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Safety

WELDING, CUTTING, AND BRAZING



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(SMSgt Pennie Hardesty)
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Certified by: HQ AFSC/SEG (Thomas M. Pazell)

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The criteria in this standard are the Air Force's minimum safety, fire prevention, and occupational health requirements for all areas where welding, cutting, and brazing operations are performed. Major commands (MAJCOM), direct reporting units (DRU), and field operating agencies (FOA) may supplement this standard when additional or more stringent safety, fire prevention, and health criteria are required. Refer to Air Force Instruction (AFI) 91-301 *Air Force Occupational and Environmental Safety, Fire Protection, and Health (AFOSH) Program* for instructions on processing supplements or variances. Report conflicts in guidance between this standard, federal standards, or other Air Force directives through MAJCOM, DRU, or FOA ground safety offices to Headquarters Air Force Safety Center, Ground Safety Division, Safety Engineering and Standards Branch (HQ AFSC/SEGS), 9700 Avenue G, Suite 222, Kirtland AFB NM 87117-5670.

This standard applies to all US Air Force organizations, including all US Air Force Reserve personnel and when Air National Guard personnel are on Federal service. It provides guidance for welders, cutters, fire watchers, and their supervisors engaged in welding, cutting, and brazing operations throughout the Air Force. It is intended to minimize or eliminate safety, fire, and health hazards to personnel and property associated with these operations. Thermite and laser welding or cutting operations are not covered by this standard. This standard implements those portions of Occupational Safety and Health Administration (OSHA) standards and other national safety consensus standards listed in the References section of **Attachment 1**.

NOTE. AFOSH 127-series standards are being converted to 91-series standards and the 161-series standards will become 48-series standards. However, not all standards have been converted as of the effective date of this standard. To help you locate these documents, references to AFOSH standards are stated in the updated series and standard number, with the outgoing series and standard number stated as "formerly designated as" in the References section of **Attachment 1**.

SUMMARY OF REVISIONS

Administrative changes have been made to update this standard to electronic format. References have been updated as required. Instructions on filling out AF Form 592 are at **Attachment 2**. Minor changes will be annotated by a .

Chapter 1

HAZARDS AND HUMAN FACTORS

1.1. Safety and Fire Hazards:

1.1.1. Welding, cutting, and brazing operations present hazardous situations which if the proper precautions are not taken, can lead to: inhalation of harmful vapors or fumes, burns, eye damage, electrical shock, and crushed toes and (or) fingers. Workers have been injured because they were not using protective equipment, were using faulty equipment, and from personnel error. Many Air Force welding, cutting, and brazing mishaps are caused by:

1.1.1.1. Inadequately trained personnel;

1.1.1.2. Poor housekeeping practices;

1.1.1.3. Poor shop layout,

1.1.1.4. Inadequate lighting and ventilation;

1.1.1.5. Improper storage and movement of compressed gas cylinders;

1.1.1.6. Exposure of oxygen cylinders and fittings to oil or grease creating a fire or explosive hazard;

1.1.1.7. Pointing welding or cutting torches at a concrete surface causing spattering and flying fragments of concrete;

1.1.1.8. Electric shock when motors, generators, and other electric welding equipment are not grounded; or

1.1.1.9. Inhalation of toxic fumes or vapors from welding metals or alloys.

1.1.2. Fires, explosions, and injuries can occur from welding operations that are:

1.1.2.1. In the proximity of combustible solids, liquids, or dusts;

1.1.2.2. In the presence or development of possible explosive mixtures of flammable gases and air;

1.1.2.3. In the presence or nature of an oxygen-enriched atmosphere, where hot work is performed; or

1.1.2.4. In close proximity of explosive hydrogen gas which is formed when sulfuric acid comes in contact with mild steel.

1.2. Health Hazards:

1.2.1. The installation Bioenvironmental Engineering (BE) monitors programs designed to protect workers from health hazards. Supervisors should contact BE personnel to ensure that workers are not being exposed to health hazards and to verify compliance with directives such as AFOSH Standards 48-1, *Respiratory, Protection Program* 48-2, *Industrial Ventilation*, and 48-8, *Controlling Exposures to Hazardous Materials*.

1.2.2. The Air Force Hazard Communication Program (AFHCP) is intended to reduce the incidence of chemically-induced occupational illnesses and injuries by informing employees of the hazards

associated with, and the proper preventive measures to be taken when using or handling hazardous materials in the workplace. Specific requirements for the AFHCP are listed in AFOSH Standard 48-21, *Hazard Communication*. For further guidance contact the Environmental Office.

1.2.3. A number of hazardous chemicals and metals are used in fluxes, paints, coatings, and fillers. Toxic fumes or gases are released to the atmosphere during welding, cutting, and brazing operations. Suppliers of welding materials provide information about the hazards associated with the use of their products. This information is listed on the product label and on Material Safety Data Sheets (MSDS). All filler metals and fusible granular materials carry the following notice: "CAUTION - WELDING MAY PRODUCE FUMES AND GASES HAZARDOUS TO HEALTH. AVOID BREATHING THESE AND GASES. USE ADEQUATE VENTILATION." (Refer to paragraph **3.18.**)

1.2.4. Brazing and welding filler metals containing cadmium carry the following notice: "WARNING- CONTAINS CADMIUM - POISONOUS FUMES MAY BE FORMED ON HEATING". (Refer to paragraph **3.18.5.**)

1.2.5. Brazing and gas welding fluxes containing fluorine compounds have the following cautionary wording on tags, boxes, or other containers: "CAUTION CONTAINS FLUORIDES." This flux when heated gives off fumes that may irritate eyes, nose, and throat. (Refer to paragraph **3.18.1.**)

1.2.6. Cleaning and other operations involving the use of Chlorinated Hydrocarbons may generate toxic vapors or mists. (Refer to paragraph **3.19.**)

Chapter 2

GENERAL REQUIREMENTS

2.1. Acquisition:

2.1.1. Only approved (as defined in **Attachment 1**) apparatus such as torches, regulators, pressure reducing valves, acetylene generators, machines, manifolds, cables, and hoses, etc., will be purchased for use.

2.1.2. Compressed gases may be purchased in either government-owned or supplier-owned cylinders. In either case, the purchase agreement shall specifically indicate that the compressed gas cylinders will meet the marking requirements of OSHA Standard 29 CFR 1910.253. In addition, they will be inspected and will have a safety relief device installed per the requirements in OSHA Standard 29 CFR 1910.101. Government-owned cylinders, which are not in compliance with the above requirements, will not be used.

2.1.3. Only approved protective clothing and equipment will be purchased for use. Refer to AFOSH Standard 91-31, *Personal Protective Equipment*.

2.1.4. Contractor activities involving welding, cutting and brazing must meet requirements of OSHA Standard 29 CFR 1910.252, *Welding, Cutting, and Brazing (General Requirements)* which may be used as a technical reference for this subject. The contracting officer will determine the necessity for specific references to OSHA standards in the contract.

2.2. Operating Precautions The information listed below provides minimum guidance on operating precautions and procedures. It will be used in conjunction with OSHA Standard 29 CFR 1910.252 on all matters involving US Air Force welding operations. Information on 29 CFR 1910.252 may be obtained by contacting the local installation ground safety office.

2.2.1. Acetylene is extremely flammable and when mixed with air, is highly explosive. Use and store acetylene cylinders in an upright position. If cylinders have been lying in a horizontal position, they must stand upright for a minimum of 2 hours prior to use. Never use acetylene at a pressure in excess of 15 pounds per square inch, gauge (psig); higher pressure may cause it to explode.

2.2.2. Follow manufacturer's procedures with respect to the sequence of operations in lighting, adjusting, and extinguishing torch flames. Purge hoses in open spaces and away from ignition sources. Light the torch with a friction lighter or stationary pilot flame, keeping a safe distance between the torch and the welder's hands. Point the torch away from persons or combustible materials when lighting. Do not attempt to light a torch from hot metal.

2.2.3. When not in use for extended periods (i.e., 30 minutes or more) or when unattended (no one in the vicinity for observation), shut off fuel gas and oxygen supply to the torch.

2.2.4. Do not open an acetylene valve more than one and one half turns of the spindle and preferably no more than three-fourths of a turn.

2.2.5. Always open the cylinder valve slowly. Do not remove the wrench or handle, used to open the cylinder, from the stem of the valve while the cylinder is in use.

2.2.6. If cylinders are manifold or coupled, ensure at least one wrench is always available for immediate use.

2.2.7. Provide ventilation in shops or rooms where work is to be performed, but avoid strong drafts directed at the welding work. Do not use oxygen to provide ventilation, because it accelerates combustion. Consult with the installation BE on proper ventilation requirements.

2.2.8. Never attempt to preheat or weld jacketed vessels, tanks, containers, or covered parts until precautions have been taken to adequately vent the confined space. Do not weld or cut a container or piping system containing hydrogen gas, flammable or combustible liquids, vapors, or other flammable materials without first inerting the container or system (refer to paragraph 3.11.2.). Take similar precautions for new containers since preservatives or other combustibles may be present. When applicable, ensure that the appropriate technical orders (TO) are followed.

2.2.9. Do not place work to be welded or heated on a concrete floor. Concrete, when heated, may spall and fly, exposing the welder to injury from flying hot particles.

2.2.10. Provide appropriate protection for welders and helpers when on elevated surfaces. Keep welding areas neat, clean, and free from tripping hazards. Refer to AFOSH Standards 91-31, and 91-2, *Vehicle Mounted Elevating and Rotating Work Platforms, Manually-Propelled, Self-Propelled Mobile Work Platforms, and Scaffolds (Towers)*, and OSHA 29 CFR 1910.28, *Safety Requirements for Scaffolding*.

2.2.11. Do not perform cutting and welding operations:

2.2.11.1. In buildings with installed sprinkler systems when the system is inoperable, unless other means of fire detection, reporting, and extinguishing have been approved by the local installation fire chief.

2.2.11.2. In explosive atmospheres or where explosives atmospheres may develop.

2.2.11.3. Within 50 feet of flammable liquids (flashpoint below 100 degrees Fahrenheit (F)).

NOTE:

When unable to comply with the above requirements, interim procedures must be established through local installation ground safety, fire, and health officials.

2.2.12. Protect welding torch hoses from damage caused by contact with hot metal, open flames, corrosive agents, or sharp edges. Release pressure on hoses at the end of each workday, during lunch or break periods, and when not in use for extended periods or when unattended (no one in the vicinity for observation). Visually inspect the entire length of welding hose once per shift (prior to use).

NOTE:

This inspection is not required when equipment will not be used during that shift.

2.2.13. Prior to use, repair or replace hoses showing leaks, cuts, burns, worn spots, or other evidence of deterioration. Ensure replacement hoses or fittings are approved for use with acetylene equipment. Use a soap and water solution to check all recently repaired or replaced hoses for leaks; do not use an open flame. Make sure hose connections are clamped or otherwise fastened in a manner that will withstand, without leakage, twice the normal service pressure (but not in any case less than 300 pounds per square inch (psi)). Use oil-free air or oil-free inert gas for the test. The oxygen hoses are green, fuel gases red, and inert-gases or air are black.

2.2.14. Provide shielding to protect personnel from heat, sparks, slag, light, and ultraviolet radiation.

2.2.15. To prevent personnel from inadvertently touching hot items, post warning signs around them when they are left unattended.

2.2.16. When working in a confined space, position the fuel gas and oxygen supply outside the confined space in a manner which will not interfere with egress. When possible, remove the unused torch and hose from the confined space. In addition, strictly adhere to all requirements outlined in AFOSH Standard 91-25 (refer to **3.17**, paragraph 3.17).

2.2.17. Wear appropriate personal protective equipment (PPE) for the welding operation being performed. Welding in confined spaces, manholes, or other space restricted areas may require additional or special PPE. Consult with the installation BE for appropriate PPE (refer to paragraphs **2.5**, and 3.17, and AFOSH Standard 91-25). Also, in case of an emergency, ensure a means to quickly extract welders is provided. Refer to AFOSH Standards 91-25, 91-31, and 48-2.

2.3. Facilities:

2.3.1. Inside Areas (refer to definition in **Attachment 1**). A specific area will be designated or approved by the installation fire department and bioenvironmental authorities for welding and cutting operations. It will be of noncombustible or fire resistive construction appropriate for its hazard classification, free of combustible and flammable materials, and segregated from adjacent areas.

2.3.1.1. Where possible, all combustible materials located within 35 feet of the operation (example: items that still contain or have contained explosive hydrogen gas, etc.) will be removed. (See also paragraph **2.3.1.9.3**.)

2.3.1.2. Where possible, welding activities will be isolated from adjacent activities. Workers and other personnel adjacent to the welding areas will be protected from the radiant energy or spatter of welding and cutting arcs, by the use of noncombustible and (or) flameproof screens.

2.3.1.3. Welding booth walls, screens, and non-rigid heat and spark barriers, used to isolate the welding activity, will be finished to limit reflectivity. Booths, screens, etc., will be arranged to ensure adequate ventilation. Tent enclosures of asbestos blankets will not be used, nor will fire resistant, non-rigid heat and spark barriers containing asbestos.

2.3.1.4. Where arc-welding is regularly carried on adjacent to painted walls, the walls will be painted with a finish having low reflectivity to ultraviolet radiation.

2.3.1.5. Procedures will be established to prevent personnel, who are entering an inside welding area, from inadvertently being exposed to welding hazards. These procedures will include, as a minimum, warning signs posted at all personnel entryways of designated welding areas. These signs will mandate the use of PPE before being exposed to welding hazards.

2.3.1.6. Combustible floors will be kept wet and covered with damp sand or protected by fire resistant shields. Where floors have been wet down and damp sand applied, rigid control will be exercised over the grounding of equipment. In addition, personnel shall be protected from possible shock. Caution will be exercised against slips and falls on any wet surfaces.

2.3.1.7. A fully charged and operable fire extinguisher, appropriate for the task, will be kept at the work area at all times while welding operations are in progress (consult installation fire personnel).

2.3.1.8. Whenever there are cracks or other floor openings, that cannot be closed or covered, within 35 feet of the welding or cutting, precautions will be taken to remove or otherwise protect combustible materials on the floor below that may be exposed to sparks. The same precautions will be observed with regard to cracks or openings in walls, open doorways, and open or broken windows.

2.3.1.9. Where sprinkler protection exists, it will be fully operational while welding or cutting work is being performed and the proper fire extinguishing equipment will be readily available. If welding or cutting is to be done within 3 feet of automatic sprinkler heads, noncombustible sheet material or damp cloth guards will be used to temporarily shield the individual heads. The type of shielding will be specified on the AF Form 592, **USAF Welding, Cutting, and Brazing Permit** by the issuing authority. Personnel authorized to issue permits will:

2.3.1.9.1. Inspect the area before allowing any welding, cutting, or brazing activities to begin.

2.3.1.9.2. Ensure a copy of the signed AF Form 592 is readily available in the immediate area of welding, cutting, and brazing operations.

2.3.1.9.3. Fire watcher procedures will be implemented whenever welding activities are within 35 feet of combustible materials, regardless of protection provided. A qualified individual proficient in the operation of available fire extinguishing equipment and knowledgeable of fire reporting procedures will observe welding or cutting activities. Their duty is to detect and prevent the spread of fire produced by welding or cutting activities. An additional fire watcher may be required to observe areas that are hidden from the view of a single fire watcher (other side of partitions, walls, ceilings, etc.).

2.3.1.9.4. A fire watch will be maintained for at least 30 minutes after completion of cutting or welding operations to detect and extinguish possible smoldering fires.

2.3.1.9.5. When fire watchers are required, upon completion of their duties they will sign line 16 of the welding permit and return it to the issuing authority. If work continues for more than 1 day, the permit will be signed daily and only tasks authorized by the original permit will be accomplished. Additional tasks will require a new permit to be issued.

2.3.2. Outside Areas. When work cannot be moved, the area will be made firesafe by removing combustibles or protecting combustibles from ignition sources.

2.3.2.1. The welding operation will be roped off or segregated by physical barrier. Placards reading: "WELDING OPERATIONS IN PROGRESS" will be prominently displayed for warning purposes. Protective screens, when possible, will be placed around welding operations. When screens are not practicable, workers and other personnel adjacent to the welding areas will be required to wear appropriate protective goggles.

2.3.2.2. Authorization, including a written welding permit, to perform welding, cutting, or brazing will be obtained from the installation fire department prior to the start of such operations (refer to attachment 2). Coordination by installation ground safety and BE officials is required for any welding, cutting, or brazing operation involving a hazardous task (as defined in attachment 1).

NOTE:

Hazardous tasks performed in an inside area will comply with paragraph **2.3.1.**

2.3.2.3. Fire watcher procedures will be implemented per requirements in paragraphs **2.3.1.9.3.** through 2.3.1.9.5.

2.3.2.4. The welding operation environment will be free of flammable liquids and vapors. Combustible materials within a radius of 35 feet of the operation will be protected from activity residue (flame, sparks, slag, etc.).

2.3.2.5. Fire extinguishing equipment will be maintained, ready for use, while welding or cutting operations are being performed. Equipment may consist of pails of water, buckets of sand, a hose, or portable extinguisher, depending upon the nature and quantity of the combustible material exposed. The welding permit issuing authority will identify the required fire extinguishing equipment.

2.3.2.6. MAJCOMs having activities involved in numerous daily welding, cutting, and brazing operations are permitted to have a certification process whereby qualified and (or) certified welding personnel (other than fire department personnel) issue welding permits. These permits will be issued on a daily basis.

The following procedures are applicable:

2.3.2.6.1. Personnel certified by the installation fire department may authorize welding, cutting, and brazing operations, using AF Form 592 for this purpose.

2.3.2.6.2. The installation fire department will instruct welding shop supervisors and other selected personnel, so they will be qualified to issue permits. Upon completing the required training, the installation fire department will certify the individuals in writing.

2.4. Installed Equipment:

2.4.1. Oxygen-fuel gas system equipment devices or attachments used for the prior mixing of air or oxygen with flammable gases must be approved (refer to **Attachment 1** for definition of approved) for that purpose, except devices at the burner or in a standard torch.

2.4.2. When acetylene cylinders are coupled, approved flash arresters will be installed between each cylinder and the coupler block. For outdoor use only, and where the number of cylinders does not exceed three, one flash arrester installed between the coupler block and regulators is acceptable.

2.4.3. Backflow protection shall be provided by an approved device that will prevent oxygen from flowing into the fuel-gas system or fuel from flowing into the oxygen system.

2.4.4. Flashback protection shall be provided by an approved device that will prevent a flame from passing into the fuel-gas system.

2.4.5. Back-pressure protection shall be provided by an approved pressure relief device, set at a pressure not greater than the pressure rating of the backflow or flashback devices, whichever is lower.

2.4.6. These three functions of protective equipment (backflow, flashback, and pressure relief devices) may be separate devices or combined into one device.

2.4.7. Clearly marked master shutoff valves will be provided for installed systems at points where they will be readily accessible. If a wrench is required to operate the master shutoff valves, then at least one wrench for this specific purpose will always be readily available in the immediate area of the master shutoff valves.

2.5. Personal Protective Equipment (PPE). Key portions of OSHA Standard 29 CFR 1910.252 covering protective equipment are included here. Personnel engaged in or exposed to welding, cutting, or brazing activities will be provided and use the proper PPE (refer to OSHA Standard 29 CFR 1910.132 , *Personal, Protective Equipment*, and AFOSH Standards 48-1 and 91-31). The appropriate protective clothing required for specific welding operations will vary with the size, nature, and location of the work to be performed.

2.5.1. Workers shall be informed that personal protective clothing may interfere with the body's heat dissipation, especially during hot weather or in confined spaces. Frequent breaks may be required.

2.5.2. Clothing shall provide sufficient coverage, and be made of suitable materials, to minimize skin burns caused by sparks, spatter, or ultraviolet radiation.

2.5.2.1. All outer clothing such as coveralls should be reasonably free from oil and grease.

2.5.2.2. Front pockets and upturned sleeves or cuffs shall be prohibited. Sleeves and collars should be kept buttoned to prevent hot metal slag and sparks from contacting the skin.

2.5.3. All welders and cutters will wear protective flame-resistant gloves. Insulated linings will be used to protect areas exposed to high radiant energy.

2.5.4. Durable flame-resistant aprons made of leather or suitable materials shall be used to protect the front of the body when additional protection against sparks and radiant energy is needed.

2.5.5. For heavy work, flame-resistant leggings or other equivalent means shall be used to give added protection to the legs.

2.5.6. Cape sleeves or shoulder covers with bibs made of leather or other flame-resistant materials shall be worn during overhead welding, cutting, or other operations, when necessary.

2.5.7. Properly fitted flame-resistant plugs in the ear canals, or equivalent protection, shall be used where hazardous noise levels exist (consult installation BE personnel).

2.5.8. Caps made from flame-resistant material shall be worn under helmets, when necessary, to prevent head burns.

2.5.9. When controls such as mechanical or natural ventilation fail to reduce air contaminants to allowable levels or when the implementation of such controls are not feasible, respiratory protective equipment shall be used to protect personnel from hazardous concentrations of airborne contaminants. Only approved respirator equipment will be used (consult installation BE personnel, according to AFOSH Standard 48-1).

2.5.10. Following are eye protection requirements:

2.5.10.1. All welding helmets must meet 29 CFR 1910.252 requirements.

2.5.10.2. Eye and face protective equipment should be inspected for serviceability prior to each use. For sanitary purposes, eye and face protectors should not be shared by other employees. Helmets shall be used during all arc-welding or arc-cutting operations, excluding submerged arc-welding. Where the work permits, submerged arc-welders must be enclosed in an individual booth coated on the inside with a nonreflective material. When two or more welders are exposed to the hazards of each other's welding operation, goggles shall be worn under the welders' helmets to provide protection from the harmful rays and flying debris. Helpers or attendants shall be provided with the proper PPE, to include eye protection.

2.5.10.3. Goggles or other suitable eye protection shall be used during all gas welding or oxygen cutting operations.

2.5.10.4. All operators and attendants of resistance welding, resistance brazing equipment, or while chipping slag shall use transparent face shields or goggles, depending on the particular job, to protect their faces or eyes, as required.

2.5.10.5. Eye protection in the form of suitable tinted goggles or spectacles shall be provided for torch brazing or soldering operations. Spectacles will be equipped with side shields.

2.5.11. Following are specifications for protectors:

2.5.11.1. Helmets and goggles should be made of a material which is an insulator for heat and electricity. Helmets, face shields, and goggles will not be readily flammable and shall be capable of withstanding sterilization.

2.5.11.2. Helmets shall be arranged to protect the face, neck, and ears from direct radiant energy from the arc.

2.5.11.3. Helmets shall be provided with filter plates and cover plates designed for easy removal.

2.5.11.4. All parts shall be constructed of a material which will not readily corrode or discolor the skin.

2.5.11.5. Goggles shall be ventilated to prevent fogging of the lenses as much as practicable.

2.5.11.6. Cover lenses or plates should be provided to protect each helmet or goggle filter lens or plate.

2.5.11.7. All glass for lenses shall be tempered and substantially free from striae, air bubbles, waves, and other flaws. Except when a lens is ground to provide proper optical correction for defective vision, the front and rear surfaces of lenses and windows shall be smooth and parallel.

2.5.11.8. Lenses shall bear some permanent distinctive markings by which the source and shade may be readily identified.

2.5.11.9. All filter lenses and plates shall meet the test for transmission of radiant energy prescribed in American National Standards Institute (ANSI) Z87.1-1989, *American National Standard Practice for Occupational and Educational Eye and Face Protection*.

2.5.11.10. Hand-held screens for shielding the face and eyes will not be used since they may be inadvertently held in the wrong position and not provide the proper protection (refer to National Institute for Occupational Safety and Health (NIOSH)).

2.6. Training and Qualification. Trainees may perform welding only under the direct supervision of an instructor. Each person performing welding operations will be qualified to perform these operations when they have satisfactorily demonstrated their skill or proficiency to their supervisor. Welders performing such work on aircraft and (or) aircraft components and missile and (or) missile components will be certified as outlined in TO 00-25-252, *Certification of USAF Aircraft and Missile Welders*.

2.6.1. Prior to commencing a welding operation outside the welding shop, supervisors will brief the welder on safety, health, and fire protection matters applicable to the specific job.

2.6.2. Commanders will ensure that supervisors and employees who handle, use, or are potentially exposed to hazardous materials in the course of official Air Force duties are provided information and training on the AFHCP and specific hazards in the workplace (refer to AFOSH Standard 48-21).

2.6.3. If a welding operator requires specialized safety, health, or fire protection guidance not addressed in this standard or in tech data, the supervisor will instruct the welder prior to commencement of the job. Assistance may be requested from the installation ground safety, fire department, or BE personnel.

2.7. Ventilation Requirements. Welding, cutting, and brazing operations may produce a toxic or an unhealthy atmosphere. Refer to your local BE and AFOSH Standard 48-2 for ventilation requirements associated with welding operations.

2.8. Gas Leaks:

2.8.1. Check gas line connections for tightness after assembly and before lighting the torch. Use soapy water or the equivalent, not a flame.

2.8.2. If a leak is found around the valve stem when the valve on a fuel-gas cylinder is opened, the valve should be closed and the gland nut tightened. If this does not stop the leak, discontinue the use of the cylinder, remove it to the outdoors, and mark it with a DD Form 1577-2, **Unserviceable (Reparable) Tag**. Place the cylinder in an upright manner well away from an ignition source and secure it to prevent falling. Near the leaking cylinder, place a sign warning personnel not to approach the leaking gas cylinder with any ignition source (such as lighted cigarette). In addition, place similar signs in a location which will notify personnel of the danger before entering into the area. These signs are intended to prevent personnel entering into a danger zone while attempting to read the sign on the cylinder. See AFOSH Standard 91-45, *Hazardous Energy Control and Mishap Prevention Signs and Tags* for danger sign specifications. Immediately notify installation fire department of any fuel-gas leaks.

2.8.3. If the fuel-gas should leak from the cylinder valve and cannot be shut off with the valve seat, follow the instructions in paragraph **2.8.2**.

2.8.4. If a leak should develop at a fusible plug or other safety device on the fuel-gas cylinder, follow the instructions in paragraph **2.8.2**. In addition, slightly open the cylinder valve to allow the fuel-gas to escape slowly and immediately notify the installation fire department.

NOTE:

Emergency cylinder repair kits are available and may be used to contain the leak until it can be moved outside. Signs warning personnel not to approach the leaking gas cylinder with any ignition source, such as lighted cigarette, will be placed near the leaking cylinder.

2.9. Electrical Safety:

2.9.1. The welder will never permit the live metal parts of an electrode holder to touch their bare skin.

2.9.2. Welding gloves will be dry.

2.9.3. Electrode holders will not be cooled by immersion in water.

2.9.4. Water-cooled holders for gas tungsten-arc, gas metal-arc, and carbon arc-welding will not be used if there is a water leak or condensation which would adversely affect the safety of the operator.

2.9.5. The welding machines supplying power to the arc will always be electrically disconnected when changing electrodes in gas tungsten-arc electrode holders.

2.9.5.1. A mechanical switching device (disconnecting or isolating switch) used for changing the connections in a circuit or for isolating a circuit and (or) equipment from a source of power, serves the same purpose as removing a plug from an outlet.

2.9.5.2. Never change electrodes with bare hands or wet gloves or when standing on wet floors or other grounded surfaces.

2.10. Filter Lenses for Protection Against Radiant Energy Table 2.1. is a guide for the selection of the proper shade numbers. These recommendations may be varied to suit the individual's needs (refer to OSHA Standards 29 CFR 1910.252 and 1910.133, *Eye and Face Protection*).

Table 2.1. Selection of Proper Shade Number for Welding Operations. Filter Lenses for Protection Against Radiant Energy

| Operations | Electrode Size 1132 in | Arc Current | Minimum * Protective Shade |
|--|------------------------|---------------|----------------------------|
| Shielded Metal Arc-Welding | Less than 3 | Less than 60 | 7 |
| | 3-5 | 60-160 | 8 |
| | 5-8 | 160-250 | 10 |
| | More than 8 | 250-550 | 11 |
| Gas Metal Arc-Welding and Flux Cored Arc-Welding | | Less than 60 | 7 |
| | | 60-160 | 10 |
| | | 160-250 | 10 |
| | | 250-500 | 10 |
| Gas Tungsten Arc-Welding | | Less than 50 | 8 |
| | | 50-150 | 8 |
| | | 150-500 | 10 |
| Air Carbon Arc-Cutting | (Light) | Less than 500 | 10 |
| | (Heavy) | 500-1000 | 11 |
| Plasma Arc-Welding | | Less than 20 | 6 |
| | | 20-100 | 8 |
| | | 100-400 | 10 |

| Operations | Electrode Size 1132 in | Arc Current | Minimum * Protective Shade |
|------------------------|--------------------------------|----------------------------|-----------------------------------|
| | | 400-800 | 10 |
| Plasma Arc-Cutting | (light)** | Less than 300 | 8 |
| | (medium)** | 300-400 | 9 |
| | (heavy) ** | 400-800 | 10 |
| Torch Brazing | | | 3 |
| Torch Soldering | | | 2 |
| Carbon Arc-Welding | | | 14 |
| Operations | Plate Thickness--Inches | Plate Thickness--mm | Minimum * Protection Shade |
| Gas Welding: | | | |
| Light | Under 1/8 | Under 3.2 | 4 |
| Medium | 1/8 to 1/2 | 3.2 to 12.7 | 5 |
| Heavy | Over 1/2 | Over 12.7 | 6 |
| Oxygen Cutting: | | | |
| Light | Under 1 | Under 25 | 3 |
| Medium | 1 to 6 | 25 to 150 | 4 |
| Heavy | Over 6 | Over 150 | 5 |

* As a rule of thumb, start with a shade that is too dark to see the weld zone. Then go to a lighter shade which gives off sufficient view of the weld zone without going below the minimum. In oxyfuel-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 (spectrum) operation.

**These values apply where the actual arc is clearly seen. Experience has shown that lighter filters may be used when the arc is hidden by the workplace.

Chapter 3

SPECIFIC APPLICATIONS

3.1. Inert Gas Welding and Brazing. When inert gas welding and brazing is done in large chambers or furnaces, instruct welders on the dangers of inert gas asphyxiation. Supervisors will ensure that chambers are completely ventilated and cooled prior to entry. Also ensure that mechanical ventilation or approved air supplied respiratory protection is provided. Personnel will comply with confined space requirements outlined in AFOSH Standard 91-25.

3.2. Electron Beam Welding. Refer to manufacturer's instructions and applicable TOs. Centers, bases, or installations performing electron beam welding will develop operating instructions covering the specific equipment used.

3.3. Plasma Arc-Cutting. Plasma arc-cutting operations are hazardous because of the high heat brilliant light and the fumes given off. Molten metal splatter and noise are also potential hazards. (Engineering controls to mitigate these hazards should be considered during equipment installation.) Because of the hazards involved, centers, bases, and installations will at a minimum:

3.3.1. Provide shielding and nonreflective surfaces (walls, floors, ceilings, etc.).

3.3.2. Ensure adequate ventilation is provided or that air supplied respiratory equipment is used.

3.3.3. Install equipment of this type in an isolated area to prevent exposing workers at other operations.

3.4. Air Carbon-Arc-Cutting. In addition to normal protective equipment required for welding and cutting, air carbon-arc-cutting requires shielding so molten slag will not be blown by compressed air onto personnel or combustibles.

3.5. Induction Welding and (or) Brazing. Because of potential burns, induction welders will preplace filler materials within induction coils and will not attempt to adjust the placement while the welding and (or) brazing equipment is activated. Inspect induction coil insulation prior to use to ensure serviceability. Replace or repair damaged or deteriorated insulation.

3.6. Magnesium-Thorium Welding, Cutting, and Grinding. Coordinate proposed welding, cutting, or grinding operations on magnesium-thorium and other potentially radioactive materials in advance with the Installation Radiation Protection Officer. Refer to AFI 40-201, *Managing Radioactive Materials in the Air Force*. All personnel must comply with the Air Force requirements for handling and processing radioactive materials.

3.7. Electric Arc-Welding. Arc-welding is the fusion process based on the principle of generating heat with an electric arc jumping an airgap to complete an electrical circuit. When an electrode is touched to metal, the electrical circuit is completed and the current flows. Tremendous heat is concentrated at the point of contact. Hazards involved in this process are: electrical shock - particularly in hot weather when the welder is perspiring, burns to the skin and eyes, and inadequate ventilation.

3.7.1. Safety Precautions. Many mishaps are caused by defective equipment, deliberate violation of safety precautions, and ignorance or neglect of safety rules or practices. Consequently, prior to use, welders need to check welding equipment to ensure the electrode connections and insulation on holders and cables are in good condition. They must keep hands and body parts insulated from the work, the metal electrode, and insulation holders and the holder, and avoid standing on wet floors or coming in contact with grounded surfaces. They must never perform welding operations outside the rated capacity of the welding cables. When welding must be done in the open, persons working nearby will wear goggles or be warned against the hazard of exposing themselves to, or looking directly at, the arc.

3.7.2. Inspection of Equipment. The welder will inspect the cables periodically for looseness at the connections, defects due to wear, or other damage. Defective or loose cables are a fire hazard. Defective electrode holders will be replaced and connections to the holder tightened prior to use.

3.8. Oxyacetylene Welding. This is one of the most common and widely used welding processes available. It can be used for fusion welding, brazing, soldering, cutting, and hard surfacing. Its hazards include burns to the skin and eyes, gas or oxygen leaks, flashbacks, cut hose whipping, improper handling and storage of cylinders, and the potential for a cylinder to become a missile if it is punctured or if the valve should break off. Both oxygen and acetylene cylinders are stored according to instructions in TO 42B5-1-2, *Use, Handling, and Maintenance Instructions — Storage Type Gas Cylinders*.

3.9. Gas-Shielded Welding. Gas-shielded welding is a fusion-welding process that uses the heat produced by an electric arc between a metal electrode and the work. An inert gas (helium or argon) is used to shield the electrode. The shielding gas flowing from the orifices in the torch head forms a protective blanket over the weld area. This prevents the air from coming in contact with the molten metal and contaminating the weld.

3.9.1. Tungsten-Inert Gas Welding (TIG). TIG welding is a type of gas-shielded welding especially adapted for light gage metal because of its good concentration of heat, precise heat control, and the ability to weld with or without filler metals. It is generally used with such metals as aluminum, magnesium, and titanium. The principle hazards are the same as electric arc-welding (possible shock, ventilation, and burns), except TIG welding takes place with little or no spatter, sparking, or fumes.

3.9.2. Metal-Inert Gas Welding (MIG). MIG welding is a type of gas-shielded welding similar to TIG, except it uses a nonconsumable tungsten electrode and is used for heavier gage metals. MIG welding has the same hazards as TIG welding, except it does create sparks, spattering, and can easily cause ultraviolet radiation burns to exposed skin.

3.10. Aircraft Welding:

3.10.1. Gas-shielded tungsten arc-welding is the approved method for welding on aircraft. Welding on aircraft should be done outside of hangars if possible. An AF Form 592 shall be issued prior to all aircraft welding operations (refer to **Attachment 2**). Welding will only be done on aircraft system components specified in the aircraft technical data. Specific hazards associated with the task and emergency procedures will be listed in Block 12 of the welding permit. If more space is required to list all precautions, a welding fire safety checklist will be prepared and attached to the form. The welding supervisor will ensure identified precautions and (or) checklist items are followed. The welding

supervisor will ensure the senior flight line supervisor (line chief and (or) production supervisor) is cognizant of the restrictions in paragraphs 3.10.2. through 3.10.11.

3.10.2. Ensure the senior flight line supervisor (production supervisor) is thoroughly briefed on the planned welding operation. This supervisor is responsible for informing other senior flight line supervisors if aircraft from different units are on the ramp.

3.10.3. Do not weld on an aircraft while any other work is in progress on a system that contains (or did contain) fuel or other flammable liquids.

3.10.4. Prior to the start of welding operations, cap off all fuel lines, valves, manifolds, or other fuel components and plug fuel tank and engine fuel vents. Close fuel tank access plates, openings, and (or) cover fuel tank vents on all aircraft within 50 feet from the point of welding.

3.10.5. Do not perform any other work within a 25-foot radius of the location of any gas-shielded arc-welding operation.

3.10.6. Do not weld on an aircraft while fuel systems work is in progress on any other aircraft within 50 feet from the point of welding.

3.10.7. Whenever welding is being done in the vicinity of sources of flammable vapors (prior to the start of welding and at least every 15 minutes during the welding operation), a qualified person shall check with a combustible gas analyzer to assure that flammable vapors do not reach 20 percent of the lower explosive limit (LEL). For confined spaces the LEL is lowered to 10 percent (reference National Fire Protection Association (NFPA) 410, *Standard on Aircraft Maintenance*, Chapter 6, *Aircraft Welding Operations*, and OSHA Standard 29 CFR 1910.146, *Permit-Required Confined Spaces*). NFPA 410 is available for review at the installation ground safety office or local fire department technical services division. When welding in a hangar, check floor drains in the same manner.

3.10.8. Rope off or segregate the welding operation by physical barrier. Prominently display warning signs reading: "WELDING OPERATIONS IN PROGRESS." Place screens, when possible, around welding operations.

3.10.9. Position all ground leads or cables as close as possible to the area being welded. Keep electrical welding equipment components (other than flexible lead cables) at least 18 inches above the floor. Ensure clamps are the "C" clamp type.

3.10.10. Assign a fire guard to monitor the welding operation and stop the welding operation if a hazardous condition develops. Provide the fire guard a 20 BC rated fire extinguisher in the immediate area and a back-up wheeled extinguisher of 80 BC rating. Refer to AFOSH Standard 91-56, *Fire Protection*.

3.10.11. Aircraft welding operations performed in hangars shall conform to NFPA 410, Chapter 6.

3.11. Welding and Cutting Tanks, Cylinders, or Containers. The following procedures apply only to tanks too small to be entered (compressed gas cylinders and pipelines are excluded). Ensure welding and cutting on containers that have held flammable liquids or gases are under the direct supervision of knowledgeable personnel.

3.11.1. Inspection Before any tank, cylinder, or other container is cut, welded, or other hot work performed, purge or make the item inert. Also make absolutely certain there are no substances such as grease, tars, or acids, which when subjected to heat, might produce explosive or toxic vapors. Discon-

nect or blank any pipe lines or connections to the drums, cylinders, tanks, or other containers. **CAUTION:** New containers must also be inerted; they may contain a flammable preservative which could form explosive vapors when heated

3.11.2. Purging and Inerting:

3.11.2.1. Purging With Steam. Steam may be introduced into the tank or container through a pipe inserted through an opening and bonded to the container, or by connecting a steam hose directly to one of the vessel nozzles. The rate of supply of steam should be sufficient to exceed the rate of condensation so the whole tank or container is heated close to the boiling point of water. The vessel must be steamed long enough to vaporize the residues from all portions of the walls (shell and heads). When testing the atmosphere in the vessel with a combustible gas indicator, the sample should be drawn through a drying tube filled with calcium chloride or other drying agent to ensure water vapor does not enter the instrument. If a drying agent is not available, the container must be allowed to cool off until excess water vapor has condensed. (Refer to NFPA Standard 327, *Standard Procedures for Cleaning or Safeguarding Small Tanks and Containers*) Hazards inherent with steam operations require the use of PPE; supervisors must ensure PPE is serviceable and enforce its wear.

3.11.2.2. Purging With Water. Where the liquid or gas previously contained is known to be readily displaced or easily soluble in water, it can be removed by completely filling the container with water and then draining. When hot work is performed on containers filled with water, extreme care will be used to eliminate any possible vapor accumulation by the proper venting or positioning of the container during the filling operation.

3.11.2.3. Purging With Air. Hazardous vapors may be displaced from inside containers by purging with air. A safe atmosphere will be maintained by continuous ventilation.

3.11.2.4. Inerting With Gas. Inert gas may be used to displace flammable gas from the container. Adequate ventilation will be maintained during the operation to ensure gas concentrations remain below hazardous levels. Examples of inert gases are carbon dioxide, nitrogen, and argon.

3.11.2.5. Venting. All hollow spaces, cavities, or containers shall be vented to permit the escape of air or gases before preheating, cutting, or welding.

3.11.2.6. Atmosphere Monitoring. In all cases, during welding or cutting operations, continuous monitoring of the vessel's atmosphere with a combustible indicator is mandatory.

3.12. Vehicle Maintenance Shops. Preferably, welding or cutting in vehicle maintenance activities is only conducted in shops which are approved by the fire department. Maintenance shop supervision will evaluate each welding or cutting task to determine if batteries or fuel tanks require removal and (or) inerting.

3.13. Portable Gas Units. Ensure portable gas welding, cutting, and brazing equipment is a type designed for the use intended.

3.13.1. Cylinders of compressed gas must have pressure reducing regulators installed.

3.13.2. Cylinders in use or transport must be stored in an upright position and secured, to prevent them from falling.

3.13.3. Gaseous systems and containers will be color coded. (Reference TO 42B5-1-2.)

- 3.13.4. Pressure hoses will be secured to prevent whipping.
- 3.13.5. Oxygen cylinders and fittings will be kept free of grease and oil at all times.
- 3.13.6. Cylinders will be kept away from external sources of heat at all times.
- 3.13.7. Cylinders will not be dropped or handled roughly. Cylinders or welding sets in excess of 40 pounds total weight will be transported to and from work sites by push cart or motorized vehicle. When cylinders or welding sets are moved by crane or derrick, suitable cradles, boats, or platforms will be used. Slings or electric magnets will not be used to move cylinders of compressed gases or welding sets.
- 3.13.8. Flashback protection shall be provided by an approved device that will prevent a flame from passing into fuel-gas system.
- 3.13.9. Backflow protection shall be provided by an approved device that will prevent oxygen from flowing into the fuel-gas system or fuel from flowing into the oxygen system.
- 3.13.10. The flashback and backflow protection may be combined in one device or may be provided by separate devices. If one device is used, such as an approved mixing handle, additional backflow devices installed on the oxygen and fuel hoses near the regulator may be advisable should the mixing handle malfunction.
- 3.13.11. An acetylene valve shall not be opened more than one and one-half turns of the spindle and preferably no more than three-fourths of a turn.
- 3.13.12. The cylinder valve should always be opened slowly. The wrench used to open the cylinder will be left in position on the stem of the valve while the cylinder is in use.
- 3.13.13. If cylinders are manifold or coupled, at least one wrench will always be available for immediate use.

3.14. Portable Electric Units:

- 3.14.1. Circuits will be deenergized before testing, checking, or transporting.
- 3.14.2. Motor-generator sets and other electrical welding equipment will be grounded prior to use.
- 3.14.3. Rotary and polarity switches will not be operated while the equipment is under an electrical load.
- 3.14.4. Arc-welding equipment will be inspected periodically and inspected prior to use following relocation. Power cables and electrode holders will be inspected prior to every use.
- 3.14.5. These units will be repaired by qualified electricians only.

3.15. Arc-Welding:.

- 3.15.1. Arc-welding equipment shall conform to the design and installation criteria of OSHA Standard 29 CFR 1910.254, *Arc-Welding and Cutting*. The frame or case of the welding machine (except engine driven machines) shall be grounded under the conditions and according to the methods prescribed in OSHA Standard 29 CFR 1910, Subpart S, *Electrical*.
- 3.15.2. Before starting operations:

- 3.15.2.1. All connections to the arc-welding machine will be checked and the work lead shall be firmly attached to the work.
- 3.15.2.2. Contact surfaces of the magnetic work clamps will be free of metal spatter particles.
- 3.15.2.3. Coiled welding cable will be spread out before use to avoid serious overheating and damage to insulation.
- 3.15.2.4. Work and electrode lead cables will be inspected for damage and wear before use. Cables with damaged insulation or exposed conductors will be replaced.
- 3.15.2.5. Electrode cables will be joined and installed according to approved methods.
- 3.15.3. Grounding of the welding machine frame will be checked. Special attention will be given to the ground connections of portable machines.
- 3.15.4. Electrode holders when not in use shall be placed where they cannot make electrical contact with persons, conducting objects, fuel, or compressed gas cylinders.
- 3.15.5. Cables with splices within 10 feet of the electrode holder will not be used. The welder will not coil or loop welding electrode cables around parts of their body.
- 3.15.6. Welders will not place welding cable and other equipment where it will obstruct passage-ways, ladders, and stairways.
- 3.15.7. Machines which have become wet will be thoroughly dried and tested before being used.
- 3.15.8. When welders are working close to each other on one structure where they may touch the exposed parts of more than one electrode holder simultaneously, the machines will be connected to minimize shock hazard as follows:
 - 3.15.8.1. All direct current (DC) machines will be connected with the same polarity.
 - 3.15.8.2. All alternating current (AC) machines will be connected to the same phase of the supply circuit and with the same instantaneous polarity.

3.16. Resistance Welding:

- 3.16.1. Thermal Protection.** Every pair of ignition tubes used in resistance welding equipment shall be equipped with a thermal protection switch. When used in a series-connected water line, a single switch will be adequate if related to the downstream tube.
- 3.16.2. Control Safeguards.** Controls, such as push buttons, foot switches, retraction, and dual-schedule switches on portable guns, etc., shall be arranged or guarded to prevent inadvertent activation.
- 3.16.3. Guarding Welding Machines.** Multi-gun welding machines will be effectively guarded at the point of operation. Devices such as an electronic eye, latches, blocks, barriers, or two-handed controls will be installed. All chains, gears, operating bus linkage, and belts will be protected by adequate guards.
- 3.16.4. Electrical Hazard.** All external weld initiating control circuits shall operate on low voltage, not over 120 volts for stationary equipment and not over 36 volts for portable equipment. All electrical equipment will be suitably interlocked and insulated to prevent access by unauthorized persons to

live portions of the equipment. Only nonferrous welding clamps should be used to prevent magnetic induction during actuation of the equipment.

3.17. Welding in Confined Spaces. (The guidance contained herein is extracted from OSHA Standard 29 CFR 1910.252 and AFOSH Standard 91-25).

3.17.1. When a welder must enter and (or) perform a welding, cutting, or brazing operation in a confined space, the requirements for confined space entry as outlined in AFOSH Standard 91-25 will be strictly adhered to. Additionally, any welding, cutting, or brazing in a confined space requires an approved AF Form 592.

3.17.2. All welding and cutting operations carried on in confined spaces shall be adequately ventilated to prevent the accumulation of toxic materials or possible oxygen deficiency. This applies not only to the welder, but also to helpers and other personnel in the immediate vicinity. As the old air is withdrawn, it will be replaced with fresh air which is clear and respirable. Oxygen shall never be used for ventilation.

3.17.3. In such circumstances where it is impossible to provide such ventilation, respirators or hose masks will be used. Only respirators and hose masks approved for use by the installation bioenvironmental health personnel are authorized.

3.17.4. Where welding operations are carried on in confined spaces, a worker shall be stationed on the outside of such confined spaces to ensure the safety of those working within.

3.17.5. When welding or cutting is being performed in any confined space, the gas cylinders and welding machines shall be left on the outside. Before operations are started, heavy portable equipment mounted on wheels shall be securely blocked to prevent accidental movement.

3.17.6. When gas welding or cutting, the torch valves shall be closed and the fuel-gas and oxygen supply to the torch positively shut off at some point outside the confined area whenever the torch is not to be used for a substantial period of time, such as during lunch hour or overnight. Where practicable, the torch and hose shall also be removed from the confined space.

3.17.7. When arc-welding is to be stopped for any substantial period of time, such as during lunch or overnight, all electrodes shall be removed from the holders and holders carefully located so accidental contact cannot occur and the machine will be disconnected from the power source.

3.18. Hazards Associated with Fluxes, Coverings, Filler Metals, and Base Metals. The guidance contained herein is extracted from OSHA Standard 29 CFR 1910.252.

3.18.1. Fluorine Compounds. The need for local exhaust ventilation or air supplied respirators for welding or cutting in other than confined spaces will depend upon the individual circumstances. However, experience has shown such protection to be desirable for fixed-location production welding and for all production welding on stainless steel. Where air samples taken at the welding location indicate that the fluorides liberated are below the maximum allowable concentration, such protection is not necessary. However, always consult MSDSs and the installation BE when handling fluorine compounds.

3.18.2. Zinc. Indoor welding or cutting involving zinc-bearing base or filler metals coated with zinc-bearing materials will be considered as working in a confined space.

3.18.3. Lead. In confined spaces or indoors, welding or cutting involving metals containing lead (other than as an impurity), or involving metals coated with lead-bearing materials (including paint), shall be done using local exhaust ventilation or air supplied respirators. Outdoors such operations shall be done using respiratory protective equipment approved for use by the installation BE. In all cases, workers in the immediate vicinity of the cutting operation shall be protected as necessary by local exhaust ventilation or air supplied respirators.

3.18.4. Beryllium. Welding or cutting indoors, outdoors, or in confined spaces involving beryllium-containing base or filler metals shall be done using local exhaust ventilation and airline respirators unless atmospheric tests under the most adverse conditions have established that the worker's exposure is within permissible concentrations. In all cases, workers in the immediate vicinity of the welding or cutting operations shall be protected as necessary by local exhaust ventilation or air supplied respirators.

3.18.5. Cadmium. The permissible exposure limit for cadmium has been established by AFOSH Standard 48-8. Refer to the installation BE for establishing safe handling practices.

3.18.5.1. Welding or cutting indoors or in confined spaces involving cadmium-bearing or cadmium-coated base metals shall be done using local exhaust ventilation or air supplied respirators unless atmospheric tests under the most adverse conditions have established that the worker's exposure is within permissible concentrations.

3.18.5.2. Outdoors such operations shall be done using respiratory protective equipment approved for use by installation BE personnel.

3.18.5.3. If chest pain, cough, or fever develops after use, a physician will be immediately contacted (refer to AFOSH Standards 91-31 and 48-2).

3.18.6. Mercury. Welding or cutting indoors or in a confined space involving metals coated with mercury-bearing materials (including paint), shall be done using local exhaust ventilation or air supplied respirators unless atmospheric tests under the most adverse conditions have established that the worker's exposure is within permissible concentrations. Outdoors such operations shall be done using respiratory protective equipment approved by installation bioenvironmental health personnel for such purpose.

3.18.7. Caution. Refer to MSDSs associated with specific chemical hazards and installation BE for determining adequacy of ventilation systems, determining exposures, and recommending appropriate respiratory protective devices in any situation where chemical hazards exist or may be believed to exist.

3.19. Cleaning and Other Operations Involving the Use of Chlorinated Hydrocarbons. Do not locate these operations in areas which allow vapors or mists to reach the vicinity of welding operations. In addition, keep trichloroethylene and perchloroethylene away from any area penetrated by the ultraviolet radiation of welding operations.

ORIN L. GODSEY, Brig Gen, USAF
Chief of Safety

Attachment 1

GLOSSARY OF REFERENCES, ABBREVIATIONS, ACRONYMS, AND TERMS

References

Air Force Instruction (AFI) 21-105, *Aerospace Equipment Structural Maintenance*.

AFI 40-201, *Managing Radioactive Materials in the Air Force*.

AFI 91-202, *The US Air Force Mishap Prevention Program*.

AFI 91-301, *Air Force Occupational Safety, Fire Protection, and Health Program* (formerly designated Air Force Regulation [AFR] 127-12).

Air Force Manual (AFM) 85-5, *Maintenance and Operation of Cathodic Systems*.

Air Force Manual (AFMAN) 91-201, *Explosive Safety Standards*.

Air Force Occupational Safety and Health (AFOSH) Standard 48-1, *Respiratory Protection Program*.

AFOSH Standard 48-2, *Industrial Ventilation* (formerly designated AFOSH Standard 161-2).

AFOSH Standard 48-21, *Hazard Communication* (formerly designated AFOSH Standard 161-21).

AFOSH Standard 91-2, *Vehicle-Mounted Elevating and Rotating Work Platforms, Manually-Propelled and Self-Propelled Mobile Work Platforms, and Scaffolds (Towers)*.

AFOSH Standard 91-25, *Confined Spaces*.

AFOSH Standard 91-31, *Personal Protective Equipment*.

AFOSH Standard 91-20, *Vehicle Maintenance Shops* (formerly designated AFOSH Standard 127-20).

AFOSH Standard 91-22, *Walking Surfaces, Guarding Floor and Wall Openings and Holes, Fixed Industrial Stairs, and Portable and Fixed Ladders* (formerly designated AFOSH Standard 127-22).

AFOSH Standard 91-45, *Hazardous Energy Control and Mishap Prevention Signs and Tags* (formerly designated AFOSH Standard 127-45).

AFOSH Standard 91-56, *Fire Protection* (formerly designated AFOSH Standard 127-56).

American National Standards Institute (ANSI)/American Welding Society (AWS) Standard FL1-85, *Sampling Airborne Particulates Generated by Welding and Allied Processes*.

ANSI/AWS Standard F4.1-88, *Recommended Safe Practice for the Preparation for Welding and Cutting of Containers That Have Held Hazardous Substances*.

ANSI Standard Z49.1-1988, *Safety in Welding and Cutting*.

ANSI Standard Z87.1-1989, *Practice for Occupational and Educational Eye and Face Protection*.

National Fire Protection Association (NFPA) Standard 5.1, *Oxygen-Fuel-Gas Systems for Welding, Cutting, and Allied Processes*.

NFPA Standard 51B, *Fire Prevention in Use of Cutting and Welding Procedures*.

NFPA Standard 327, *Standard Procedures for Cleaning or Safeguarding Small Tanks and Containers, Chapter 3, Cleaning Procedures, Paragraph 3-4.1, Steam Cleaning*.

NFPA Standard 410, *Standard on Aircraft Maintenance*, Chapter 6, *Aircraft Welding Operations*.
National Institute of Occupational Safety and Health (NIOSH) Standards.
Occupational Safety and Health Administration (OSHA Standard 29 CFR 1910.28, *Safety Requirements for Scaffolding*.
OSHA Standard 29 CFR 1910.101, *Compressed Gases (General Requirements)*.
OSHA Standard 29 CFR 1910.102, *Acetylene*.
OSHA Standard 29 CFR 1910.104, *Oxygen*.
OSHA Standard 29 CFR 1910.132, *Personal Protective Equipment*.
OSHA Standard 29 CFR 1910.133, *Eye and Face Protection*.
OSHA Standard 29 CFR 1910.146, *Permit-Required Confined Spaces*.
OSHA Standard 29 CFR 1910.252, *Welding, Cutting, and Brazing (General Requirements)*.
OSHA Standard 29 CFR 1910.253, *Oxygen-Fuel-Gas Welding and Cutting*.
OSHA Standard 29 CFR 1910.254, *Arc-Welding and Cutting*.
OSHA Standard 29 CFR 1910.255, *Resistance Welding*.
OSHA Standard 29 CFR 1910.304, *Wiring Design and Protection*.
OSHA Standard 29 CFR 1910.1200, *Hazard Communication*.
OSHA Standard 29 CFR 1910, Subpart S, *Electrical*.
Technical Order (TO) 00-25-224, *Welding High Pressure and Cryogenic Systems*.
TO 00-25-252, *Certification of USAF Aircraft and Missile Welders*.
TO 34W4-1-5, *Welding Theory and Application*.
TO 42B5-1-2, *Use, Handling, and Maintenance Instructions-Storage Type Gas Cylinders*.

Abbreviations and Acronyms

AC—Alternating Current
AFHCP—Air Force Hazard Communication Program
AFI—Air Force Instruction
AFM—Air Force Manual (Obsolete Designation)
AFMAN—Air Force Manual (New Designation)
AFOSH—Air Force Occupational Safety and Health
AFR—Air Force Regulation (Obsolete Designation)
AFSC—Air Force Safety Center
ANSI—American National Standards Institute
AWS—American Welding Society

BE—Bioenvironmental Engineering
C—Celsius
CFR—Code of Federal Regulations
DC—Direct Current
DOT—Department of Transportation
DRU—Direct Reporting Unit
EM—Engineers Manual
F—Fahrenheit
FOA—Field Operating Agency
HQ—Headquarters
LEL—Lower Explosive Limit
MAJCOM—Major Command
MIG—Metal-Inert Gas
MSDS—Material Safety Data Sheets
NFPA—National Fire Protection Association
OSHA—Occupational Safety and Health Administration
PEL—Permissible Exposure Limit
PPE—Personal Protective Equipment
PSI—Pounds Per Square Inch
PSIG—Pounds Per Square Inch, Gauge
TIG—Tungsten-Inert Gas
TO—Technical Order
TWA—Time-Weighted Average

Terms

Acetylene— At 70 degrees F and atmospheric pressure, pure acetylene is a colorless, odorless gas. The commercial grade of acetylene, generated from calcium carbide, has a distinctive garlic-odor.

Acetylene, Low Pressure— Acetylene at a pressure not exceeding 1 psig.

Acetylene, Medium Pressure— Acetylene at pressure exceeding 1 psig, but not exceeding 15 psig.

Approved—Listed and approved by Underwriter’s Laboratories, Inc., Factory Mutual Engineering Corporation, The Bureau of Mines, NIOSH, ANSI, NFPA, or other nationally-recognized agencies which list, approve, test, or develop specifications for equipment to meet fire protection, health, or safety requirements.

Brazing—A process where metals are soldered together by heating the metal to temperatures above 800

degrees F and using a nonferrous filler metal having a lower melting point to join the metals together.

Combustible Liquid—Any liquid having a flashpoint at or above 100 degrees F (37.8 degrees C).

Compressed Gas Cylinder—A container specifically designed for compressed gases. High pressure cylinder means those approved for a service pressure of 900 psi or greater. Low pressure cylinders are those marked with a service pressure of less than 900 psi.

Confined Space—A space that:

- Is large enough and configured so a worker can bodily enter and perform assigned work; and
- Has limited or restricted means for entry or exit (for example: tanks, vessels, silos, storage bins, hoppers, vaults, manholes, and pits are spaces that may have limited means of entry); and
- Is not designed for continuous human occupancy.

Cylinder Storage—Cylinders of compressed gas not in use or attached ready for use.

Electrically Disconnected—Deenergized-free from any electrical connection to a source of potential difference and from electrical charge; not having a potential different from that of the earth.

Electric Welding—The process in which electrical energy is converted into heat for welding. In arc-welding, the heat liberated in the arc stream is used to fuse the metals. For resistance welding, the work is placed in the path of a high amperage current and the heat required for welding is generated by the resistance to the passage of the current. Application of pressure is also involved to produce bonding of the parts.

Firesafe—No threat of fire.

Fire Watcher—A person assigned to work with a welder, normally outside an authorized welding shop, to watch for fires resulting from the welding, cutting, or brazing operations. Fire watchers will have fire extinguishing equipment readily available and be trained in its use. They will be familiar with the location of and use of the nearest fire alarm. They should attempt to extinguish fires only when obviously within the capacity of their equipment; otherwise sound the alarm.

Flammable Gas—Any substance that exists in the gaseous stage at normal atmospheric temperature and pressure. It is capable of being ignited and readily oxidized when mixed with the proper proportions of air.

Flammable Liquid—Any liquid having a flashpoint below 100 degrees F (37.8 degrees C).

Flow Welding—A process where fusion is produced by heating with molten filler metal poured over the surfaces to be welded until the welding temperature has been attained and the required filler metal has been added.

Forge Welding—A process where the ends of the parts to be welded are extremely heated to a plastic state and the parts are then united by hammering or by the application of pressure.

Fuel-Gas—Gases, such as acetylene, natural gas, hydrogen, propane, methylacetylene propadiene, synthetic fuels, and hydrocarbons are usually used with oxygen to produce heating. Fuel-gases will be identified by their proper names; acetylene, hydrogen, etc., and not by the word gas.

Fusion—The process of blending, unifying, or joining together parts to form one mass.

Gas Welding—A group of welding processes wherein fusion is produced by heating with a gas flame, with or without the application of pressure or filler metals.

General Ventilation—The supply and (or) removal of air by natural and (or) mechanical means.

Hazardous Task—A welding, cutting, brazing, or soldering operation which involves any tank, cylinder, line, tubing, hollow space, vent, cavity, or container that contained: flammables, combustibles, acids, gases, or cryogenics. **NOTE:** Hazardous tasks performed in an inside area will require compliance with paragraph 2.3. of this standard.

Hot Tapping—A procedure where a qualified individual welds a connection to a pipeline containing a gas or liquid.

Hydrogen Gas—When sulfuric acid and mild steel come in contact with each other hydrogen gas is formed. This presents an explosive hazard when trapped or contained and heat is applied.

Induced Welding—The process where fusion is produced by the heat obtained from resistance of the work to the flow of induced electric current, with or without the application of pressure.

Inert Gas—Non-flammable, chemically inactive, and noncontaminating gas for the use intended.

Inside Area—A specified area designated or approved by the base fire department and bioenvironmental authorities specifically for welding, cutting, and brazing operations.

Inerting— Use of an inert gas to make the atmosphere of an enclosure substantially oxygen-free so combustion cannot take place.

Listed—Equipment or material included in a list published by a nationally recognized testing laboratory. Refer also to the definition of "approved."

Local Exhaust Ventilation—The removal of contaminants at their source by means of mechanical ventilation.

Manifold—An assembly of pipe and fittings for connecting two or more cylinders for the purpose of supplying gas to a piping system or directly to a cooling device.

May —Indicates an acceptable or satisfactory method of accomplishment.

Mechanical General Ventilation—Ventilation created by such devices as power driven fans.

Natural Ventilation—Normal air currents or drafts passing through open doors, windows, and vents.

Outside Area—An area in which work cannot be moved but can be made firesafe. It requires a fire watch and a written permit prior to any welding, cutting, or brazing operation.

Oxygen—A colorless, tasteless gas, capable of combining with nearly all other elements. It is used with fuel gases to increase flame temperatures in welding and cutting. Oxygen will be identified by its proper name.

Oxygen Manifold, High-Pressure—A manifold connecting oxygen containers having a US Department of Transportation (DOT) service pressure exceeding 250 psig.

Oxygen Manifold Low Pressure—A manifold connecting oxygen containers having DOT service pressure not exceeding 250 psig.

Purging—A process used to displace vapors and gases from an enclosure.

Shall—Indicates a mandatory requirement

Should— Indicates a preferred method of accomplishment.

Station Outlet—Point at which gas is withdrawn from the service piping system.

Striae—Furrow, channel, hollow a minute groove of channel, a threadlike line or narrow band (as in color).

Welder or Welding Operator—A qualified and certified person who operates electric or gas welding and cutting equipment.

Welding—A joining process where fusion is produced by heating the metal to suitable temperatures, with or without the application of pressure or filler metals.

Will— Is also used to indicate a mandatory requirement and to express a declaration of intent, probability, or determination.

Attachment 2

HOW TO FILL OUT AF FORM 592, USAF WELDING, CUTTING, AND BRAZING PERMIT

BLOCK 1. Control Number (Optional). Control numbers, if used, should be kept in a log so duplicate numbers are not assigned. A control number consists of the year, a dash, and the number from the log. Example: 97-001 would be the first control number assigned in the year 1997.

BLOCK 2. Date Permit Issued. (Self-Explanatory).

BLOCK 3. Time Permit Issued. (Self-Explanatory).

BLOCK 4. Expiration/Date and Time. Date and Time the Permit Expires.

BLOCKS 5 AND 6. Aircraft Tail No. Identify aircraft tail number OR building number and floor number and whether the aircraft is inside or outside.

BLOCK 7. Open Area (Specify). Identify location if welding in an open area.

BLOCK 8. Welding to be Performed. Give a brief description of the work.

BLOCK 9. Fire Watch is Required During Operation and 10 Minutes Thereafter. Put a checkmark in the box if a fire watch is required.

BLOCK 10. An After Operation Inspection is Required. Put a checkmark in the box if a follow-up inspection is needed and enter the fire inspector's phone number.

BLOCK 11. BLOCK 11. Call _____ Upon Completion of Operation. Put a checkmark in the box ONLY if notification of completion is needed. Enter the fire inspector's phone number.

BLOCK 12. Special Precautions. This block will be filled out by the fire inspector.

BLOCK 13. The Location Where This Work is to be Done has been Examined. Necessary Precautions Taken to Provide a Fire Safe Environment and Permission is Granted for this Work. The fire inspector signs this block.

BLOCK 14. I am Fully Qualified to Perform this operation and understand my responsibilities as outlined in AFOSH Standard 91-5. Operator or on-scene supervisor signs here.

BLOCK 15. An after operation inspection has been performed and the area is declared safe. The fire inspector signs here.

BLOCK 16. Operator/Fire Watch Has Declared the Area Safe. Put a checkmark in the box if the operator or fire watch calls to say the job is complete and the area is safe. Fill in the caller's name, date, and time.

Attachment 3

ALL PURPOSE CHECKLIST WELDING, CUTTING, AND BRAZING

Acquisition:

A3.1. Are only approved (as defined in **Attachment 1**) apparatuses purchased for use? (Reference paragraph **2.1.1.**)

A3.2. Does personal protective clothing and equipment meet or exceed the requirements of AFOSH Standard 91-31? (Reference paragraph **2.1.3.**)

A3.3. Are contractors advised that they must comply with OSHA requirements when conducting welding, cutting, and brazing on Air Force facilities? (Reference paragraph **2.1.4.**)

Operating Precautions:

A3.4. Are Acetylene cylinders used and stored in an upright position? (Reference paragraph **2.2.1.**)

A3.5. Is the fuel gas and oxygen supply to the torch shut off during extended periods of time, such as lunch or break periods, and when left unattended? (Reference paragraph **2.2.3.**)

A3.6. Are welders aware that welding on concrete floors may cause the concrete to spall and fly? (Reference paragraph **2.2.9.**)

A3.7. Are welders provided appropriate fall protection when working on elevated surfaces? (Reference paragraph **2.2.10.**)

A3.8. Does the welding operation supervisor ensure installed sprinkler systems are operational before the welding operation begins? (Reference paragraph **2.2.11.1.**)

A3.9. Are hoses visually checked for damage once a shift, before each use? (Exception: If equipment is not used, this inspection is not required.) (Reference paragraph **2.2.12.**)

A3.10. Are warning signs posted to prevent personnel from inadvertently touching hot items which are left unattended? (Reference paragraph **2.2.15.**)

A3.11. When working in a confined space are the requirements outlined in AFOSH Standard 91-25 strictly complied with? (Reference paragraph **2.2.16.**)

Facilities (Inside areas):

A3.12. Have all combustible materials located within 35 feet of the operation been removed? (Reference paragraph **2.3.1.1.**)

A3.13. Have workers and other personnel adjacent to the welding areas been protected from radiant energy or spatter by use of noncombustible and (or) flameproof screens? (Reference paragraph **2.3.1.2.**)

A3.14. Are walls, screens, and non-rigid heat and spark barriers finished to limit reflectivity? (Reference paragraph **2.3.1.3.**)

A3.15. Have procedures been established to prevent personnel from entering an inside welding area and inadvertently being exposed to welding hazards? (Reference paragraph **2.3.1.5.**)

A3.16. Where floors have been wet down or damp sand applied, have rigid controls been established to ensure proper grounding of equipment and are personnel protected from possible electrical shock? (Reference paragraph **2.3.1.6.**)

A3.17. Is a fully charged and operational fire extinguisher, appropriate for the task, kept in the work area at all times? (Reference paragraph **2.3.1.7.**)

Facilities (Outside Areas):

A3.18. Are welding operations roped off or segregated by physical barriers to prevent unauthorized entry into the area? (Reference paragraph **2.3.2.1.**)

A3.19. Are outside welding operations placarded to warn bystanders that welding operations are in progress? (Reference paragraph **2.3.2.1.**)

A3.20. Has a written permit been obtained from the Fire Department prior to the start of welding operations? (Reference paragraph **2.3.2.2.**)

A3.21. Whenever welding activities are within 35 feet of combustible materials are fire watcher procedures implemented? (Reference paragraph **2.3.2.3.**)

A3.22. Has a fire watch been assigned to monitor the operation for 30 minutes after completion of cutting or welding operations, to detect and extinguish possible smoldering fires? (Reference paragraph **2.3.2.3.**)

A3.23. Is the welding operation environment free of flammable liquids and vapors? (Reference paragraph **2.3.2.4.**)

A3.24. While welding and cutting operations are being performed, is fire extinguishing equipment available and ready for use? (Reference paragraph **2.3.2.5.**)

Installed Equipment:

A3.25. Are approved flash arresters installed between each cylinder and the coupler block, when acetylene cylinders are coupled? (Reference paragraph **2.4.2.**)

A3.26. Has backflow protection been provided that will prevent oxygen from flowing into the fuel-gas system or fuel from flowing into the oxygen system? (Reference paragraph **2.4.3.**)

A3.27. Has flashback protection been provided by an approved device? **2.4.4.** (Reference paragraph 2.4.4)

A3.28. Has back-pressure protection been provided by an approved relief device, set at a pressure not greater than the pressure rating of the backflow or flashback device, whichever is lower? (Reference paragraph **2.4.5.**)

A3.29. Are clearly marked master shut off valves provided for installed systems at points which are readily accessible? (Reference paragraph **2.4.7.**)

Personal Protection Equipment:

A3.30. Are workers given frequent breaks when wearing personal protective clothing that interferes with the body's heat dissipation in hot weather? (Reference paragraph **2.5.1.**)

A3.31. Does clothing provide sufficient coverage to minimize skin burns? (Reference paragraph **2.5.2.**)

A3.3 2. Is all outer clothing reasonably free of oil and grease? (Reference paragraph **2.5.2.1.**)

A3.33. Are front pockets and upturned sleeves or cuffs prohibited? (Reference paragraph **2.5.2.2.**)

A3.34. Are insulated linings used with flame-resistant leggings or other equivalent means used to give added protection to the legs? (Reference paragraph **2.5.3.**)

A3.35. When additional protection is needed, are durable flame-resistant aprons made of leather or suitable materials provided to protect the front of the body? (Reference paragraph **2.5.4.**)

A3.36. For heavy work, is flame-resistant leggings or other equivalent means used to give added protection to the legs? (Reference paragraph **2.5.5.**)

A3.37. When necessary, are cape sleeves or shoulder covers used during overhead welding, cutting, or other operations? (Reference paragraph **2.5.6.**)

A3.38. When hazardous noise levels exist, are properly fitted flame-resistant plugs or equivalent protection used? (Reference paragraph **2.5.7.**)

A3.39. When necessary, are flame-resistant caps worn under helmets to prevent head burns? (Reference paragraph **2.5.8.**)

A3.40. Are only approved respirator equipment used when working in atmospheres of hazardous concentrations of airborne contaminants? (Reference paragraph **2.5.9.**)

A3.41. Do all welding helmets meet the requirements of 29 CFR 1910.252? (Reference paragraph **2.5.10.1.**)

A3.42. When two or more welders are exposed to each other's arc, are filter lens goggles worn under the welders helmets to protect from the harmful rays? (Reference paragraph **2.5.10.2.**)

A3.43. Are goggles or other suitable eye protection used during all gas welding or oxygen cutting operations? (Reference paragraph **2.5.10.3.**)

A3.44. Is eye protection in the form of suitable tinted goggles or spectacles provided for brazing operations? (Reference paragraph **2.5.10.5.**)

A3.45. Are workers trained to arrange helmets to protect the face, neck, and ears from the arc's radiant energy. (Reference paragraph **2.5.11.2.**)

A3.46. Are only goggles used that provide ventilation to prevent fogging of the lenses? (Reference paragraph **2.5.11.5.**)

A3.47. Are hand-held shields designed to shield the face and eyes prohibited from use? (Reference paragraph **2.5.11.10.**)

A3.48. Does the commander ensure that employees who handle, use, or are potentially exposed to hazardous materials provided training according to AFHCP? (Reference paragraph **2.6.2.**)

Ventilation Requirements and Gas Leaks:

A3.49. When a welding, cutting, or brazing operation has the potential to create a toxic or unhealthy atmosphere, is the BE contacted for guidance? (Reference paragraph **2.7.**)

A3.50. Do welders check connections after assembly and before lighting the torch? (Reference paragraph **2.8.1.**)

Electrical Safety:

A3.51. Is the welding machine's power supply always disconnected before changing electrodes? (Reference paragraph **2.9.5.**)

A3.52. Are welders trained to never change electrodes with bare hands or wet gloves? (Reference paragraph **2.9.5.2.**)

Aircraft Welding:

A3.53. Is welding on aircraft accomplished outside of hangars whenever possible? (Reference paragraph **3.10.1.**)

A3.54. Does the welding supervisor ensure the senior flight line supervisor is thoroughly briefed on the planned welding operation? (Reference paragraph **3.10.2.**)

A3.55. Prior to the start of welding operations, are fuel tank and engine fuel vents plugged on any aircraft within 50 feet of the welding operation? (Reference paragraph **3.10.4.**)

A3.56. Does the welder rope off or segregate the welding operation by a physical barrier prior to starting the welding operation? (Reference paragraph **3.10.8.**)

A3.57. Is the fire guard informed to stop the welding operation if a hazardous condition develops? (Reference paragraph **3.10.10.**)

A3.58. Do aircraft welding operations performed in hangars conform to the requirements of NFPA 410? (Reference paragraph **3.10.11**)

Welding and Cutting Tanks, Cylinders, or Containers:

A3.59. Has the tank, cylinder, or other container which is to be cut, welded, or have other hot work performed on it been purged or inerted? (Reference paragraph **3.11.1.**)

A3.60. Are new containers inerted or purged prior to cutting, welding, or other hot processes being applied to it? (Reference paragraph **3.11.1.**)

Vehicle Maintenance Shops:

A3.61. Are welding or cutting operations only conducted in vehicle maintenance activities which have approval by the base fire department? (Reference paragraph **3.12.**)

A3.62. Does maintenance shop supervision evaluate each welding or cutting task to determine if batteries need to be removed or fuel tanks require removal and (or) inerting? (Reference paragraph **3.12.**)

Portable Gas Units:

A3.63. Do cylinders of compressed gas have pressure reducing regulators installed? (Reference **3.13.1**, paragraph 3.13. 1)

A3.65. Are oxygen cylinders and fittings kept free of grease and oil at all times? (Reference paragraph **3.13.5**.)

Portable Electric Units:

A3.66. Have circuits been deenergized before testing? (Reference paragraph **3.14.1**.)

A3.67. Are power cables and electrode holders inspected prior to every use? (Reference paragraph **3.14.4**.)

A3.68. Before starting operations, has the work lead been firmly attached to the work? (Reference **3.15.2.1**.)

A3.69. Have cables with damaged insulation or exposed conductors been replaced? (Reference paragraph **3.15.2.4**.)

A3.70. Are electrode holders which are not in use, placed where they cannot make electrical contact with personnel, conducting objects, fuel, or compressed gas cylinders? (Reference paragraph **3.15.4**.)

Welding in Confined Spaces:

A3.71. Has the welding supervisor reviewed the requirements of AFOSH Standard 91-25, for entry into confined spaces? (Reference paragraph **3.17**.)

A3.72. Has written permit (AF Form 592) been obtained from the Fire Department, with coordination by SEG and BE, prior to starting welding operations in a confined space? (Reference paragraph **3.17.1**, and AFOSH Standard 91-25)

A3.73. When welding or cutting operations are conducted in confined spaces, is there adequate ventilation to prevent the accumulation of toxic materials or possible oxygen deficiency? (Reference paragraph **3.17.2**.)

A3.74. Before operations are started, is heavy portable equipment mounted on wheels securely blocked? (Reference paragraph **3.17.5**.)