

# Welding, Cutting and Brazing

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## University of Tennessee Safety Guide GS-095

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### Purpose

The purpose of this policy is to provide safety requirements for welding, cutting and brazing in accordance with OSHA under 29 CFR 1910.252 requirements.

### Scope and Applicability

This policy applies to all employees, students, faculty and contractors who may perform welding, cutting, or brazing in their job functions.

### Abbreviations and Definitions

#### Abbreviations

**OSHA:** Occupational Safety and Health Administration

**PPE:** Personal Protective Equipment

#### Definitions

**Brazing:** Applies heat to the metal, usually from an oxy-acetylene gas flame. The metal does not reach its melting point. Instead, filler material and flux from a welding rod melt to form the weld.

**Designated Area:** An area where welding, cutting, and or brazing is authorized.

**Fire Watch:** Trained personnel who are in attendance during the entire cutting and welding operation and are immediately available to extinguish a fire or take other effective action if necessary.

**Gas Cutting:** Creates a molten pool of metal using heat from a gas torch. A jet of oxygen is injected into the pool to accelerate the oxidation of the material.

**Gas Welding:** Typically uses an oxy-acetylene gas flame as a source of heat. Some types of gas welding, such as soldering, use propane or other fuel gasses.

**Hot Work:** Any temporary operation involving open flames or producing heat and/or sparks. This includes, but is not limited to, grinding, cutting, brazing, soldering, torching, and welding.

**Hot Work Permit:** A special permit issued by the Supervisor or EHS which authorizes specific welding, cutting, and/or brazing activities at a specific location and time.

**Hot Work Operator:** Employee who is qualified and authorized to perform hot work, such as; welding, brazing, soldering, and other associated work tasks.

**Permit:** Authorized Individual: employee who is trained and is authorized to issue a hot work permit.

**Soldering:** Like brazing, is accomplished without melting the metal parts that will be joined.

**Welder/Welder Operator:** Any operator of electric or gas welding and cutting equipment.

## Roles and Responsibilities

### Supervisors of employees or students who conduct welding, cutting or brazing shall:

- i. Ensure that all directly supervised employees and contractors are utilizing appropriate welding, cutting and brazing procedures.
- ii. Ensure that the conditions of designated hot work areas have not changed prior to authorizing hot work.
- iii. Ensure that all welding and cutting equipment is maintained in a safe operating condition.
- iv. Ensure that employees are trained in the operation of the equipment and safe use of the process.
- v. Ensure hot work permits for work under their supervision.
- vi. Determine the combustible materials and hazardous areas present or likely to be present in the work area.
- vii. Determine that fire protection and fire extinguishing equipment are properly located at the site.
- viii. When fire watches are required, make sure they are available at the site.
- ix. Review and approve locations proposed for Hot Work areas.
- x. Periodically inspect designated areas to be sure that conditions have not become unsafe for welding or cutting.
- xi. Suspend welding, cutting and brazing work if conditions become unsafe for the work being performed.
- xii. Provide training for the fire watches and ensure that the proper firefighting equipment is in working condition, and is available to standby personnel.
- xiii. Advise contractors about flammable materials or hazardous conditions of which they may not be aware.
- xiv. Communicate all hazards associated with the potentially hazardous materials employed in fluxes, coatings, coverings and filler materials, complying with the OSHA HAZCOM standard. Ensure employees have access to labels on containers and safety data sheets, and are trained in accordance with HAZCOM regulations.
- xv. Ensure proper engineering and administrative controls are established to protect employees from welding hazards; provide personal protective equipment to employees when necessary.

### Employees and students performing hot work shall:

- i. Read and understand the UT welding, cutting and brazing policy.
- ii. Complete hot work training.
- iii. Ensure that PPE is worn properly for the specific hazard involved and that all equipment is in good working condition.
- iv. Conduct welding, cutting, brazing and/or hot work activities in accordance with all safety guidelines and procedures.
- v. Protect nearby personnel against heat, sparks, etc. when working in occupied workplaces.
- vi. Inform their supervisors of any hazards that they feel are not adequately addressed in the workplace and of any concerns that they have regarding the program.

### EHS shall:

- i. Review and revise the welding, cutting and brazing policy on a periodic basis.
- ii. Provide technical guidance and assistance upon request.
- iii. Provide training resources upon request.

- iv. Conduct air exposure monitoring if requested.
- v. Perform checks on local exhaust ventilation and provide consultation on general and local exhaust ventilation.

**Contractors shall:**

- i. Follow UT's Welding, Cutting and Brazing Policy and follow all OSHA requirements.
- ii. Provide personal protective equipment and other engineering and administrative means to protect against harmful exposures during welding.

**Guidance****Welding Hazards**

Welding joins pieces of metal by the use of heat, pressure, or both. There are more than 80 different types of welding processes. Three major types of welding processes include:

- Gas – Slower and easier to control than electric arc. Uses gas flame over metals until molten puddle is formed. Most popular fuels used with oxygen include acetylene, mapp gas, and hydrogen.
- Arc – Two metals are joined by generating an electric arc between a covered metal electrode and the base metal.
- Oxygen and Arc Cutting – Metal cutting in welding is the severing or removal of metal by a flame or arc.

The most common cutting processes include:

- Oxygen Cutting: Metal is heated by gas flame and an oxygen jet does the cutting.
- Arc Cutting: Intense heat of electric arc melts away the metal.

Examples of common types of welding include: arc welding, plasma welding, welding processes that use oxy-acetylene gas (SAW), lasers, and electron beams. Welding can generate toxic fumes and gases. Brazing or soldering involves a filler metal or alloy (combination of metals) which has a lower melting point than the metals being joined. The filler materials (such as lead and cadmium) can be very toxic. Cutting involves heating the metal with a flame and directing a stream of pure oxygen along the line to be cut.

Factors affecting worker exposure include:

- Type of welding process
- Base metal and filler metals used
- Welding rod composition
- Location (outside vs. enclosed space)
- Welder work practices
- Air movement
- Use of ventilation controls

Both health and physical hazards are associated with welding depending upon the welding process, the base material, the filler material, and the shielding gas that may be used. Health hazards may be either acute or chronic. The following are the most common:

- Burns
- Electrical shock and burns

- Infrared and ultraviolet eye injury from looking at the arc without eye protection
- Lung irritation or poisoning from toxic gases or fumes from the welding operation
- Musculoskeletal injuries from posture, heavy lifting

Physical Hazards associated with welding operations include:

- Fire
- Potential Explosion when welding in close proximity to closed containers that have held flammable liquids or other combustible materials
- Potential Flash fire when welding in close proximity to flammable or combustible vapors at the worksite
- Noise exposure possibly resulting in permanent hearing loss.
- Electrical hazards; danger of electric shock

Potential health hazards depend on metal being welded and the composition of the welding electrode. Welding or cutting on work pieces that have metallic alloys have potential to be especially hazardous. Welding metals generates welding fumes, which can include toxic metals, such as: aluminum, antimony, arsenic, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, silver, tin, titanium, vanadium and zinc. Acute health effects of breathing welding fumes result in eye, nose and throat irritation, dizziness and nausea. Workers who begin experiencing these symptoms should leave the work area immediately and seek fresh air and medical attention. . Health effects from certain fumes can cause metal fume fever, stomach ulcers, kidney failure and nervous system damage. Prolonged exposure to manganese fumes can cause Parkinson's-like symptoms. Long term exposure to welding fumes may cause lung cancer, and other types of cancer, such as larynx and urinary tract cancer.

Welding fumes can also generate toxic gases generated from shielding, such as argon, helium, nitrogen, carbon dioxide. Other gases are generated from processes, such as: nitric oxide, nitrogen dioxide, carbon monoxide, ozone, phosgene, hydrogen fluoride and carbon dioxide.

Chromium is a component in stainless steel, nonferrous alloys, chromate coatings, and some welding consumables. Chromium is converted to its hexavalent state during the welding process. Hexavalent chromium fumes are highly toxic, and can damage the eyes, skin, nose, throat and lungs and can cause cancer. OSHA regulates worker exposure to hexavalent chromium under its chromium standard, 29 CFR 1910.1026 and 1926.1126. OSHA's Permissible Exposure Limit (PEL) for hexavalent chromium is 5µg/m<sup>3</sup> as an 8 hour time weighted average.

Some types of welding, including shielded metal arc welding, has the potential to produce nitrogen oxides in significant quantities. However, this is not usually an issue in open shop areas with adequate ventilation. Gas Metal Arc (GMA) welding can result in possible inhalation of phosgene gas. Gases, such as helium, argon, and carbon dioxide displace oxygen in the air, and can lead to suffocation (especially when working in confined spaces). Carbon dioxide can form, causing a serious asphyxiation hazard.

Other names for metal fume fever include: "zinc fume fever", "brass chills", or "brass founders ague". Although metal fume symptoms do not typically last more than a day, it is possible to get metal fume fever more than once. Zinc and copper metal oxides are usually the metals associated with metal fume fever.

Radiation exposure is also a risk during welding. "Flash burn" or "arc eye" is an acute condition due to exposures to ultraviolet light while SMA welding. The radiation is absorbed by the cornea and causes severe

photo keratitis. The UV radiation from inert gas shielded operations will cause skin reddening; therefore, the welder must protect their face, neck and arms.

Welding, cutting, and allied processes produce molten metal, sparks, slag, and hot work surfaces 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. Sparks can travel up to 35 feet from the work area. Sparks and molten metal can travel greater distances when falling. Sparks can pass through or become lodged in cracks, clothing, pipe holes, and other small openings in floors, walls, or partitions. Typical combustible materials found inside buildings include: wood, paper, rags, clothing, chemicals, flammable liquids and gases, and dusts. Parts of buildings such as floors, partitions, and roofs may also be combustible. Welding and cutting can cause explosions in spaces containing flammable gases, vapors, liquids, or dusts.

Below, is a table illustrating the type of fumes and the health effects after being exposed to these fumes.

| Source                | Effects and Symptoms   |   |
|-----------------------|--|---|
| <i>Fumes</i>          |  |   |
| <b>Aluminum</b>       | Aluminum component of some alloys, e.g., copper, zinc, steel, magnesium, brass and filler materials. | Respiratory irritant.   |
| <b>Beryllium</b>      | Hardening agent found in copper, magnesium, aluminum alloys and electrical contacts.                 | “Metal Fume Fever.” A carcinogen. Other chronic effects include damage to the respiratory tract.  |
| <b>Cadmium Oxides</b> | Stainless steel containing cadmium or plated materials, zinc alloy.                                  | Irritation of respiratory system, sore and dry throat, chest pain and breathing difficulty. Chronic effects include kidney damage and emphysema. Suspected carcinogen.      |
| <b>Chromium</b>       | Most stainless-steel and high-alloy materials, welding rods. Also used as plating material.          | Increased risk of lung cancer. Some individuals may develop skin irritation. Some forms are carcinogens (hexavalent chromium).  |
| <b>Copper</b>         | Alloys such as brass, bronze. Also some welding rods.  | Acute effects include irritation of the eyes, nose and throat, nausea and “Metal Fume Fever.”   |
| <b>Fluorides</b>      | Common electrode coating and flux material for both low- and high-alloy steels.                      | Acute effect is irritation of the eyes, nose and throat. Long-term exposures may result in bone and joint problems. Chronic effects also include excess fluid in the lungs. |
| <b>Iron Oxide</b>     | The major contaminant in all iron or steel welding processes.  | Siderosis – a benign form of lung disease caused by particles deposited in the lungs. Acute symptoms  |

| Source                   |   | Effects and Symptoms   |
|--------------------------|---|--|
|                          |   | include irritation of the nose and lungs. Tends to clear up when exposure stops.   |
| <b>Lead</b>              | Solder, brass and bronze alloys, primer/coating on steels.  | Chronic effects to nervous system, kidneys, digestive system and mental capacity. Can cause lead poisoning.  |
| <b>Manganese</b>         | Most welding processes, especially high-tensile steels.   | "Metal Fume Fever." Chronic effects may include central nervous system problems.   |
| <b>Molybdenum</b>        | Steel alloys, iron, stainless steel, nickel alloys.   | Acute effects are eye, nose and throat irritation, and shortness of breath.  |
| <b>Nickel</b>            | Stainless steel, Inconel, Monel, Hastelloy and other high-alloy materials, welding rods and plated steel. | Acute effect is irritation of the eyes, nose and throat. Increased cancer risk has been noted in occupations other than welding. Also associated with dermatitis and lung problems.            |
| <b>Vanadium</b>          | Some steel alloys, iron, stainless steel, nickel alloys.  | Acute effect is irritation of the eyes, skin and respiratory tract. Chronic effects include bronchitis, retinitis, fluid in the lungs and pneumonia.   |
| <b>Zinc Oxides</b>       | Galvanized and painted metal.   | Metal Fume Fever   |
| <b>Gases</b>             |   |  |
| <b>Carbon Monoxide</b>   | Formed in the arc.  | Absorbed readily into the bloodstream, causing headaches, dizziness or muscular weakness. High concentrations may result in unconsciousness and death.   |
| <b>Hydrogen Fluoride</b> | Decomposition of rod coatings.  | Irritating to the eyes and respiratory tract. Overexposure can cause lung, kidney, bone and liver damage. Chronic exposure can result in chronic irritation of the nose, throat and bronchi.   |
| <b>Nitrogen Oxide</b>    | Formed in the arc.  | Eye, nose and throat irritation in low concentrations. Abnormal fluid in the lung and other serious effects at higher concentrations. Chronic effects include lung problems such as emphysema. |
| <b>Oxygen Deficiency</b> | Welding in confined spaces, and air displacement by shielding gas.  | Dizziness, mental confusion, asphyxiation and death.   |

| Source                                  |  | Effects and Symptoms   |
|---|--|--|
| <b>Ozone</b>                            | Formed in the welding arc, especially during plasma-arc, MIG and TIG processes.                                    | Acute effects include fluid in the lungs and hemorrhaging. Very low concentrations (e.g., one part per million) cause headaches and dryness of the eyes. Chronic effects include significant changes in lung function. |
| <b>Organic Vapors</b>                   |  |  |
| <b>Aldehydes (such as formaldehyde)</b> | Metal coating with binders and pigments. Degreasing solvents.  | Irritant to eyes and respiratory tract.  |
| <b>Di-isocyanates</b>                   | Metal with polyurethane paint.   | Eye, nose and throat irritation. High possibility of sensitization, producing asthmatic or other allergic symptoms, even at very low exposures.  |
| <b>Phosgene</b>                         | Metal with residual degreasing solvents. (Phosgene is formed by reaction of the solvent and welding radiation.)    | Severe irritant to eyes, nose and respiratory system. Symptoms may be delayed.   |
| <b>Phosphine</b>                        | Metal coated with rust inhibitors. (Phosphine is formed by reaction of the rust inhibitor with welding radiation.) | Irritant to eyes and respiratory system, can damage kidneys and other organs.  |

### **Heat Stress and Cold Stress during Welding:**

Precautions should be taken and work schedules adjusted to ensure that every worker's core body temperature is maintained. If fluids are not taken to replace those lost by sweating, heat exhaustion can occur.

### **Eye injury**

Radiation from welding arcs resulting in eye damage include:

- Arc welding: from UV radiation
- Cataracts/l from UV and IR radiation
- Retinal burns (from both visible or IR radiation)

UV radiation is the most likely to cause injury, because its effects are not noticed during the time of exposure.

### **Ventilation Guidelines for Welding, Cutting and Brazing Operations**

There are two major types of ventilation that can be utilized to protect from harmful welding fumes, which include general ventilation and local exhaust ventilation.

#### **General or Dilution Ventilation:**

Relies on diluting airborne contaminants with fresh air from open doors, windows or fans, and is acceptable for less hazardous air contaminants. General ventilation provides enough air movement to keep the fumes and

gases out of the welder's breathing zone. Workers should position themselves to avoid breathing welding fumes and gases. For example, welders should stay upwind when welding in open or outdoor environments. Welding outdoors does not guarantee adequate ventilation. In work areas without ventilation and exhaust systems, welders should use natural drafts and proper positioning to keep fumes and gases away from their breathing zone.

If requirements for natural ventilation are not met, then the area needs to be mechanically ventilated. Ventilation must exhaust at least 2,000 cubic feet per minute of air for each welder, except:

- Where local exhaust hoods or booths are used
- Where air-line respirators are used.

#### **Local Exhaust Ventilation (LEV):**

Local exhaust ventilation is much more effective in controlling welding fumes and gases because it captures the fumes and gases close to the source and keeps them from entering the welder's breathing zone. This is usually accomplished by the use of hoods and ducts. Welding must not be done in confined spaces without ventilation. Local exhaust ventilation may consist of freely movable hoods designed to be placed by the welder as close as practical to the work. The system shall be capable of removing fumes and smoke at the source and keep the concentration of them in the breathing zone at a safe distance. The contaminated air exhausted from the workspace must be discharged in the open air, or clear of the source of intake air. Oxygen and compressed air cannot be used for ventilation purposes, blowing off dust, or cleaning clothes. Hoods and ductwork should be constructed of fire-resistant materials. Welding booths should be painted with a dull finish that does not reflect UV light.

To be effective, local exhaust ventilation must:

- Be close to the welding arc or flame where the fumes, gases and heat are generated,
- Have enough velocity to draw away the contaminants.
- Ensure protection from fume and gases by (depending on circumstances) one or a combination of:
  - Good general ventilation (generally limited to less hazardous air contaminants)
  - Use of a booth
  - Local exhaust ventilation such as fume hoods and ducts
  - Movable hoods placed as close to the work as practical and provided with a rate of 100 feet per minute in the zone of welding when the hood is at its most remote distance from the point of welding. The rates of ventilation required to accomplish this velocity using a 3-inch wide flanged suction opening accordance with 29 CFR 1910.252(c)(3)(i) are shown in the following table:

| Welding Zone                    | Minimum air flow<br>cubic feet/minute | Duct diameter, inches |
|---------------------------------|---------------------------------------|-----------------------|
| 4 to 6 inches from arc or torch | 150                                   | 3                     |
| 6 to 8 inches from arc or torch | 275                                   | 3 ½                   |



|                                   |     |     |
|-----------------------------------|-----|-----|
| 8 to 10 inches from arc or torch  | 425 | 4 ½ |
| 10 to 12 inches from arc or torch | 600 | 5 ½ |

**Ventilation Requirements for Welding and Cutting – 1910 Standards:**

| <b>Metal Compound</b>                   | <b>Requirements Confined Space</b>   | <b>Requirements Indoors</b>   | <b>Requirements Outdoors</b>  |
|---|--|---|---|
| <b>Fluorine Compound</b>                | Air replacement or airline respirator or self-contained breathing apparatus needed | Air sample tests to determine if exhaust hood, booth, and airline respirator are required | Same as indoors   |
| <b>Lead, Zinc, Galvanized Compounds</b> | Air replacement or airline respirator or self-contained breathing apparatus        | Exhaust hood or booth   | Combination particulate and vapor and gas removing type respirator if tests indicate need |
| <b>Beryllium</b>                        | Exhaust hood or booth and airline respirator if air sample tests indicate need     | Exhaust hood or booth and airline respirator if air sample tests indicate need            | Exhaust hood or booth and airline respirator if air sample tests indicate need            |
| <b>Cadmium Mercury</b>                  | Exhaust hood or booth and airline respirator if air sample tests indicate need     | Exhaust hood or booth and airline respirator if air sample tests indicate need            | Combination particulate and vapor and gas removing type respirator if                     |

1. Airline or self-contained breathing apparatus are required in confined areas that are immediately hazardous to life.
2. Local exhaust hoods or booths must provide airflow of at least 100 linear feet per minute.
3. Mechanical ventilation at 2,000 cubic feet of air per minute per welder is required when welding or cutting on metals other than described above; when there is less than 10,000 cubic feet of space per welder; or where the ceiling height is less than 16 feet; or in confined spaces or where structural barriers (such as partitions or balconies) significantly obstruct cross ventilation. 1910.252(c)(2)(i)(A) through (C).

**Note:** Mechanical ventilation is necessary when an exhaust hood or fixed booth provide for a rate of airflow sufficient to maintain a velocity away from the welder or not less than 100 linear feet per minute.

Welding in Confined Spaces:

General or LEV must be provided when working in confined spaces. When sufficient ventilation cannot be achieved without blocking means of access, workers must be protected by airline respirators, and an employee must be stationed outside the confined space to aid them in an emergency. When the welder enters the confined space, they must be attached to a lifeline so that they can quickly be removed.

When welding with materials containing zinc, lead cadmium and chromium in enclosed spaces, LEV, or respiratory protection must be provided. When working with beryllium compounds, LEV and airline respirators must be provided. Specific OSHA requirements exist under 29 CFR 1926.353 for workers performing certain types of arc welding operations in confined spaces.

The following safety guidelines should be followed when performing various welding operations:

### **Electric Welding and Cutting:**

1. Perform Safety Check on all equipment
2. Ensure fire extinguisher is charged and available.
3. Perform Safety Check on all equipment
4. Ensure electrical cord, electrode holder and cables are free from defects (no cable splices are allowed within 10 feet of the electrode holder.
5. Ensure PPE (welding hood, gloves, rubber boots/soled shoes, aprons) are available and have no defects.
6. Ensure the welding unit is properly grounded.
7. Examine equipment frequently to determine that all electrical connections and insulations on holders and cables are in good condition. Loose cable connections may overheat or arc cause a fire.
8. Keep welding cables dry, grease and oil-free, and protected from sparks or hot metal.
9. Store welding rods in the container on the welding machine; do not throw on floors or staging.

### ***Set Voltage Regulator no higher than the following for:***

- Manual Alternating Current Welders – 80 volts.
- Automatic Alternating Current Welders – 100 volts.
- Manual or automatic Direct Current Welders – 100 volts.

### ***Uncoil and spread out welding cable.***

- To ensure proper contact of work leads and connection.
- To remove any metal fragments from magnetic work clamps (to avoid electric shock do not wrap welding cables around a body part and avoid welding in wet conditions).

### ***Avoid overheating:***

- Prior to spot welding, the material is usually cleaned in a caustic or slightly acid bath. Employees performing these wash operations shall be protected from splashing liquid.
- The operator shall make necessary adjustment to the contactors.
- In hand spot welding installations, eye protection shall be required to protect the operator from the spattering metal.
- Welding of materials such as stainless and high carbon steels causes excessive spattering of metal. Operators shall be cautioned to protect against the possible penetration of the metal into the tips of the fingers.

### **Gas Welding and Cutting**

1. Perform Safety Check on all equipment

2. Ensure tanks have gas and fittings are tight.
3. Ensure fire extinguisher is charged and available.
4. Ensure hoses have no defects.
5. Ensure PPE (welding hood, gloves, rubber boots/soled shoes, aprons) are available and have no defects.
6. All defective equipment must be repaired or replaced before use.
7. Remove flammables and combustibles
8. Remove all nearby flammable or combustible materials before striking an arc or lighting a flame.
9. Remove all flammable and readily combustible materials from your pockets, such as matches and cigarette lighters.
10. Place welding screen or suitable barricade around work area to provide a fire safety zone and prevent injuries to passersby.

### **Welding Operators Protection (See more details in PPE policy GS 50)**

Before beginning a welding job, it is very important to identify the hazardous for that particular welding operation. Welders should understand the hazards they are working with. A Safety Data Sheet (SDS) should be provided to identify the hazardous materials used in the welding operation. Less hazardous materials can be substituted for some welding chemicals, such as cadmium –free solders and asbestos-free electrodes, gloves and hot pads.

Welding surfaces should be cleaned of any coatings that could potentially create toxic exposure, such as paint and solvent residue.

Workers should position themselves to avoid breathing welding fumes and gases. For example, welders should stay upwind when welding in open or outdoor environments.

Welders need to be protected against heat, sparks, ultraviolet rays, hot slag, fumes and toxic gases. Make sure employees are outfitted with the following personal protective equipment (PPE):

### **Personal Protective Equipment:**

#### ***Body Protection:***

- Clothing should provide sufficient coverage, and be made of suitable materials, to minimize skin burns caused by sparks, splatter, or radiation.
- Keep clothing dry and change when needed to reduce risk of electric shock.
- Keep clothing clean (free of grease, oil and solvents, which can catch fire and burn easily).
- Do not wear synthetic fabrics; wear cotton or wool.
- Protective clothing and equipment shall be suitable for the type of work to be performed, kept in good repair, and kept free of oil and grease.
- Sleeves shall be kept buttoned at the wrist.
- Collars shall be kept buttoned.
- Fire-resistant gloves and aprons shall be worn during welding, flame cutting and brazing processes.
- Safety shoes should be worn to protect the operator from spark hazard.

#### ***Eye and Face Protection***

- Safety glasses, goggles, face shields, helmets, or other suitable eye protection having the proper lens shade for the work being done shall be worn during all welding, cutting, and brazing operations.
- Fire Watch personnel shall wear eye and face protection as appropriate.

- Wear flame resistant gloves (such as leather welder's) that are dry, hole-free and insulated.
- Goggles shall be ventilated to prevent fogging of the lenses as much as practicable.
- Goggles, helmets, and face shields shall be checked frequently.
- The following table is a guide for the selection of the proper shade numbers. These recommendations may be varied to suit the individual's needs in accordance with 29 CFR 1910.252(b) (2) (ii) (H) of the Occupational Safety and Health Administration.

| Welding operation   | Shade No. |
|---|-----------|
| Shielded metal-arc welding 1/16, 3/32, 1/8, 5/32-inch electrodes            | 10        |
| Gas-shielded arc welding (nonferrous) 1/16, 3/32, 1/8, 5/32-inch electrodes | 11        |
| Gas-shielded arc welding (ferrous) 1/16, 3/32, 1/8, 5/32-inch electrodes    | 12        |
| Shielded metal-arc welding: 3/16, 7/32, 1/4 inch electrodes                 | 12        |
| Shielded metal-arc welding: 5/16, 3/8-inch electrodes                       | 14        |
| Atomic hydrogen welding   | 10 – 14   |
| Carbon arc welding  | 14        |
| Soldering   | 2         |
| Torch brazing   | 3 or 4    |
| Light cutting, up to 1 inch   | 3 or 4    |
| Medium cutting, 1 inch to 6 inches  | 4 or 5    |
| Heavy cutting, 6 inches and over  | 5 or 6    |
| Gas welding (light) up to 1/8 inch  | 4 or 5    |
| Gas welding (medium) 1/8 inch to 1/2 inch                                   | 5 or 6    |
| Gas welding (heavy) 1/2 inch and over                                       | 6 or 8    |

NOTE: In gas welding or oxygen cutting where the torch produces a high yellow light, use a filter or lens that absorbs the yellow

**Head protection**

- Head protection made of a flame resistant material shall be worn.

**Respiratory Protection (for more information, refer to Respiratory Policy IH-003)**

- Engineering controls and safe work practices are the primary means to prevent employee over exposure to welding fumes, toxic gases, and dusts.
- Employees will not perform welding that cannot be safely done without the use of a respirator.
- Employees will follow the requirements for respirator use set forth in UT's Respirator Protection policy.

**Hearing Protection (for more information, refer to Hearing Conservation Policy IH-010).**

- Devices may be required during some welding operations.
- If loud noise is present, approved ear plugs or ear muffs shall be worn to prevent hearing loss.

**Foot and Leg Protection**

- Wear leather, steel-toed, high top boots in good condition
- In heavy spark and slag areas, used fire-resistant foot protectors or leather spats strapped around pant legs and boot tops.
- Do not tuck pant legs into boots.

**OSHA Required Designated Signs:**

All filler metals and fusible granular materials shall carry the following notice, as a minimum on tags, boxes or other containers:

CAUTION: Welding may produce fumes and gases hazardous to health. Avoid breathing these fumes and gases. Use adequate ventilation. See ANSI Z49.1-1967 Safety in Welding and Cutting published by the American Welding Society.

Brazing filler metals containing cadmium in significant amounts shall carry the following notice on tags, boxes and other containers:

WARNING

CONTAINS CADMIUM-POISONOUS FUMES MAY BE FORMED ON HEATING

Do not breathe fumes. Use only with adequate ventilation such as fume collectors, exhaust ventilators, or air-supplied respirators. See ANSI Z49.1-1967

Brazing and gas welding fluxes containing fluorine compounds shall have a cautionary wording to indicate that they contain fluorine compounds. One such cautionary wording recommended by the American Welding Society for brazing and gas welding fluxes reads as follows:

CAUTION

CONTAINS FLUORIDES

This flux when heated gives off fumes that may irritate eyes, nose and throat.

- a. Avoid fumes—use only in well-ventilated spaces.
- b. Avoid contact of flux with eyes or skin.
- c. Do not take internally.

### **Hot Work Areas**

- All hot work shall be performed in a Designated Hot Work Area, if possible.
- A Designated Hot Work Area must meet the following requirements:
- The Designated Hot Work Area shall be a discrete area, sectioned off by noncombustible walls, or curtains.
- Adequate ventilation, such as a suction hood system providing 20 air changes per hour, should be provided for the work area.
- Where welding, cutting and brazing are done near walls, partitions, ceilings, or a roof of combustible construction, fire-resistant shields or guards shall be provided to prevent ignition.
- Protective dividers such as welding curtains or non-combustible walls will be provided to contain sparks and slag to the combustible free area.
- Flammable and combustible liquids and material will be kept 35 feet from work area.
- Floors shall be swept and clean of combustibles within 35 feet of work area. A fire extinguisher should be within access of the 35 feet of work area, and shall be maintained in a state of readiness for instant use.

### **Hot Work Procedures**

- All hot work permits shall be returned to the issuing supervisor when the hot work has been completed.
- Supervisor and employee are responsible for identifying and controlling workplace hazards before hot work is performed.
- Hot Work Permit (for non-designated hot work area) will be issued for a period covering the duration of hot work.

### **Prior to Hot Work**

- Inspect the hot work area to identify any fire hazards.
- Remove all flammable or combustible materials within a thirty five (35) foot radius of the hot work.
- Sweep floor of all loose combustible debris.
- Place non-combustible or flame resistant screens so as to protect personnel in adjacent work areas from heat, flames, radiant energy and welding splatter.
- Cover sprinkler heads directly above the hot work area with wet rags or other non-combustible materials so they will not be triggered during the work if the hot work area has any.
- Cover smoke detectors located in close proximity of the work area, or notify the electrical shop to deactivate smoke detectors in the hot work area.
- Notify anyone nearby who may be affected by the work.
- Make provisions for proper ventilation

### **During Hot Work**

- Combustible floors shall be kept wet during the hot work.
- Store acetylene and other fuel cylinders in a secure and upright position.
- Place hoses so that they will not be crushed or damaged.

**After Hot Work**

- Remove any covers from sprinkler heads immediately upon completion of the hot work if the hot work area has any.
- Remove covers from any smoke detectors immediately upon completion of the hot work, or notify the electrical shop to reactivate them if they have been deactivated.
- Clean up any slag, debris or used electrodes resulting from the work.
- Restore ventilation to its original condition.

**Hot Work in Areas not designated as Hot Work Areas.**

When welding, cutting, or brazing work is to be done outside of a Designated Hot Work Area, it is necessary to meet the following requirements:

- A Hot Work Permit is required for all Hot Work. See UT's Hot Work Policy FS 15 found in the Safety Manual.
- Flammable materials that cannot be removed from the area must be adequately covered or guarded before hot work is started.
- All floor openings and cracks shall be closed, sealed and/or covered to ensure that sparks cannot drop into the openings and come into contact with combustible materials.
- Guards, shields, and or fire-blankets shall be used to confine the heat, sparks and/or slag from coming into contact with any combustible material with 35 feet of the hot work
- Portable welding curtains or shields must be used to protect other workers in the welding area.
- Airflow away from the welder and others present must be established and maintained.
- Plastic materials must be covered with welding tarps during welding procedures.
- Suitable fire extinguishing equipment shall be maintained in a state of readiness at all times for instant use. This may include fire extinguishers, water hoses or buckets of sand, depending on the nature of the combustible material exposed

**Prohibited Hot Work Areas**

Areas that are prohibited from conducting hot work include:

- Areas not authorized by management.
- Areas equipped with sprinkler systems that are out of order.
- In the presence of potentially explosive atmospheres, e.g., a flammable liquid.
- Areas where combustible or flammable materials are within 35 feet and cannot be moved or protected.
- Areas where appropriate fire fighting equipment is not readily available.
- Areas where floor and wall openings cannot be covered.

**Fire Watch:**

Fire Watchers shall be required whenever these activities are performed in locations where other than a minor fire might develop. The Fire Watcher:

- Shall be present to ensure that sparks, slag and heat generated by the hot work do not start a fire while the welder is working.
- Shall remain at the work location for at least thirty (30) minutes after the hot work has been completed to ensure that no sparks or slag are smoldering and that the heat generated by the hot work did not cause other materials to smolder thus creating a potential fire hazard.

- Shall be trained in the proper use of fire extinguishing equipment and be prepared to use it.
- Shall be familiar with facilities for sounding an alarm in the event of a fire or other emergency situation.
- Shall also be trained to react to other potential hazards associated with the work activity such as exposure to welding fumes, welding flash and any other potential hazards unique to the area in which the work is being performed.
- The person performing hot work and the Fire Watch shall be required to read the Hot Work Permit and sign the permit acknowledging the fact that they understand the potential hazards and will follow the requirements of the permit.
- If feasible, floors shall be wetted, or covered with a fire blanket, fire pad, or other flame resistant material prior to start of hot work to prevent ignition.

More information on fire watch requirements may be found in the UT Fire Watch Procedure FS 011.

### Equipment Inspection and Handling

- Inspect cylinders, regulators and hoses before use.
- A hammer or wrench shall not be used to open cylinder valves. If valves cannot be opened by hand, the supplier shall be notified.
- When a special wrench is required it shall be left in position on the stem of the valve while the cylinder is in use so that the fuel-gas flow can be quickly turned off in case of emergency.
- Smoking is never allowed for your safety and the safety of others.
- Inspect the cylinder and the gas identification tag.
- Unless cylinders are secured on a special truck, regulators shall be removed and valve-protection caps, when provided, shall be put in place before cylinders are moved.
- Inspect the work area for grease or oils before use of compressed gas.
- Always use regulators for all gas cylinder hookups, valves must be fully shut off when not in use.
- Use only non-sparking tools for flammable gases.
- Be sure the cylinder is secure in the work area.
- You should limit pressure to 30 psi or less for air blow down.
- Never refill or attempt to repair a gas cylinder.
- Remove leaking cylinders from the building and properly vent all remaining gas.
- Damaged cylinders should be marked "Damaged-Do not Use".
- Be sure to check all hose fittings for compressed air systems by using a control nozzle with self-closing valve at the operators end.

### Cylinder Storage:

Cylinders used for welding, brazing and cutting work shall be stored using the following guidelines. For more information on cylinder safety refer to UT Cylinder Safety Policy HM 15 found in the Safety Manual.

- Label and separate the empty cylinders from the full ones.
- Always install the caps on the cylinder.
- Store cylinders upright and away from heat sources.
- Keep the storage area dry and well ventilated.
- Store oxygen cylinders separately from the other types.
- Cylinders should be chained or strapped to prevent tipping.



- Fuel gas and oxygen must be stored at a minimum of 20 feet apart or separated by a one-hour rated fire wall.

### APPROVED FIRE RESISTANT MATERIALS FOR HOT WORK AREAS:

**Welding Blanket:** A welding blanket is a heat-resistant fabric designed to be placed in the vicinity of a hot work operation. Intended for use in horizontal applications with light to moderate exposures such as that resulting from chipping, grinding, heat treating, sand blasting, and light horizontal welding. They are designed to protect machinery and prevent ignition of combustibles such as wood that are located under the blanket. They are made from different materials such as fiberglass, silica, and other fire resistant materials.



**Welding Pads:** A welding pad is heat-resistant fabric designed to be placed directly under a hot work operation such as welding or cutting. Welding pads are intended for use horizontal applications with severe exposures such as that resulting from molten substances of heavy horizontal welding.

**Welding Curtain:** A welding curtain is a heat-resistant fabric designed to be placed in the vicinity of a hot work operation. It is intended for use in vertical application with light to moderate exposures such as that resulting from chipping, grinding, heat treating, and light horizontal welding. It's designed to prevent sparks from escaping a confined area.



*\*Welding blankets and curtains are required to be listed, approved, or the equivalent for such use. One such approval includes ANSI/FM 4950, American National Standard for Evaluating Welding Pads, Welding Blankets and Welding Curtains for Hot Work Operations.*

### Welding and Hot Work In and Around Tanks:

Whenever possible, avoid hot work and consider alternative methods. Analyze the hazards prior to initiation of hot work. Perform a hazard assessment that identifies the scope of work, potential hazards, and methods of hazard control.

- Work is not allowed and shall not be performed in or near tanks that contain or have contained flammable liquids. The tanks must be thoroughly drained, purged, and atmospherically tested with a combustible gas meter (indicator) if work will be done on or in the vessel. This will ensure the tank is free from the accumulation of flammable gases or vapors.
- Once approved safe for hot work, atmospheric monitoring must be performed using a portable combustible gas analyzer before and during the work by only trained personnel Assistance can be obtained with atmospheric monitoring by contacting EHS Department at 974-5084.
- If any detectable readings are obtained, then work cannot begin or continue until the source of vapor is found and suitably mitigated such that the concentration is maintained below 10% of the Lower Flammable/Explosive Limit. For technical assistance regarding combustible gas meters, contact EHS.

***Electric 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 are to use proper precautionary measures and recommended safe practices at all times to avoid electrical shocks. 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:

- Never use a bare hand or wet glove to change electrodes
- Do not touch an energized electrode while you are in contact with the work circuit
- Never stand on a wet or grounded surface when changing electrodes.
- Do not allow the electrode holder or electrode to come in contact with any other person or any grounded object.
- Ground the frames of welding units.
- Insulate yourself from the workpiece 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.
- If utilizing long lengths of cable, suspend them overhead whenever possible. 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; or when there is a high risk of unavoidable or accidental contact with the workpiece 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,
  - AC welder with reduced open-circuit voltage. In most situations, use of a DC constant voltage wire welder is recommended. And do not work alone!

***Fall Protection and Hot Work:***

Fall protection used in welding operations presents special challenges, since the hot slag generated from hot work can damage harnesses and other fall protection equipment. Full body harnesses made of heat resistant material should be used to protect equipment from heat and UV exposure. All fall protection equipment must be OSHA requirements.

***Air and Noise Monitoring:***

Air samples are normally taken within the worker's breathing zone to determine concentrations (typically during an 8 hour working day)

Routine air monitoring should be conducted to determine the levels of hazardous materials and noise in the welding area. EHS can perform hazard monitoring upon request.

***Medical Monitoring:***

The early symptoms of harmful exposure to most substances produced during welding are similar. These may consist of irritation of the eyes, nose, respiratory system and sometimes the skin (such as "nickel itch," caused

by exposure to nickel fumes). Coughing, a tight chest or chest pains, headaches, nausea, vomiting and fatigue may also be some persistent symptoms. Since these symptoms are common to many other illnesses, it is important to determine whether or not they are related to work. NIOSH recommends that all workers exposed to welding processes should receive annual medical exams.

## Training and Information

Training shall be provided to all personnel affected by this procedure and at any time there is a modification to this procedure that will affect work practices. The degree of training provided shall be determined by the potential hazards of the welding, cutting, and brazing job assignment.

### Initial training

- To ensure employees recognize the hazards associated with welding, cutting and brazing operations.
- To know the safe work practices for welding, cutting and brazing operations.
- To understand the importance and requirements of Hot Work Permits.
- To understand the requirements to establish and maintain Hot Work Areas
- To use the appropriate personal protective equipment (PPE) for the job
- Employees performing the hot work shall be trained in the proper use of the equipment they will be using to perform the hot work.
- Employees shall be trained in the proper use of the fire extinguishing equipment that is provided for the use of the Fire Watch.
- Employees shall also be trained in the proper use of any protective equipment or procedures necessary to protect themselves or other personnel in the area and the facility.

### Additional or refresher training

- All authorized and affected employees shall receive appropriate training whenever there is a change in their job assignments or a change in welding equipment or processes that present a new hazard.
- Employees or supervisors have reason to believe that there are deviations from or inadequacies in the employees' knowledge of known hazards, or use of equipment or procedures.

### Sources of Training:

- Online sources (EHS website)
- Traditional classroom programs are available upon request by EHS.

## Recordkeeping

All training records must be documented. Each department must maintain a record of the training. The following information should be contained in the training record: date of training, instructor, name of employee, location and a brief description or outline of what was covered.

Provisions shall be made for individuals who have limited reading skills to ensure they are familiar with the necessary information.

A test is recommended at the end of each training program to demonstrate that the participants have the requisite knowledge.

## References

[OSHA: 29 CFR 1910.133 Eye and Face Protection](#)

[OSHA: 29 CFR 1910 Subpart Q: Welding, Cutting, and Brazing](#)

[OSHA 29 CFR 1910 Subpart J: Welding and Cutting](#)

[OSHA 29 CFR 1915 subpart D: Welding, Cutting and Heating](#)

[OSHA: 29 CFR 1926.350 Gas, Welding, and Cutting](#)

[OSHA 29 CFR 1910.146: Permit Required Confined Spaces](#)

[OSHA 29 CFR 1910.1200: Hazard Communication](#)

[OSHA 29 CFR 1910.134: Respiratory Protection](#)

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## **Appendices**

Appendix A: Welding and Cutting Checklist

Appendix B: Welding, Cutting and Brazing Training Documentation Checklist

## **Disclaimer**

The information provided in these guidelines is designed for educational use only and is not a substitute for specific training or experience.

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## Appendix A: Welding and Cutting Checklist

Welding and cutting operations can result in various hazardous conditions. Welding, cutting, and allied processes produce molten metal, sparks, slag, and hot work surfaces that can cause fire or explosion if precautionary measures are not followed. Electric shock from 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. Many welding, cutting, and allied processes also produce toxic fumes and gases which must be controlled. The below sample checklist is not all-inclusive and should be used as a means to help monitor your worksite.

| Topic  | Yes | No |
|--|-----|----|
| <b><i>Cylinder Storage</i></b>   |     |    |
| Are welding gas cylinders stored upright?  |     |    |
| Are valve protectors placed on all cylinders not in use?   |     |    |
| Are cylinders secured with a chain, strap, or cable to a stationary building support or secured to an appropriate cylinder cart to prevent them from tipping or falling? |     |    |
| Are cylinders stored in designated locations, away from exits, traffic aisles, elevators, stairs, or gangways?   |     |    |
| Are cylinders kept away from sources of heat and electrical circuits?  |     |    |
| Are cylinders stored in a dry, well-ventilated area at least 20 feet from combustible materials?   |     |    |
| Is the cylinder storage area marked with appropriate precautionary signs?  |     |    |
| Are oxygen cylinders separated from fuel gas (i.e. acetylene) by a distance of at least 20 feet or separated with a fire resistant barrier with a ½ hour fire rating?    |     |    |
| Are cylinders legibly marked to clearly identify the gas contained?  |     |    |
| Are empty cylinders appropriately marked, with valves closed, and separated from full cylinders?   |     |    |
| Are cylinders regularly examined for obvious signs of defects, deep rusting, or leakage?   |     |    |
| <b><i>Operations</i></b>   |     |    |
| Is only approved welding apparatus (torches, regulators, pressure-reducing valves, acetylene generators, manifolds) used?  |     |    |
| Are cylinders, cylinder valves, couplings, regulators, hoses, and related welding equipment kept free of oily or greasy substances?                                      |     |    |
| Are friction lighters readily available for lighting torches?  |     |    |
| Are hoses free from damage or decay?   |     |    |

| Topic   | Yes | No |
|---|-----|----|
| Are there any repairs of welding cable within 10 feet of the holder? If yes, they must be discarded.  |     |    |
| Are the arc welder cable connections insulated for protection?  |     |    |
| Are electrodes removed from holders when left unattended?   |     |    |
| Before removing a regulator, is the valve closed and the gas released from the regulator?   |     |    |
| Are welding generators properly grounded in accordance with the manufacturer's recommendations?   |     |    |
| When mounted on vehicles or trailers, are portable welding generators grounded to the frame of the vehicle by a ground wire or bolted metal-to-metal contact? |     |    |
| Is sufficient ventilation provided in the welding/cutting area?   |     |    |
| Are oxygen and fuel gas cylinders prohibited in confined spaces?  |     |    |
| <b>Hot Work</b>   |     |    |
| Is there an established hot work permit program?  |     |    |
| Is all combustible material removed to at least 20 feet away from welding and cutting areas?  |     |    |
| When the object to be welded cannot be moved and/or surrounding fire hazards cannot be removed, are shields used to confine heat, sparks, and slag?           |     |    |
| When welding or cutting is performed on walls, floors, or ceilings, are precautions taken to protect combustibles on the other side?                          |     |    |
| Are sufficient fire extinguishers readily available?  |     |    |
| Are fire watchers assigned whenever welding or cutting is performed in locations where a serious fire may develop?  |     |    |
| If combustible floors are wet down, are personnel protected from possible electrical shock?   |     |    |
| Is welding or cutting prohibited near flammable liquids or heavy dust concentrations?   |     |    |
| <b>Personal Protective Equipment</b>  |     |    |
| Are appropriate eye protection helmets, hand shields, and goggles provided and readily available?   |     |    |
| Are protective garments such as leather gloves, heavy shirt, aprons, shoulder covers, leggings, high shoes, and a cap available?                              |     |    |
| Are welders prohibited from wearing pants with cuffs or shirts with open pockets or any clothing that can catch and hold molten metal or sparks?              |     |    |
| Are employees instructed to remove any combustibles, such as a butane lighter or matches, from their clothing prior to welding or cutting?                    |     |    |
| Are noncombustible screens or barriers used to protect adjacent personnel?  |     |    |

| Topic   | Yes | No |
|---|-----|----|
| Are respirators available to protect workers from metal fumes during welding or cutting?  |     |    |
| Training  |     |    |
| Are only authorized and trained personnel permitted to use welding, cutting, or brazing equipment?  |     |    |
| Have employees been instructed in the handling and storage of cylinders, safety valves, relief valves and related welding equipment?  |     |    |
| Have employees been instructed on the proper means to transport cylinders?  |     |    |
| Have employees been instructed to “crack” the valve (standing to one side momentarily open the valve and then close it immediately) before connecting a regulator to clear the valve of dust or dirt? |     |    |
| Are employees prohibited from leaving cylinder valves open when not in use, such as during breaks and at the end of a shift?  |     |    |
| Are employees reminded to open valves slowly by hand to avoid gauge damage?   |     |    |
| Are employees reminded not to coil or loop welding electrode cable around their body?   |     |    |
| Is welding equipment frequently inspected for wear and damage?  |     |    |
| Is damaged welding equipment immediately removed from service?  |     |    |
| Are welders and adjacent employees screened (i.e. interviewed) for having a pacemaker or defibrillator prior to entry into a welding/cutting area?  |     |    |

### Appendix B:

## Welding, Cutting and Brazing Training Documentation Checklist

| <i>Department:</i>  |  | <i>Supervisor:</i>   |                  |
|---|--|----------------------|------------------|
| <i>Date</i>   |  |                      |                  |
| <input type="checkbox"/> Fire Prevention Precautions<br><input type="checkbox"/> Personal Protective Equipment<br><input type="checkbox"/> Hot Work Permits<br><input type="checkbox"/> Precautionary labels<br><input type="checkbox"/> Cylinder storage and use<br><input type="checkbox"/> Ventilation<br><input type="checkbox"/> Welding in confined spaces<br><input type="checkbox"/> Welding and cutting of containers<br><input type="checkbox"/> Exposure hazards related to stainless steel, galvanized and leaded materials |  |                      |                  |
| <i>Trainees:</i>  |  |                      |                  |
| <i>Employee Name: (print)</i>   |  | <i>Employee ID #</i> | <i>Signature</i> |
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