

Production Practicum: Welding Safety.

Basic Welding Principles.

What is welding? Welding is a process of joining two metals by heating them to their melting point, adding a filler metal, and allowing the joint to cool in an anaerobic (oxygen-free) environment.

With **Oxy-Acetylene Welding**, a flame provides the heat necessary to bring the **work** (materials being welded) to melting point. When the metal is at that point, it can be welded, brazed or cut. At SPU, we do not “torch weld,” braze or cut.

In straight **Shielded Metal Arc Welding (SMAW)**, also known as **stick welding**, the heat to melt the metals is provided by electricity continuously **arcing** (sparking) from the positively-charged **electrode** (filler rod) to the negatively-charged work. The metal stick electrode is **consumable**--that is, it is melted into the work as you weld. The coating on the electrode burns as you weld, and the small envelope of smoky gases produced protects the weld from the air for the first milliseconds of cooling. The stick welding process may be introduced to advanced welding students.

The process known as **Gas Metal Arc Welding (GMAW)**, or **Metal Inert Gas (MIG) Welding**, is the process the SPU theatrical scenery shop uses. In this process, a continuously-fed, positively-charged wire electrode is pushed into the work, which has a negative charge. The electric arc that results from short-circuiting the electricity melts the wire and the two pieces being joined; and as they cool, they form a weld. The weld is protected from the air by an envelope of nonreactive gas, usually a mixture of argon (what’s in an incandescent light bulb) and carbon dioxide, flowing around it as it melts. The initial cooling and crystallizing of the metal’s solid atomic structure takes fractions of a second.

Types of Metals. At SPU, we weld only iron-based, ferrous metals, such as mild, low-carbon steel and cast iron. We avoid stainless and hardened steels, other composition-ferrous metals, and most nonferrous metals. Aluminum is the exception; instruction on MIG welding of aluminum may be available by arrangement.

Hazards. There are life-threatening dangers present when welding; but these can be minimized by following proper safety practices. The dangers include:

- Light. The arc that melts the metals is bright enough to burn the corneas of your eyes in just a few seconds, damaging your sight; if there is enough exposure, it can be permanent. Never look at the arc unprotected. This light also contains high levels of the radiation the sun emits, so it also quickly sunburns bare skin.
- Heat. At the point it strikes, the arc produces temperatures up to 13,000° Fahrenheit. This is enough to produce uncomfortable temperatures a few inches away, as close as your hand when you are welding. The metal being welded will remain too hot to touch with bare hands for several minutes. The burns resulting from holding just-welded metals can be very painful. Never weld barehanded.
- Sparks. The sparks produced from welding are actually small globules of burning metal. Where they land can start fires. If they land on the skin, they cause small but deep and painful burns. If they land in hair, they can burn the hair and the scalp. They can find their way behind the welding mask to your eyes. These are also responsible for...
- Fire. The sparks produced from welding can ignite any flammable material in a surprisingly large surrounding area.
- Gases and fumes. Welding actually burns some of the work and the electrode --the steel--as it melts them; this produces smoke and molten metal fumes. If there are any contaminants on the metal, such as oil, paint, mill scale, etc., they must be removed before welding; the fumes produced from burning these contaminants are also toxic. Though inert, the shielding gas is also unhealthy, and the welder should avoid breathing it.
- Electrical Shock. One of the most immediate dangers in welding is electrical shock. The danger of grounding any electricity though the human body is serious. Even small amounts of electricity can affect heart rhythms, and large amounts can burn and kill. While modern welders are well-grounded, the output is often over 100 amps at high voltages (enough to power a large house), and the utmost care must be taken to insure that the work, welding machine, and all equipment is in safe working order and properly grounded.

Preventative Measures, and Personal Protective Equipment (PPE). These measures, coupled with the correct equipment and common sense, will protect you from the hazards present when welding.

- Eyes.
 - > Protect your eyes. Wear a welding mask with the proper shade of light **filter**, in good repair and with the safety lens installed.
 - Filters available to welders range in shade from 1 through 15. For example, 1 and 2 are common sunglasses shades; 5 is common for oxyacetylene flames; 10 to 12 for MIG welding; and 12 or 13 for TIG welding. Our welding masks are rated at 10 or 11, and are too dark to see through in normal daylight.
 - Make sure the filter is not cracked, scratched or dirty; this will obscure vision. If the filter is gold, it must not have any scratches, as they will transmit light; the filter must be replaced.
 - It is essential that the clear, shatterproof plastic lens is installed at the very front of the mask, as it protects the filter from being pitted or broken by sparks.
 - Don't use the mask to look at the sun--it won't protect you.
 - Wear goggles behind the welding mask. The welding mask will only protect you from light and sparks coming directly at the face. Sparks and debris can get behind the helmet, however, especially when performing any **out-of-position** welding--that is, any welding which is not **overhand** (nozzle pointed down) with the work on a table, floor, or other horizontal surface.
 - > Protect others' eyes. Set up the amber plastic welding shields so that they surround the welding on all sides exposed to the floor space; they protect bystander's eyes from flash burns during accidental glances at the arc.
- Skin and Body. The dangers to the skin and body are light, heat and sparks. You must protect your whole body, from your hair to your feet, in order to weld safely.
 - > You should wear a hat of nonflammable material--a welding cap is recommended. Baseball caps of cotton are OK; but any plastic or nylon may melt or catch fire and are prohibited.

- > The welding leathers protect the arms and torso from exposure to the heat, light and sparks of the arc. The welding leathers are also essential for protecting the neck--a skin area prone to sun burn--so the leathers must be buttoned up fully.
- > Long denim or canvas pants are required to protect the legs. Unroll cuffs, as they can catch sparks and start the pants afire.
- > For footwear, leather shoes or boots are recommended, but canvas or nonflammable shoes will suffice. Any shoes of manmade fabric (such as nylon) will burn and are not to be worn when welding.
- > Never weld barehanded. The only gloves that should be used are welding gauntlets. They extend up the arm, are much thicker and sturdier than conventional leather gloves, and have varying degrees of insulation from heat. They will not protect you from the heat of an object freshly welded; use tongs, such as a vise-grip, or allow it to cool.
- Dusts/Fumes. The smoke and fumes created by welding are unhealthy to breathe, but the **source capture** fume removal system in the welding area can remove nearly all dangerous contaminants, if it's used correctly.
 - > As a general rule, keep your face and head out of the smoke plume of the weld; stay off to one side, away from directly above the weld, and avoid being between the collector and the weld.
 - > Use the filter system every time you weld. Without the collector the smoke may dissipate, but it merely lessens in concentration, and is not removed from the workspace and filtered out. Using the system assures nobody in the shop or outdoors breathes the fumes.
 - > In order to work, the nozzle must be 12" or less above the welding. Move the nozzle with you between welds.
 - > If contaminants, such as paint, grease, **mill scale**, **galvanization**, etc., are on the steel to be welded, you must clean them off before welding. Use a wire brush (or sandpaper, steel wool, etc.), bench grinder, simple green, or other nontoxic cleaner. If you cannot clean the steel, do not weld.
 - Galvanized steel, such as garbage cans and **electrical conduit (EMT)**, is especially dangerous; clean off the galvanization thoroughly to three to four inches above the weld area, wearing a dust/mist mask or the ventilation system while wire brushing.
 - > If for any reason you feel dizzy or ill when welding, alert the supervisor, and immediately shut down the equipment and get to fresh air.

Welding Procedural Rules. Follow these every time, every time, every time! The dangers present in welding must be taken very seriously.

- For All Jobs. You cannot weld without supervision; it's the law. Each individual job must be discussed with the supervisor before beginning welding, to insure the necessary safety equipment is available and proper safety procedures are prescribed and followed.
- Fire. This is a very serious danger, for which Washington law prescribes specific prevention practices.
 - > There can be no flammables in the immediate welding area; remove all flammables from the welding anteroom (garage).
 - > Clean the floor; a quick sweep will keep sawdust, leaves, etc. out of the work area.
 - > If you cannot remove the flammables, or are welding in a place other than the garage, you must set up the spark shields on all sides of the welding area. Additionally, shields may be placed over specific flammable items, as appropriate. If it is impossible to protect the flammables, you must not weld.
 - > You cannot see or smell a fire smoldering when welding. Therefore, when welding in a space where a fire might develop, such as in the theater or backstage, a fire watch must be maintained until 30 minutes after the welding stops; and someone must stand by with an extinguisher near the welding area in case of fire.
- Grounding Rules. The welding machine is professionally installed and is grounded properly, but hazards still exist. There are rules to protect yourself from accidental shock.
 - > Avoid holding both the **ground** and the **whip** at the same time.
 - > Always inspect the ground cable and clamp, welding whip, and power connections before beginning to weld; if any are worn, cut or otherwise damaged, do not weld. Tell the supervisor.
 - > Make sure the ground clamp is secure to the work, and close to the weld area. It is important for a good weld and for safe operation. If the clamp arcs when welding, tighten the clamp and/or reposition it.

- **Off-Site Welding.** If you want to weld somewhere other than the welding garage, we need to apply to the Seattle Fire Department for a Hot Work Permit. It is a simple procedure; see the supervisor for this.
- **Water Hazard.** There is a special danger if there is water present. Water increases electrical conductivity in just about everything, and increases the chance of shock while welding.
 - > Never weld if the floor is wet; if your shoes are wet; if the work is wet; or if your gloves are wet.
 - > Wear boots or shoes with thick rubber soles; this will help insulate you from a moist floor.
- **Gas Cylinders.** At SPU we only use cylinders containing inert, nonflammable gas. However, these cylinders begin life with pressures up to 2000+ lb./sq in., making them explosive if mishandled. Cylinders are essentially “bombs,” and are to be treated with much respect. See supervisor for terrifying stories of mishandled cylinders.
 - > Never drop or bang a cylinder.
 - > Never weld, heat or cut a cylinder.
 - > **Protective Caps.** Always leave the protective cap on the cylinder until it is chained in place on the welder and the regulator is ready to be installed. The valve on top is the weakest part of the cylinder, and the part most likely to break off if the cylinder falls.
 - > **Spare Cylinders.** Any cylinders not in use should be chained to the wall in the corral in the wood shop; and must be marked “full” or “empty.” Avoid knocking corralled cylinders.
 - > **Installing Cylinders.** When a cylinder is installed on the welder, it must be chained in place.
 - > **Regulator.** When cylinders are installed on the welder, do not over tighten or under tighten the regulator. Always operate the welder with the main valve wide open.
 - > **End Of Session.** Always turn the cylinder valve to off and drain the regulators at the end of the welding session; it saves wear and tear on the regulators, and avoids accidents with pressurized gas lines.