hazards to more than 560,000 workers in a wide variety of industries. The risk from fatal injuries alone is more than four deaths per thousand workers throughout a working lifetime.

There are numerous health hazards associated with exposure to fumes, gases, and ionizing radiation generated during welding, cutting, and brazing. These hazards include heavy metal poisoning, lung cancer, metal fume fever, flash burns, and many others. The risks associated with these hazards vary depending upon the type of welding materials and welding surfaces.

Real-Life Accident

In 2008, a welder installed a flow regulator on a cylinder of carbon dioxide, which was the shielding gas for the metal inert gas (MIG) welder he was using to prevent exposure of the molten weld pool to oxygen, nitrogen and hydrogen contained in the air atmosphere. The welder felt a shock from the MIG welder and asked a coworker to see if he could feel it. The coworker refused and went back to his work area. Shortly thereafter, the coworker heard a yell from the welder and saw him holding the ground clamp in one hand and the electrode holder in the other hand. Another coworker unplugged the welder. Once the MIG welder was unplugged, the welder fell to the floor. A co-worker performed CPR on the welder until rescue personnel arrived. The welder was transported by ambulance to Buchanan County General Hospital, where he was pronounced dead from electrocution.

This course introduces the student to the hazards and safety precautions related to welding, cutting, brazing, and soldering. The course discusses general welding operations, applicable OSHA standards, and suggestions for protecting welders and coworkers from exposures to the many hazards inherent in those operations.

The course discusses the various types of welding operations, as well as exposure to thermal and chemical hazards and precautions including the personal protective equipment required to mitigate those hazards.

Module 1: The Basics

In order to discuss the various aspects of welding, cutting and brazing safety, first we need to cover the basics in this first module. So let us get started.

Welding, Cutting, and Brazing

Welding is a process that joins materials together by melting a metal work piece along with a filler metal to form a strong joint. Heat metal parts to a temperature that is high enough to join the metal parts by coalescence.

Coalescence

Coalescence occurs when two metals seem to pull together, or grow into one body, of the base metal parts when there is the slightest contact. There are two basic requirements for coalescence: heat and intimacy of contact.

Heat: Welding processes differ depending on the source of heat, the manner in which heat is applied or generated, and the intensity of the heat. The fuel used as a heat force may be:

- acetylene or hydrogen in air or in oxygen;
- an electric arc;
- an electric, gas, or oil furnace;
- the resistance of metal to the flow of electric current; or
- a chemical reaction between a metal oxide and finely divided aluminum.

The intensity of heat applied or generated at the joint varies according to the metals being joined and to the welding process being used. All welding processes, except brazing, use temperatures high enough to melt the base metals.

Intimacy of contact

In the second basic requirement for coalescence, intimacy of contact, you can divide the welding processes into two groups: pressure processes and non-pressure processes.

- **Pressure Processes:** In pressure processes, there should not be any space between the surfaces being joined. Welders apply pressure while the contact surfaces are at a high enough temperature to allow plastic flow of the metal.
- **Non-pressure processes:** In non-pressure processes, leave space between the joined surfaces. Fill this space, either progressively or all at once, with molten metal. The molten metal may be produced by:
  - a filler metal (welding rod or electrode),
  - melting the surfaces to be joined, or
  - combining a filler metal and melted base metal.

Brazing

Brazing is a welding process using nonferrous filler alloys that do not contain iron or steel and have a melting point above 840°F but below that of the base metal. Brazing is also called 'hard soldering' or 'silver soldering.' Brazing is the only welding process in which the melting of the base metal is not necessary for coalescence. Click here for more information on brazing alloys.

Soldering

Soldering is a joining process using non-ferrous filler alloys. Soft soldering uses alloys that melt between 190 to 840°F and is used in electronics, plumbing, and joining sheet metal parts. Soldering is not considered a welding process. Lead and tin are common alloys used in soldering, but there is also less common lead-free solder to decrease environmental impacts.

Weldability

The term WELDABILITY, or joinability, means:

- the ability of metal to be welded into a structure that will perform its purpose satisfactorily, and
- the degree of simplicity of the procedures used to produce welds with properties that are equal to or better than the properties of the base material.

Many factors influence the weldability of metal, including:

- the chemical composition of the metals involved;
- the effect of radical temperature changes on the various elements;
- the expansion and contraction characteristics of the base metals;
- the filler metal (welding rod or electrode);
- the joint design; and
- the welding procedure.

Filler Materials and Flux

The metals added during the welding process are known as filler materials or filler metals. In welding processes in which space is left between the parts to be joined, filler metals provide the intimacy of contact necessary for coalescence. Filler materials used in welding processes include welding rods and electrodes.

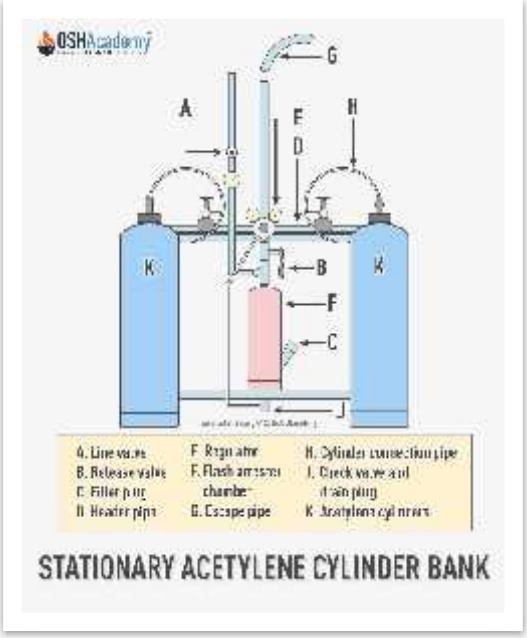
Welding Rods: The term welding rod refers to a filler metal, in wire or rod form, used in gas welding and brazing processes and in certain electric welding processes (tungsten inert gas) in which the filler metal is not a part of the electric circuit. A welding rod serves only one purpose—it supplies filler metal to the joint.

As a rule, rods are uncoated except for a thin film resulting from the manufacturing process. Welding rods for steel are often copper-coated to protect them from corrosion during storage. Most rods are furnished in 36-inch lengths and a wide variety of diameters, ranging from 1/32 to 3/8 inch. Rods for welding cast iron vary from 12 to 24 inches in length and are frequently square rather than round in cross section. The rod diameter selected for a given job is governed by the thickness of the metals being joined.

Electrodes: In electric welding, electrodes form a part of the electrical circuit. In gas tungsten arc welding, electrodes melt off and are a source of the filler metal supply.

- **Solid Electrodes-** These electrodes are consumable (composed of steel, copper, aluminum, various alloys, and other metals) or non-consumable (primarily tungsten). They produce less fumes, compared with flux-cored wire or coated electrodes.

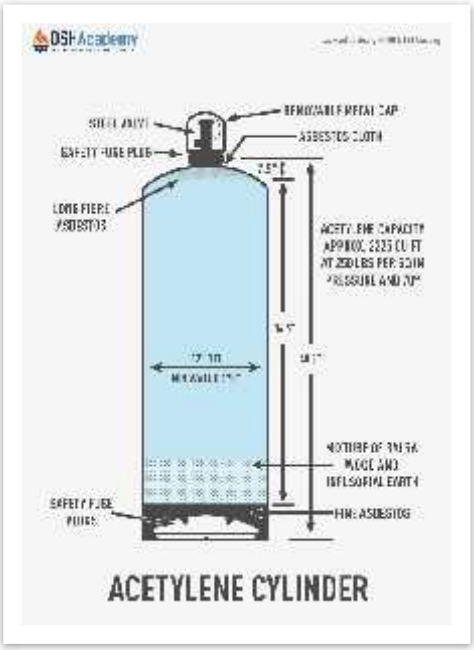
- **Covered and Coated Electrodes-** These are the largest group of electrodes used in welding. The covering provides the flux from the weld. Major metals from the coatings include fluoride, nickel, iron, chromium, manganese, copper, and molybdenum.



Fluxes: Welding or brazing certain materials requires the use of flux to produce a sound joint. Fluxes are available as liquids, pastes, and powders. They have a melting point below that of the base and filler metals, and they are not incorporated into the weld. Their primary purpose is to prevent the formation of oxides on the weld joint before and during welding operations. Fluxes should never be used as a substitute for proper cleaning.

Observe the following precautions when you are working with fluxes.

- Unless the base metal is properly cleaned and the correct flux applied to the joint, fluxing will hinder rather than aid in making the joint.
- Flux should not be overheated, or it will fail to serve its purpose.
- Fluxes will also deteriorate if they are kept at brazing temperatures for too long.
- Fluxes should always be used in a well-ventilated space.



Oxyacetylene Cylinders

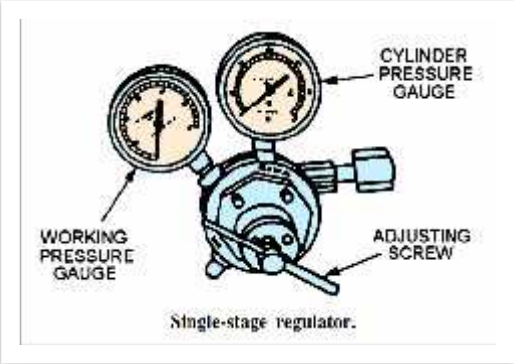
Oxyacetylene equipment consists of a cylinder of acetylene, a cylinder of oxygen, two regulators, two lengths of hose with fittings, a welding torch with tips, and either a cutting attachment or a separate cutting torch.

Accessories include a friction igniter to light the torch, an apparatus wrench to fit the various connections on the regulators, the cylinders, and the torches; goggles with

filter lenses for eye protection; and gloves for protection of the hands. Flame-resistant clothing is worn when necessary.

Regulators

Reduce the gas pressure in a cylinder to a suitable working pressure before it can be used. This is done by a regulator or reducing valve. Regulators are either the single-stage or the double-stage type:



Single-stage regulator.

- Single- stage regulators reduce the pressure of the gas in one step;
- two-stage regulators do the same job in two steps or stages. Less adjustment is generally necessary when two-stage regulators are used.

Acetylene regulators and oxygen regulators are of the same general type, although those designed for acetylene are not made to withstand such high pressures as are those designed for use with oxygen cylinders.

Welding Torches

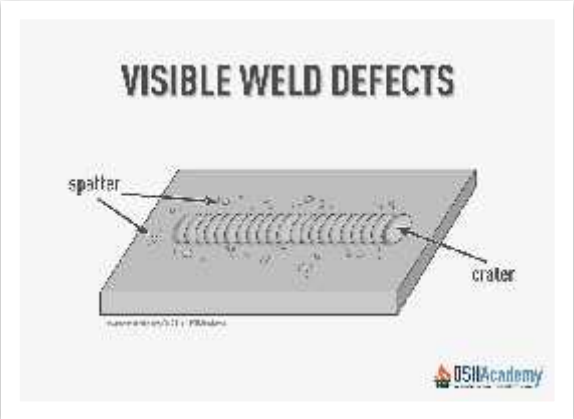
The oxyacetylene welding torch is used to mix oxygen and acetylene gas in the proper proportions and to control the volume of these gases burned at the welding tip. Torches have two needle valves, one for adjusting the flow of oxygen and the other for adjusting the flow of acetylene. They have a handle (body), two tubes (one for oxygen and one for acetylene), a mixing head, and a tip. Welding tips are made from a special copper alloy, which dissipates heat (less than 60 percent copper), and are available in different sizes to handle a wide range of plate thicknesses.

Hoses

Hoses used to make the connection between a torch and a regulator are strong, nonporous, and flexible and light enough to make torch movements easy. It is made to withstand high internal pressures, and the rubber used in its manufacture is specially treated to remove sulfur to avoid the danger of spontaneous combustion.

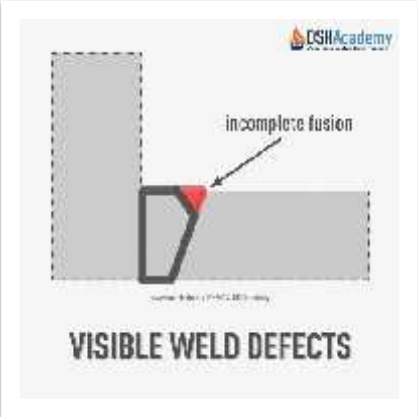
The hoses used for acetylene and oxygen are the same in grade, but they differ in color and have different types of threads on the hose fittings. The oxygen hose is GREEN, and the acetylene hose is RED. For added protection against mixing of the hoses during connection, the oxygen hose has right-hand threads and the acetylene hose has left-hand threads. The acetylene fittings also have a notch that goes around the circumference of the fittings for an additional identification factor.

Welding Defects

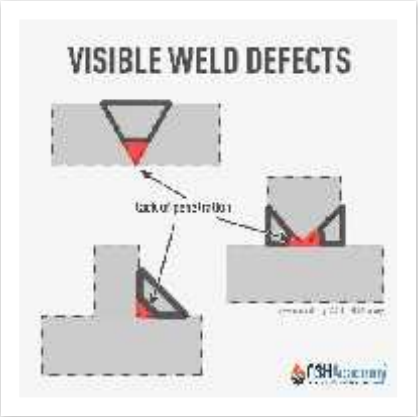


Common weld defects that you should be familiar with to ensure your safety include:

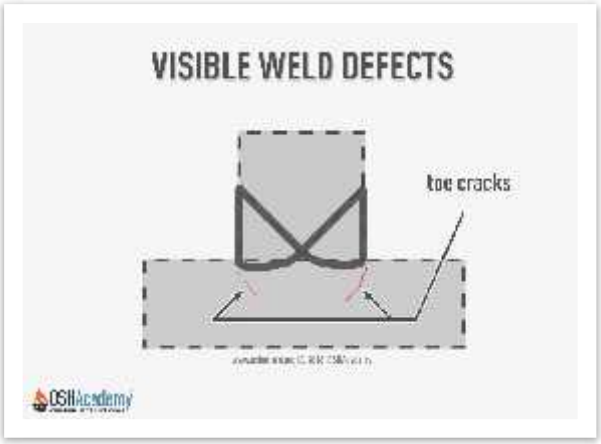
- **Incomplete fusion**: Incomplete fusion occurs when the weld fails to fuse one side of the joint in the root.
- **Inadequate joint and root penetration:** Inadequate joint and root penetration is cause for rejection of a weld even if it is sound in all other respects. The strength required in a weldment is achieved only when the specified joint and root penetration is achieved.

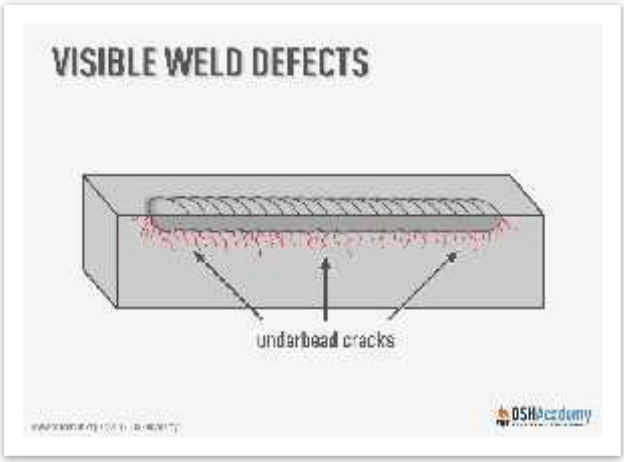


- **Spatter:** Spatter is the term used to describe metal particles or globules expelled during welding and that do not form part of the weld. When spatter occurs, small balls of metal are stuck to the surface of the base metal along the line of weld.
- **Overlap:** Overlap is a protrusion of the weld metal beyond the bond at the toe of the weld.
- **Undercut:** An undercut is a groove melted into the base metal adjacent to the toe and not filled with weld metal.
- **Root cracks:** Root cracks are similar to toe cracks except that they occur at the root of the weld. Root cracks may be in the weld metal or in the base metal.



- **Toe cracks:** Toe cracks occur in the base metal, at the toe of the weld.
- **Crater cracks:** One common kind of crack is the crater crack. This occurs in the crater or depression at the termination of a weld bead in gas or arc welding.
- **Underbead cracks:** Underbead cracks occur in the heat-affected zone underneath a bead and do not extend to the surface of the metal.
- **Voids:** Voids, also called gas pockets or blow holes, occur as the result of gas being absorbed during the welding and then trapped as the metal solidifies.
- **Inclusions:** Slag inclusion is the term used to describe the weld defect in which non-metallic solid material is trapped in the weld metal or at the bond between the weld metal and the base metal.





Module 1 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

1. **Which of the following occurs when two metals seem to pull together, or grow into one body, of the base metal parts when there is the slightest contact?**

    a. Melding
    b. Coalescence
    c. Phosphorescence
    d. Penetration

2. **Which of the following is the only welding process in which the melting of the base metal is not necessary for coalescence?**

    a. Welding
    b. Cutting
    c. Brazing
    d. Molding

3. **Oxyacetylene equipment has two hoses: the oxygen hose is _____and the acetylene hose is _____.**

    a. blue, orange
    b. orange, blue
    c. red, green
    d. green, red

4. **Which of the following is <u>NOT</u> one of the possible defects during welding?**

    a. Voids
    b. Melts
    c. Overlaps and undercuts
    d. Cracks

5. _____ is the term used to describe metal particles or globules that are expelled during welding and that do not form part of the weld?

a. Fission
b. Incomplete fusion
c. Spatter
d. Root penetration

Module 2: Welding Processes and Hazards

Protecting yourself when performing welding operations depends on your understanding of the hazards involved and the proper way to control them. Controlling welding hazards includes avoiding eye injury, respiratory protection, ventilation of the work area, protective clothing, and having safe equipment to use.

Gas Welding

Oxy-acetylene Welding/Cutting: Oxy-acetylene welding or cutting is also called torch or gas welding or cutting. Two metals are joined by melting or fusing their adjoining surfaces in the process. This is done by directing a flame from burning gas (usually acetylene) to melt metal at a joint to be welded, and is a common method for welding iron, steel, cast iron, and copper.

Since gas welding is slower and easier to control than electric arc welding, it is commonly used in general maintenance work, brazing, and soldering.

- **Equipment:** Oxyacetylene equipment consists of a cylinder of acetylene, a cylinder of oxygen, two regulators, two lengths of hose with fittings, a welding torch with tips, and either a cutting attachment or a separate cutting torch. Accessories include a friction igniter to light the torch, an apparatus wrench to fit the various connections on the regulators, the cylinders, and the torches; goggles with filter lenses for eye protection; and gloves for protection of the hands. Flame-resistant clothing is worn when necessary.
- **Acetylene:** Acetylene (chemical formula C2H2) is a fuel gas made up of carbon and hydrogen. When burned with oxygen, acetylene produces a very hot flame, having a temperature between 5700°F and 6300°F. Acetylene gas is colorless, but has a distinct, easily recognized odor.
- **MAPP Gas:** MAPP (methylacetylene-propadiene) gas is an all-purpose industrial fuel that has the high flame temperature of acetylene and the handling characteristics of propane.
    - MAPP is not sensitive to shock and nonflammable in the absence of oxygen. There is no chance of an explosion if a cylinder is burnped, jarred, or dropped. The cylinders may be stored or transported in any position with no danger of an explosive air pocket being formed.
    - MAPP toxicity is rated “very slight,” but high concentrations (5,000 ppm) may have an anesthetic effect. Local eye or skin contact with MAPP gas vapor causes

no adverse effect. However, the liquid fuel will cause dangerous frostlike burns due to the temperature at which MAPP gas should be stored.

- **Oxygen:** Oxygen is a colorless, tasteless, odorless gas that is slightly heavier than air. Oxygen will not burn by itself, but it will support combustion when combined with other gases.
    - Take extreme care to ensure compressed oxygen does not become contaminated with hydrogen or hydrocarbon gases or liquids.
    - A highly explosive mixture will be formed if uncontrolled compressed oxygen becomes contaminated. Oxygen should NEVER come in contact with oil or grease.
    - Oxygen cylinders are supplied in several sizes. The size most commonly used 9 1/8 inches in diameter, weighs about 145 pounds, and has a capacity of 200 cubic feet. At 70°F, the gas is under a pressure of 1800 psi.

Arc Welding and Cutting

Arc welding is the process in which fusion is produced by heating with an electric arc that is generated between an electrode and the surface of the base metal.

Arc cutting is the process in which the cutting or removal of metals is done by melting with the heat of an arc between an electrode and base metal.

Arc welding and cutting types include:

- **Flux Core Arc Welding (FCAW)** is an arc welding process where coalescence is produced by heating with an arc between a continuous filler metal electrode and the work.
- **Submerged Arc Welding (SAW)** also known as Sub Arc and automatic welding. This is an arc welding process which produces coalescence by heating with an arc or arcs between a bare metal electrode or electrodes and the work.
- **Shielded Metal Arc (SMAW)** is an arc welding process which produces coalescence by heating with an electric arc between a covered metal electrode and the surface of the base metal.

- **Gas Metal Arc (GMAW or MIG):** This is also called stick welding. This is an arc welding process wherein coalescence is produced by heating with an arc between a continuous filler metal electrode (typically a steel alloy wire) and the work.

- **Gas Tungsten Arc/Tungsten Inert Gas Welding (GTAW or TIG)**, also called Heli-arc welding, is an arc welding process wherein coalescence is produced by heating with an arc between a single tungsten electrode and the work.

- **Plasma Arc Welding**, also called plasma welding, is an arc welding process similar to gas tungsten arc welding (GTAW). The electric arc is formed between an electrode (which is usually but not always made of sintered tungsten) and the workpiece.

- **Plasmas Arc Cutting:** This is also called plasma cutting. The metal is cut by melting a localized area with a constricted arc and removing the molten material with a high-velocity jet of hot, ionized gas in this process.

- **Carbon Arc Cutting:** This is also called Arc Gouging and Air-arcing.

For more information on arc welding, read Safe Arc Welding by Lincoln Electric.

Other Welding Processes

Thermite welding: Thermite welding uses a chemical reaction to produce intense heat instead of using gas fuel or electric current.

Pressure welding: Pressure welding uses heat along with impact-type pressure to join the pieces.

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 beams is extremely dangerous.

Electron Beam Welding: This method 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 Welding: Many industries are beginning to use robot welders in place of human workers on the assembly line. This removes workers from the hazard but focuses on job elimination rather than workplace improvements.

Real-Life Accident

Worker Burned When Acetylene Leak Ignites

In 2013, an employee was prepping steel using a grinder. He was working by himself on the first level of an oil rig platform sub-base. Another Fitter/Welder was working on the second level of the platform, while the crew supervisor was working on the second level of the platform. The worker was using a grinder and was standing inside a recessed box, where the oxygen acetylene torch hoses were also present. A leak from the acetylene hose provided the fuel source and a spark from the grinder provided the ignition source for a flash fire to occur. This fire resulted in serious burns to his legs and feet. He was admitted to the hospital for ten days for burn injuries. The investigation concluded thefire occurred due to a defective splice on the acetylene hose that allowed the acetylene to leak, causing a fire and the serious injury.

Welding Hazards and Precautions

Safe procedures and practices must always be when working around or with arc welding equipment to avoid being injured.

Avoid the following hazards in arc welding:

- radiation from the arc, in the form of ultraviolet and infrared rays
- flying sparks and globules of molten metal
- electric shock
- metal fumes
- burns

Radiation: Radiation from the arc is hazardous to the eyes. Eyes should be protected from radiation from the arc by use of an arc welding helmet or face shield with approved lenses.

- Cover the face, hands, arms, and other skin surfaces to prevent exposure to the radiation.
- Gloves should be worn and other parts of the body covered by clothing of sufficient weight to shut out the rays of the arc.
- Without proper clothing, burns comparable to sunburn will result.

Arc Flash: When possible, shield arc-welding operations so no one may accidentally look directly at the arc or have it shine or reflect into his or her eyes.

- An arc “flash” may cause a person to be temporarily blinded.
- The severity of an arc flash and the time it will take to recover varies with the length of time a person was exposed to the arc.
- Long exposure has been known to cause permanent damage to the retina of the eye.
- If someone is severely “flashed,” medical personnel should provide special treatment at once.

Electric shock: Avoid the possibility of dangerous electric shock by using insulated electrode holders and wearing dry leathers and gloves.

- When possible, avoid using arc-welding equipment in wet or damp areas.
- Never perform arc-welding in an area that is not well ventilated.

Flying sparks and molten metal: Flying sparks usually accompany arc welding. These present a hazard if they strike unprotected skin, lodge on flammable clothing, or hit any other flammable material.

- When arc welding, wear suitable weight clothing and cuff less trousers.
- Cover pockets so they will not collect sparks, and remove any flammable materials, such as matches, plastic combs, or gas lighters.
- Wear the proper foot protection. Wear high top boots with steel toes.

Hot metal and burns: Hot metal will cause severe burns. Never handle it with bare hands until it has cooled naturally or has been quenched in the quenching tank. Therefore, use leather gloves with tight fitting cuffs that fit over the sleeves of the jacket. Many welders wear a full set of leathers that consists of the following:

- jacket or set of sleeves
- gauntlet gloves
- leggings
- spats
- apron
- welders hat liner

In gas welding, the high temperatures of the welding flame and the sparks will burn skin. Gas welding can also cause radiation burns due to infrared rays emitted by the red-hot material. Wear flame-resistant or flame-retardant clothing and the hair protected at all times.

Real-Life Scenario

Welder's Hand Burnt by Weld Spark

In 2011, an employee was tasked to pin weld the inside insulation of the metal duct and wipe the surface with a propanol solution for shipment. The employee noticed that one pin weld of the duct failed. He decided to replace the defective pin. When he drove a new weld, the sparks from the weld ignited the residue of the propanol on his glove. His right hand caught fire and caused second-degree burns.

Gases and fumes: Fluxes used in certain welding and brazing processes produce vapors that are irritating to the eyes, nose, throat, and lungs. Welding fumes and gases generally come from the following sources:

- base material being welded or the filler material used
- coatings and paints on the metal or electrode coatings;
- shielding gases supplied from cylinders;
- chemical reactions due to ultraviolet light of the arc and heat; and
- contaminants in the air from cleaners and degreasers.

Perform welding in a well-ventilated area and always wear approved safety goggles. Here are a few options:

- The darkest shade of the goggles that still show a clear outline of the work without producing eyestrain is recommended.
- Sunglasses are not adequate.

Module 2 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

1. **Which of the following is slower and easier to control, and most commonly used in general maintenance work?**

    a. electric arc welding
    b. gas welding
    c. laser welding
    d. thermite welding

2. **_____ is the process in which fusion is produced by heating with an electric arc that is generated between an electrode and the surface of the base metal.**

    a. Arc flashing
    b. Arc cutting
    c. Arc welding
    d. Arc soldering

3. **_____ uses a chemical reaction to produce intense heat instead of using gas fuel or electric current.**

    a. Arc welding
    b. Oxy-acetylene welding
    c. Tungsten welding
    d. Thermite welding

4. **When welding, what can cause permanent damage to the retina of the eye?**

    a. reflected light from the arc
    b. looking directly at the arc
    c. periodic exposure to flux
    d. cracks in the weld causing flashes

5. Many welders wear a full set of leathers that consists of all of the following, EXCEPT:

a. gauntlets
b. helmet
c. spats
d. apron

Module 3: Welding Best Practices and Precautions

Importance of Welding Location

The first consideration for safety in welding is the location and peculiarities of the space in which the welding operation is to be performed.

Weld or cut only in locations specifically designated for this purpose unless you have obtained approval of the job and have taken the necessary precautions to eliminate fire and explosion hazards.

Do not weld in any location outside the shop unless you take the necessary precautions and get authorization. Before you weld in any compartment, room, tank, or adjacent space which contains or which has contained flammable or explosive materials, liquids, or vapors, make sure they are:

- made safe,
- tested, and
- proclaimed safe.

These restrictions also apply to closed drums, tanks, and similar containers.

Restrictions

Allow welding or cutting only in areas that are or have been made “fire safe.”

- When you cannot move work practically, as in most construction work, the area must be made safe by removing combustibles or protecting combustibles from ignition sources.
- If you cannot remove fire hazards, install suitable guards, or take special precautions as discussed below, then welding and cutting should not be performed.
- If you cannot move the object to be welded or cut and if not all the fire hazards can be removed, use guards to confine the heat, sparks, and slag, and to protect the immovable fire hazards.

Prohibited Areas

Do not permit welding or cutting in the following situations:

- in areas not authorized by management
- in sprinklered buildings while such protection is impaired
- in the presence of explosive atmospheres (mixtures of flammable gases, vapors, liquids, or dust with air)
- inside uncleaned or improperly prepared tanks or equipment which have previously contained such explosive atmospheres or have the potential for explosive atmospheres
- in areas with an accumulation of combustible dust
- in areas near the storage of large quantities of exposed, readily ignitable materials such as bulk sulfur, baled paper, or cotton

Fire Prevention and Protection

Eliminate fire and explosion hazards by removing or reducing combustible or explosive materials or vapors by preventing them from accumulating. The methods for making a space safe for welding and the tests used to ensure a space is free of fire and explosion hazards should be the responsibility of a welding supervisor.

Special Precautions for Fire Prevention

Combustible material: Wherever there are floor openings or cracks in the flooring that you cannot close, you should take precautions so no readily combustible materials on the floor below is exposed to sparks that might drop through the floor. Use the same precautions for cracks or holes in walls, open doorways and open or broken windows.

Combustible covers: Never weld on a metal partition, wall, ceiling or roof having a combustible covering nor on walls or partitions of combustible sandwich-type panel construction.

Relocation of combustibles: If possible, relocate all combustibles at least 35 feet (10.7 m) from the work site. When relocation is not possible:

- protect combustibles with flame-proofed covers, or

- shield combustibles with metal or asbestos guards or curtains.

Floors: Where combustible materials such as paper clippings, wood shavings, or textile fibers are on the floor, sweep the floor clean within a radius of 35 feet (10.7 m). In addition:

- If floors are combustible, keep them wet, covered with damp sand, or protected by fire-resistant shields.
- Protect workers operating arc welding or cutting equipment from shock where floors have been wet down.

Ducts: Protect or shut down ducts and conveyor systems that might carry sparks to distant combustibles.

Combustible walls: Where cutting or welding is done near walls, partitions, ceiling or roof of combustible construction, provide fire-resistant shields or guards to prevent ignition.

Non-combustible walls: If you need to do welding on a metal wall, partition, ceiling or roof, prevent ignition of combustibles on the other side, preferably by relocating combustibles. Where you do are not able to relocate the combustibles, be sure to provide a fire watch on the opposite side from the work.

Pipes: Do not cut or weld on pipes or other metal in contact with combustible walls, partitions, ceilings or roofs if the work is close enough to cause ignition by conduction.

Fire extinguishers: Position suitable fire extinguishing equipment and maintain it in a state of readiness for instant use. Depending on the nature and quantity of the combustible material, fire-extinguishing equipment may consist of:

- pails of water,
- buckets of sand,
- hoses, or
- portable extinguishers.

Hot Work

Hot work is any work that involves burning, welding, using fire- or spark-producing tools or that produces a source of ignition. Follow these general best practices below for hot work.

- Do not perform hot work where flammable vapors or combustible materials exist.
- Relocate work and equipment outside of the hazardous areas, when possible.
- Make suitable fire-extinguishing equipment immediately available in a state or readiness. The equipment may consist of pails of water, buckets of sand, hose, or portable extinguishers dependent upon the nature and quantity of the combustible material exposed.
- When performing hot work, assign a fire watch to guard.

Fire Watch: A worker designated at the "Fire Watch" is required whenever welding or cutting is performed in locations where other than a minor fire might develop, or any of the following conditions exist:

- Appreciable combustible material, in building construction or contents, closer than 35 feet (10.7 m) to the point of operation.
- Appreciable combustibles are more than 35 feet (10.7 m) away but are easily ignited by sparks.
- Wall or floor openings within a 35-foot (10.7 m) radius expose combustible material in adjacent areas including concealed spaces in walls or floors.
- Combustible materials are adjacent to the opposite side of metal partitions, walls, ceilings, or roofs and are likely to be ignited by conduction or radiation.

Fire Watch Duties: The duties of a qualified fire watch include:

- They must have fire-extinguishing equipment readily available.

- Train them in how to use fire-extinguishing equipment.
- They must be familiar with facilities for sounding an alarm in the event of fire.
- They must watch for fires in all exposed areas, try to extinguish them only when obviously within the capacity of the equipment available, or otherwise sound the alarm.
- They must maintain a fire watch for at least a half hour after completion of welding or cutting operations to detect and extinguish possible smoldering fires.

Welding or Cutting Containers

Used containers: Do not weld, cut, or perform other hot work on used drums, barrels, tanks or other containers until you clean them.

- Clean them so thoroughly to make absolutely certain there are no flammable materials present or any substances such as greases, tars, acids, or other materials which when subjected to heat, might produce flammable or toxic vapors.
- Disconnect or blanket any pipelines or connections to the drum or vessel.

Venting and purging: Vent all hollow spaces, cavities or containers to permit air or gases to escapte before preheating, cutting or welding. You should purge with inert gas.

Module 3 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

1. **The first consideration for safety in welding is the _____.**

    a. length and duration of the welding process
    b. location and peculiarities of the space where welding is performed
    c. temperature and humidity of the immediate environment
    d. approval of OSHA and local regulatory agencies

2. **Welding or cutting should be permitted only in areas that are or have been made _____.**

    a. explosion proof
    b. hazard free
    c. fire safe
    d. OSHA approved

3. **Welding should not be accomplished inside uncleaned or improperly prepared tanks or equipment which have previously contained _____.**

    a. temperature extremes
    b. Oxy-acetylene equipment
    c. used welding materials
    d. explosive atmospheres

4. **Which of the following is defined as any work that involves burning, welding, using fire- or spark-producing tools, or that produces a source of ignition?**

    a. Permit work
    b. Hot work
    c. Restricted processes
    d. Approved processes

5. **What is required when appreciable combustible material is closer than 35 feet (10.7 m) to the point of the welding operation?**

    a. Fire watch
    b. Fire monitor
    c. Safety watch
    d. Safety monitor

Module 4: Operating Equipment Safely

Safety precautions when operating welding equipment vary considerably because of the different types of equipment involved. Consequently, this course discusses only general precautions pertaining to gas welding and to metal-arc welding. You can find more precautions in the technical manuals furnished by the manufacturers of the equipment.

Operating Gas Welding Equipment

Follow these precautions for when operating gas welding equipment:

- Use only approved apparatus that has been examined and tested for safety.
- Stow all cylinders carefully according to prescribed stowage procedures.
    - Stow cylinders in dry, well-ventilated, well-protected places, away from heat and combustible materials.
    - Do NOT stow oxygen cylinders in the same compartment as acetylene or other fuel gas cylinders.
    - Stow cylinders in an upright position rather than horizontally.
    - If acetylene cylinders are stowed in a non-upright position (valves at the top), do not use them until they have been allowed to stand in an upright position for at least 2 hours.
- Do not allow anyone to tamper with cylinder safety devices.
- When cylinders are in use, keep them far enough away from the actual welding or cutting so they will not be reached by sparks, hot slag, or flame.
- Never place a cylinder in such a position that it could form part of an electrical circuit.
- Never interchange hoses, regulators, or other apparatus intended for oxygen with those intended for acetylene.
- Never attempt to:
    - transfer acetylene from one cylinder to another,
    - refill an acetylene cylinder, or

- mix any other gas with acetylene.

- Keep the valves closed on empty cylinders.
- Do not stand in front of cylinder valves while opening them.
- When a special wrench is required to open a cylinder valve, leave the wrench in position on the valve stem while using the cylinder so you are able to close the valve quickly in an emergency.
- Keep oxygen cylinders and fittings away from oil and grease. Even a small amount of oil or grease may ignite violently, with explosive force, in the presence of oxygen.
- NEVER lubricate any part of an oxygen cylinder, valve, or fitting.
- Do not drop cylinders. Do not handle them roughly. Rough handling may cause a cylinder valve to break off, and the sudden release of gas from a full cylinder may cause it to take off like a rocket.
- Always open cylinder valves slowly. (Do not open the acetylene cylinder valve more than 1 1/2 turns.)
- Close cylinder valves before moving cylinders.
- Never attempt to force unmatching or crossed threads on valve outlets, hose couplings, or torch valve inlets. The threads on oxygen regulator outlets, hose couplings, and torch valve inlets are right-handed; for acetylene, these threads are left-handed. The threads on acetylene cylinder valve outlets are right-handed but have a pitch that is different from the pitch of the threads on the oxygen cylinder valve outlets. If the threads do not match, the connections are mixed.
- Always use the correct tip or nozzle and the correct pressure for the particular work involved. You can get this information from tables or worksheets supplied with the equipment.
- Do not allow acetylene or acetylene and oxygen to accumulate in confined spaces. Such mixtures are highly explosive.
- Keep a clear space between the cylinders and the work so you can reach the cylinder valves quickly and easily if necessary.

- Open the acetylene valve first and ignite the gas while the closed oxygen valve when lighting the torch.
- Do not allow unburned acetylene to escape and accumulate in small or closed compartments.
- Close the acetylene valve first and then close the oxygen valve when extinguishing the torch.
- Secure the equipment when stopping the welding or cutting for a period of 15 minutes or more, or when the operator leaves the area.

Backfire and Flashback

Unless the system is thoroughly purged of air and all connections in the system are tight before the torch is ignited, the flame is likely to burn inside the torch instead of outside the tip. The difference between the two terms backfire and flashback is this:

- **Backfire**: In a backfire, there is a momentary burning back of the flame into the torch tip. A backfire is characterized by a loud snap or pop as the flame goes out. A backfire is less serious. Usually you can lit the flame again without difficulty. If backfiring continues whenever the torch is lit, check for these causes:
    - overheated tip,
    - gas working pressures greater than that recommended for the tip size being used,
    - loose tip, or
    - dirt on the torch tip seat.
- **Flashback:** In a flashback, the flame burns in or beyond the torch mixing chamber. A hissing or squealing sound usually accompanies a flashback. At the same time, the flame at the tip becomes smoky and sharp pointed. A flashback can have the same causes as a backfire. It may also indicate improper handling or something radically wrong either with the torch, such as a distorted or cracked torch head. When a flashback occurs, immediately shut off the torch oxygen valve and then close the acetylene valve. You can stop the flashback at once if you close the oxygen valve immediately.

In most instances, backfires and flashbacks result from carelessness. You can avoid these difficulties by making certain that:

- all connections in the system are clean and tight;
- torch valves are closed (not open or merely loosely closed) when the equipment is stowed;
- the oxygen and acetylene working pressures used are those recommended for the torch employed; and
- the system is purged of air before the apparatus is used.

Purging the system of air is especially necessary when you incorporate the newly connected hose and torch, or a new cylinder, into the system.

Operating Arc Welding Equipment

Precautions for the operation of metal-arc welding equipment include the following:

- Use only approved welding equipment, and be sure that it is in good condition.
- Before starting to work, make sure that:
  - the welding machine frame is grounded and attached firmly to the work, not merely laid loosely upon it,
  - neither terminal of the welding generator is bonded to the frame, and
  - all electrical connections are securely made.
- Lay primary supply cable separately from portable machine cables to prevent entanglement.
- De-energize the equipment when stopping work for any appreciable length of time.
- Completely disconnect the equipment from the source of power when it is not in use.
- Keep welding cables dry and free of oil or grease, in good condition, and protected from damage.
- If it is necessary to carry cables some distance from the machines, run the cables overhead, if possible. Make sure you use adequate supporting devices.

Real-Life Accident

In 2008, an employee was on an aerial lift, welding connections on beams at a building under construction. He was holding the 220V welding feeder in his right hand and removing slag with his left hand using a metal scraper. As the feeder in his right hand was feeding wire out of the tip, it curled toward his arm and contacted his jacket, which was saturated with water and sweat. The worker then received an electric shock. He was found unconscious with his arm on fire. The employee was hospitalized for treatment.

GTA and GMA Welding Safety Precautions

Gas tungsten arc (GTA) welding, is also called tungsten inert gas (TIG) welding, and gas metal arc (GMA) welding. In addition to the safety precautions listed in the previous section, following these general precautions:

- Properly ventilate the welding area without excessive drafts that can affect the welding arc and shielding gas.
- Do NOT use carbon tetrachloride or other chlorinated hydrocarbons for cleaning aluminum before welding. OSHA recommends using alcohol and acetone as chemical cleaners. Make sure to thoroughly dry the cleaned surfaces with these materials before welding. You should not perform welding in any area where fumes from solvents are present.
- DO NOT work on any wiring in an energized circuit.
- The surface where welding is being done should be dry.
- Welding transformers or rectifiers should have a power ground so that welders cannot get a shock from stray current. The AC transformer used for GTA welding or the dc generator rectifier for GMA welding is normally fed from a 220- to 440-volt circuit. These voltages can cause severe or fatal injuries.
- Do not lay the torch on the work or worktable. Hang it up in a safe place so the electrode is not touching metal that may be grounded.

- Do not change a tungsten electrode before it has cooled or while the transformer switch is in the “on” position.
- Do not change spools of filler wire while the generator or rectifier is on.
- Do not use defective welding cable. If any of the connections is operating hot, you may have a poor electrical connection.
- Use a welding helmet when looking at the arc. Use the correct shade of lens, usually No. 10 for GTA and No. 12 for GMA. If your eyes become irritated, see the doctor immediately. If not treated promptly, the irritation caused by burning rays of the arc becomes very painful and feels like hot sand in the eyes. The doctor will give you eye drops that will relieve unnecessary suffering.
- Wear suitable clothing to protect yourself from the spatter or molten particles and to shield your body from rays of the arc.
- Do not strike an arc on a compressed gas cylinder.
- Mark metal “HOT” because aluminum does not change color when heated.
- Do not chip or grind without safety goggles and a suitable face shield.
- Do not move individual cylinders unless the valve protection cap, where provided, is in place and tight.
- Do not drop or abuse cylinders in any way.
- Make sure you fastened cylinders properly in their stations so they will not fall.
- Do not use a hammer or wrench to open cylinder valves.
- Never force connections that do not fit.
- Never tamper with cylinder safety devices.
- Always protect hose and welding cable from being trampled or run over. Avoid tangles and kinks. Do not leave the hose and cable so they can trip people.

- Protect the hose, cable, and cylinders from flying sparks, hot metal, hot objects, and open flame.
- Do not expose a hose to oil or grease; these rot the rubber and cause a hazard.
- Be sure the connections between the regulators, adaptors, and cylinder valves are gas tight. Test them with soapy water under gas pressure.
- If you need to stop welding for an extended length of time, release the pressure-adjusting screws of the regulators.
- If you need to stop welding for a longer time, close the cylinder valves and then release all gas pressure from the regulators and hose.
- Prior to taking down equipment, close the cylinder valves, make certain all gas pressures are released from the regulators and hose, and make sure the pressure-adjusting screws are turned in the counterclockwise direction.
- Use flat black paint on bulkheads and overhead of weld areas to reduce ultraviolet light reflected from GTA or GMA welding areas.

Module 4 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

1. **Never interchange hoses, regulators, or other apparatus intended for _____ with those intended for _____.**

    a. electric arc, gas
    b. oxygen, acetylene
    c. flux, rods
    d. welding, cutting

2. **When lighting the torch, open the _____ valve first and ignite the gas while the _____ valve is still closed.**

    a. oxygen, acetylene
    b. nitrogen, oxygen
    c. acetylene, oxygen
    d. nitrogen, acetylene

3. **When a flashback occurs, immediately shut off the torch _____ valve, then close the _____ valve.**

    a. cylinder, regulator
    b. regulator, mixing
    c. acetylene, oxygen
    d. oxygen, acetylene

4. **Which of the following is recommended as chemical cleaners for surfaces before welding?**

    a. carbon tetrachloride
    b. alcohol, acetone
    c. chlorinated hydrocarbons
    d. acetylene, organic cleaners

5. All of the following are appropriate safety precautions when welding, EXCEPT:

a. You may use a hammer or wrench to open cylinder valves.
b. Never tamper with cylinder safety devices.
c. Do not strike an arc on a compressed gas cylinder.
d. Do not lay the torch on the work or worktable.

Module 5: Cutting, Brazing, and Soldering

Cutting Hazards and Precautions

Another part of the welder's job involves cutting operations such as oxyacetylene cutting and plasma arc cutting. Observe these safety precautions when performing any cutting operation:

- Never place hands or fingers between the metal plate and the bed.
- Never place hands under the hold-downs or knife.
- Ensure all personnel is clear from the piece being cut.
- Support the plate to avoid injuries to workers if the cut end of the metal falls away.
- When using oxyacetylene cutting equipment, ensure that the work area is gas-free. This is particularly important when working in bilges and other spaces where dangerous vapors may collect.
- Always post a fire watch to protect the surrounding areas and personnel. The high-pressure oxygen stream used in cutting with an oxyacetylene torch can throw molten metal for a distance of 50 to 60 feet.
- When using oxyacetylene cutting equipment, remove and tag out any interfering systems, if necessary.
- Install all covers, insulators, and handles before attempting to operate the plasma arc cutting equipment.
- When using plasma arc cutting equipment, open all primary disconnect switches before charging any electrical connections.

Brazing and Soldering Hazards and Precautions

Cadmium and beryllium: Brazing and soldering with or on alloys containing cadmium or beryllium can be extremely hazardous because the fumes are extremely toxic and can cause death.

- Always avoid skin contact with cadmium and beryllium.
- Consult an expert in industrial hygiene whenever using cadmium or beryllium compounds or when performing repairs on parts containing the metals.

Fluoride compounds: Fluxes containing fluoride compounds are also toxic. Good ventilation is essential when soldering or brazing and the operator should always observe good safety practices.

Exposure: A common hazard when soldering is exposure of the skin, eyes, and clothing to acid fluxes. Be sure to observe these safety precautions when brazing or soldering:

- Always work in a way that flux will not be spilled on the skin or clothing.
- Always wear chemical splash-proof goggles, rubber gloves, and long sleeves when using cleaning solutions, pickling solutions, or acids.
- If you are exposed to any chemical solutions, acids, or fluxes, wash the affected area at once, and seek medical attention immediately.
- Remove or keep away all flammable material from the heating flames. Remember, heating soldering copper sometimes presents a fire hazard if an open flame is used.
- When performing hot work, make sure there are no flammable vapors present, such as gasoline, acetylene, or other flammable gases.
- Do NOT start a job until you have taken all safety precautions and the fire marshal notified, if applicable.

Wounds

A wound is another problem that could be the result of an electrical shock. Welders could accidentally suffer an electrical shock, which could cause a loss of balance. This could result in a minor or serious injury. Because workplace injuries can occur, you should know the basics of first aid.

Wounds are classified according to their general condition, size, location, how the skin or tissue is broken, and the agent that caused the wound.

Burns: The causes of burns are generally classified as thermal, electrical, chemical, or radiation. Whatever the cause, shock always results if the burns are extensive. The four types of common burns experienced by welders include:

- **Thermal burns** are caused by exposure to intense heat, such as that generated by fire, bomb flash, sunlight, hot liquids, hot solids, and hot gases. Their care depends upon the severity of the burn and the percentage of the body area involved.
- **Electrical burns:** Electric current passing through tissues or the superficial wound caused by electrical flash causes electrical burns. They may be far more serious than they first appear. The entrance wound may be small; but as electricity penetrates the skin, it burns a large area below the surface. Usually there are two external burn areas: one where the current enters the body and another where it leaves.
- **Chemical burns** are generally not caused by heat, but by the direct chemical destruction of body tissues. When acids, alkalis, or other chemicals come in contact with the skin or other body membranes, they can cause injuries generally referred to as chemical burns. The extremities, mouth, and eyes are the areas that are most often affected. Alkali burns are usually more serious than acid burns because they penetrate longer. When chemical burns occur, carry out emergency measures immediately. Do not wait for the arrival of medical personnel.
- **Radiation burns** are the result of prolonged exposure to the ultraviolet radiation. First- and second-degree burns may develop. Treatment is essentially the same as that for thermal burns.

Module 5 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

1. **The high-pressure oxygen stream used in cutting with an oxyacetylene torch can throw molten metal for a distance of _____.**

    a. six inches
    b. 50-60 feet
    c. 12-24 inches
    d. 10-20 feet

2. **Brazing and soldering with or on alloys containing _____ or _____ can be extremely hazardous because the fumes are extremely toxic and can cause death.**

    a. oxygen, cadmium
    b. nitrogen, oxygen
    c. cadmium, beryllium
    d. beryllium, acetylene

3. **Which of the following is a common hazard when soldering?**

    a. burns from flying metal
    b. eye injury due to arc flash
    c. exposure to acetylene and oxygen
    d. exposure to acid fluxes

4. **What action should you take if exposed to any chemical solutions, acids, or fluxes?**

    a. pour a powder such as flour on the wound
    b. wash the affected area at once
    c. induce vomiting immediately
    d. acetylene, organic cleaners

5. **The four types of common burns experienced by welders include all of the following, EXCEPT:**

    a. abrasive burns
    b. thermal burns
    c. chemical burns
    d. radiation burns

Module 6: Ventilation Requirements

Ventilation for General Welding and Cutting

Be sure to provide adequate ventilation in all spaces in which welding is done to eliminate health hazards such as gases, fumes, and dust.

When welding or cutting on lead-bearing steels, lead-coated or cadmium-coated metals, or metal covered with paint containing lead or cadmium, you should wear an airline mask even if you are doing the work in the open air or in a well-ventilated space.

Provide mechanical ventilation welding or cutting if done on metals:

- In a space of less than 10,000 cubic feet (284 m (3)) per welder.
- In a room having a ceiling height of less than 16 feet (5 m).
- In confined spaces or where the welding space contains partitions, balconies, or other structural barriers to the extent that they significantly obstruct cross ventilation.

Minimum rates: Ventilation must be at the minimum rate of 2,000 cubic feet (57 m (3)) per minute per welder. An exception to this requirement is when approved local exhaust hoods and booths or respirators are provided. Natural ventilation is sufficient for welding or cutting operations where the restrictions above are not present.

Local exhaust hoods and booths: Mechanical local exhaust ventilation may be either of the following:

- **Hoods:** The welder should place freely movable hoods as near as possible to the welded work. These hoods should have a rate of airflow of 100 linear feet (30 m) per minute in the zone of welding when the hood farthest from the point of welding.
- **Fixed enclosure:** A fixed enclosure with a top, and not less than two sides, which surround the welding or cutting operations and with a rate of airflow sufficient to maintain a velocity away from the welder of not less than 100 linear feet (30 m) per minute.

Screens: When welding in a space entirely screened on all sides, arrange the screens so no serious restriction of ventilation exists. Mount the screens so they are about 2 feet (0.61 m) above the floor unless performing the work at so low a level that the screen is extended nearer to the floor to protect nearby workers from the glare of welding.

Ventilation in Confined Spaces

A confined space is generally defined as a restricted space such as a tank, boiler, pressure vessel, silo, or small compartment.

Air replacement: Provide adequate ventilation to all welding and cutting operations in confined spaces to prevent the accumulation of toxic materials or possible oxygen deficiency. The welder, helpers, and other personnel in the immediate vicinity must get adequate clean and respirable ventilation.

Airline respirators: Use NIOSH-approved airline respirators or hose masks when it is impossible to provide adequate ventilation.

Self-contained units: In areas immediately hazardous to life and health (IDLH), use one of the following:

- a full-facepiece, pressure-demand, self-contained breathing apparatus, or
- a combination full facepiece, pressure demand supplied-air respirator with an auxiliary, self-contained air supply approved by NIOSH.

Outside helpers: When providing welders and helpers with NIOSH-approved hose masks, either with blowers or self-contained breathing equipment, a worker must be stationed on the outside of the confined spaces to ensure the safety of those working within.

Maximum allowable concentrations: The need for local exhaust ventilation or airline respirators for welding or cutting in other than confined spaces will depend upon the individual circumstances. If air samples taken at the welding location indicate the fluorides liberated are below the maximum allowable concentration, this protection is not necessary.

Securing cylinders and machinery: Leave gas cylinders and welding machines on the outside when welding or cutting in any confined space. Securely block heavy portable mounted equipment before starting operations to prevent accidental movement.

Lifelines: If a welder must enter a confined space through a manhole or other small opening, you must provide a way to quickly removing the welder in an emergency. In this purpose, attach safety belts and lifelines to the welder so his body cannot be jammed in a small exit opening. Place an attendant with a pre-planned rescue procedure outside to observe the welder at all times and be capable of putting rescue operations into effect.

Electrode removal: When suspending arc welding for any substantial period, such as during lunch or overnight, remove all electrodes from the holders and the holders should be carefully located so accidental contact cannot occur and the machine disconnected from the power source.

Gas cylinder shutoffs: In order to eliminate the possibility of gas escaping through leaks of improperly closed valves:

- Close the torch valves. Also, completely shut off the fuel-gas and oxygen supply to the torch at some point outside the confined area.
- Remove the torch and hose from the confined space when it is practicable.

Warning signs: After completing the welding, the worker must mark the hot metal or provide some other means of warning other workers.

Torch valves: It is important to eliminate the possibility of gas escaping through leaks or improperly closed valves. If the torch will be unused for a long time (ie: overnight), close the torch valves. Shut-off the gas supply to the torch at some point outside the confined area. When necessary, remove the torch and hose from the confined space.

Hazard Communication

The following three factors in arc and gas welding govern the amount of contamination to which welders may be exposed:

- dimensions of space in which welding is to be done (with special regard to the height of the ceiling)
- number of welders
- possible evolution of hazardous fumes, gases, or dust according to the metals involved

The employer must include the potentially hazardous materials in fluxes, coatings, coverings, and filler metals used in welding and cutting in the Hazard Communication Program (HCS). The employer must also include the materials released into the atmosphere during welding and cutting in the HCS. The employer must properly train and make sure each employee has access to labels on containers of such materials and safety data sheets.

Additional considerations for hazard communication in welding, cutting, and brazing include:

- The suppliers must determine and must properly label any hazards associated with the use of their materials in welding, cutting, and brazing.
- All filler metals and fusible granular materials must carry the following notice, as a minimum, on tags, boxes, or other containers:

  > *"Do not use in areas without adequate ventilation. See ANSI Z49.1-1967 Safety in Welding, Cutting, and Allied Processes published by the American Welding Society."*

- Where brazing (welding) filler metals contain cadmium in significant amounts, the labels must indicate the hazards associated with cadmium including cancer, lung and kidney effects, and acute toxicity effects.
- Where brazing and gas welding fluxes contain fluorine compounds, the labels must indicate the hazards associated with fluorine compounds including eye and respiratory tract effects.

Oxygen for Ventilation

- Never use oxygen for ventilation.

Gases and Fumes

Welding "smoke" is composed of fine particles (fumes) and gases and can be extremely toxic. The following is a list of chemical substances that may be found in welding smoke:

- acrolein
- arsenic
- asbestos
- beryllium
- cadmium
- carbon monoxide
- chromium
- cobalt
- copper
- fluorine compounds
- lead
- manganese
- nickel
- nitrogen oxides
- ozone
- phosgene
- selenium
- silica
- zinc

Beryllium

Welding or cutting indoors, outdoors, or in confined spaces involving beryllium-containing base or filler metals must be done using local exhaust ventilation and airline respirators unless atmospheric tests under the most adverse conditions have established the workers' exposure is within the acceptable concentrations defined by 1910.1000. In all cases, protect all workers in the immediate vicinity of the welding or cutting operations with local exhaust ventilation or airline respirators.

Cadmium

In confined spaces or indoors, welding or cutting operations involving cadmium-bearing or cadmium-coated base metals should be done using local exhaust ventilation or airline respirators unless atmospheric tests under the most adverse conditions show that employee exposure is within the acceptable concentrations specified by 29 CFR 1910.1000. Welding or cutting, when done outdoors, should be done using respirators, such as fume respirators, approved for this purpose by NIOSH. Welding (brazing) involving cadmium-bearing filler metals must be done using ventilation as described in 1910.252(c)(3)or (c)(4) if the work is to be done in a confined space.

Fluorine Compounds

In confined spaces, welding or cutting involving fluxes, coverings, or other materials which contain fluorine compounds must be done in accordance with 1910.252(c)(4). A fluorine compound is one that contains fluorine, as an element in chemical combination, not as a free gas.

Indoors: Indoors, welding or cutting involving zinc-bearing base or filler metals coated with zinc-bearing materials must be done in accordance with 1910.252(c)(3).

Lead

Confined spaces: In confined spaces, welding involving lead-base metals (erroneously called lead-burning) must be done in accordance with 1910.252(c)(3).

Indoors: Indoors, welding involving lead-base metals must be done in accordance with 1910.252(c)(3).

Local ventilation: In confined spaces or indoors, welding or cutting operations involving metals containing lead, other than as an impurity, or metals coated with lead-bearing materials, including paint, should be done using local exhaust ventilation or airline respirators.

Operations performed outdoors, should use respirators approved for this purpose by NIOSH. In all cases, local exhaust ventilation or airline respirators should protect workers in the immediate vicinity of the cutting operation.

Mercury

In confined spaces or indoors, welding or cutting operations involving metals coated with mercury-bearing materials, including paint, should be done using local exhaust ventilation or airline respirators, unless atmospheric tests under the most adverse conditions show employee exposure is within the acceptable concentrations specified by 29 CFR 1910.1000. Such operations, when done outdoors, should be done using respirators approved for this purpose by NIOSH.

Zinc

Confined spaces: In confined spaces welding or cutting involving zinc-bearing base or filler metals or metals coated with zinc-bearing materials must be done in accordance with 1910.252(c)(4).

Cleaning Compounds

Manufacturer's instructions: In the use of cleaning materials, because of their possible toxicity or flammability, make sure to follow the appropriate precautions, such as manufacturer’s instructions.

Degreasing: Degreasing and other cleaning operations involving chlorinated hydrocarbons must be located so no vapors from these operations will reach or be drawn into the atmosphere surrounding any welding operation. In addition, keep trichloroethylene and perchloroethylene out of atmospheres penetrated by the ultraviolet radiation of gas-shielded welding operations.

Cutting of Stainless Steels

Use mechanical ventilation that is adequate to remove the fumes generated by oxygen cutting when using either a chemical flux or iron powder or gas-shielded arc cutting of stainless steel.

First-aid Equipment

First-aid equipment must be available at all times. Report all injuries as soon as possible for medical attention. Perform necessary first aid until medical attention is available.

Module 6 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

1. **When must mechanical ventilation be provided when welding or cutting is done on metals in a confined space?**

    a. In all confined spaces
    b. In spaces where no structural barriers exist
    c. In a room having a ceiling height of less than 8 feet (2.5 m)
    d. In a space of less than 10,000 cubic feet (284 cubic meters) per welder

2. **When welding or cutting is being performed in any confined spaces the gas cylinders and welding machines must _____.**

    a. be approved for use in a confined space
    b. be left on the outside
    c. properly grounded to the tank
    d. positioned with 10 feet of the work

3. **When welding in confined spaces, each of the following factors in arc and gas welding governs the amount of contamination to which welders may be exposed, EXCEPT:**

    a. dimensions of the space
    b. number of welders
    c. location of the work
    d. possible evolution of hazardous fumes, gases or dust

4. **Oxygen must _____ be used for ventilation.**

    a. always
    b. never

5. **When welding exposes workers to lead, zinc, mercury, and cadmium, which of the following personal protective equipment should be used?**

    a. local exhaust ventilation or airline respirators
    b. N95 dust masks
    c. contained breathing apparatus
    d. natural ventilation or fans

Module 7: Welding Personal Protective Equipment

Fall Protection

If it is necessary for a welding operator to work on platforms, scaffolds, or runways at an elevation of more than 5 feet, fall protection is required. To accomplish this, use railings, safety belts, lifelines, or some other equally effective safeguards.

Real-World Accident

In 2014, a worker was engaged in welding while positioned on a mast scaffold. He finished working in one area, unhooked his fall protection safety device, a double lanyard, and began to transit from the west end of the scaffold. According to witnesses, he tripped over the welder. He fell downward feet first, hitting the small welding platform and then an extended part of the building called a "burnpout." The area that he fell through was 14 feet long and 55 inches from the building. He then fell to the asphalt surface below, which was a fall height of 75 feet 6 inches. The worker died in the fall.

Face and Eye Protection

Helmets and Face Shields: Use helmets or face shields during all arc welding or arc cutting operations, excluding submerged arc welding. Provide proper eye protection to all helpers or attendants.

Goggles and Spectacles: Use goggles or other suitable eye protection during all gas welding or oxygen cutting operations. It is okay to use spectacles without side shields, with suitable filter lenses, during gas welding operations on light work, for torch brazing or for inspection.

All operators and attendants of resistance welding or resistance brazing equipment must use transparent face shields or goggles, depending on the particular job, to protect their faces or eyes, as required.

Eye protection in the form of suitable goggles must be provided where needed for brazing operations not covered in 1910.252 (b)(2)(i).

Specifications for Protectors

- Helmets and face shields must be made of a material that is an insulator for heat and electricity.

- Helmets, shields, and goggles must be not readily flammable and must be capable of withstanding sterilization.
- Arrange helmets and face shields to protect the face, neck and ears from direct radiant energy from the arc.
- Provide helmets with filter plates and cover plates designed for easy removal.
- Construct all parts of a material that will not readily corrode or discolor the skin.
- Ventilate goggles to prevent fogging of the lenses as much as practicable.
- Temper all glass for lenses, substantially free from striae, air bubbles, waves and other flaws.
- The front and rear surfaces of lenses and windows must be smooth and parallel, expect when a lens is ground to provide proper optical correction for defective vision.
- Lenses must bear some permanent distinctive marking which may readily identify the source and shade.

The following is a guide for the selection of the proper shade numbers. Employers can vary these recommendations to suit the individual's needs.

Welding operation	Shade No.
Shielded metal-arc welding - 1/16-, 3/32-, 1/8-, 5/32-inch electrodes	10
Gas-shielded arc welding (nonferrous) - 1/16-, 3/32-, 1/8-, 5/32-inch electrodes	11
Gas-shielded arc welding (ferrous) - 1/16-, 3/32-, 1/8-, 5/32-inch electrodes	12
Shielded metal-arc welding:	
3/16-, 7/32-, 1/4-inch electrodes	12
5/16 -, 3/8-inch electrodes	14
Atomic hydrogen welding	10-14
Carbon arc welding	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, 6 inches and over	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) 1/2 inch and over	6 or 8

NOTE: In gas welding or oxygen cutting where the torch produces a high yellow light, it is desirable to use a filter or lens that absorbs the yellow or sodium line in the visible light of the operation.

Filter lenses should meet the test for transmission of radiant energy prescribed by consensus standards.

Protection from arc welding rays: Where the work permits, enclose the welder in an individual booth painted with a finish of low reflectivity such as zinc oxide (an important factor for absorbing ultraviolet radiations) and lamp black, or must be enclosed with noncombustible screens similarly painted.

- Booths and screens must permit circulation of air at floor level.
- Protect workers or other persons adjacent to the welding areas from the rays by non-combustible or flameproof screens or shields. If this is not possible, they must be required to wear appropriate goggles.

Protective Clothing

A variety of special clothing is available to protect the body during cutting and welding operations. The protective clothing will vary with the size, location, and nature of the work performed.

During ANY welding or cutting operation, you should wear flameproof gauntlets at all times.

- For gas welding and cutting, a five-finger glove is generally used.
- For electric arc welding, a gauntlet-type mitt is recommended.
- Gauntlets protect the hands from both heat and metal spatter.
- The one-finger mitt designed for electric arc welding has an advantage over the glove because it reduces the danger of weld spatter and sparks lodging between the fingers. It also reduces the chafing of fingers, which sometimes occurs when using five-finger gloves for electric arc welding.

Choosing the proper clothing for welding and cutting is important for safety and comfort.

- Do not wear oilskins or plastic clothing during welding or cutting.
- If leather protective clothing is not available, wear woolen garments rather than cotton garments. Wool does not ignite as readily as cotton, and it affords greater protection from changes in temperature.

- Chemically treat cotton clothing, if necessary, to reduce its flammability. Do not wear synthetic fabrics.

Real-Life Accident

In 2011, a worker was operating a plasma cutter, cutting notches in a 3-inch by 6-inch (76 mm by 152 mm) steel tubing, when sparks and/or slag from the cut contacted his shirt. The shirt, labeled 100 percent cotton, caught on fire and burned at a rapid pace consistent with that of clothing made from a synthetic material. He sustained second- and third-degree burns on the side of his abdomen and to his left arm.

Light Gas Welding and Cutting

Some light gas welding and cutting jobs require no special protective clothing other than gauntlets and goggles, if you wear regular work clothing correctly. Wearing clothing in the manner described below decreases the probability that sparks will lodge in folds of cloth, such as rolled-up sleeves and cuffs, pockets, or the shirt collar.

- Roll sleeves down, button collar and cuffs. Eliminate pockets not protected by button-down flaps from the front of work clothing.
- Do not turn trouser cuffs up on the outside. All other clothing should be free of oil and grease.
- Wear high-top or safety shoes, instead of low-cut shoes with unprotected tops.

Medium and Heavy Welding

During medium and heavy welding, specially designed flameproof clothing made of leather, or other suitable material, may be required. A wide choice of protective clothing is available so you can select the type required for any particular welding or cutting job. This clothing consists of aprons, sleeves, a combination of sleeves and bib, jackets, and overalls.

Consider the following when selecting protective clothing:

- Capes and sleeves are particularly suitable for overhead welding because the cape protects the back of the neck, top of the shoulders, and upper part of the back and chest.
- Use of the bib in combination with the cape and sleeves gives added protection to the chest and abdomen in jobs where protection for the lower part of the back is not required.
- As needed, wear the jacket only when complete all-around protection for the upper part of the body, such as when several welders are working near each other.
- Aprons and overalls provide protection to the legs and, therefore, are suitable for welding operations on the floor.
- For very heavy work, wear fire-resistant leggings or high boots. Do NOT wear shoes or boots that have exposed nail heads or rivets.

Overhead Operations

During overhead welding operations, it is important to wear additional personal protective equipment (PPE) to protect against burns and falling objects.

- Wear leather caps under helmets to prevent head burns.
- Where the welder may be exposed to sharp or heavy falling objects attach hard hats or head protectors in such a way as to form a part of the welding helmet.

For more information on welding PPE, see the Personal Protective Equipment poster by Lincoln Electric.

Module 7 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

1. **If it is necessary for a welding operator to work on platforms, scaffolds, or runways at an elevation of more than _____, provisions should be made to prevent falling.**

    a. 15 feet
    b. 4 feet
    c. 10 feet
    d. 5 feet

2. **Arrange helmets and face shields to protect the _____ from direct radiant energy from the arc.**

    a. hands, head, and eyes
    b. eyes and ears
    c. face, neck, and ears
    d. face, ears

3. **When should the welder wear flameproof gauntlets?**

    a. While arc welding
    b. During any welding or cutting operation
    c. When performing gas welding and cutting
    d. As determined by Table-2 in the OSHA welding standard

4. **Which of the following provide protection to the legs and, therefore, are suitable for welding operations on the floor?**

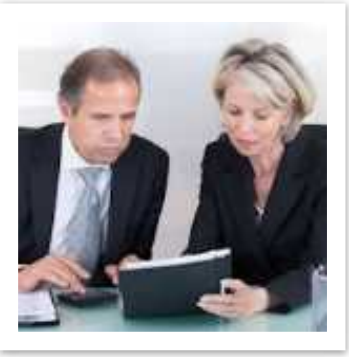
    a. aprons and overalls
    b. jackets
    c. caps and sleeves
    d. bibs and jackets

5. **If leather protective clothing is not available, what type of protective clothing should be worn because it does not catch fire as readily?**

    a. woolen
    b. cotton
    c. synthetic
    d. plastic

Module 8: Safe Welding Program

Purpose of the Program



An effective welding, cutting, and brazing program should protect workers injury or death and property from fire, atmospheric contaminants, and other hazards during operations.

Effective implementation of a safe welding program requires support from all levels of management within the company.

- All affected employees should be familiar with the elements of the program.
- The program should encompass all facilities, worksites, and projects, regardless of the size of the workforce or work schedules.
- It should establish clear policies and objectives related to welding, cutting, brazing and soldering safety.

Definitions

Approved means listed or approved by a nationally recognized testing laboratory (NRTL). For more information on the Nationally Recognized Testing Laboratory Program, see OSHA's current list of NRTLs.

Hot Work means any work that involves burning, welding, using fire or spark-producing tools, or that produces a source of ignition.

Welder and **welding operator** means any operator of electric or gas welding and cutting equipment.

Click here to view a sample Safe Welding Program – Source: WV Department of Labor

Management Responsibilities

Management should recognize its responsibility for the safe use of cutting and welding equipment on its property, as well as the following things:

- Based on fire potentials of plant facilities, establish areas for cutting and welding, and establish procedures for cutting and welding, in other areas.
- Designate an individual responsible for authorizing cutting and welding operations in areas not specifically designed for such processes.
- Insist cutters or welders and their supervisors are suitably trained in the safe operation of their equipment and the safe use of the process.
- Advise all contractors about flammable materials or hazardous conditions of which they may not be aware.

Supervisor Responsibilities

The supervisor should:

- be responsible for the safe handling of the cutting or welding equipment and the safe use of the cutting or welding process
- determine the combustible materials and hazardous areas present or likely to be present in the work location
- protect combustibles from ignition by the following:
    - Have the work moved to a location free from dangerous combustibles.
    - If you cannot move the work, have the combustibles moved to a safe distance or have the combustibles properly shielded against ignition.
    - Schedule cutting and welding at a time when plant operations that might expose combustibles to ignition are not started during cutting or welding.

- Secure authorization for the cutting or welding operations from the designated management representative.
- Ensure the cutter or welder sees conditions are safe before going ahead.
- Make sure fire protection and extinguishing equipment are properly located at the site.
- Where fire watches are required, make sure they are available at the site.

Authorization

Before permitting cutting or welding, the individual responsible for authorizing cutting and welding operations should:

- inspect the area,
- designate precautions to be followed, and
- grant authorization to proceed preferably in the form of a written permit.

Reporting Injuries

Report all injuries to the medical department as soon as possible. Treat even a slight burn or scratch promptly to prevent infection. Treat eye burns IMMEDIATELY. In addition, a medical professional should evaluate all eye burns as soon as possible.

Housekeeping

Welding cables: Welders must place welding cable and other equipment so that it is clear of passageways, ladders, and stairways.

Welding Program Audit Checklist

Use this checklist when auditing the welding program:

_____ Do you allow only authorized and trained personnel to use welding, cutting, or brazing equipment?

_____ Are compressed gas cylinders regularly examined for signs of defect, deep rusting, or leakage?

_____ Are cylinders kept away from sources of heat?

_____ Are employees prohibited from using cylinders as rollers or supports?

_____ Are empty cylinders appropriately marked, their valves closed, and valve-protection caps placed on them?

_____ Are signs posted that read “DANGER — NO SMOKING, MATCHES, OR OPEN LIGHTS,” or the equivalent?

_____ Are cylinders, cylinder valves, couplings, regulators, hoses, and apparatus kept free of oily or greasy substances?

_____ Unless secured on special trucks, are regulators removed and valve-protection caps put in place before moving cylinders?

_____ Do cylinders without fixed hand wheels have keys, handles, or nonadjustable wrenches on stem valves when in service?

_____ Are liquefied gases stored and shipped with the valve end up and with valve covers in place?

_____ Before a regulator is removed, is the valve closed and gas then released from the regulator?

_____ Is open circuit (no load) voltage of arc welding and cutting machines as low as possible and not more than the recommended limit?

_____ Are electrodes removed from holders when not in use?

_____ Are employees required to shut off the electric power to the welder when no one is using it?

_____ Is suitable fire extinguishing equipment available for immediate use?

_____ Are welders forbidden to coil or loop welding electrode cable around their bodies?

_____ Is work and electrode lead cable frequently inspected for wear and damage and replaced when needed?

_____ Do the means for connecting cable lengths have adequate insulation?

_____ When the object to be welded cannot be moved, and fire hazards cannot be removed, are shields used to confine heat, slag, and sparks?

_____ Are fire watchers assigned when welding or cutting is performed in locations where a fire might develop?

_____ When welding is done on metal walls, are precautions taken to protect combustibles on the other side?

_____ Before hot work begins, are drums, barrels, tanks, and other containers thoroughly cleaned and tested so that no substances remain that could explode, ignite, or produce toxic vapors?

_____ Do eye-protection helmets, face shields, and goggles meet appropriate standards?

_____ Do employees use appropriate PPE when exposed to the hazards of welding, cutting, or brazing operations?

_____ Do you check for adequate ventilation where welding or cutting is performed?

_____ When welders work in confined spaces is the atmosphere monitored and is there a means for their quick evacuation in an emergency?

_____ Are regulator pressure adjusting screws released when welding or cutting is stopped for an extended period of time?

Module 8 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

1. **_____ means listed or approved by a nationally recognized testing laboratory (NRTL).**

    a. Qualified
    b. Certified
    c. Authorized
    d. Approved

2. **Who designates an individual responsible for authorizing cutting and welding operations in areas not specifically designed for such processes?**

    a. Safety manager
    b. Supervisor
    c. Management
    d. Qualified welder

3. **Who should be responsible for advising all contractors about flammable materials or hazardous conditions of which they may not be aware?**

    a. Safety manager
    b. Supervisor
    c. Management
    d. Qualified welder

4. **Who is responsible for the safe handling of the cutting or welding equipment and the safe use of the cutting or welding process?**

    a. Safety manager
    b. Supervisor
    c. Management
    d. Qualified welder

5. **Before cutting or welding is permitted, the individual responsible for authorizing cutting and welding operations should do all of the following, EXCEPT _____.**

    a. get safety manager approval
    b. inspect the area
    c. designate precautions
    d. grant authorization

Module 9: Hexavalent Chromium

Hexavalent chromium (Cr(VI)) is one of the valence states of chromium and it is usually produced by an industrial process. Cr(VI) can cause cancer and it also targets the respiratory system, kidneys, liver, skin, and eyes.

OSHA 29 CFR 1910.1026 and 1926.1126, Chromium (VI) standard, establishes a Permissible Exposure Limit (PEL) for Cr(VI) of an average of 5 micrograms per cubic meter (µg/m3) over an 8-hour work shift.

Here's how Cr(VI) is used in industrial applications:

- Chromium metal is added to alloy steel to make it harder and corrosion resistant. A major source of worker exposure to Cr(VI) occurs during "hot work" such as welding on stainless steel and other alloy steels containing chromium metal.
- Cr(VI) compounds may be used as pigments in dyes, paints, inks, and plastics. It also may be used as an anticorrosive agent added to paints, primers, and other surface coatings.
- The Cr(VI) compound chromic acid is used to electroplate chromium onto metal parts to provide a decorative or protective coating.

Requirements to protect workers from Cr(VI) exposure are addressed in specific OSHA hexavalent chromium standards covering:

- general industry (1910.1026),
- shipyards (1915.1026), and
- construction (1926.1126).

Hexavalent Chromium Exposure

More than 500,000 workers in a variety of occupations are potentially exposed to Cr(VI) in the United States. Workplace exposures occur mainly in the following areas:

- welding and other types of "hot work" on stainless steel and other metals that contain chromium

- use of pigments, spray paint, and coatings
- operating chrome plating baths

Evaluating Exposure

Occupational exposure to hexavalent chromium can occur from:

- inhalation of dust, mists, or fumes containing hexavalent chromium, or
- eye or skin contact.

Controlling Exposure

Exposure to CR(VI) can be controlled through a number of strategies; Engineering controls, administrative/work practice controls, and personal protective equipment (PPE):

- OSHA Cr(VI) standards require employers to use feasible engineering and administrative/work practice controls to reduce and maintain employee exposures at or below the permissible exposure limit (PEL).
- Wherever feasible engineering and administrative/work practice controls are not sufficient, the employer should use such controls to reduce employee exposure to the lowest levels achievable, then supplement those controls with respiratory protection and, in general industry, establish a regulated area to warn employees and limit access.
- Include hygiene areas and practices, housekeeping and cleaning methods, medical surveillance, and employee information and training.
- Where a hazard is present or is likely to be present from skin or eye contact with Cr(VI), the employer should provide appropriate personal protective clothing and equipment.

How to reduce exposure

General work practice controls to reduce exposure include:

- Clean welding surfaces of any coating that could potentially create toxic exposure, such as solvent residue and paint.

- Workers should position themselves to avoid breathing welding fume and gases. For example, workers should stay upwind when welding in open or outdoor environments.

- General ventilation, the natural or forced movement of fresh air, can reduce fume and gas levels in the work area. Welding outdoors or in open workspaces does not guarantee adequate ventilation. In work areas without ventilation and exhaust systems, welders should use natural drafts along with proper positioning to keep fume and gases away from themselves and other workers.

- Use local exhaust ventilation systems to remove fume and gases from the welders breathing zone. Keep fume hoods, fume extractor guns and vacuum nozzles close to the plume source to remove the maximum amount of fume and gases. Position portable or flexible exhaust systems so fumes and gases are drawn away from the welder. Keep exhaust ports away from other workers.

- Consider substituting a lower fume-generating or less toxic welding type or consumable.

- Do not weld in confined spaces without adequate forced air ventilation.

Videos

The following videos are an excellent source of information on Cr(VI) safety. The University of Washington and the State of Washington Department of Labor and Industries produced these videos. To view each of the following videos, please click the link to go to the online page for this course.

HexChEC Introduction

This video introduces sources of occupational exposure to hexavalent chromium, health effects associated with overexposure to hexavalent chromium, and steps that can be taken to reduce exposure.

HexChEC Module1

This video introduces an exposure assessment tool for stainless steel welders.

HexChEC Module2

This video introduces ventilation controls and how to effectively use local exhaust ventilation to reduce exposure to hexavalent chromium in welding fumes.

HexChEC Module3

This video demonstrates the effectiveness of local exhaust ventilation controls in reducing welding fume exposure using video exposure monitoring.

HexChEC Module4

This video introduces alternative exposure controls other than ventilation that may reduce exposure to hexavalent chromium.

HexChEC Module5

This video explains some requirements for complying with Washington State Labor & Industries hexavalent chromium regulations.

Module 9 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

1. **OSHA 29 CFR 1910.1026 and 1926.1126, Chromium (VI) standard, establishes a PEL for Cr(VI) of an average of _____ µg/m3 over an _____-hour work shift.**

    a. 5, 8
    b. 8, 8
    c. 15, 6
    d. 20, 4

2. **According to the text, when does exposure to Chromium (VI) occur when welding?**

    a. Hot work on oil pipelines
    b. Welding on brake linings
    c. Hot work and welding on stainless steel
    d. Welding during steel construction

3. **In general industry, what must the employer do when engineering and work practice controls are not sufficient?**

    a. Encourage welders to use respirators.
    b. Use respirators and establish regulated areas.
    c. Manage exposure with administrative controls.
    d. Do nothing unless indoors.

4. **Where should workers should position themselves to avoid breathing welding fume and gases while outdoors?**

    a. upwind
    b. downwind
    c. above
    d. below

5. When welding in confined spaces, be sure to use adequate _____.

a. vacuum ventilation
b. pure oxygen ventilation
c. natural ventilation
d. forced air ventilation

Endnotes

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