

Lesson I: Safety and Maintenance Procedures for Arc Welding

Arc welding, a process that uses the heat from an electric arc to join pieces of metal together, is commonly used in agricultural mechanics for construction and repair. Welding can pose hazards such as burns and electric shock, but it is a safe process when the welding equipment is installed correctly and the operator is well trained and follows the safety precautions. This lesson discusses the hazards of arc welding and the ways to avoid such hazards so that accidents can be prevented. It does not cover every possible risk. Your instructor can provide other safety rules for the particular work setting or welding process. Learning how to weld safely is as important as learning the skill itself.

Safety and Health Risks

Four major risks associated with arc welding are electric shock, burns from fire, burns from arc rays, and breathing hazards.

Electric Shock

Arc welders produce relatively low voltage, but electric shock is possible if proper safety precautions are not followed. Electric shock can happen if the welder is not properly installed, the equipment is defective or damaged, or adjustments are made when the welder is connected to the power. Electric shock can also occur if the operator does not wear the proper protective clothing. All electrical conductors on the welder and in the work area can be dangerous if they are not insulated. A conductor is any material that allows electric current to flow easily.

Burns and Fire

The arc produced by an arc welder can reach temperatures in excess of 9,000° F, which poses a great risk for burns and fire. Skin burns can occur from hot metal or spattering molten metal. Burns can also occur from the steam given off by hot metal after it is immersed in water. Fires can start when welding is performed in a booth that is not fireproof or that is near combustible or flammable materials, such as trash, feed, oil, or gasoline.

Burns from Arc Rays

The arc welder produces light rays that can cause first- and second-degree burns within minutes of exposure to the skin or flash burns of the eyes within seconds. These rays cannot be seen and their effects are not felt until after exposure. The light that is reflected off surfaces during the welding process is as dangerous as the direct light. There is a great risk of burns from arc light if proper protective clothing and eyewear are not worn. Workers in the area are also at risk of burns.

Breathing Hazards

All welding processes produce fumes and gases that are given off from the electrode flux and melting metal. Breathing hazards can be from oxygen displacement and from toxic fumes and gases. Oxygen displacement occurs when the arc, flame, fumes or gases replace the oxygen in the air. Oxygen displacement can cause asphyxiation. Exposure to toxic fumes and gases given off in the welding process can cause symptoms such as coughing, a tightness in the chest, nausea, and a metallic taste in the mouth. Toxic fumes and gases are a particular problem with some of the metals, such as those that are painted or coated with grease or other chemical agents. Plated metals also pose a risk of exposure to toxic substances. For example, brass, galvanized, or cadmium-plated metals give off highly toxic fumes. Gases are especially hazardous when welding is done in a confined space. One type of gas is ozone, which is caused by ultraviolet radiation during the welding process. Ozone is extremely irritating to the nose, eyes, mouth, and lungs.

Avoiding Electric Shock

The following safety precautions should be followed to help prevent shock or electrocution.

- **Make sure the welder is properly installed and hooked up.** Welders should be installed by or under the supervision of a qualified electrician. The welder itself should be properly grounded, which helps prevent injury from stray current. When inspection is done to make sure the welder is grounded, it is important to not confuse the grounding device with

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the ground clamp that attaches to the work. The welder should have a power disconnect switch within close reach of the operator for quick, emergency shutoff. The welder should be on its own circuit with a fuse or breaker of the appropriate size.

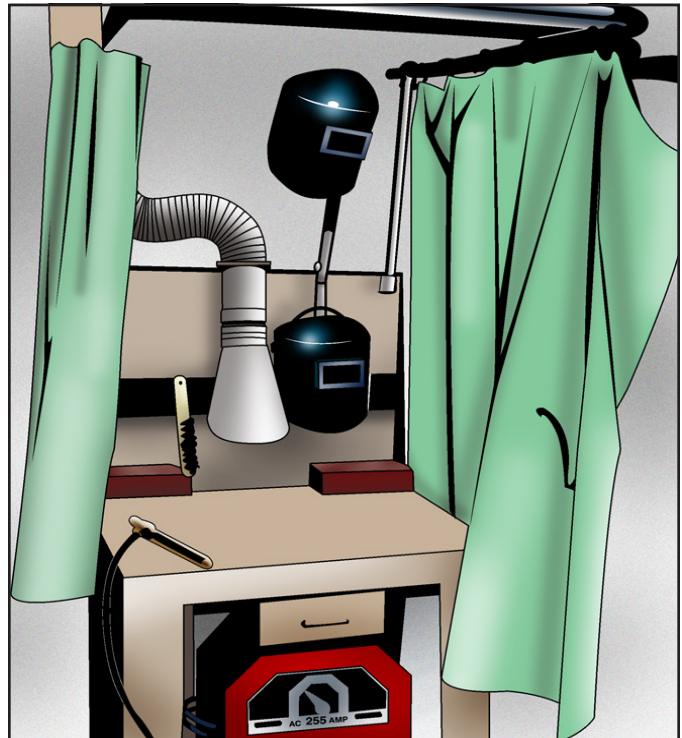
- **Inspect equipment for damage or defects.** The wire and cable connections should be kept tight and clean, because bad connections can heat up and cause dangerous arcs or melting. Do not use electrode holders or cables that are damaged or display poor insulation.
- **Disconnect the welder from the power source before making any repairs.** This includes the power switch on the welder and the main power disconnect switch.
- **Do not change the current setting while the machine is under a load.** The term “under a load” refers to the time in which there is an arc between the electrode and the work. Making adjustments while welding may cause damage to the switch and in turn injury to the person throwing the switch.
- **Keep clothing, gloves, floors, and equipment dry.** Even a small amount of moisture can conduct electricity and cause electric shock. If work must be done in a wet area, the operator should stand on a dry board or rubber mat and wear rubber gloves under the welding gloves to prevent electric shock. Similarly, if it is necessary to stand on a conductive material such as steel, the operator should stand on a dry board or a rubber mat. If the operator is perspiring, rubber gloves should be worn under the welding gloves. The electrode should never be changed when gloves are wet or when standing on a wet surface.
- **Do not put the electrode holder in water to cool it.**
- **Do not use water to put out electrical fires or any fire near the welder.** Water can damage the equipment or cause a shock hazard. Use an appropriately rated fire extinguisher to put out a fire.
- **Remove the electrode from the holder when the work is finished and disconnect the welder from the power source.**

Avoiding Burns and Fires

The following safety precautions should be followed to help prevent burns and fire.

- **Make the work area as fire resistant as possible.** In a shop environment, welding should only be done in a designated area and in a booth constructed of fireproof or fire-resistant materials such as metal sheeting or concrete blocks. The booth should have fire-resistant curtains across its opening to protect people in the area from harmful arc rays. See Figure I.1. Like the walls of the booth, the floor should be made of a fire-resistant material such as concrete. Cracks in the floor should be repaired to prevent sparks or molten metal from collecting in them. The work area should be clean and free of trash, grease, oil, and other flammable materials. In case a person's clothes catch on fire, a fire blanket should be available to wrap around the person to smother the fire. An appropriately rated fire extinguisher, first-aid kit, and safety equipment should be kept within easy reach. Aisles and stairs should be kept free of obstacles to allow a quick exit in case of fire.

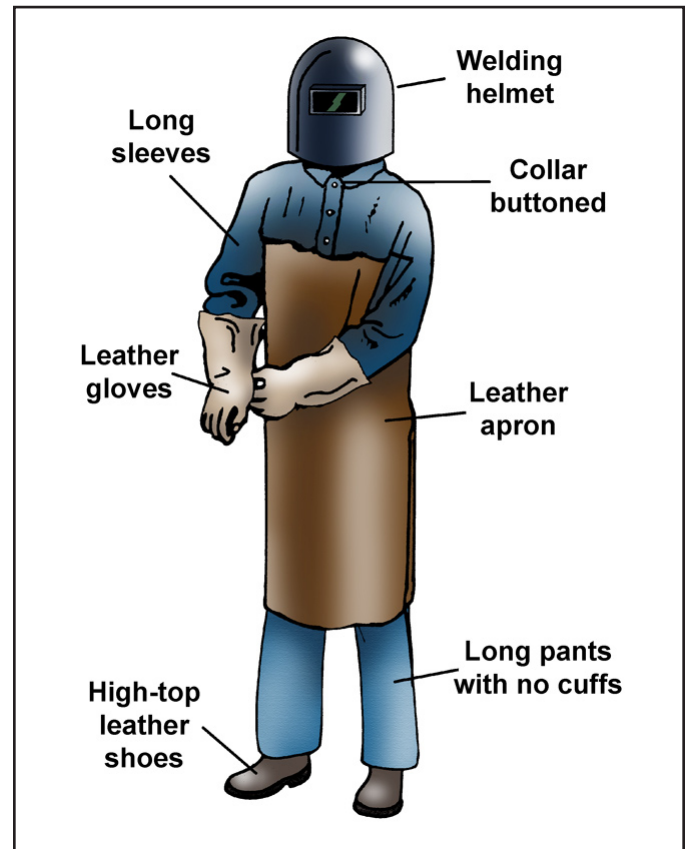
Figure I.1 – Welding Booth



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- **Be careful with hot work pieces.** Handle hot metal with tongs or pliers, not gloved or bare hands. If metal pieces are cooled in water, do so carefully to avoid steam burns. Do not walk around the shop carrying hot metal. If hot metal must be left where others could be in contact with it, carefully mark it “Hot” with soapstone or chalk.
- **Wear appropriate clothing and safety gear.** Various types of safety gear are required to prevent injury from sparks, hot metal, rays from the arc, and flying debris. See Figure 1.2.
 - Hands and feet: Leather gauntlet-style gloves and high-top leather shoes should be worn to protect the hands and feet.
 - Body: Clothing should be made of wool or cotton, not a synthetic material. It should be dark and tightly woven, which also helps block arc rays. Shirts should be long sleeved and the sleeves and front of the shirt should be buttoned, including the top collar button. Pants should come down over the tops of the boots and not have cuffs. Sparks could fall in cuffs. Long-sleeved fire-resistant coveralls provide excellent protection. Other protective gear, such as leather aprons and leather sleeves, are also available and should be worn as needed. Clothing with tears or frayed areas should not be worn because the skin might not be protected and the shreds of material could easily catch fire from sparks. Clothing made of synthetic materials should not be worn because such fabrics can burn readily and give off poisonous gases when they are burning. Pockets should not contain flammable materials, such as matches or butane lighters, which could potentially catch fire or explode.
 - Head and eyes: A cap and safety goggles should always be worn. Safety glasses or goggles and additional head and eye protection such as a flameproof skullcap or face shield should be worn as needed to avoid burns when chipping hot slag from welds. When welding, an arc welding helmet should be worn for protection against harmful arc rays. (See the section on arc rays for more details.)
- **Do not attempt to heat, cut, or weld containers such as tanks, drums, and barrels.** These types of

Figure 1.2 – Protective Clothing and Gear for Welding



containers may have been used to store flammable substances such as gasoline. If so, the welding process could cause a big explosion and fire. Even though a container looks clean, it may still have fumes that could catch fire.

Avoiding Arc Rays

The following safety precautions should be followed to help prevent burns from arc rays during the welding process.

- **Wear a welding helmet with a filter lens classified as no. 10 or higher, depending on the work being done.** Manufacturers of welding equipment provide recommendations for appropriate lenses. Welding helmets are available in different types, including some that have a flip-up or fixed shaded lens. A flip-up lens allows work, such as chipping, to be done without removing the helmet. See Figure 1.3 and Figure 1.4. If a helmet with a flip-up lens is not

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used, safety glasses must be worn under the helmet. Inspect the helmet and lens assembly to make sure they are undamaged and the gaskets are fitting properly to avoid light leaks. Do not use a helmet or lens that is damaged. In addition to the helmet, dark, tightly woven clothing protects the body from exposure to arc rays. All persons in the welding area should wear eye protection, such as flash glasses, to avoid eye injury from the reflected light. Before starting a weld, the operator should always say “cover up” as a warning for others to protect themselves.

Figure I.3 – Helmet with a Flip-up Filter Lens

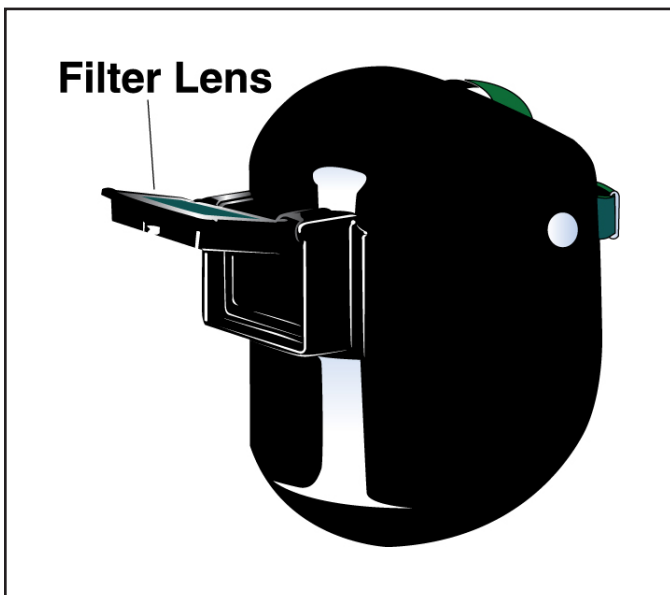
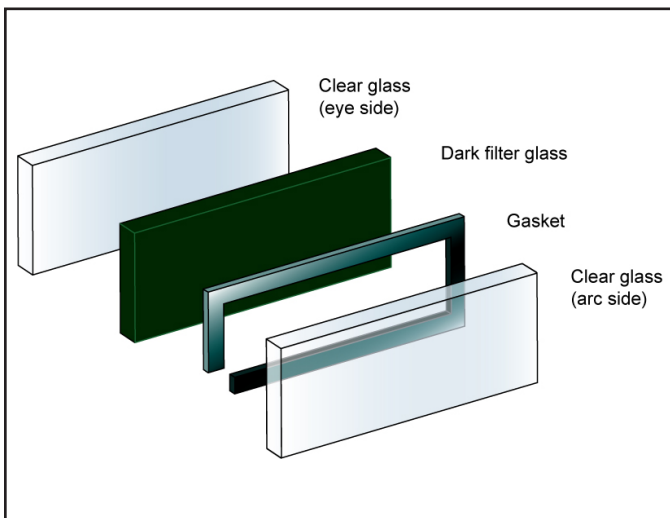


Figure I.4 – Parts of a Filter Lens on a Welding Helmet



Avoiding Breathing Hazards

The following safety precautions should be followed to help prevent respiratory problems.

- **Work in an area with adequate ventilation.** Working outdoors or in a large shop with high ceilings and natural ventilation is best.
- **Use forced ventilation if natural ventilation is not sufficient.** Forced ventilation, such as hoods and exhaust fans, is probably needed in small shops and in shops with many welders operating at the same time. Forced ventilation may also be required if welding is being performed on metals that contain extremely toxic substances. The ventilation system should be as close to the work as possible.
- **Supplement ventilation as needed with an appropriate respirator.** Respirators may be required depending on the size of the work area, ventilation available, and the type of metal being welded. Different types of respirators are available. Some models supply fresh air and other models are designed to filter specific contaminants. See Figure I.5.

Figure I.5 – Respirator With a Powered Air Purifier



Unit II – Arc Welding

- **Clean metal before welding.** It is important to remove chemicals from the metal so they do not mix with the other fumes produced by welding and create a worse breathing hazard. It is also safer and easier to establish an arc on a clean surface than a dirty surface.
- **Operate engine-powered welders in well-ventilated areas or with the exhaust vented directly outdoors.** This is to prevent carbon monoxide, a poisonous gas produced by gas and diesel engines, from building up in the shop.

Care and Maintenance of Arc Welding Equipment

Regular maintenance of welding equipment and inspection of the equipment before each use are critical for safe operation.

- **Inspect the electrode holder frequently to be sure it is not damaged or in need of repair.** Defective jaws, loose connections, and poor insulation are electric shock hazards.
- **Keep cables free of oil and grease.** These substances on the cables may cause them to catch fire.
- **Run cables so that they will not be damaged or cause a tripping hazard.** Be sure that cables will not be exposed to sparks and molten metal and are not located where the operator or others must walk or stand. In temporary work sites, keep cables covered to protect them from traffic.
- **Do not shut off or start the welder while the electrode or electrode holder is in contact with the work or the welding table.** This prevents the possibility of damage to the welder. The electrode holder should be hung from an insulated hanger when it is not in use.
- **Keep the welder and electrodes dry.**
- **Do not allow dust to accumulate on the transformer coils.** Dirty coils can start a fire, short out electrical components, and cause other equipment failures.

Summary

The arc welding process has potential safety risks like electric shock, burns and fire, burns from arc rays, and breathing hazards. Following safety precautions, maintaining the welding equipment, and inspecting it before each use will help prevent injuries to the welder and others in the work area.

Credits

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