Welding, Cutting and Brazing Safety Program
January 19, 2016

1. INTRODUCTION

1.1. Purpose
Indiana University Environmental Health and Safety (IUEHS) developed this Program to provide occupational safety guidelines for welding, cutting and brazing (WCB) flame activities in order to comply with Occupational Safety and Health Administration (OSHA) regulations 29 CFR 1910.252, 1910.253, and 1910.254.

1.2. Scope
This Program applies to all welding, cutting, and brazing work activities performed by IU employees and other employees who are under the supervision and direction of IU employees. This includes Facilities Services/Physical Plant (FS/PP) employees.

2. AUTHORITY AND RESPONSIBILITY

2.1. University Environmental Health and Safety (IUEHS) is responsible for:
2.1.1. Developing the Welding, Cutting, and Brazing Program and revising the Program as deemed appropriate;
2.1.2. Stopping any welding, cutting, or brazing activities that pose safety or health concerns; and
2.1.3. Conducting exposure assessments.

2.2. Departments are responsible for:
2.2.1. Coordinating specific welding, cutting, and brazing training.
2.2.2. Notifying employees who perform welding, cutting, or brazing activities of the purpose and intent of this Program;
2.2.3. Ensuring that affected employees are trained in welding, cutting, and brazing hazards;
2.2.4. Providing departmental specific information and training relating to this Program for affected employees;
2.2.5. Ensuring that employees comply with this Program;
2.2.6. Notifying INLOCC/Facility Services/Physical Plant for your respective campus of welding, cutting, or brazing activities that require a hot work permit;
2.2.7. Consulting with IUEHS for the respective campus if unsure of health or safety issues related to welding, cutting, or brazing activities;
2.2.8. Complying with the Hot Work and Welding Management Procedures; and
2.2.9. Providing IUEHS for the respective campus with records of training performed by the department.

2.3. Employees are responsible for:
Complying with this Program;
Complying with the Hot Work and Welding Management Procedures and attending hot work training;
Notifying their supervisor when a hot work permit is needed;
Obtaining a hot work permit when performing hot work in non-designated areas;
Understanding and taking necessary precautions when welding, cutting, or brazing;
Inspecting all welding, cutting, or brazing equipment for proper working condition; prior to use;
Using personal protective equipment (i.e. gloves, clothing, lenses, respirator, etc.);
Utilizing warning signs, barricades, and barriers around WCB activities when necessary; and
Utilize local ventilation equipment when welding, cutting, or brazing or respiratory protection if local ventilation is not possible due to process.

1.1. INLOCC is responsible for:

3. PROGRAM ELEMENTS
3.1. Hazard Identification and Prevention
Welding, cutting, and similar processes produce molten metal, sparks, slag, and hot work surfaces that can cause fire or explosion if precautionary measures are not followed. Flying sparks are the main cause of fires and explosions in welding and cutting.

3.1.1. Hot Work Permit Policy and Procedures
Indiana University Insurance, Loss Control and Claims (INLOCC) and IUEHS have developed Hot Work and Welding Management Procedures to prevent accidental fires, loss of life, and injury from hot work activities (exposure to sparks, heat or flames, and/or loss of property that may result from welding, cutting, and/or brazing activities).

Anyone performing hot work must comply with the Hot Work and Welding Management Procedures and obtain a hot work permit to perform hot work activities.

Exceptions: Processes performed in designated areas, as identified by INLOCC, or during an immediate emergency situation.

3.1.2. Electrical Shock Hazards and Safety Precautions
Electric shock from electrical welding and cutting equipment can result in death or severe burns. Additionally, serious injury can occur if the welder falls as a result of the shock. This safety hazard is associated with operations that use electricity to generate heat, such as arc and resistance welding and cutting.

Employees shall use proper precautionary measures and recommended safe practices at all times to avoid electrical shocks (See IU’s Electrical Safety Program). Personnel using electrical welding and cutting equipment must be trained on safe work practices and procedures before use of this equipment. Some measures to prevent electrical shock include:
3.1.2.1. Never use a bare hand or wet glove to change electrodes.
3.1.2.2. Do not touch an energized electrode while you are in contact with the work circuit.
3.1.2.3. Never stand on a wet or grounded surface when changing electrodes.
3.1.2.4. Do not allow the electrode holder or electrode to come in contact with any other person or any grounded object.
3.1.2.5. Ground the frames of welding units.
3.1.2.6. Insulate yourself from the work piece and ground using dry insulating mats or covers big enough to prevent any physical contact with the work or ground, or wear properly designed and approved rubber-soled boots in good condition.

3.1.2.7. If utilizing long lengths of cable, suspend them overhead whenever possible.

3.1.2.8. If run along the floor, be sure they do not create a tripping hazard, become damaged, or tangled.

Additional safety precautions are required when welding is performed under any of the following electrical hazardous conditions:

- In damp locations or while wearing wet clothing;
- On metal floors, gratings, scaffolds, or other metal structures;
- In cramped positions such as sitting, kneeling, or lying; and
- When there is a high risk of unavoidable or accidental contact with the work piece and ground.

Where these conditions are present, use one of the following types of equipment presented in order of preference:

- Semiautomatic DC constant voltage metal electrode (wire) welder;
- DC manual covered electrode (stick) welder; or
- AC welder with reduced open-circuit voltage.

In most situations, use of a DC constant voltage wire welder is recommended. Do not work alone!

3.1.3. Fumes and Gases

3.1.3.1. When engaging in welding, cutting, or brazing activities, various fumes, gases and vapors are generated from the metals, fluxes, and fillers being used in addition to coatings, paints, galvanizing and plating. In order to protect workers from these, appropriate personal protective equipment (PPE) in the form of a respirator and/or ventilation is recommended. Fume and gas hazards to be considered prior to conducting WCB are:

3.1.4.1.1 Fumes (metals) – Aluminium, Antimony, Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Manganese, Molybdenum, Nickel, Silver, Tin, Titanium, Vanadium, and Zinc;

3.1.4.1.1 Shielding Gases – Argon, Helium, Nitrogen, Carbon Dioxide; and

3.1.4.1.1 Process Gasses – Nitric Oxide, Nitrogen Dioxide, Carbon Monoxide, Ozone, Phosgene, Hydrogen, Fluoride, and Carbon Dioxide.

3.2 Personal Protective Equipment (PPE)

Employees exposed to the hazards created by welding, cutting, or brazing operations shall be protected by PPE. Appropriate protective clothing required for any welding operation will vary with the size, nature and location of the work to be performed. PPE must protect against hazards such as burns, sparks, spatter, electric shock, optical radiation, and inhalation hazards as identified below.

3.2.1 General Protective Equipment

The following are minimum requirement for proper personal protective equipment needed for welding activities:

3.2.1.1 Eye and Face Protection;
3.2.1.2 Clothing with adequate body coverage;
3.2.1.3 Leather boot protection;
3.2.1 Hand protection; and
3.2.1.5 Additional personal protective equipment may include the use of respiratory protection.

3.2.2 **Eye and Face Protection**

3.2.2.1 All filter lenses and plates must meet the test for transmission of radiant energy prescribed in the ANSI standard Z87.2010, *Personal Eye and Face Protection Devices* (see Appendix B).

3.2.2.2 Helmets and hand shields shall protect the face, forehead, neck and ears to a vertical line in back of the ears, from the arc’s direct radiant energy, and weld splatter.

3.2.2.3 Welding helmets with filter plates are intended to protect users from arc rays and from weld sparks and spatters which strike directly against the helmet. They are not intended to protect against slag chips, grinding fragments, wire wheel bristles, and similar hazards which can ricochet under the helmet. Spectacles, goggles or other appropriate eye protection must also be worn to protect against these impact hazards.

3.2.2.4 OSHA requires that when arc cutting and arc welding with open arcs, helmets or hand shields with filter lenses and cover plates shall be used by operators and nearby personnel viewing the arc also subject to wear proper protection. Spectacles with a shade 2 lens are recommended for general purpose protection for viewers. When resistance welding or brazing; operators of resistance welding must use face shields, spectacles, or goggles depending on the particular job to protect their faces and eyes from welding hazards.

3.2.3 **Protective Clothing**

3.2.3.1 Appropriate protective clothing for any welding and cutting operation will vary with the size, nature and location of the work to be performed. Clothing shall provide sufficient coverage and be made of suitable materials to minimize skin burns caused by sparks, spatter or radiation. Covering all parts of the body is recommended to protect against ultraviolet and infrared ray flash burn.

3.2.3.2 Dark clothing works best to reduce reflection under the face shield. Heavier materials such as wool clothing, heavy cotton or leather are preferred as they resist deterioration. Materials that can melt or can cause severe burn due to sparks that may lodge in rolled-up sleeves, pockets of clothing or pant cuffs are not recommended.

3.2.3.3 Other protective clothing includes durable, flame-resistant aprons made of leather or other suitable materials to provide protection to the front of the body when additional protection against sparks and radiant energy is needed.

3.2.4 **Gloves**

3.2.4.1 The standard requires all welders and cutters to wear protective flame-resistant gloves, such as leather welder's gloves, which provide the heat resistance needed for welding. A gauntlet cuff offers additional arm protection, and insulated linings shall be used to protect areas exposed to high radiant energy.

3.2.5 **Respiratory Protection**

3.2.5.1 Respiratory protection is recommended for all welding, cutting, or brazing operations regardless of ventilation due to the variable nature of potential toxic exposure to fumes that are carcinogenic or toxic at very low levels as in the case of manganese or hexavalent chrome. It is precautionary to assume that fumes will be above the level of acceptable risk during all WCB activities. Further guidance can be found at IU’s *Respiratory Protection Program*.

3.2.5.2 Respirators are required when “adequate ventilation” as defined in 3.3.1 is not present or is insufficient to control the fumes.
3.3 Ventilation
Ventilation refers to changes of room air as often as necessary to prevent welders and other workers from breathing high levels of airborne contaminants. Ventilation is a means of providing adequate breathing air, and must be provided for all welding, cutting, brazing and related operations (see Appendix G and 29 CFR 1910.252(c)(3) for further mechanical ventilation requirements).

3.3.1 Adequate Ventilation - depends on the following factors:
3.3.1.1 Volume and configuration of the space where the welding operations occur;
3.3.1.2 Number and type of operations that are generating contaminants;
3.3.1.3 Natural air flow rate where operations are taking place (see Appendix H for natural ventilation requirements); and
3.3.1.4 Locations of the welders' and other workers’ breathing zones in relation to the contaminants or sources.
3.3.1.5 Welding in a confined space can be extremely dangerous. Without adequate ventilation, welding can transform an acceptable atmosphere into a toxic one very quickly. When welding in a confined space, atmospheric monitoring shall be conducted before anyone enters the space and periodically during the entry to ensure that the process of welding is not creating a hazardous atmosphere.

3.4 Compressed Gas Cylinders
3.4.1 Gas cylinders shall be stored in approved spaces and must be secured from falling.
3.4.2 The control valves of cylinders not in use will be covered by protective caps.
3.4.3 Compressed gas cylinders shall be legibly marked to identify the gas contents.
3.4.4 Acetylene cylinders must be kept in an upright position to prevent acetone (solvent used to dissolve the acetylene) from spewing out with the gas.
3.4.5 All gas units must have anti-flashback devices installed on them.
3.4.6 For further guidance, see IUEHS Compressed Gas Cylinder Safety Program.

3.5 Welding and Cutting of Hazardous Materials
When welding, cutting, or brazing where hazardous materials are involved the following rules will apply:

3.5.1 Before welding, cutting, or brazing has begun on any surface covered by a preservative coating whose flammability is not known, a test will be made to determine its flammability and toxicity. Preservative coatings will be considered highly flammable when scrapings burn with extreme rapidity.
3.5.2 Preservative coatings will be removed from the area to be heated to ensure any temperature increase of the unstripped metal will not be appreciable, artificial cooling of the metal surrounding the heating area may be used to limit the area to be stripped.
3.5.3 When welding, cutting, or brazing toxic preservative coatings in enclosed spaces, all surfaces covered with toxic preservatives will be stripped of coverings for a distance of at least 4 inches from the area of heat application or the employees will be protected by respirators.
3.5.4 All welding, cutting or brazing of toxic preservative coated metal will be performed with both local exhaust and respiratory protection. When welding, cutting, or heating toxic preservative coatings in the open air, employees will be protected by respirators.
3.5.5 Before heat is applied to a drum, container, or hollow structure, a vent or opening will be provided for the release of any built-up pressure generated during the application of heat.
3.5.6 Cutting or welding shall not be permitted in the following situations:
3.5.6.1 In the presence of flammable or explosive atmosphere;
3.5.6.2 Near readily ignitable materials;
3.5.6.3 In operating air handling units or ducts; and
3.5.6.3 Outside of a regularly assigned welding area without authorization.
4. TRAINING & RECORDKEEPING

4.1. Training

4.1.1. Training is required when employees are first hired and every three years for refresher training. Welding, Cutting and Brazing Safety training includes the following topics:

- Proper equipment operation
- Handling and storage of welding materials
- Compressed gas cylinder safety
- Physical and chemical hazards
- Hazard control
- PPE selection and use
- Fire precautions
- Fire watch
- Hot work procedures, including how to obtain the written hot work permit (refer to Hot Work and Welding Management Procedures); and
- Confined space training is required when the work necessitates confined space entry.

4.1.2. Additionally, employees are required to attend training when a new process or equipment has been obtained, when an unsafe act has been observed, or when the supervisor feels that retraining is necessary.

4.2. Recordkeeping

4.2.1. Training Records

- Copies of training records are to be maintained within the department and an additional copy sent to IU EHS for your respective campus.

5. REFERENCES

- IU Hot Work and Welding Management Procedures
- 29 CFR 1910.101 - Compressed gases (general requirements)
- 29 CFR 1910.102 - Acetylene
- 29 CFR 1910 Subpart I - Personal Protective Equipment
- 29 CFR 1910 Subpart I Appendix B, Non-mandatory Compliance Guidelines for Hazard Assessment and Personal Protective Equipment Selection
- 29 CFR 1910 Subpart Q, Welding, Cutting, and Brazing
- 29 CFR 1910.251, Definitions
- 29 CFR 1910.252, General requirements
- 29 CFR 1910.254, Arc welding and cutting
- 29 CFR 1910.255, Resistance welding
- 29 CFR 1910 Subpart Z, Toxic and Hazardous Substances
- 29 CFR 1910.1026, Chromium (VI)
- 29 CFR 1910.1027, Cadmium
- 29 CFR 1926 Subpart J, Welding and Cutting
- 29 CFR 1926.350, Gas welding and cutting
- 29 CFR 1926.351, Arc welding and cutting
- 29 CFR 1926.352, Fire prevention
- 29 CFR 1926.353, Ventilation and protection in welding, cutting, and heating
- 29 CFR 1926.354, Welding, cutting, and heating in way of preservative coatings
- 29 CFR 1926 Subpart Z, Toxic and Hazardous Substances
- 29 CFR 1926.1126, Chromium (VI)
- 29 CFR 1926.1127, Cadmium
6. REVISIONS
    January 19, 2016
APPENDIX A – Glossary

**Brazing** - Uses molten metal to join two pieces of metal. The metal added during the process has a melting point lower than that of the work piece.

**Combustible Materials** - Solid or liquid materials that are capable of burning or igniting.

**Cutting** - Any process which produces sparks capable of igniting combustible or flammable materials and transmits heat to the work material from a hot gas.

**Designated Hot Work Area:** A permanent area that has been designated by INLOCC for the performance of hot work operations such as welding, torching, grinding, cutting, etc. This may include areas such as zone maintenance shops, art facilities, or laboratories and does not require a daily permit to perform hot work.

**Flammable Compressed Gas** - Gases that are under high pressure and can easily catch fire and burn rapidly. They include acetylene, hydrogen, natural gas, and propane.

**Flammable Materials** - Solid or liquid materials that are capable of igniting at a low temperature and continue to burn.

**Hot Work:** Any operation involving open flames or producing heat/sparks which includes, but is not limited to brazing, open–flame soldering, oxygen cutting, grinding, arc welding/cutting, oxy–fuel gas welding, hot taps, and torch applied roofing that are capable of initiating fires or explosions.

**Hot Work Operations:** Temporary maintenance, renovation, or construction operations using gas– or electric–powered equipment, which produces flames, sparks, or heat that is sufficient to start a fire or ignite flammable/combustible materials. This includes operations such as cutting, welding, Thermit welding, brazing, soldering, grinding, thermal spraying, thawing pipe, installation of torch–applied roof systems or any other similar operation.

**Hot Work Permit** – A document that will be required when the task requires the use of a flame, sufficient heat or sparks to generate or serve as a source of ignition. Permits are issued by the responsible person at the facility under the Hot Work and Welding Management Procedures permitting welding or other hot work to be done in locations referred to in Chapter 35 of the IFC 2014 edition or like codes in other states.

**Welding** - A way of permanently joining metals together by applying heat to metal pieces, melting and fusing them together to form a permanent bond. The most common forms of welding include: oxygen-fuel gas, arc, gas tungsten and gas metal arc.
## Filter Shade Selection for Type of Welding

<table>
<thead>
<tr>
<th>Operation</th>
<th>Electrode Size (mm)</th>
<th>Arc Current (A)</th>
<th>Min Shade</th>
<th>Suggested Shade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shielded Metal</td>
<td>&lt; 2.5 mm</td>
<td>&lt; 60</td>
<td>7</td>
<td>*</td>
</tr>
<tr>
<td>Arc Welding</td>
<td>2.5 - 4mm</td>
<td>60 - 160</td>
<td>8</td>
<td>10</td>
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<tr>
<td></td>
<td>4 - 6.4mm</td>
<td>160 - 250</td>
<td>10</td>
<td>12</td>
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<tr>
<td></td>
<td>&gt; 6.4mm</td>
<td>250 - 550</td>
<td>11</td>
<td>14</td>
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<tr>
<td>Gas Metal Welding and Flux Cored Arc</td>
<td>&lt; 60</td>
<td>60 - 160</td>
<td>7</td>
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<td></td>
<td>160 - 250</td>
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<td>250 - 500</td>
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<td>12</td>
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<tr>
<td>Gas Tungsten Arc Welding</td>
<td>&lt; 50</td>
<td>50 - 150</td>
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<tr>
<td></td>
<td>50 - 150</td>
<td>8</td>
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<tr>
<td>Air Carbon Arc Cutting</td>
<td>150 - 500</td>
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<td>14</td>
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<td></td>
<td>&lt; 500</td>
<td>10</td>
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<td></td>
<td>500 - 1000</td>
<td>11</td>
<td>14</td>
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<tr>
<td>Torch Brazing</td>
<td></td>
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<td>3 or 4</td>
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<tr>
<td>Torch Soldering</td>
<td></td>
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<td>2</td>
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<tr>
<td>Carbon Arc Welding</td>
<td></td>
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<td>14</td>
<td></td>
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<tr>
<td>Gas Welding (plate under 1/8” thick, light)</td>
<td></td>
<td></td>
<td>4 or 5</td>
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</tr>
<tr>
<td>Gas Welding (plate 1/8” to 1/2” thick, medium)</td>
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<td>5 or 6</td>
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<tr>
<td>Gas Welding (plate over 1/2” thick, heavy)</td>
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<td>6 or 8</td>
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<tr>
<td>Oxygen Cutting (plate under 1” thick, light)</td>
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<td>3 or 4</td>
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<tr>
<td>Oxygen Cutting (plate 1” to 6” thick, medium)</td>
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<tr>
<td>Oxygen Cutting (plate over 6” thick, heavy)</td>
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<td>5 or 6</td>
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</tbody>
</table>

*As a rule of thumb, start with a shade that is too dark to see the weld zone. Then go to a lighter shade that gives sufficient view of the weld zone without going below the minimum. In Oxy-fuel gas welding or cutting where the torch produces a high yellow light, it is desirable to use a filter lens that absorbs the yellow or sodium line in the visible light of the operation.

**This applies to where the actual arc is clearly seen. Experience has shown that lighter filters may be used when the arc is hidden by the work piece.

Workers with prescription lenses are not exempt from wearing proper eye protection.
When performing GMAW, GTAW, and FCAW, the following rules will apply:

**Chlorinated Solvent Safety**
- Chlorinated solvents will be kept at least 200 ft. away, unless shielded, from the exposed arc.
- Surfaces prepared with chlorinated solvents need to be dry before welding is permitted on such surfaces.

**UV/Arc Protection**
- Persons in the area not protected from the arc by screening will be protected by filter lenses.
- When two or more welders are exposed to each other’s arc, filter lens goggles will be worn under welding helmets.
- Hand shields will be used to protect the welders against flashes and radiant energy when either the helmet is lifted or the shield is removed.
- Welders and other persons who are exposed to radiation will be protected so that the skin is covered to prevent burns and other damage by ultraviolet rays.
- Welding helmets and hand shields will be free of leaks, openings, and highly reflective surfaces.

**Stainless Steel Welding**
- When gas metal arc welding is performed on stainless steel, persons will be protected against dangerous concentrations of nitrogen dioxide by local exhaust ventilation or airline respirators.
APPENDIX D - Oxy-fuel Gas Welding and Cutting

When performing oxy-fuel gas welding and cutting the following rules will apply:

- Oxy-fuel gas welding and cutting equipment shall be listed by a nationally recognized testing laboratory.
- Oxygen cylinders and apparatus will be kept free from oil, grease, and other flammable or explosive substances and will not be handled with oily hands or gloves.
- Oxygen cylinders and apparatus will not be used interchangeably with any other gas.

**Hoses**

- Fuel gas hose and oxygen hose will be readily distinguishable from each other.
- Oxygen and fuel gas hoses will not be interchangeable; a single hose having more than one gas passage will not be used.
- Hose couplings of the type that can be unlocked or disconnected without a rotary motion are prohibited.
- Hose which has been subject to flashback or which shows severe wear or damage will be tested to twice the normal pressure to which it is subjected, and in no case less than (300 psi). Defective hose, or hose in doubtful condition, will not be used.
- When parallel runs of oxygen and fuel gas hose are taped together, not more than 4 inches out of every 12 inches will be covered by tape.
- Boxes used for the storage of gas hose will be ventilated.
- Hose connections will be clamped or otherwise securely fastened in a manner that will withstand, without leakage, twice the pressure to which they are normally subjected in service, but not less than 300 psi.

**Torches**

- Torches shall be inspected, at the beginning of each working shift, for leaking shutoff valves, hose couplings, and tip connections. Defective torches will not be used.
- Hoses will be purged individually before lighting the torch for the first time each day. Hoses will not be purged into confined spaces or near ignition sources.
- Clogged torch tip openings shall be cleaned with suitable cleaning wires, drills, or other devices designed for such purposes.
- Torches will be lighted by friction lighters or other approved devices, not by matches or from hot work.
- Torch valves will be closed and the gas supply shut off whenever work is suspended.
- The torch and hose will be removed from confined spaces whenever work is suspended.
- Oxy-fuel gas, and other fuel gas-oxygen, welding and cutting systems utilizing cylinder-hose-torch will have a reverse-flow check valve, in each hose, between the torch and the regulator (Reverse-flow check valves that are integral with the torch are acceptable.).
APPENDIX E - Arc Welding (SMAW) and Cutting

When performing SMAW, the following rules will apply:

Manual Electrode Holders

- Only manual electrode holders specifically designed for arc welding and cutting of a capacity capable of safety handling the maximum rated current required by the electrodes may be used.
- All current carrying parts of the holder which are gripped by the welder or cutter, and the outer jaws of the holder, will be fully insulated against the maximum voltage encountered to ground.

Cables and Connectors

- Cables shall be completely insulated, flexible, and capable of handling the maximum current requirements of the work in progress and in good repair.
- Cables with splices or repaired insulation within 10 feet of the holder shall not be used.
- Where it becomes necessary to connect or splice lengths of cable together, insulated connectors of a capacity at least equivalent to that of the cable shall be used. When connections are affected by cable lugs, they shall be securely fastened together to give good electrical contact and the exposed metal parts of the lugs shall be completely insulated.
- The frames of arc welding and cutting machines shall be grounded either by a third wire in the cable connecting the circuit conductor or by a separate wire which is grounded at the source of the current.
APPENDIX F - Brazing

Brazing is frequently necessary to join metals at low temperatures. Since brazing is a process requiring heat, precautions shall be taken for handling hot objects to prevent workers from being burned.

Brazing Compound Safety

- The caution notices on the packages shall be followed when using brazing fluxes. Fumes generated during brazing can be a serious hazard. Brazing fluxes generate fluoride fumes when heated. Cadmium in silver brazing alloys vaporizes when overheated and produces cadmium oxide, a highly toxic substance. If cadmium oxide fumes are inhaled into the respiratory tract, they can cause pulmonary distress, shortness of breath and in cases of severe exposure, may cause death.

- When using silver solder, the guidance listed below shall be followed.
  o Know the materials with which you are working. Be sure you are not brazing on cadmium plated parts.
  o Read warning labels on filler metals and fluxes and label instructions.
  o Wear eye and face protection and protective clothing as required by the job.
  o Work in well ventilated areas, or use respirators as required by the job.
  o Apply heat to base metal, not directly to the brazing filler metal.
  o Do not overheat either the base metal or the brazing filler metal.
  o Wash hands thoroughly after handling brazing fluxes and filler metals.

- To use silver solder safely, the following information should be kept in mind.
  o Silver brazing filler metals containing cadmium are: BAg-1, BAg-1a and BAg-2 and BAg-3. These silver brazing alloys can be safely used however, if precautions are followed.
  o The BAg-1 and BAg-1a classes of silver brazing filler metal can be successfully and properly used at temperatures below 1400 degrees F; brazing can be carried on safely using these two classes of filler metal. The remaining two classes of silver brazing temperature ranges are 1295-1550 degrees F. Brazing can be carried on safely using temperatures below 1400 degrees F with these latter classes of filler metal. Since temperatures in the upper portion of these ranges can be reached, it is important to provide adequate local exhaust ventilation or where this is not possible, individual respirators. “Local exhaust or general ventilation systems shall be provided and arranged to keep the amount of toxic fumes, gases or dusts below the maximum allowable concentration as defined by the Acceptable Concentrations of Toxic Dusts and Gases, American Standard Z37”
  o It should be noted that the most serious cause of cadmium oxide fume generation occurs when all of these silver brazing filler metals are overheated. Care must be taken to control the temperature of the silver brazing operation. Under no circumstances shall a torch flame be applied directly to the silver brazing alloy. The heat of the base metal shall be used to melt and flow the brazing filler metal.
  o Another source of cadmium fumes is from brazing on cadmium plated parts. Since the torch flame is applied directly to the base metal, cadmium plated parts are potentially more hazardous than cadmium-bearing silver brazing alloys. When in doubt about a base metal, check with the supplier of the part. Cadmium plating shall be removed before heating for brazing.
APPENDIX G - Mechanical Ventilation

In order to protect employees from vapors and fumes during WCB activities, mechanical ventilation might consist of the following:

- Mechanical ventilation options generally fall into two basic categories. The first is the low vacuum system which takes large volumes of air at low velocities. These systems consist of hoods positioned at a distance from the work area. The hood and housing may have to be repositioned by the worker to get maximum benefit from this means of ventilation. Hoods generally remove the fumes and contaminated air through ducting and exhaust the contaminants to the outdoors. Hoods shall be placed as near as practical to the work, and shall provide effective air flow and capture velocity that complies with 29 CFR 1910.252(c)(3)(i).

- Another category of mechanical ventilation is the high vacuum system fume extraction system (LEV). These are close-range extractors that are aimed at capturing and extracting fumes as near to the work as possible. Fume extractors often have an immediate area of welding. By removing a small volume of air at a high velocity, the potentially hazardous materials are effectively removed before reaching the welder’s breathing zone. These systems often are equipped with a fan that pulls the contaminants into a filtration system, with a HEPA (High Efficiency Particulate Absolute) filter or combination of HEPA filter and pre-filter and then re-circulate the clean air back into the work area. Advantages of high vacuum systems are greater flexibility for job adaptation, more efficient means of fume removal, and greater visibility to the welder due to reduced clouds of fumes and vapors being created.

- Air sampling to verify the concentration levels of toxic fumes and gases is necessary, and respiratory protection is required along with mechanical ventilation in the cutting and/or welding of certain metals and compounds.
  - Such ventilation shall be at the minimum rate of 2,000 cubic feet per minute per welder, except when local exhaust ventilation or respirators are provided.
APPENDIX H - Natural Ventilation

In the event portable mechanical ventilation is infeasible, natural ventilation may be used as long as the below are met and an exposure evaluation is conducted.

- Space of more than 10,000 square feet is provided per welder;
- A ceiling height of more than 16 feet; and
- Welding is not done in a confined space.