# Module 18: Welding and Cutting
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- Most fuel-powered tools use gasoline and the main hazards arise from fuel vapors and exhaust. As a result, they *should not* be used in enclosed and confined spaces if it can be avoided. Use only approved flammable liquid containers to transport fuel, and always shut down the engine and allow it to cool before refilling a fuel-powered tool tank.

# Module 18: Welding and Cutting

## Module Description

Safety is a critical consideration for any welding project. Welding is a safe occupation when proper precautions are taken, but if safety measures are ignored or not in place, welders face an array of hazards that can be potentially dangerous, including electric shock, fumes and gases, fire, explosions, and more.

This module is intended to provide an overview of the hazards associated with welding, cutting, and brazing and the protective measures necessary to assure the work is performed safely. The module is specifically designed to help workers meet OSHA compliance regarding welding, cutting, and brazing.

## Module Learning Objectives

At the conclusion of this module, students will be able to:

- Discuss OSHA's general requirements concerning welding, cutting, and brazing
- Identify the general safety requirements for all types of welding
- Describe the general characteristics for various types of welding
- Name the specific safety requirements for oxygen-fuel gas welding and cutting, arc welding and cutting, and resistance welding

## Lesson 1: General Requirements

### Lesson Focus

At the end of this lesson, students will be able to:

- Describe the necessary fire prevention and protection methods for welding operations
- Explain how to properly protect workers while they perform welding operations
- Describe the necessary health protection measures necessary, including ventilation

## Introduction

Welding, cutting, and brazing are some of the most common industrial processes. However, if proper preventive measures are not taken, these processes can be extremely hazardous. The use of compressed gases to create extremely hot flames can expose workers to highly dangerous conditions. Fires, burns to the skin, and flash burns to the eyes are some of the more immediate and serious hazards associated with welding, cutting, and brazing.

There are many welding techniques that have different types of hazards associated with them, including the risk associated with fire, explosion, gas, and fumes. The OSHA standard mandates all employers adopt and follow good work practices in all welding, cutting, and brazing techniques to prevent injuries, fires, and explosions.

**Supervisor's Responsibility**

The supervisor's duties include:

- Safe handling of the cutting or welding equipment, and the safe use of the cutting or welding process
- Identifying any combustible materials and hazardous areas present or likely to be present in the work location
- Have the work moved to a location free from dangerous combustibles
    - If the work cannot be moved, have the combustibles moved to a safe distance from the work or have the combustibles properly shielded against ignition
- See that cutting and welding are so scheduled that 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
- Determine that the cutter or welder secures approval that conditions are safe before going ahead
- Determine that fire protection and extinguishing equipment are properly located at the site

## Fire Prevention and Protection

In order to protect workers from fire-related hazards, OSHA has specified a variety of basic preventive measures, as well as certain special preventive measures for exceptionally dangerous tasks, like welding and cutting containers and welding in confined spaces.

The OSHA standard's basic preventive measures for fire in welding, cutting, and brazing use the following strategies to eliminate fire hazards:

- Before an object is welded or cut, it must be moved to a safe place.

- If the object to be welded or cut cannot be moved, then the area must be cleared of all moveable fire hazards.
- If certain fire hazards cannot be removed from the area, then workers are required to use guards to protect the immovable fire hazards from heat, sparks, and slag.
- If, however, the requirements mentioned above cannot be met, then employees **must not** perform any welding and cutting tasks.

Apart from these basic preventive measures for fires in welding and cutting, OSHA requires all workers to take certain special precautions. The OSHA standard requires workers to have proper fire extinguishing equipment available. All fire extinguishing equipment must be in proper working condition and must be kept close by for instant use. Preventive equipment may consist of buckets of sand, pails of water, fire extinguishers, or hoses. However, these may vary according to the nature of the work and the quantity of combustible material present in the vicinity.

Where there is a considerable amount of combustible material present closer than 35 feet from the work location, OSHA requires employers to station fire watchers whenever welding or cutting is performed. OSHA also requires employers to station fire watchers if considerable amounts of combustible materials are present that can be easily ignited by sparks, even if they are more than 35 feet away. The OSHA standard requires the fire watch to be maintained for at least a half hour after the welding or cutting task has been completed, and for a longer period of time if necessary.

**When Welding is Prohibited**

The OSHA standard has specified certain situations in which welding, cutting, or brazing is not allowed. Cutting or welding is not allowed in:

- Buildings that have damaged sprinkler systems
- Areas that are not authorized by management
- Locations that have explosive atmospheres due to the presence of mixtures of flammable gases, liquids, or dusts in the air
- Areas where there is a risk of explosive atmospheres, including areas inside unclean or improperly prepared tanks and areas with an accumulation of flammable gasses, vapors, liquids, or combustible dusts

There are many containers that require additional safety precautions apart from the basic preventive measures. The OSHA standard specifies that welding, cutting, or other hot work should not be performed on barrels, used drums, tanks, or other containers until they are properly cleaned. Cleaning should remove all materials or substances like tars, acids, greases, or other flammable or toxic materials. It is also important to remove or blank any pipeline or connections to the container being welded or cut.

### Welding in Confined Spaces

Personnel who are required to work in confined spaces must follow additional safety guidelines. OSHA defines a confined space as a relatively restricted space that has limited means of entry or exit. Examples of confined spaces include tanks, boilers, and pressure vessels. Before working in a confined space, all appropriate safety measures must be in place. The space must be ventilated thoroughly to be rid of any flammable or toxic gasses.

It is important for all employees who are assigned the task of welding or cutting inside a confined space to leave their gas cylinders and welding machines outside the space. If arc welding is suspended for a long period of time, such as during lunch or overnight, all electrodes must be removed from the holders. The holders must be placed carefully so that accidental contact does not occur. Also, the machine must be disconnected from the power source when not in use.

When an operation is suspended, all torch valves must be closed so that no gas escapes through the nozzle. Whenever the torch is not to be used for a long period of time, the gas supply to the torch must be properly shut off at a point outside the confined area. If possible, the hose and torch must also be removed from the confined space.

If a welder is to enter a confined space, employers must station an attendant outside the space to monitor the welder at all times. The attendant must be capable of putting rescue operations into effect.

### Case Study: Welding Hazards

In a refinery, two newly recruited workers were required to weld pipes near some storage tanks. These tanks contained highly flammable hydrocarbons. Sometime after work commenced, the combustible material caught fire and resulted in a large explosion. Three workers who were working in the area died on the spot and seven were seriously wounded, three of whom died later as a result of their injuries. This accident occurred because no preventive measures were taken before welding operations were started. No one made sure that there were no hazardous materials present in the vicinity of the work area, as required by the OSHA standard. Also, the workers were new and had not received any safety training and education regarding hazards associated with tasks like welding, cutting and brazing.

## Personnel Protection

In addition to fire protection, OSHA has specified guidelines requiring personnel involved in welding and cutting operations to take protective measures against other hazards too. These guidelines for personnel cover fall protection, eye protection, and protective clothing. If welders are required to work at a height, for example on a

platform, a runway, or a scaffold, OSHA mandates the use of railings, lifelines, or some equally effective safeguards.

Performing operations like welding, cutting, or brazing without proper eye protection may cause serious eye injuries. OSHA requires all personnel to wear helmets and hand shields during all arc welding or arc cutting operations in order to protect themselves from direct radiant energy from the arc. However, OSHA does not require personnel to wear helmets and hand shields while involved in submerged arc welding. OSHA also mandates that all helpers and attendants have proper eye protection. The material that is used to make the helmets and hand shields must be an insulator for heat and electricity. It is very important to ensure that the helmets, goggles, and shields are not readily flammable, and they must be strong enough to withstand sterilization.

If the work permits, welding should be performed behind a non-combustible screen with a low reflectivity surface, such as zinc oxide. This helps in absorbing ultra-violet radiation that may harm a welder; however, all booths and screens used must allow the circulation of air at floor level. People in the vicinity of the area where welding or cutting operations are being carried out must be provided with non-combustible screens, shields, or goggles if necessary.

All personnel involved in welding, cutting, or brazing operations must be provided with personal protective equipment to protect themselves from burns and fires.
The type of protective clothing may vary according to the nature of the welding operation and the location where work has to be performed. Employers must provide personal protective equipment materials that are designed to provide maximum protection from hot metal and sparks.

**Protective Clothing**

Welders should wear appropriate PPE to cover all exposed skin, including safety glasses or goggles, a welding helmet, hearing protection, welding gloves, and leather high-top shoes. Protective clothing should cover all parts of the body that could be injured by weld spatter and ultraviolet and infrared ray flash burn. It should be made of suitable fire-resistant materials to minimize skin burns caused by sparks, spatter, or radiation.

Always avoid clothing with tears, snags, rips, or worn spots as these are easily ignited by sparks. The sleeves and collars should be kept buttoned. The hands should be protected with leather gauntlet gloves. A pair of high-top leather shoes, preferably safety shoes, is good protection for the feet. If low shoes are worn, the ankles should be protected by fire resistant leggings.

## Health Protection and Ventilation

Some materials that are used in welding operations can be extremely hazardous even if precautionary measures have been taken. These materials must be removed by proper

ventilation. The materials that are considered extremely hazardous include fluorine compounds, zinc, lead, beryllium, cadmium, mercury, certain cleaning compounds, and stainless steel (nitrogen dioxide is a harmful gas released from the processing of stainless steel). When working with the materials stated above, workers must protect themselves with proper PPE.

### Lesson Summary

- The use of compressed gases to create extremely hot flames can expose workers to highly dangerous conditions. Fires, burns to the skin, and flash burns to the eyes are some of the more immediate and serious hazards associated with welding, cutting, and brazing.
- Before an object is welded or cut, it must be moved to a safe place. If the object to be welded or cut cannot be moved, then the area must be cleared of all moveable fire hazards. If certain fire hazards cannot be removed from the area, then workers are required to use guards to protect the immovable fire hazards from heat, sparks, and slag.
- In addition to fire protection, OSHA has specified guidelines requiring personnel involved in welding and cutting operations to take protective measures against other hazards too. These guidelines for personnel cover fall protection, eye protection, and protective clothing. If welders are required to work at a height, for example on a platform, a runway, or a scaffold, OSHA mandates the use of railings, lifelines, or some equally effective safeguards.
- Some materials that are used in welding operations can be extremely hazardous even if precautionary measures have been taken. These materials must be removed by proper ventilation.

## Lesson 2: Oxygen-fuel Gas Welding and Cutting

### Lesson Focus

At the end of this lesson, students will be able to:

- Describe the safety precautions necessary for cylinders and containers that may contain fuel gas
- Describe the safety guidelines for manifolding cylinders
- Explain the safety requirements for service pipe systems

### Introduction

In this lesson, we will discuss the hazards associated with oxygen-fuel gas welding and cutting, and the measures necessary to protect workers. Welders must guard against mixtures of fuel gasses and air or oxygen, as such mixtures may be explosive. No devices are to be used that mix air or oxygen with flammable gasses before they have to be consumed unless they have been approved by an authorized person.

The OSHA standard requires all welders to take special care when dealing with acetylene. Acetylene should never be generated or stored except in approved cylinders. It should not be utilized at a pressure exceeding 15 pounds per square inch gauge (PSIG) or 30 pounds per square inch absolute (PSIA). Using acetylene at pressures exceeding 15 PSIG (30 PSIA) can be extremely hazardous because at those pressures gaseous acetylene is highly unstable and may decompose, resulting in an explosion. The decomposition of acetylene must be avoided by storing it in cylinders that have been specially designed for storing such gasses.

## Cylinders and Containers

The OSHA standard requires all portable cylinders that are used for storage and shipment of compressed gasses to be constructed and maintained according to the regulations set out by the U.S. Department of Transportation (49 CFR Parts 171-179). OSHA has also provided specific guidelines for using and handling cylinders and containers containing compressed gasses. All personnel must know how cylinders are marked and stored, as well as their operating procedures.

### Approval and Marking

OSHA mandates that all compressed gas distributors clearly mark all compressed gas cylinders. Markings must include either the chemical or trade name of the gas stored in the cylinder. It is very important to ensure that all stamping, stenciling, or labeling used for marking the cylinder is not easily removable. The cylinder must be marked on the shoulder where it does not come into contact with other surfaces. Marking cylinders not only ensures proper use but also helps personnel to store them properly. No employer or employee should attempt to use the contents of an unmarked cylinder.

### Storage of Cylinders

The OSHA standard also emphasizes the importance of properly storing cylinders. All cylinders must be stored away from radiators and other devices that produce heat. If cylinders are stored inside buildings, steps must be taken to protect and ventilate the location thoroughly. The storage area must be dry and at least 20 feet (6.1 m) away from highly combustible materials. It is additionally important to store cylinders away from stairs, elevators, exit routes, or other areas where they can be toppled or damaged by people or falling objects, or where they could otherwise be tampered with. Personnel responsible for storing cylinders must make sure to close valves of all empty cylinders. Some cylinders are designed with valve protection caps—when the cylinders are not in use, these protection caps must be placed on the valves and appropriately tightened. The purpose of the valve protection cap is to protect the valve and to buffer the shock received if the cylinder falls.

### Fuel Gas Cylinders

All fuel gas cylinders stored inside a building must be limited to a total gas capacity of 2,000 cubic feet (56 m3) or 300 pounds (135.9 kg) of liquefied petroleum gas. All fuel gas cylinders with a gas capacity greater than 2,000 cubic feet (56 m3) or 300 pounds of liquefied petroleum gas must be stored in a separate room or a special building. These buildings or rooms must not have any heating or lighting and should be kept properly ventilated at all times. However, this limitation does not apply to cylinders that are being used or are ready to be used.

Acetylene cylinders are required to be stored with the valve end up. If these cylinders are stored on their side, acetone may leak out and create a hazardous condition.

### Oxygen Cylinders

Oxygen cylinders must be stored away from fuel-gas cylinders or other combustible materials, such as oil or grease. These cylinders must be stored at a minimum distance of 20 feet (6.1 m) from highly combustible material.

Oxygen cylinders outside generator houses are required to be separated from the generator by using a partition that has a fire-resistance rating of at least one hour. The partition must not have any openings and must not allow any gasses to accumulate. OSHA has specified this preventive measure in order to protect personnel from fire hazards.

### Operating Procedures

Due to the potential hazards associated with cylinders containing compressed gasses, OSHA requires all personnel to store and operate these cylinders properly. Care must be taken to eliminate all traces of oil and grease from cylinders, cylinder valves, regulators, couplings, hoses, and other apparatus when welding operations are being carried out. Welders must not operate or handle cylinders with oily hands or gloves and must ensure that no oily surface or greasy clothing is exposed to a jet of oxygen.

Compressed gas cylinders have two critical components that must be handled carefully: the valve outlet and the regulator. Valve protection caps are used to protect valves from getting damaged or coming into contact with oil or grease. The OSHA regulation specifies that workers should never use valve protection caps for lifting the cylinders as the caps may accidentally come loose and fall, possibly causing a sudden release of pressure. Regulators must be removed and valve-protection caps placed properly before cylinders are moved.

A regulator must always be attached to a compressed gas cylinder before it is used, except when connected to a manifold. It is important to ensure that the regulator being used is compatible with the gas in the cylinder and its service pressure. The regulator

must be cleaned with a clean filter installed. All manifolds and headers should be capped when not in use to prevent injuries. Before a regulator is attached, the protective cap must be removed from the cylinder and the valve opened slightly for an instant, and then closed immediately. This practice ensures that the cylinder valve is cleared of any dust or dirt that may have accumulated during storage. Dirt can damage vital parts of a regulator and may cause a fire or an explosion.

Cylinders that are not equipped with fixed hand wheels must have keys, handles, or non-adjustable wrenches on valve stems while they are being used. The valve of a cylinder containing acetylene should not be opened more than one and a half turns of the spindle and preferably no more than three-fourths of a turn. This allows adequate flow of the gas and permits the welder to close the valve quickly in an emergency situation.

While the welding or cutting operations are being carried out, all cylinders must be kept far away from the work location so that no sparks, hot slag, or flame can reach them. If they cannot be removed, they must be protected with fire-resistant shields. The OSHA standard also specifies that cylinders must not be placed in an area where they can become a part of an electric circuit.

## Manifolding of Cylinders

Welders do not always use portable cylinders as a source of gas. Sometimes a service pipe system is used to provide a manifolding effect. Manifolding is the process of using multiple-line fluid inputs into a single intake chamber for the purpose of combining gasses when they are needed for welding.

Portable outlet headers are used in order to control the flow of a particular gas. Each portable outlet header consists of a nozzle and a hose that can be connected to a portable cylinder or a service pipe. The OSHA standard specifies that, except for temporary service where conditions preclude a direct supply, portable outlet headers must never be used indoors.

All service piping outlets used to withdraw and supply oxygen or fuel gas to a portable outlet header must consist of a shut-off valve that is easily accessible. The service outlet on the portable outlet header must be equipped with a valve assembly that must consist of a detachable outlet seal cap attached to the body of the valve. The use of a seal cap ensures that the outlet pipe thread will remain free from oil or grease and not be damaged. Damaged pipe threads can result in leaky connections.

Because gas cylinders have not been scattered throughout the work area but instead have been kept centrally,

- The possibility of accidents is reduced
- More space is available at each workplace
- In case of fire, one can easily reach the cylinders

- There is more efficient use of the gases
- Cylinders are transported by less distance
- There is no replacement of cylinders inside the workshop

## Service Piping Requirements

All service piping systems being utilized must be designed and installed according to the safety requirements specified by OSHA. The pipes should be at least Schedule 40, and all fittings must be of standard weight in sizes up to and including 6-inch nominal. Schedule 40 pipe has a working pressure of up to 125PSI, and it should always be tested before use.

A close inspection is also required because problems may arise if line extensions are made with a pipe type other than Schedule 40. OSHA has specified some special requirements when personnel are using service pipe systems with oxygen or acetylene. The piping system is required to have a minimum pressure of 250 PSIG if oxygen is supplied to a service piping system from a low-pressure oxygen manifold without any pressure-regulating device. When the connected equipment is used at pressures less than 250PSIG, a pressure-regulating device must be used for each station outlet.

For acetylene or acetylenic compounds, the piping must be made of steel or wrought iron. Under certain conditions, acetylene forms explosive compounds with copper, silver, and mercury; therefore, employers must ensure that unalloyed copper is not used for acetylene or acetylenic compounds except when using certain listed equipment. All piping must be installed in a way that it runs as directly as possible. Some space should be allowed for expansion, contraction, jarring, and vibration. This will help protect the pipes from damage. Pipes that have to be laid underground must be located below the frost line, and protective measures must be taken to prevent or protect against corrosion.

After installation, the piping has to be blown out with air, nitrogen, or carbon dioxide to remove any foreign materials. For oxygen piping, the air, nitrogen, or carbon dioxide that is used must be completely oil-free. When air or gas is released from combustible gas lines, care must be taken to ensure that no source of ignition is allowed near uncapped openings.

Underground piping must be protected against corrosion by covering or painting it with a suitable material that would allow maximum protection against corrosion. After installing piping systems, they must be tested to ensure that they are gas-tight at 1.5 times the maximum operating pressure. Oxygen must be tested by only using oil-free and non-combustible materials. Under no circumstances are personnel allowed to use flames to detect leaks.

## Protection of Service Pipe Systems

The OSHA standard requires employers to ensure that the service pipe system is always protected against the build-up of excessive pressure and leaks. Protection may be provided using pressure relief devices, protective equipment, regulators, and hoses.

### Pressure Relief Devices

Pressure relief devices are used to protect service piping from excessive pressure build-up. They must be set to activate at no more than the pressure specified for the system. The pressure relief device must be made to discharge upwards to a safe location. OSHA mandates the use of pressure relief valves for preventing excessive build-up in fuel-gas piping systems.

### Piping Protective Equipment

The OSHA standard mandates the use of approved protective equipment for fuel-gas piping in order to prevent:

- The backflow of oxygen into the fuel-gas system
- The passage of a flash-back into the fuel-gas supply system
- Excessive backpressure of oxygen in the fuel-gas supply system

Personnel can use one device that performs all three functions of the protective equipment or separate devices to achieve each task separately. In a fuel-gas piping system, the protective equipment is required either at the main supply line, at the head of each branch line, or at each location where fuel-gas is withdrawn. However, it is preferable to place the protective equipment at the main supply as this would provide the best protection.

### Regulators

Pressure-reducing regulators can be used to control pressure in piping systems. OSHA has specified that pressure-reducing regulators should only be used for the gas and pressures for which they are made. If any part of these regulators is out of order and needs repair, only skilled mechanics that have had proper training should fix it. The regulators for oxygen piping systems must be labeled with a warning advising the user to: "USE NO OIL."

### Hoses

Apart from using release devices, the piping system must be designed using proper hoses to protect against leaks. The OSHA standard specifies that the hose and hose connections must be clamped or securely fastened so that they can withstand twice the pressure to which they are normally subjected. This pressure cannot be less than 300PSI. To test the hoses, oil-free air or oil-free inert gas must be used.

The oxygen hose is green and has a right-hand threaded nut for connecting to the torch. The acetylene fuel-gas hose is usually red (sometimes black) and has a left-hand threaded nut for connecting to the torch. Hoses that are burnt, worn, or have other defects must be replaced or repaired before any operations are performed. OSHA also prohibits personnel from using leaky hoses. When inspecting hoses, look for charred sections close to the torch. These may have been caused by flash-back. Also check that hoses are not taped up to cover leaks.

**Safe Practices**

Always make sure a regulator is in the closed position to prevent unregulated gas flow before attaching it to a cylinder. Stand to the side of a regulator, not in front of it, when opening cylinder valves. Other measure to ensure safety include:

- Do not leave regulators attached to the cylinders when not in use
- Do not use sealants or other materials on fitting and connections
- Do not use a regulator for more than one type of gas
- Inspect hoses for defects/deterioration before use
- Use a bubble solution (never a flame!) to check hoses for leaks before use
- Protect hoses from damage, foreign materials and sharp objects or physical abrasion
- Make sure there a check valve and flame arrestor in the system
- Disconnect hoses after use- do not leave residual gases in the hoses

## Lesson Summary

- The OSHA standard requires all portable cylinders that are used for storage and shipment of compressed gasses to be constructed and maintained according to the regulations set out by the U.S. Department of Transportation (49 CFR Parts 171-179).
- The OSHA standard also emphasizes the importance of properly storing cylinders. All cylinders must be stored away from radiators and other devices that produce heat. If cylinders are stored inside buildings, steps must be taken to protect and ventilate the location thoroughly.
- Manifolding is the process of using multiple-line fluid inputs into a single intake chamber for the purpose of combining gasses when they are needed for welding.
- All service piping systems being utilized must be designed and installed according to the safety requirements specified by OSHA. The pipes should be at least Schedule 40, and all fittings must be of standard weight in sizes up to and including 6-inch nominal. Schedule 40 pipe has a working pressure of up to 125PSI, and it should always be tested before use.
- Pressure relief devices are used to protect service piping from excessive pressure build-up. They must be set to activate at no more than the pressure specified for the system.

# Lesson 3: ARC Welding and Resistance Welding

## Lesson Focus

At the end of this lesson, students will be able to:

- Describe the safety requirements for arc welding and cutting
- Describe the safety requirements for resistance welding and cutting

## ARC Welding and Cutting

In the arc welding process, an electric current is passed through the welding rod and is forced to jump—or arc—across a gap. The heat produced through this process is intense enough to perform welding and cutting operations. Most of the precautions and safe practices specified by OSHA are common to oxy-fuel gas welding, but there are certain requirements that are unique to arc welding.

Electric shock is one of the most serious and immediate risks facing a worker while arc welding. Electric shock can lead to severe injury or death, either from the shock itself or from a fall caused by the reaction to a shock. One of the other unique requirements of arc welding is shielding. If air is kept away from the weld puddle, the welds produced have better physical and chemical properties. Some gasses like oxygen, hydrogen, and nitrogen, when mixed with moisture, can reduce the quality of the weld. Therefore, shielding is used to preserve the integrity of the weld joint. The primary health hazard with these gases is the potential for displacement of breathing air if significant quantities are released into a poorly ventilated area. However, these gases are also supplied in high pressure compressed gas cylinders that can present physical hazards, such as rupture if exposed to intense heat.

### Application

The OSHA standards pertaining to arc welding require standard arc welding tools to have certain design and other features. For example, they must be designed to carry their rated load with rated temperature rises. The maximum temperature of the cooling air should be 40 degrees Celsius (104 degrees Fahrenheit), and the maximum altitude is 3,300 feet (1,005.8 m). The machines should be suitable for operation in atmospheres containing gases, dust, and light rays produced by the welding arc.

To carry out the arc welding process, a welder can either use an alternating current (AC) or a direct current (DC). For alternating current machines, the voltage should not exceed the limit of 80 volts for manual and 100 volts for automatic arc welding and cutting. For direct current machines, the voltage must not exceed the limit of 100 volts for both manual and automatic arc welding and cutting.

If certain special welding and cutting processes are carried out that require values of the voltages higher than the specified limits, OSHA mandates that employers provide all personnel with adequate insulation or other means that would ensure their safety.
If arc welding and cutting operations are being carried out at a location where the surroundings are warm and humid, or where perspiration is a factor, OSHA recommends the use of reliable automatic controls for reducing no-load voltage to reduce the shock hazard. Some of the older AC machines do not have an automatic control and are on load all the time.

**Design**

The OSHA standard requires all types of arc welding machines and control apparatus to be enclosed except for the operating wheels, levers, and handles. It is also very important to enclose input power terminals, tap change devices, and live metal parts so that they can only be accessed by means of tools.

While carrying out welding operations, all personnel are required to protect the terminals for welding leads from accidental contact by workers or by metal objects such as hooks, vehicles, cranes, etc. To achieve this, OSHA specifies the use of:

- Dead-front receptacles for plug connections.
- Recessed openings with non-removable hinged covers.
- Heavy insulating sleeving or taping.

The connections for portable control devices must never be connected to an AC circuit of higher than 120 volts. On circuits above 50 volts, all exposed metal parts of portable control devices should be grounded by a grounding conductor in the control cable.
Personnel must never use AC reactors or auto transformers to obtain welding current directly from an AC power source with a voltage exceeding 80 volts.

**Installation**

Proper installation of equipment is very important to ensure safety during arc welding and cutting operations. One of the most critical requirements is proper grounding.
OSHA requires personnel to ensure that the frame or case of the welding machine (except with engine-driven machines) is properly grounded before it is used.
The OSHA standard specifies that conduits that contain electrical conductors must never be used for completing a work-lead circuit. Pipelines must not be used as a permanent part of a work-lead circuit. However, they may be used during extension, construction, or repair, but only when current is not being carried through threaded joints, flanged bolted joints, or caulked joints. Special precautions must be taken to avoid sparking at the connection of the work-lead cable.

### Supply Connections and Conductors

If a welding machine does not have a disconnecting switch or a controller as an integral part, one must be provided at or near the machine. A disconnect switch with overload protection is required for each outlet that has to be connected to a portable welding machine.

The rated current-carrying capacity of the supply conductors for individual welding machines must not be less than the rated primary current of the welding machines. Operations that involve many welders working on one structure may require both polarities in the DC welding process. Supply circuit limitations for AC welding may require allocation of machines among the phases of the supply circuit. In a situation like that, no-load voltages between electrode holders should be twice as normal on DC machines, or 1, 1.41, 1.73, or twice as normal on AC machines.

### Operation and Maintenance

OSHA requires personnel to check all connections of the machines before initiating the operations to ensure that all requirements have been fulfilled. Work clamps that are magnetic must be cleared of all metal particles that might be sticking to them. Welders must spread out all coiled welding cables before use to prevent overheating and damage to insulation.

While the welding operations are being carried out, cables with splices within 10 feet (3 meters) of the holder must not be used. It is important that the welding electrode cables are never coiled around parts of the welders' bodies. OSHA mandates the replacement of all cables that have damaged insulation or exposed bare conductors. Work and electrode cables must only be joined by using means that are particularly designed for that purpose.

## Resistance Welding

The third type of welding process is resistance welding. Resistance welding utilizes pressure and heat that is generated in the pieces to be welded using resistance to an electric current.

All personnel who are required to perform resistance welding must be properly trained and judged to be competent before they perform any tasks. While resistance welding, workers should ensure that all equipment is installed by a qualified electrician. All machines must have disconnecting switches or circuit breakers that are located at or near the machine. Thermal protection switches must also be provided for all ignitron tubes used in resistance welding equipment.

For all non-portable spot and seam welding machines, all external circuits must not operate on a voltage higher than 120 volts. All resistance welding equipment and control panels that involve voltages of over 550 volts must be properly insulated and

shielded. OSHA requires all doors and access panels for the resistance welding machines and control panels to be kept locked and interlocked in order to prevent unauthorized persons from coming in contact with the live portions of the equipment.

Where there is a possibility of the operator's fingers getting under the point of operation, all press welding machine operations must be effectively guarded by the use of a device such as an electronic eye safety circuit, two-hand controls, or protection similar to that prescribed for punch press operation. In all press welding operations, if the operator is required to have his or her fingers under the point of operation, he or she must be provided with effective protective equipment.

Wherever practical, a shield guard of safety glass or suitable fire-resistant plastic must be installed at the point of operation to avoid the hazard of flying sparks. Also, protective shields should be installed to prevent flying sparks from harming passing persons.
All foot switches that may be present on the machine must be guarded so that the machine does not get started accidentally. On special multi-spot welding machines, including 2-post and 4-post weld presses, there must be at least two safety emergency stop buttons.

OSHA requires all portable welding guns, transformers, and related equipment suspended from overhead structures to be outfitted with safety chains or cables. In case of failure of any component of the supporting system, these safety chains and cables must be capable of enduring the shock load.

All initiating switches, including retraction and dual schedule switches, located on the portable welding gun should be equipped with suitable guards capable of preventing accidental initiation. The outer casing of all portable welding transformers must be grounded. The OSHA standard requires all flash welding machines to comprise a protective hood to control flying flash.

**Safe Practices**

While welding, remember never to touch the electrode, or the metal parts of the electrode holder, with skin or welding clothing! Insulate yourself from the work and ground. To avoid secondary voltage shock, welding operators should wear dry gloves in good conditions, and be sure to insulate themselves from the work and ground, keeping dry insulation between their body and the metal being welded or ground (such as a metal floor or wet surface). Welding operators also should inspect the electrode holder for damage before beginning to weld and keep the welding cable and electrode holder insulation in good condition.

## Case Study

An Arc Welder Washer operator was putting on his leather protective clothing preparing for work as he conversed with the worker in the adjoining Weld Booth. After a brief conversation with his co-worker, he walked into Booth #1 to power up the Miller 1500

arc wash machine. As he leaned over the metal cross bar to turn the handle of the circuit breaker switch of the side electrical panel, the co-worker in the next booth heard a scream. The co-worker ran for assistance, finding a supervisor who called for help. The Coroner's findings verified severe burns on both hands, indicating the flow of current through the chest area of the body. For approximately three to four months before the fatality occurred, the main power switch (toggle switch) of the Miller 1500 was not working properly. Two weeks prior to the incident, an operator at Booth #1 received a serious shock when trying to turn on the machine. He was reaching over the angle iron cross bar to turn the machine on when he received a "whole body shock." In addition, the operator reported that there was a spark between the frame which the part rested in and a hoist. The fatality was caused by contact with voltage current that was able to travel through the victim, from the disconnect switch handle on the machine to the metal crossbar behind the machine. The handle was "hot" with voltage current due to an electrical fault in the machine. The fault would usually cause an electrical circuit interruption (circuit breaker or fuse), but the ground wires not being connected prevented this safety device from working.

### Lesson Summary

- In the arc welding process, an electric current is passed through the welding rod and is forced to jump—or arc—across a gap. The heat produced through this process is intense enough to perform welding and cutting operations. Most of the precautions and safe practices specified by OSHA are common to oxy-fuel gas welding, but there are certain requirements that are unique to arc welding. Electric shock is one of the most serious and immediate risks facing a worker while arc welding.
- Resistance welding utilizes pressure and heat that is generated in the pieces to be welded using resistance to an electric current. All personnel who are required to perform resistance welding must be properly trained and judged to be competent before they perform any tasks. While resistance welding, workers should ensure that all equipment is installed by a qualified electrician. All machines must have disconnecting switches or circuit breakers that are located at or near the machine. Thermal protection switches must also be provided for all ignitron tubes used in resistance welding equipment.

# Module 19: Silica Exposure

## Module Description

OSHA estimates 2.3 million American workers are exposed to respirable crystalline silica within their job site or manufacturing plant. Over 80% of the workers that are exposed to silica dust are in the construction industry. Crystalline Silica has been linked to several medical conditions and even death to workers exposed to the deadly dust. Exposure to respirable crystalline silica is a health concern for exposed workers. The



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