Safety Guidelines for Students – Welding, Cutting and Brazing

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# Table of Contents

Introduction .................................................................................................................................................. 2  
Training ......................................................................................................................................................... 3 
Choice of location ......................................................................................................................................... 3 
Personal Protection Equipment .................................................................................................................... 4 
  Head & Eye Protection .............................................................................................................................. 4 
  Hands ........................................................................................................................................................ 6 
  Hearing Protection .................................................................................................................................... 7 
  Clothing and Feet ...................................................................................................................................... 7 
  Respirators ................................................................................................................................................ 7 
  Putting it all together ................................................................................................................................ 8 
Ventilation ..................................................................................................................................................... 9 
  Why ventilation is important .................................................................................................................... 9 
  Indoor Temporary Hot Work Areas .......................................................................................................... 9 
Storage of gas cylinders ............................................................................................................................... 10 
  Storage of gas and oxygen cylinders not being used .............................................................................. 10 
  Cylinders in use ....................................................................................................................................... 11 
Fire Prevention ............................................................................................................................................ 11 
  Recommended fire prevention steps ........................................................................................................ 11 
Protection of other people .......................................................................................................................... 12 
Safety tips for Specific Operations .............................................................................................................. 13 
  Oxygen Gas Welding & Cutting (Oxy-fuel) .............................................................................................. 13 
  Shielded Metal Arc Welding ..................................................................................................................... 13 
APPENDIX A: Guide for Shade Numbers ................................................................................................... 15
Introduction
It is well known that hot work operations (welding, cutting, and brazing) are associated with many health & safety hazards as well as being a source for fires. The National Fire Protection Association (NFPA) reported that from 2007-2011 the United States annually experienced 2417 fires caused by hot work resulting in $155 million in direct property damage, 5 civilian fatalities and 87 civilian injuries.\(^1\)

Hot work takes place daily in various locations on campus by staff, faculty, contractors, and students. Additionally, students may perform these operations off-campus while working on projects associated with the University (for example, construction of Homecoming floats).

It is the intention of these guidelines to assist students in performing hot work operations safely and without damage to property.

The attached guidelines will focus on the following areas:

- Training
- Choice of Location
- Personal Protective Equipment (PPE)
- Ventilation
- Storage of gas cylinders
- Fire Prevention
- Protection of Others
- Safe Operating Procedures

These guidelines were developed in accordance to the following standards:

- OSHA 29 CFR §1910.252 - §1910.255
- NFPA 51B {Standard for Fire Prevention During Welding, Cutting, and Other Hot Work}
- ANSI Z49.1:2012 {Safety in Welding, Cutting, and Allied Processes}

Important Note
This set of guidelines does not preclude any requirement contained in the Baylor University HOT WORK PROGRAM. The Baylor Hot Work Program gives the requirements that staff and faculty are required to follow and is based with the intent of fulfilling the requirements of OSHA 29 CFR §1910.252 to §1910.255. The Baylor University Hot Work Program can be found on the Department of Public Safety website [http://www.baylor.edu/dps/](http://www.baylor.edu/dps/) and on the Department of Environmental Health & Safety website: [www.baylor.edu/ehs/](http://www.baylor.edu/ehs/).

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\(^1\) John R. Hall, Jr., *Non-Home Structure Fires By Equipment Involved in Ignition*, NFPA 2013
Training
DO NOT attempt to perform any type of welding or cutting without training. Attempting to “train yourself” through trial and error is dangerous to yourself and others and may lead to destruction of property.

Training should consist of two parts: (1) hands-on instruction by a qualified instructor and (2) theoretical instruction including reading the owner’s manual for the welder being used.

If the hot work being done by the student is in connection with a Baylor University class (for ex. Construction of Baja Carts in Engineering or Sculpture in the Fine Arts Department) then the training should be documented and records retained by the instructor in charge.

Choice of location
The proper selection and preparation of a site to be used for hot work is of absolute importance in regards to safety. Generally, there are only two kinds of areas where hot work should be performed: a permanently designated hot work area; or a temporary hot work area that can be controlled and made safe.

Permanently designated hot work area: A permanent location designed or approved for hot work operations. This area has been made safe for hot work by the removal of all ignitable fuel sources, has ample ventilation and, if needed, has curtains to prevent eye injury to others in the area. Permanent hot work areas may also be equipped with ventilation systems. These examples of permanent hot work areas are located in the Lewis Art Building.

Safe temporary work area: An area under full control of the people performing the hot work, that has been inspected and all ignitable materials removed. It is also an area that has been determined to have ample ventilation to safely perform hot work.

Students often perform hot work operations as part of the homecoming float construction process. This work typically takes place in a garage, storage facility or warehouse type of structure. Vitally important is to inspect the area and remove all combustible materials and flammable liquids within 35' of the hot work area. Common combustible materials and flammable liquids found in these work areas often include paper (drawings, newspapers, notes, checklists), cardboard, oil based lubricants such as WD-40, oily rags, gasoline (for a generator), paints and thinners, and saw dust.
Welding, Cutting and Brazing Student Safety Guidelines

Never perform hot work or grind metal in proximity to flammable gas cylinders...

Personal Protection Equipment

The specific Personal Protection Equipment (PPE) required will depend on the type of hot work being performed. For example, cutting with an oxy/acetylene torch will require a different type of eye protection than would shielded metal arc welding (SMAW). This section will give guidance to the specific PPE students will need in order to perform their work safely.

PPE for the head, eyes and hands is an absolute must. There is simply no way to get started welding or cutting without a welding helmet and welding gloves. Other PPE listed below is not quite as critical but is needed in order to perform the work safely.

Head & Eye Protection

A welder needs to protect his face and head from the heat generated, the IR and UV radiation emitted and from the splatter flying off the work during a welding operation.

and don’t be this guy!

Never perform hot work or grind metal in proximity to flammable gas cylinders... or by other flammable liquids...
**Shielded Metal Arc Welding (SMAW)**

For SMAW, a welding hood or helmet that meets ANSI Z87.1 needs to be used. ANSI stands for American National Standards Institute and their standards ensure your welding helmet provides ample protection from flying projectiles as well as IR and UV rays. This is an absolute must.

The next consideration is shade of the lens. Lens come in different shades from #4 (least amount of shading) to #14 (darkest). For most SMAW, a lens with #10-#12 shading will be sufficient. See appendix A for a table of operations and their respective recommended lens shade number.

Helmets come in many styles and costs. Lens may be fixed shade, or variable shade with auto-darkening. Which welding helmet a user chooses comes down to personal preference and affordability.

Safety glasses such as those pictured should be worn under the welding helmet while welding. Splatter (hot metal) from welding will fly in all directions and can occasionally end up under the helmet. Safety glasses meeting ANSI Z87.1 will protect your eyes from the splatter and will also provide needed protection from flying debris when you use the chipping hammer and wire brush on the weld.
Oxygen/Acetylene Welding (Gas Welding)
For gas welding, welding goggles, welding glasses, a welding shield or welding helmet with a lens shade number of #4-#8 is recommended. It is very important to note that welding goggles designed for oxygen/fuel welding and cutting will NOT protect you from the intense UV rays generated by SMAW.

Lastly, to protect your head and the back of your neck, a welding cap is recommended. Note: A welding cap is not the same as a baseball cap. A welder’s cap is fire resistant and has a longer bill to better protect the back of your neck and to prevent hot splatter from going down your back.

Hands
As anyone who has ever welded knows, proper protection for the hands is essential when welding or performing any other kind of hot work. However, the type of hand protection used will depend on what kind of work you are doing.

MIG (Metal Inert Gas) welding and SMAW: When performing either of these types of welding, you will not need a lot of dexterity but you will need sufficient heat resistance due to the extremely high temperatures (up to 7000°F) your hands are exposed to. A thick leather welding glove like the one pictured is what most professional welders will wear during these welding operations.

Gas Welding: Gas welding (typically acetylene/oxygen) does not produce the same levels of heat as do MIG and SMAW. A medium weight welding glove will
provide sufficient heat resistance for gas welding but will also give the welder improved manual dexterity.

**TIG Welding:** TIG (Tungsten Inert Gas) welding requires less protection from heat and sparks and also requires significantly higher levels of dexterity. There are a wide range of specialty gloves for TIG welding such as the one pictured.

**Hearing Protection**
Metal working can often generate a lot of very loud noises. For this reason the use of hearing protection is highly recommended. Most welders will use ear plugs such as the ones shown below, while others will use ear muffs designed to fit over welding helmets.

**Clothing and Feet**
It is very important that proper clothing be worn when performing hot work. Students should wear natural fibers (cotton, wool) and should **NEVER wear materials such as polyester or fleece**. Long sleeves and heavy duty pants (denim blue jeans) are needed. When performing SMAW, gas welding or MIG welding it is strongly recommended that a **welding jacket** be worn, and the use of **leather chaps** to protect the legs is encouraged.

**Flip flops, open shoes, and sneakers should NEVER be worn into a shop environment.** Work boots (steel-toed preferred) is what is needed to protect your feet when working with metal. Many welders prefer pull-on boots (cowboy boots) when welding because welding slag will roll off a pull-on boot as opposed to getting caught in the lacing area of a boot with laces.

**Respirators**
See section on Ventilation, page 9.
Welding, Cutting and Brazing Student Safety Guidelines

Putting it all together

- Welding Helmet
- Welding Curtain
- Welding Cap
- Safety Glasses
- Fire resistant welding jacket
- Leather gloves
- Heavy Denim pants
- Leather work boots (not shown)
Ventilation
These guidelines are not intended to address the ventilation requirements of permanent hot work areas (shops) on campus. Permanent hot work areas on campus will comply with OSHA 29 CFR §1910.252(c) and ANSI Z49.1 §5.

It is the intent of this section to discuss the need for ventilation in a general manner and with the intent that the information contained within will assist students in performing hot work in a safe manner.

Why ventilation is important
Welding fumes are a complex mixture of compounds including various metallic oxides, silicates and fluorides. The exact composition of the fumes will vary depending on the metal being welded, any residue (for example oils or paint) on the metal, and the specific welding rod being used. Regardless of the composition of the fumes being generated, a welder does not want to be breathing in welding fumes on a regular basis.

NOTE: For additional information on the hazards associated with a specific welding rod, refer to the Safety Data sheet for that welding rod.

Indoor Temporary Hot Work Areas
When choosing a location for temporary hot work it is beneficial to consider the ventilation requirements that will be needed for the work being done. For hot work, including SMAW and gas welding/cutting students should look for areas that meet the following criteria:

- A minimum 10,000 cu.ft. per welder
- A ceiling that is at least 16’ high
- A structure that has overhead doors, windows and/or ceiling and ventilation

In addition to choosing a work area that meets the above criteria, students should take steps to provide additional ventilation.

- General mechanical dilution ventilation: Wall fans, ceiling exhaust fans, and/or portable floor fans can be used to keep the welding plume away from the welder’s breathing space.
- Natural dilution ventilation: Students should weld out of the plume and use a tight fitting welding helmet to shield from the plume. By opening doors, windows and other openings in a building’s structure, fresh air can be added to an area to decrease the concentration of an
airborne contaminant and eventually remove it. This type of ventilation is generally considered the least effective because there is no direct control of how the airborne contaminants will move through the work area.

- **Local exhaust ventilation**: This type of flexible ducted ventilation is the preferred method of exhausting welding fumes, but they may not be available to students performing work at sites off campus (such as when constructing homecoming floats). An example of a local exhaust ventilation system is shown.  

**IMPORTANT NOTE**: Students should never attempt hot work inside a confined space such as a tank, boiler, small enclosed rooms or rooms that are portioned to the extent that there can be no cross ventilation. If work must be done in areas such as this, mechanical ventilation conforming to OSHA 29 CFR §1910.252 (c)(2) must be provided.

Additional respiratory protection can be obtained through use of a NIOSH approved respirator. A ½ face respirator with filters designed for welding will give the welder the most protection. A N95 mask with charcoal will give limited protection from fumes and particulate matter. It is important to note that a welder needs to be cleared by a doctor before utilizing a respirator.

**Storage of gas cylinders**
Students may often perform gas welding (oxygen/acetylene, oxygen/propane) and cutting. One of the practical advantages being that electricity is not needed when using a torch. One of the safety considerations when using gas is the proper storage of the cylinders.

**Storage of gas and oxygen cylinders not being used**
Oxygen and fuel cylinders should be stored in a secure upright position and separate from each other by a minimum of 20’, or separated by a wall of at least 5’ high with a fire rating of at least 1/2 hour.

Cylinders should NOT be stored close to sources of heat such as radiators.
Cylinders in use
Cylinders in use should be set in a secure and upright position. Because the cylinders often need to be moved around, many welders will have the cylinders secured to a cart such as shown below:

Fire Prevention
Fire caused by flying hot debris from welding is one of the biggest hazards welders have to contend with. The sparks and flying metal from welding can fly up to 35 feet and are easily capable of igniting combustible solids and flammable liquids. Taking steps to reduce the risk of fire is a serious obligation for anyone about to engage in performing hot work.

Failure in taking the steps necessary to prevent fire has led to thousands of fires resulting in catastrophic monetary and human losses. One of the most infamous accidents involving hot work occurred when a welder began to weld close to a hydraulic hose under pressure. The heat from the arc welder caused the metal shield of the hose to weaken and the hose burst. The hydraulic fluid caught fire instantly and the resulting inferno claimed the lives of 53 workers (Searcy AR missile silo, August 9, 1965).

Recommended fire prevention steps
1. Before commencing hot work, the area (35 feet diameter from point of work) must be closely inspected and all combustible materials removed. Combustible materials include saw dust (sweep the floors!), paper (newspapers, drawings, instruction manuals, check lists, etc.), clothing and rags, cardboard etc.
2. Remove flammable liquids including paint and paint thinners, oil based lubricants such as WD-40, gasoline/diesel/kerosene, hydraulic fluids, solvents, and degreasers.
3. Remove any flammable compressed gas such as tanks of propane.
4. Have on hand and readily accessible a minimum of one 5lb. ABC fire extinguisher.
5. Have fellow students keep an eye on the area and watch for fires that the welder may not see.
6. After the hot work is complete, keep an eye on the area for at least 30 minutes and complete a thorough inspection of the area prior to leaving.
7. NEVER weld or cut a drum, even an empty drum. People have been killed by welding on a drum that they thought was adequately cleaned but in reality had a small amount of residual solvent which created enough flammable vapors to cause an explosion once ignited.

8. If combustible materials cannot be removed, use of an approved welding blanket may be required as shown below.

![Welding Blanket Example](image)

**Protection of other people**

If there are other people in the area where hot work is to take place, steps should be taken to ensure they do not suffer any injuries, particularly injury to the eyes. Even if a person is not looking directly at the arc flash, just catching a glimpse out of the corner of the eye can be enough to cause painful flash burns. To prevent this, the most effective means is to use a welding curtain.

![Welding Curtain Example](image)

Note the gap at the bottom of the curtain. This is important because it will allow air flow and help improve ventilation of harmful welding fumes.
Safety tips for Specific Operations

**Oxygen Gas Welding & Cutting (Oxy-fuel)**

1. NEVER use oxygen to clean your clothes. Oxygen can be absorbed by your clothes and the slightest spark can result in severe burns.
2. Keep oxygen away from combustibles and keep equipment free from oil, grease, etc.
3. Cylinders should be kept far enough from actual welding or cutting operations so that sparks or hot slag or flame will not reach them, and if that is not possible a fire resistant shield or blanket needs to be used.
4. Cylinders should not be placed where they can become part of an electrical circuit. Avoid contact with layout tables, piping systems, radiators, etc. that may be used for grounding electrical circuits such as for arc welding.
5. Never strike an arc on a cylinder.
6. Do NOT attempt to light your torch using a lighter, match, or welding arc. Use a flint lighter.
7. Inspect your equipment, especially hoses and connections before each use. Replace any damaged hoses or any equipment showing signs of leakage. Do NOT attempt to repair leaky or worn hoses with duct tape. Be sure to recheck equipment for leaks once it is pressurized (leak detection solution is available at any welding supply shop).
8. Use care when handling cylinders. Don’t drop, strike against something or use as a roller.
9. Open valves to cylinders SLOWLY. Follow manufacturers chart for proper pressures. Acetylene should never be set above 15 psig regardless of operation being performed.
10. Open and light the acetylene (or other fuel) first then adjust oxygen to get proper flame. You only need to open the acetylene valve about ½ turn.
11. When done, turn off valves and bleed of hoses to take pressure of regulators.

**Shielded Metal Arc Welding**

1. Do not attempt to use an electric AC or DC welding machine in high moisture areas. Water and electricity is a dangerous combination!
2. Ensure your work is properly grounded. The work clamp should be clamped to the work itself or onto the metal welding table where the work will be welded. Be sure the clamps are in good condition and that you have a “clean” point to which to clamp.
   a. Note: The work clamp is sometimes **erroneously** referred to as the “ground clamp or ground cable. The work cable (or

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Welding, Cutting and Brazing Student Safety Guidelines

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13 | Page
clamp) is not the same as a ground clamp or cable. It is preferable to connect the work clamp directly to the work, hence the name work clamp.

3. Prior to welding, inspect equipment. There should be no leaks of cooling water, shielding gas, or engine fuel that could affect the welder’s safety. Worn or damaged cables must be replaced (failure to do so can cause electrocution).

4. Remove conductive articles of jewelry or clothes such as watch bands, bracelets and rings.

5. Do NOT coil or loop welding electrode cables around parts of the body.

6. Be sure welding gloves are dry (wet or damp gloves may lead to electric shock).

7. If a ladder is required when performing arc welding, the ladder should be made of a non-conductive metal, or well insulated from the work and the ground.
### APPENDIX A: Guide for Shade Numbers

- **Shaded Metal Arc Welding (SMAW)**
  - Less than 3/32 (2.4 mm)
  - 3/32-5/32 (2.4-4.0 mm)
  - 5/32-1/4 (4.0-6.4 mm)
  - More than 1/4 (6.4 mm)
  - Electrode Size
  - Arc Current (Amperes)
  - Minimum Protective Shade
  - Suggested Shade No. (Comfort)

- **Gas Metal Arc Welding (GMAW) and Flux Cored Arc Welding (FCAW)**
  - Electrode Size
  - Arc Current (Amperes)
  - Minimum Protective Shade
  - Suggested Shade No. (Comfort)

- **Gas Tungsten Arc Welding (GTAW)**
  - Electrode Size
  - Arc Current (Amperes)
  - Minimum Protective Shade
  - Suggested Shade No. (Comfort)

- **Air Carbon Arc (Light) Cutting (CAC-A) (Heavy)**
  - Electrode Size
  - Arc Current (Amperes)
  - Minimum Protective Shade
  - Suggested Shade No. (Comfort)

- **Plasma Arc Welding (PAW)**
  - Electrode Size
  - Arc Current (Amperes)
  - Minimum Protective Shade
  - Suggested Shade No. (Comfort)

- **Plasma Arc Cutting (PAC)**
  - Electrode Size
  - Arc Current (Amperes)
  - Minimum Protective Shade
  - Suggested Shade No. (Comfort)

- **Torch Brazing (TB)**
  - Electrode Size
  - Arc Current (Amperes)
  - Minimum Protective Shade
  - Suggested Shade No. (Comfort)

- **Torch Soldering**
  - Electrode Size
  - Arc Current (Amperes)
  - Minimum Protective Shade
  - Suggested Shade No. (Comfort)

- **Carbon Arc Welding (CAW)**
  - Electrode Size
  - Arc Current (Amperes)
  - Minimum Protective Shade
  - Suggested Shade No. (Comfort)

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**Plate Thickness**

<table>
<thead>
<tr>
<th>Oxygen Gas Welding (OFW)</th>
<th>Suggested Shade No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>Medium</td>
</tr>
<tr>
<td>Under 1/8</td>
<td>1/8 to ⅛</td>
</tr>
<tr>
<td>Under 3</td>
<td>3 to 13</td>
</tr>
<tr>
<td>4 or 5</td>
<td>5 or 6</td>
</tr>
</tbody>
</table>

**Oxygen Gas Cutting (OC)**

| Light | Medium | Heavy |
| Under 1 | 1-6 | Over 6 |
| Under 25 | 25 to 150 | Over 150 |
| 3 or 4 | 4 or 5 | 5 or 6 |

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² As a rule of thumb, start with a shade that is too dark to see the weld zone. Then go to a lighter shade which gives sufficient view of the weld zone without going below the minimum. In oxyfuel gas welding, cutting or brazing where the torch and/or flux produces a high yellow light, it is desirable to use a filter lens that absorbs the yellow or sodium line of the visible light spectrum.

² American Welding Society F2.2:2001 (R2010), *Lens Shade Selector*