ANSI Z49.1:2021
An American National Standard

Safety in Welding, Cutting, and Allied Processes

American Welding Society®

ANSI Z49.1:2021
An American National Standard

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Safety in Welding, Cutting, and Allied Processes

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Prepared by the
Accredited Standards Committee Z49,
Safety in Welding and Cutting

Secretariat
American Welding Society

Abstract

This standard covers all aspects of safety and health in the welding environment, emphasizing oxygen gas and arc welding processes with some coverage given to resistance and high energy beam welding, brazing and soldering. It contains information on protection of personnel and the general area, ventilation, fire prevention and protection, and confined spaces. A significant section is devoted to precautionary information, showing examples, and an extensive bibliography is included.

American Welding Society®

American National Standard

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Foreword

This foreword is not part of this standard but is included for informational purposes only.

The huge demands for production placed on the United States by World War II brought a tremendous expansion to the use of welding. In mid 1943, it was recognized that some type of code or standard was needed relating to safe practices for performing welding. Under the auspices of the American Standards Association, the standard was drafted and published in 1944. It was entitled American War Standard Z49.1, S*afety in Electric and Gas Welding, and Cutting Operations*.

Following the war, the standard was first revised in 1950. Subsequent revisions occurred in 1958, 1967, 1973, and 1983. Each updated the standard in accordance with changing technology and welding practices. The revisions up to and including 1973 were largely evolutionary and closely preserved the format of the original war standard.

In 1983, a major rewrite was undertaken to take proper account of the vast changes in welding which had occurred in the 40 years of the standard's existence and to clarify the somewhat patchwork presentation that had built up during the evolutionary revisions. The scope was redefined to address in greater detail the safety rules to be practiced by the welder and enforced by welding supervision and management. Provisions which had appeared in earlier editions, but which dealt more with building construction and piping installation over which the welder had little control, were deleted. The 1988, 1994, 1999, 2005, 2012, and 2021 revisions follow this same philosophy. Revisions are identified by a vertical line in the margin next to the text.

During the period of its publication, the American Standards Association has become the American National Standards Institute and War Standard ASA Z49.1-1944 has now become ANSI Z49.1:2021.

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, Z49 Committee, American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166.

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Safety in Welding, Cutting, and Allied Processes

(American National Standard Z49.1:2021 uses a two-column format to provide both specific requirements and supporting information. The left column is designated as "Standard Requirements" and the right column is designated as "Explanatory Information." The paragraph number of the Explanatory Information is preceded by the letter "E.")

Standard Requirements	Explanatory Requirements

Part I
General Aspects

1. Purpose and Scope

1.1 Purpose. This standard is for the protection of persons from injury and illness and the protection of property (including equipment) from damage by fire and explosions arising from welding, cutting, and allied processes.

E1.1 Beginning with the revision of 1983, the scope of ANSI Standard Z49.1 has been refocused towards those safe practices for performing welding, cutting, and allied processes, which are generally within the implementation control of the welder or the weld shop management. It is written in a manner suitable for issuance to the welder and shop management to give practical information to help them perform these functions safely. It also contains information useful to educators, industrial hygienists, engineers, and similar parties also responsible for safety and health in welding. With this refocused scope, some provisions which appeared in prior editions have been deleted. Those were provisions which dealt more in matter of building design and construction, facility pipelines, and electrical installations. Those provisions, of course, are still important and necessary and must be followed. They are not provisions usually under the immediate control of welding and cutting operations.

1.2 Scope and Applicability. This standard shall be for the guidance of educators, operators, managers, and supervisors in the safe setup and use of welding and cutting equipment, and the safe performance of welding and cutting operations.

E1.2 Specific provisions are included for oxyfuel gas and arc welding and cutting, resistance welding, electron beam welding, laser beam cutting and welding, and brazing and soldering.

However, the requirements of this standard are generally applicable to the other welding processes such as submerged arc welding and allied processes shown in the American Welding Society Master Chart of Welding and Allied Processes, included in Annex D.

1.3 Exclusions. This standard shall not pertain to the following:

(1) Guidelines for the design or manufacture of equipment

(2) Building piping systems

(3) Pipeline protection systems and station outlet equipment

(4) Bulk gas supply systems

(5) Building electrical installations.

1.4 Equivalency. Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard.

1.4.1 Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

1.4.2 The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

2. Definitions

AWS A3.0M/A3.0, *Standard Welding Terms and Definitions*, provides the basis for terms and definitions used herein. However, the following terms and definitions are included below to accommodate usage specific to this document.

2.1 Approved. *Approved* and *approval* as used in this standard mean acceptable to the authority having jurisdiction.

2.1.1 Authority Having Jurisdiction. This term refers to the organization, office, or individual responsible for "approving" equipment, an installation, or a procedure.

E1.3 Some of these were included in former issues of the standard. These items were eliminated from ANSI Z49.1 to avoid their being included in two separate standards under separate auspices which can lead to conflict or confusion between standards.

These are contained in standards and codes of the National Fire Protection Association (NFPA) as follows:

(1) Oxyfuel gas piping systems, pipeline protective devices, and station outlet equipment—NFPA 51, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes*

(2) Storage and manifolding of multiple gas cylinders—NFPA 51

(3) Acetylene generators and calcium carbide storage—NFPA 51

(4) Bulk oxygen systems—NFPA 50, *Standard for Bulk Oxygen Systems at Consumer Sites*

(5) Bulk LP-Gas and MPS systems—NFPA 58, *Storage and Handling of Liquefied Petroleum Gases*

(6) Building electrical installations—NFPA 70, *National Electrical Code®*

(7) Industrial machinery—NFPA 79, *Electrical Standard for Industrial Machinery*

2.1.2 Listed. This term means the equipment or material included in a list published by a nationally recognized testing laboratory that maintains periodic inspection of production of listed equipment or materials.

2.2 Confined Space. Refers to a relatively small or restricted space such as a tank, boiler, pressure vessel, or small compartment. Confinement implies poor ventilation as a result of construction, size, or shape rather than restriction of egress of personnel.

2.3 Cylinder Storage. Refers to cylinders of compressed gas standing by on the site (not those in use or attached ready for use).

2.3.1 Cylinders in Use. This term refers to the following:

(1) Cylinders connected for use;

(2) A single cylinder for each gas to be used, in the use location, ready to be connected; or

(3) A one day supply of cylinders, in the use location, ready to be connected.

2.4 Immediately Dangerous to Life or Health (IDLH). IDLH is a condition which poses an immediate threat of loss of life; may result in irreversible or immediate severe health effects, or other conditions which could impair escape.

2.5 Management. All persons who are responsible for welding operations such as owners, contractors, educators, and others**.**

2.6 Qualified Person. A person who by reason of training, education, and experience is knowledgeable in the operation to be performed and is competent to judge the hazards involved.

2.7 Shall. *Shall* is used to indicate provisions which are mandatory.

2.8 Should. *Should* or *it is recommended that* is used to indicate provisions which are not mandatory.

2.9 Supervisor. All persons who are responsible for supervising welding operations such as owners, contractors, educators, and others."

2.10 Ultraviolet Radiation. Electromagnetic radiation with wavelengths from 100 nm to 400 nm. For the purpose of this standard, only wavelengths between 200 nm to 400 nm need to be considered.

2.11 Unit. Numerical values are given in U.S. Customary and Metric (SI) Units.

E2.2 For additional information, see ANSI Z117.1, *Safety Requirements for Confined Spaces*, and applicable OSHA standards 29 CFR 1910.145 for General Industry, 29 CFR 1926.353(b) for Construction, and 29 CFR 1915 Subpart B for Maritime.

2.12 Welder. "Welder" and "welding operator" as used herein are intended to designate any operator of electric or oxyfuel gas welding or cutting equipment, or allied processes.

E2.12 This term also includes educators and students that are engaged in similar activities.

3. General Provisions, Management, and Supervision

3.1 Setup and Installation

3.1.1 Equipment and Condition Maintenance. All welding and cutting equipment shall be inspected as required to assure it is in safe operating condition. When found to be incapable of reliable safe operation, the equipment shall be repaired by qualified personnel prior to its next use or withdrawn from service.

3.1.2 Operation. All equipment shall be operated in accordance with manufacturers' recommendations and instructions, provided these are consistent with this standard.

E3.1.2 Most manufacturers provide safety information along with operational and maintenance information. Operators should become familiar with, and follow, that safety information.

3.1.3 Heavy Portable Equipment on Wheels. Heavy portable equipment mounted on wheels shall be secured in position to prevent accidental movement before operations are started.

E3.1.3 See 7.2.2 for additional information.

3.2 Responsibilities. Operators and management shall recognize their mutual responsibilities for safety in welding and cutting.

3.2.1 Management

3.2.1.1 Training. Management shall assure that welders and their supervisors are trained in the safe operation of their equipment, the safe use of the process, and emergency procedures.

3.2.1.2 Hazard Communication. Management shall assure that hazards and safety precautions are communicated to and understood by workers prior to the start of work.

E3.2.1.2 The hazards which may be involved in welding are communicated to users through manufacturers' instructions, safety data sheets, and product labeling. See Clause 9, Precautionary Information, of this standard. See especially OSHA 29 CFR, Section 1910.1200, *Hazard Communication Standard*.

3.2.1.3 Designated Areas and Responsibilities. Management shall designate approved areas and establish procedures for safe welding and cutting. A designated management representative shall be responsible for authorizing welding and cutting operations in areas not specifically designed or approved for such processes. Management shall assure that the individual is aware of the hazards involved and familiar with the provisions of this standard.

E3.2.1.3 See 6.3 for additional information.

3.2.1.4 Approved Equipment. Management shall assure that only approved apparatus, such as torches, manifolds, regulators, pressure reducing valves, acetylene generators, welding machines, electrode holders, and personal protective devices are used.

3.2.1.5 Contractors. Management shall:

(1) Select contractors to perform welding who provide trained and qualified personnel, and who have an awareness of the risks involved.

(2) Advise contractor management about flammable materials or hazardous conditions that are specific to the job site.

E3.2.1.5 For the purposes of this standard, in contract operations, the responsibility for the welder rests with the contractor supervisor and the contractor management.

3.2.2 Supervisors

3.2.2.1 Safe Use of Equipment. Supervisors shall be responsible for the safe handling of the welding equipment and for the safe use of the welding process.

3.2.2.2 Fire Hazards. Supervisors shall determine what flammable and combustible materials are present or likely to be present in the work location. They shall ensure that such materials are not exposed to ignition by taking one or more of the following actions:

(1) Have the work moved to a location free from combustibles and away from hazardous areas.

(2) Have the combustibles moved a safe distance from the work or properly shielded against ignition if the work cannot readily be moved.

(3) Schedule welding and cutting so that such materials are not exposed during welding and cutting operations.

E3.2.2.2 See also Clause 6, Fire Prevention and Protection.

3.2.2.3 Authorization. Authorization for the welding or cutting operations shall be obtained from the designated management representative prior to the commencement of hot work or entering a confined space. Supervisors shall oversee that the welder has approval that conditions are safe before going ahead.

E3.2.2.3 See 6.3 and 7.1. There are some circumstances where the authorization must be written; for example, permit-required confined space entry. See especially OSHA 29 CFR, Section 1910.146, *Permit-Required Confined Space Standard*.

3.2.2.4 Protective Equipment and Fire Protection. Supervisors shall assure that proper personal protective and fire protection equipment is used. They shall assure that fire protection and fire extinguishing equipment are properly located at the site, and that fire watchers are assigned and hot-work authorization procedures are followed where required.

Where fire watchers are not required, a final inspection shall be made by supervision.

E3.2.2.4 See 6.2, 6.3, and 6.4. The inspection is usually made to detect and extinguish possible smoldering fires. Be alert for circumstances which may require an extension of the final inspection interval.

3.2.3 Welders

3.2.3.1 Safe Handling of Equipment. Welders shall understand the hazards of the operation to be performed and the procedures being used to control

E3.2.3.1 Welders make the final choice to weld or not to weld. They need to understand the hazards before proceeding.

hazardous conditions. Welders shall handle the equipment safely and use it so as not to endanger lives and property.

3.2.3.2 Permission. Welders shall have permission of management before starting to weld or cut. Welders shall continue to weld or cut only so long as conditions are unchanged from those under which permission was granted.

E3.2.3.2 See 6.3. In many facilities, management grants blanket permission for cutting and welding where fire hazards are not present.

3.2.3.3 Safe Conditions. Welders shall cut or weld only where all safety precautions have been met.

E3.2.3.3 Do not work alone where conditions are especially hazardous, such as where electric shock is a hazard, or where ventilation is poor, etc.

3.2.3.4 Marking Hot Materials. Where others may unknowingly come in contact with hot material remaining from welding, a notice shall be posted.

4. Protection of Personnel and the General Area

4.1 Protection of the General Area

4.1.1 Equipment. Welding equipment, machines, cable, and other apparatus shall be located so that it does not present a hazard to personnel. Good housekeeping shall be maintained.

E4.1.1 For example, locations such as passageways, ladders, or stairways should be kept clear.

4.1.2 Signs. Signs shall be posted designating welding areas, and indicating that eye protection and other applicable protective devices shall be worn.

E4.1.2 Additional precautionary information should be posted when circumstances present additional hazards.

4.1.3 Protective Screens. Workers or other persons adjacent to the welding areas shall be protected from the radiant energy and spatter of welding and cutting by noncombustible or flame-resistant screens or shields, or shall be required to wear eye and face protection, and protective clothing.

E4.1.3 Radiation-protective, semitransparent materials are permissible. Screens should permit circulation of air at floor level as well as above the screen. Refer to NFPA 701, *Standard Methods of Fire Tests for Flame Propagation Textiles and Films*, for information on ignition resistance criteria. For additional information on radiation protection, see 4.2.2. The intensity of arc radiant energy depends on many factors, including current, voltage, and the materials employed. Refer to 4.2.2.

4.1.4 Reflectivity. Where arc welding is regularly carried out, adjacent walls and other surfaces shall have low reflectivity to ultraviolet radiation.

E4.1.4 Finishes formulated with pigments such as titanium dioxide or zinc oxide have low reflectivity to ultraviolet radiation. Color pigments may be added if they do not increase reflectivity. Lamp black has been recommended as a paint additive in the past, but it reduces visible light and is accordingly less desirable in view of the need for good lighting as well as ultraviolet radiation absorption.

Pigments based on powdered or flaked metals are not recommended because of their high reflectivity of ultraviolet radiation.

Welding curtains are another means of reducing reflectivity. For further guidance, see *Ultraviolet Reflectance of Paint*, published by and available from the American Welding Society.

4.1.5 Welding Booths. Where operations permit, welding stations shall be separated by noncombustible screens or shields with characteristics as described in 4.1.3.

4.2 Eye and Face Protection. Eye and face protection shall comply with ANSI/ISEA Z87.1, *Occupational and Educational Personal Eye and Face Protection Devices.* Additionally, the protection for ultraviolet radiation shall include the range from 380 nm to 400 nm.

E4.2 ANSI/ISEA Z87.1 currently defines the upper limit of ultraviolet radiation as 380 nm. For the purposes of this standard the upper limit of ultraviolet radiation is 400 nm. See 2.10.

4.2.1 Type Selection

4.2.1.1 Arc Welding and Arc Cutting with Open Arcs. Helmets or hand shields with filter lenses and cover lenses shall be used by operators and nearby personnel when viewing the arc.

Additionally, protective spectacles with side shields, arc goggles, or other approved eye protection shall also be worn.

E4.2.1.1 Welding helmets with filter lenses are intended to protect users from arc rays and from weld sparks and spatter which impinge directly against the helmet. To protect the user from impact hazards when the welding helmet may be raised during use, spectacles with lateral protection or goggles should also be worn.

The spectacles or goggles may have either clear or filtered lenses, depending upon the amount of exposure to adjacent welding or cutting radiation (see Table 1). Others in the immediate welding area should wear similar eye protection. Welding helmets will not protect against the severe impact of fragmenting grinding wheels, abrasive discs, or explosive devices.

4.2.1.2 Oxyfuel Gas Welding and Cutting and Submerged Arc Welding. Welding goggles, or welding helmet or welding faceshield over spectacles or goggles shall be worn during all oxyfuel gas welding and cutting, and submerged arc welding operations.

E4.2.1.2 It is recommended that such eye protection offer lateral (side) coverage. (See Table 1.)

4.2.1.3 Resistance Welding and Brazing. Operators of resistance welding or brazing equipment and their helpers shall wear welding goggles, or welding helmet or welding faceshield over spectacles or goggles for eye and face protection.

4.2.1.4 Large Area Viewing. For large area viewing, such as training, demonstrations, shows, and certain automatic welding operations, a large filter window or curtain shall be permitted to be used in lieu of eye and face protection. The radiation transmission of window or curtain material shall be equivalent to that in AWS F2.3, *Specification for Use and Performance of Transparent Welding Curtains and Screens*, with a shade number providing a comfortable view.

Additionally, suitable arrangements shall be provided to prevent direct viewing of the arc without filter protection and to protect viewers from sparks and chipped slag.

4.2.2 Requirements for Eye and Face Protection

4.2.2.1 Filter Lenses. Filter lenses shall be in accordance with ANSI/ISEA Z87.1, and the shade shall be selected in accordance with AWS F2.2, *Lens Shade Selector*, or Table 1.

E4.2.2.1 See latest edition of AWS F2.2. Filter lenses should be free from any flaws which may distract, block, or otherwise impair vision.

Persons with special eye conditions should consult their physician for specific information on protective equipment.

4.2.2.2 Material Properties. Helmet and hand shield bodies shall be made of material that is thermally and electrically insulating, noncombustible or self-extinguishing, and opaque to visible, ultraviolet, and infrared radiation, and shall comply with the requirements of ANSI/ISEA Z87.1, *Occupational and Educational Personal Eye and Face Protection Devices*.

E4.2.2.2 Welding helmets, hand shields, and goggles complying with ANSI/ISEA Z87.1 are limited in combustibility.

4.2.2.3 Area of Protection. When there is a possibility of hazardous exposure, helmets and hand shields shall protect the face, forehead, neck, and ears to a vertical line in back of the ears, from direct radiant energy from the arc, and from direct weld spatter.

E4.2.2.3 Some low current processes, such as with micro Plasma Arcs, may not present a hazardous radiation exposure, but may have a spatter exposure. Therefore, operators should be provided with safety glasses even if there is no radiation hazard.

4.2.2.4 Effect of Materials on Skin. Materials in contact with the body shall not readily irritate or discolor the skin.

4.2.2.5 Goggle Ventilation. Goggles shall be vented to deter fogging of the lenses in accordance with ANSI/ISEA Z87.1.

4.2.2.6 Outer Cover Lenses. Outer lenses shall be provided to protect the filter lens or filter lens in goggles, helmets, or hand shields from welding spatter, pitting, or scratching. Outer cover lenses shall be of clear glass or self-extinguishing plastic, but need not be impact resistant.

4.2.2.7 Inner Lenses or Plates. When the "lift front" type of welders' helmet is used, there shall be a fixed impact resistant safety lens or plate on the inside of the frame nearest to the eyes to protect the welder against flying particles when the front is lifted.

4.2.2.8 Marking. Filter lenses shall bear some permanent distinctive marking by which the manufacturer may be readily identified. In addition, all filter lenses shall be marked with their shade number and in accordance with the requirements of ANSI/ISEA Z87.1.

4.2.2.9 Radiation Transmittance Properties. All filter lenses shall meet the "Ultraviolet, Luminous, and Infrared Transmittance" requirements of ANSI/ISEA Z87.1, with the protection for ultraviolet radiation extended from 380 nm to 400 nm (see 4.2).

4.2.2.10 Maintenance. Helmets, handshields, and goggles shall be well maintained, and should not be transferred from one employee to another without being cleaned.

E4.2.2.10 For methods of cleaning, refer to the manufacturer's instructions.

Table 1
Guide for Shade Numbers

(from AWS F2.2:2001 (R2019), *Lens Shade Selector*)

Shade numbers are given as a guide only and may be varied to suit individual needs.

Process	Electrode Size in (mm)	Arc Current (Amperes)	Minimum Protective Shade	Suggested* Shade No. (Comfort)
Shielded Metal Arc Welding (SMAW)	Less than 3/32 (2.4)	Less than 60	7	—
	3/32–5/32 (2.4–4.0)	60–160	8	10
	5/32–1/4 (4.0–6.4)	160–250	10	12
	More than 1/4 (6.4)	250–550	11	14
Gas Metal Arc Welding (GMAW) and **Flux Cored Arc Welding (FCAW)**		Less than 60	7	(Note b)
		60–160	10	11
		160–250	10	12
		250–500	10	14
Gas Tungsten Arc Welding (GTAW)		Less than 50	8	10
		50–150	8	12
		150–500	10	14
Air Carbon Arc Cutting (CAC-A)				
Light		Less than 500	10	12
Heavy		500–1000	11	14
Plasma Arc Welding (PAW)		Less than 20	6	6–8
		20–100	8	10
		100–400	10	12
		400–800	11	14
Plasma Arc Cutting (PAC)		Less than 20	4	4
		20–40	5	5
		40–60	6	6
		60–80	8	8
		80–300	8	9
		300–400	9	12
		400–800	10	14
Torch Brazing (TB)		—	—	3 or 4
Torch Soldering (TS)		—	—	2
Carbon Arc Welding (CAW)		—	—	14
	Plate Thickness			**Suggested* Shade No. (Comfort)**
	in	**mm**		
Oxyfuel Gas Welding (OFW)				
Light	Under 1/8	Under 3		4 or 5
Medium	1/8 to 1/2	3 to 13		5 or 6
Heavy	Over 1/2	Over 13		6 or 8
Oxygen Cutting (OC)				
Light	Under 1	Under 25		3 or 4
Medium	1 to 6	25 to 150		4 or 5
Heavy	Over 6	Over 150		5 or 6

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

4.3 Protective Clothing. Clothing shall be selected to minimize the potential for ignition, burning, trapping hot sparks, or electric shock.

E4.3 Heavier materials such as leather or Flame-Resistant Clothing (FRC) which has been chemically treated to reduce its combustibility or is inherently flame-resistant are preferable to lighter materials because they are more difficult to ignite. Clothing treated with flame resistant materials may lose some of its protective characteristics after repeated washing or cleaning. Follow manufacturer's recommendations for care of FRC. Materials which can melt and cause severe burns should not be used as clothing when welding or cutting.

Sparks may lodge in rolled-up sleeves, pockets of clothing, or cuffs of overalls or pants. It is therefore recommended that sleeves and collars be kept buttoned and pockets be eliminated from the front of clothing. When pockets are present, they should be emptied of flammable or readily combustible materials. Pants or overalls should not have cuffs and should not be turned up on the outside. Pants should overlap shoe tops to prevent spatter from getting into shoes. Frayed clothing is particularly susceptible to ignition and burning and should not be worn when welding or cutting. Refer to 11.3 and 11.4.

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

E4.3.1 Appropriate protective clothing for any welding and cutting operation will vary with the size, nature, and location of the work to be performed. Clothing should be kept clean, as oil and grease can reduce its protective qualities.

4.3.2 Gloves. All welders and cutters shall wear protective flame-resistant gloves. All gloves shall be in good repair, dry, and capable of providing protection from electric shock by the welding process.

E4.3.2 Gloves made of leather, rubber, or other suitable materials are recommended. Insulating linings should be used to protect areas exposed to high radiant energy. See E11.2.2.

4.3.3 Aprons. Durable flame-resistant aprons shall be used to protect the front of the body when additional protection against sparks and radiant energy is needed.

E4.3.3 Aprons made of leather or other suitable materials are recommended. Insulated linings should be used to protect areas exposed to high radiant energy. See E11.2.2.

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

E4.3.4 In production work, a sheet metal screen in front of the worker's legs can provide further protection against sparks and molten metal in cutting operations.

4.3.5 Capes and Sleeves. Cape sleeves or shoulder covers with bibs made of leather or other flame-resistant material shall be worn during overhead welding, cutting, or other operations, when necessary.

4.3.6 Other Protective Clothing. Properly fitted flame-resistant plugs in the ear canals, or equivalent protection, shall be used where hazards to the ear canals exist.

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

4.4 Noise Control. Noise shall be controlled at the source when feasible. When control methods fail to bring noise exposure within allowable limits, personal protective devices such as ear muffs or ear plugs shall be used.

E4.4 In welding, cutting, and allied operations, noise results from the process and from the equipment. Processes that may produce high noise levels are air carbon arc cutting and gouging, and plasma arc cutting and gouging, plus some oxyfuel processes and equipment, and support equipment.

Equipment which sometimes have a high noise level are engine driven generators. Other equipment and processes, such as chipping and grinding, may produce hazardous noise exposure, depending on specific circumstances.

4.5 Respiratory Protective Equipment. When controls such as 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.

E4.5 See 5.1 for a discussion of allowable levels. For guidance on use of respirators in confined spaces, refer to Clause 7, Confined Spaces, of this standard.

4.5.1 Only approved respiratory protective equipment shall be used.

E4.5.1 Approvals of respiratory equipment are issued by the National Institute for Occupational Safety and Health (NIOSH) or the Mine Safety and Health Administration (MSHA).

4.5.2 Whenever the use of respirators is required, a program to establish the proper selection and use of respirators shall be implemented.

E4.5.2 Federal regulations for respirator use dictate that respirators not be passed from one employee to another without being sanitized per OSHA 29 CFR, Section 1910.134, *Respiratory Protection Standard*.

4.5.3 Compressed air for air supplied respirators or other breathing equipment shall at least meet the Grade D requirements of the Compressed Gas Association ANSI/CGA G-7.1, *Commodity Specification for Air.*

4.6 Training. Persons exposed to welding hazards shall be trained in the use of, and understand the reasons for, protective clothing and equipment.

E4.6 Persons include workers and their immediate supervisors. See appropriate ANSI standards on protective clothing and equipment.

5. Ventilation

5.1 General. Adequate ventilation shall be provided for all welding, cutting, brazing, and related operations. Adequate ventilation shall be enough ventilation such that personnel exposures to hazardous concentrations of airborne contaminants are maintained below the allowable limits specified by the authority having jurisdiction.

Respiratory protective equipment as specified in 4.5 shall be used when adequate ventilation is not practical.

E5.1 The factors for determining adequate ventilation include the following:

(1) Volume and configuration of the space in which operations occur (see Clause 7, Confined Spaces)

(2) Number and type of operations generating contaminants

(3) Concentrations of specific toxic or flammable contaminants being generated (see 5.2)

(4) Natural air flow (rate and general atmospheric conditions where work is being done)

(5) Location of the welder’s and other person’s breathing zones in relation to the contaminants or sources

In cases where the values for allowable exposure limits vary among recognized authorities, the lower values should be used to effect the maximum personnel protection.

Fumes and gases from welding and cutting cannot be classified simply. The composition and quantity of fumes

and gases are dependent upon the metal being worked, the process and consumables being used, coatings on the work such as paint, galvanizing, or plating, contaminants in the atmosphere such as halogenated hydrocarbon vapors from cleaning and degreasing activities, as well as the factors itemized in this section for adequate ventilation. A good practice to reduce the generation of fumes and gases from paints and primers is to grind or sand the surface to bare metal prior to welding. Note however that the method of removal may generate particulates that require worker protection.

In welding and cutting, the composition of the fumes is usually different from the composition of the electrode or consumables.

Reasonably expected fume products of normal operation include those originating from consumables, base metals and coating, and the atmospheric contaminants noted.

Reasonably expected gaseous products include carbon monoxide, carbon dioxide, fluorides, nitrogen oxides, and ozone.

The recommended way to determine adequate ventilation is to sample for the composition and quantity of fumes and gases to which personnel are exposed (see 5.2).

The Occupational Safety and Health Administration (OSHA) or others may be the authority having jurisdiction.

Although not an authority having jurisdiction, many of these exposure limits are adopted from the publications of the American Conference of Governmental Industrial Hygienists (ACGIH). Refer to E4.1.3, Protective Screens, and Clause 7, Confined Spaces.

5.2 Breathing Zone Sampling. Where concentrations of airborne fume contaminants are to be determined by sampling of the atmosphere, sampling shall be in accordance with AWS F1.1, *Method for Sampling Airborne Particulates Generated by Welding and Allied Processes*. When a helmet is worn, the samples shall be collected inside the helmet in the welder's breathing zone.

5.3 Avoid the Fume. Welders and cutters shall take precautions to avoid breathing the fume directly.

E5.3 Avoiding the fume can be done by positioning of the work, the head, or by ventilation which captures or directs the fume away from the face. Tests have shown that fume control is more effective when the air flow is directed across the face of the welder, rather than from behind. Most of the fume appears as a clearly visible plume which rises directly from the spot of welding or cutting.

5.4 Types of Ventilation. If natural ventilation is not sufficient to maintain contaminants below the allowable limits referenced in 5.1, mechanical ventilation or respirators shall be provided.

E5.4 Natural ventilation is acceptable for welding, cutting, and related processes where the necessary precautions are taken to keep the welder's breathing zone away from the fumes and where sampling of the

atmosphere shows that concentration of contaminants are below the allowable limits referenced in 5.1.

Mechanical ventilation includes local exhaust, local forced air, and general area mechanical air movement. Local exhaust ventilation is preferred.

Local exhaust ventilation means fixed or moveable exhaust hoods placed as near as practicable to the work and able to maintain a capture velocity sufficient to keep airborne contaminants below the allowable limits referenced in 5.1. Local forced ventilation means a local air moving system (such as a fan) placed so that it moves the air horizontally across the welder's face. General mechanical ventilation may be necessary in addition to local forced ventilation.

Examples of general mechanical ventilation are roof exhaust fans, wall exhaust fans, and similar large area air movers.

General mechanical ventilation is not usually as satisfactory for health hazard control as local mechanical ventilation. It is often helpful, however, when used in addition to local ventilation.

Ventilation should not produce more than approximately 100 feet per minute (0.5 meters per second) air velocity at the work (welding or cutting) zone. This is to prevent disturbance of the arc or flame. It should be recognized that approximately 100 feet per minute (0.5 meters per second) air velocity is a recommended maximum value for quality control purposes in welding and cutting. It is not intended to imply adequacy in contaminant control for worker health protection.

5.4.1 Recirculation. Precautions shall be taken to ensure that excessive levels of contaminants are not dispersed to other work areas. When air is recirculated, the buildup of the contaminants beyond allowable limits referred to in 5.1 shall be prevented. Manufacturer's precautions pertaining to consumables and processes shall be observed.

5.4.2 Air Cleaners. Air cleaners shall be used only if it has been determined by atmospheric sampling that they maintain the level of hazardous contaminants below the allowable limits referred to in 5.1.

E5.4.2 Air cleaners are devices which circulate contaminated air through filters and return the filtered air to the ambient environment.

The devices reduce the amount of air exhausted to the outdoors and reduce make-up air requirements. Most filters do not remove gases. Therefore, adequate monitoring must be done to assure concentrations of harmful gases remain below allowable limits.

5.5 Special Ventilation Concerns

5.5.1 Low Allowable-Limit Materials. Whenever the following materials are identified as constituents in welding, brazing, or cutting operations, and unless

E5.5.1 Certain materials, sometimes contained in the consumables, base metals, coatings, or atmospheres of welding or cutting operations, have very low allowable limits.

breathing zone sampling under the most adverse conditions has established that the level of hazardous constituents is below the allowable limits of 5.1, the special ventilation precautions given in 5.5.1.1 and 5.5.1.2 shall be taken: Antimony, Arsenic, Barium, Beryllium Cadmium, Chromium, Cobalt, Copper, Lead, Manganese, Mercury, Nickel, Ozone, Selenium, Silver, Vanadium.

Based on 2018 changes to exposure limits, the trace chromium levels present in steels may be enough to result in an exposure concern when welding. Welding consumables and materials being joined may produce some amount of hexavalent chromium (CrVI), and other chromium compounds such as chromium oxide, as byproducts in the fume. In 2018, the American Conference of Governmental Industrial Hygienists (ACGIH) lowered the Threshold Limit Value (TLV) for hexavalent chromium from 50 micrograms per cubic meter of air (50 $\mu g/m^3$) to 0.2 $\mu g/m^3$. At these new limits, CrVI exposures at or above the TLV may be possible in cases where adequate ventilation is not provided.

Refer to safety data sheets provided by the manufacturer to identify any of the materials listed here.

5.5.1.1 Confined Spaces. Whenever materials exceed the allowable limits referred to in 5.5.1 in confined space operations, local exhaust mechanical ventilation and, when required, respiratory protection shall be used (see also Clause 7).

5.5.1.2 Adjacent Persons. All persons in the immediate vicinity of welding or cutting operations involving the materials listed in 5.5.1 shall be similarly protected.

5.5.2 Fluorine Compounds. In confined spaces, when welding or cutting operations involve fluxes, coatings, or other materials that contain fluorine compounds, local exhaust mechanical ventilation or respiratory protection shall be provided.

E5.5.2 Fumes and gases from fluorine compounds can be dangerous to health and can burn eyes and skin on contact. See 9.6 for labeling of brazing and gas welding fluxes containing fluorides.

In open spaces, when welding or cutting involves materials containing fluorine compounds, the need for local exhaust ventilation or respiratory protection will depend upon the individual circumstances. However, experience has shown that such protection is desirable for fixed location production welding and for all production welding on stainless steels. Such protection is not necessary when air samples taken in breathing zones indicate that the fluorides liberated are below allowable limits.

5.5.3 Zinc or Copper. Welding or cutting operations involving consumables, base metals, or coatings containing zinc or copper shall be done as described in 5.5.2 for fluorine compounds.

E5.5.3 Fumes containing zinc or copper compounds may produce symptoms of nausea, dizziness, or fever, sometimes called “metal fume fever.”

5.5.4 Cleaning Compounds. When using cleaning compounds prior to welding, manufacturers’ instructions shall be followed.

5.5.4.1 Chlorinated Hydrocarbons. Degreasing or cleaning operations involving chlorinated hydrocarbons shall be so located that vapors from these operations will not reach or be drawn into the atmosphere surrounding molten weld metal or the arc.

E5.5.4.1 A reaction product having a characteristic objectionable, irritating odor, and including highly toxic phosgene gas is produced when such vapors enter the atmosphere of arc welding operations. Low levels of exposure can produce feeling of nausea, dizziness, and

In addition, these materials shall be kept out of atmospheres penetrated by the ultraviolet radiation of arc welding operations.

5.5.5 Arc and Gas Cutting. Oxygen cutting using either a chemical flux or iron powder, gas-shielded arc cutting, or plasma cutting shall be done using local mechanical ventilation or other means adequate to remove the fumes generated.

5.5.6 Brazing Furnaces. In all cases, adequate mechanical ventilation shall be provided to remove all explosive or toxic gases which may emanate from furnace purging and brazing operations.

5.5.7 Asbestos. Where welding or cutting is to be done on surfaces that are covered by asbestos insulation, the regulations of the authority having jurisdiction shall be consulted before beginning the work.

malaise. Heavy exposures may produce serious health impairments.

E5.5.5 Use of water tables, water curtains, underwater cutting, ventilation or combination of these will depend upon the individual circumstances. Experience has shown that such protection is desirable for fixed location production welding and for all production welding on stainless steels. Such protection is not necessary when air samples taken in breathing zones indicate that the materials liberated are below allowable limits.

E5.5.6 Where complete combustion takes place in or at the furnace during the heating cycle, the ventilation requirement may diminish.

E5.5.7 Protection of the employees in the area may require training, respiratory protection, wetting down the asbestos, and use of special protective clothing in addition to special ventilation. See also OSHA asbestos standards.

6. Fire Prevention and Protection

6.1 Areas Containing Combustibles

6.1.1 Conditions for Cutting or Welding. No welding or cutting shall be done unless the atmosphere is nonflammable and unless combustibles are moved away or protected from fire hazards.

6.1.2 Work Movable. Where practical, the work shall be moved to a designated safe location.

6.1.3 Fire Hazards Movable. Where it is not practical to move the work, all movable nearby fire hazards shall be relocated to a safe location.

6.1.4 Work and Fire Hazards Immovable. Where the work and fire hazards are not movable, safeguards shall be used to protect the immovable fire hazards and nearby personnel from the heat, sparks, and slag.

6.1.4.1 Combustible Floors. Combustible floors shall be clean and protected by wetting with water or covering with damp sand, sheet metal, or the equivalent.

E6. Fire Prevention

For more information on the following precautions, as well as on the fire protection and prevention responsibilities of welders, supervisors (including outside contractors), educators and management, see NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*.

E6.1 Welding and cutting should preferably be done in specially designated areas which have been designed and constructed to minimize fire risk. Good housekeeping should be maintained.

Provisions shall be taken to protect personnel from electric shock when floors are wet. Exception: Wood floors laid directly on concrete shall not be required to be wetted.

6.1.4.2 Nearby Openings. All cracks or openings in the floor shall be covered or closed or precautions shall be taken to protect flammable or combustible materials on the floor area below from sparks which might drop through the openings. The same precautions shall be observed with regard to cracks or openings in walls, open doorways, or open or broken windows.

6.2 Fire Protection

6.2.1 Extinguishers and Sprinklers

6.2.1.1 Sufficient fire extinguishing equipment shall be ready for use where welding and cutting work is being done. Permissible fire extinguishing equipment shall be pails of water, buckets of sand, hose, or portable extinguishers, depending upon the nature and quantity of combustible material exposed.

6.2.1.2 Where sprinkler system protection exists, it shall remain operable during the welding or cutting. Automatic sprinkler heads in the immediate vicinity of the welding shall be permitted to be temporarily shielded with noncombustible sheet material or damp cloth guards where they could be activated by the heat of the welding process.

6.2.2 Fire Watchers. Fire watchers shall be qualified individuals, knowledgeable about fire reporting procedures, and emergency rescue procedures, who are assigned duties to detect and prevent spread of fires. Fire watchers shall be posted where welding or cutting is done and where a large fire might develop, or whenever any of the following conditions exist:

(1) *Proximity of Combustibles.* Combustible materials in building construction or contents are closer than a radius of 35 feet (10.7 meters) to the point of operation.

(2) *Openings.* There are wall or floor openings within a radius of 35 feet (10.7 meters) which expose combustible material in adjacent areas, including concealed spaces in walls, ceilings or floors.

(3) *Metal Walls and Pipes.* Combustible materials adjacent to the opposite side of metal partitions, walls, ceilings, or roofs, or in contact with pipes, and are likely to be ignited by conduction or radiation.

(4) *Ship Work.* Ship work performed on opposite sides of tank shells, decks, overheads, and bulkheads, where direct penetration of sparks or heat transfer in welding may introduce a fire hazard to an adjacent compartment.

E6.2.2 Fire watchers are persons assigned to work with welders, to watch for fires resulting from welding, cutting, and brazing operations. When welding or cutting at elevated positions, care should be taken to protect against falling sparks and spatter. Accumulations of dust may be ignited by sparks or spatter, and carry a fire to other locations.

Fire watchers normally would watch for fires in areas not readily observed by the welder, such as on opposite sides of walls, levels below, or hidden areas, or to observe in an area after the welder has left.

Processes such as air carbon arc cutting and plasma arc cutting can cause sparks to travel in excess of 35 feet (10.7 meters).

In Canada, the recommended distance is 50 feet (15 meters).

6.2.3 Additional Fire Watchers. Where it is necessary to observe areas that are hidden from the view of a single fire watcher (other side of partitions, walls, ceilings, etc.) additional fire watchers shall be posted.

6.2.4 Fire Watch Duties. Fire watchers shall be trained in the use of fire extinguishing equipment. They shall be familiar with facilities for sounding an alarm in the event of a fire, and shall remain outside of any confined space to be in communication with those working inside.

They shall watch for fires in all exposed areas, try to extinguish them only when obviously within the capacity of the equipment available, or otherwise sound the alarm. A fire watch shall be maintained for at least one hour after completion of welding or cutting operations to detect and extinguish possible smoldering fires. Fire watchers shall be permitted to have additional duties; however, these additional duties shall not distract them from their fire watcher responsibilities.

E6.2.4 In 2019, the National Fire Protection Association adopted a one-hour Hot Work Fire Watch. See the 2019 Edition of NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*."

6.3 Hot-Work Authorization. Before welding or cutting is begun in a location not designed for such purposes, inspection and authorization by a designated management representative shall be required.

E6.3 Hot work is any work involving burning, welding, or similar operations capable of initiating fires or explosions. Authorization is usually in the form of a written permit. See NFPA 51B for an example of a hot-work permit.

6.4 Welding or Cutting Containers. Welding or cutting work shall not be started until the container has been prepared for hot work. Workers shall be fully familiar with AWS F4.1, *Safe Practices for the Preparation of Containers and Piping for Welding and Cutting*, prior to the commencement of hot work.

E6.4 All containers should be considered unsafe for welding or cutting unless they have been rendered safe, or declared safe by a qualified person. When welding or cutting containers, there is the possibility of explosions, fires, and the release of toxic vapors or fumes. Containers include jacketed vessels, tanks, drums, covered parts or other equivalent situations. Seemingly empty containers might have materials hidden in cracks and crevices, which will release hazardous fumes when heated by welding or cutting. By-products of corrosion can result in explosive atmospheres (hydrogen) in a container. Even a water tank should be considered hazardous unless a qualified person has declared it safe to weld or cut.

Information on preparing containers that have held hazardous substances can also be found in NFPA 326, *Standard for the Safeguarding of Tanks and Containers for Entry, Cleaning, or Repair*, and several API documents. See Annexes B and C for details.

7. Confined Spaces

7.1 Ventilation in Confined Spaces. Ventilation in confined spaces shall be sufficient to assure adequate oxygen for life support, to prevent accumulation of asphyxiants or flammable or explosive mixtures, to prevent oxygen-enriched atmospheres, and to keep airborne contaminants in breathing atmospheres below allowable limits, as referred to in 5.1.

E7.1 Work in confined spaces requires special precautions. Workers, including both owner and contractor personnel, should be familiar with written confined space work program guidelines or should have the work supervised by a trained person. Asphyxiation causes unconsciousness and death without warning. Oxygen enriched atmospheres greatly intensify combustion, and may rapidly cause severe and often fatal burns.

7.1.1 Ventilation Before Entry. Confined spaces shall not be entered unless they are well ventilated and tested to assure they are safe for entry. When it is not practical to maintain the space safe for entry, the space shall only be entered when the following conditions are met:

(1) the space has been tested and determined not to present an oxygen deficient or oxygen enriched atmosphere, a hazard of fire or explosion, or an atmosphere hazardous to life;

(2) a trained second person equipped for rescue is present outside the confined space.

E7.1.1 See 7.5.

7.1.2 Testing Atmospheres. Confined spaces shall be tested for toxic or flammable gases, dusts, and vapors, and for adequate or excess oxygen before entering and during occupancy. The same precautions shall apply to areas such as pits, tank bottoms, low areas, and areas near floors when heavier than air gases and vapors are present, and to areas such as tank tops, high areas and near ceilings when lighter than air gases are present.

E7.1.2 See ANSI Z117.1 and OSHA 29 CFR 1910.146 for further precautions. If possible, a continuous monitoring system with audible alarms should be used for confined space work. Gases such as argon, propane and carbon dioxide are heavier than air. Gases such as helium and natural gas are lighter than air.

7.1.3 Adjacent Persons. Adequate ventilation in confined spaces shall be assured not only to protect welders or cutters themselves, but to protect all personnel who may be present in the area.

7.1.4 Air Quality and Quantity. The quality and quantity of air for ventilation shall be such that personnel exposures to hazardous contaminants are maintained below the allowable limits specified in 5.1. Breathing air supplied by cylinders or compressors shall meet the Grade D requirements of ANSI/CGA G-7.1.

The supply air line for respirators shall be a dedicated line that is not capable of being valved to any other line which could allow hazardous or toxic gases into the respirator air line.

E7.1.4 Additional information on air quality for respirators and their use can be found in 29 CFR 1910.134.

7.1.5 Prohibited Ventilation Gases. Oxygen, or any other gas or mixtures of gases, except air, shall not be used for ventilation.

E7.1.5 Air may be natural air or synthesized air for breathing purposes.

7.1.6 Ventilation in Areas Immediately Dangerous to Life or Health (IDLH). When welding, cutting, or related processes are performed in areas immediately dangerous to life or health, the requirements of OSHA 29 CFR 1910.146 shall be followed.

E7.1.6 See 7.5.1 for information on attendant responsibilities.

7.2 Location of Service Equipment

E7.2 The purpose of this provision is to prevent contamination of the atmosphere of a confined space by possible leaks from gas cylinders or fumes from welding power sources or similar equipment and to minimize the possibility of electric shock.

7.2.1 Compressed Gas Cylinders and Welding Power Sources. When welding or cutting in confined

spaces, gas cylinders and welding power sources shall be located outside the confined space.

7.2.2 Heavy Portable Equipment on Wheels. Heavy portable equipment mounted on wheels shall be secured in position to prevent accidental movement before operations are started in a confined space. See 3.1.3 for additional information.

7.2.3 Ventilation Ducts. Ducts used to provide local exhaust ventilation for welding, cutting, or related operations shall be constructed of noncombustible materials. These ducts shall be inspected as necessary to insure proper function and that the internal surfaces are free of combustible residuals.

E7.2.3 When welding or cutting activities occur near ventilation ducts, or conveyor systems, care should be taken to see that sparks and spatter are not carried to locations with combustible or explosive material.

7.3 Adjacent Areas. When welding or cutting is to be done over, or adjacent to, any confined space, personnel shall be made aware of the hazards in the confined space and shall not enter such spaces without first following the precautions specified in ANSI Z117.1 and OSHA 29 CFR 1910.146.

7.4 Emergency Signal. When a person enters a confined space through a manhole or other small opening, means shall be provided for signaling outside personnel for help as specified in OSHA 29 CFR 1910.146.

7.5 Attendants in Areas Immediately Dangerous to Life or Health (IDLH). When operations are carried on in confined spaces where atmospheres immediately dangerous to life or health may be present or may develop, attendants shall be stationed on the outside of the confined space as specified in OSHA 29 CFR 1910.146.

7.5.1 Attendants Responsibilities. Attendants shall have a preplanned rescue procedure for quickly removing or protecting those working inside in case of emergency, shall observe the workers inside or be in constant communication with them, and shall be capable of putting rescue operations into effect. Positive pressure, self-contained breathing apparatus shall be available for each attendant required to enter as a rescuer or first responder.

E7.5.1 Rescue operations should take into consideration such elements as the number of workers requiring rescue, the time available to perform the rescue given different accident scenarios, and the time needed for additional rescue personnel to be summoned.

7.5.2 Body Harness Systems. When body harness systems are used for emergency rescue purposes, they shall be attached to the person’s body so that they do not become obstructed in passing through a small or tortuous exit path in following the preplanned rescue procedure.

7.6 Brazing Furnaces

E7.6 Brazing furnaces are in many respects a type of confined space. These employ a variety of atmospheres to exclude oxygen during the brazing process. Such atmospheres may include inert gas, flammable gas, flammable gas combustion products, or vacuum. The

following are potential hazards in the operation of brazing furnaces:

(1) asphyxiation of personnel entering or working in adjacent areas where there is insufficient oxygen in the atmosphere to support life,

(2) development of explosive mixtures of flammable gas and air within the furnace during generation or venting of atmosphere within the furnace,

(3) accumulation of hazardous fumes or gases in the work area due to the brazing process.

7.6.1 Life Support. If brazing furnaces require personnel entry into the furnace or adjacent areas, the provisions of 7.1 shall be observed.

7.6.2 Fire and Explosion. If brazing furnaces utilize a flammable gas for their interior atmosphere, or if a flammable gas is burned to create an interior atmosphere, procedures shall be followed which will assure that an explosive mixture of flammable gas and air is not produced in the furnaces.

7.6.3 Venting. Venting of the atmosphere from within brazing furnaces shall be exhausted to a location where it will not expose personnel to hazard.

8. Public Exhibitions and Demonstrations

8.1 Application. All requirements of the standard shall apply to public exhibitions and demonstrations, except when superseded by this section.

E8. Refer to NFPA 51B. Local codes and regulations may require additional measures.

8.2 Supervision. Installation and operation of welding, cutting, and related equipment shall be done by, or under the supervision of, a qualified person.

E8.1 This section contains safety precautions specific to welding and cutting performed at public demonstrations and exhibits, displays, and trade shows (referred to hereinafter as the site) to ensure the protection of viewers, demonstrators, and the public.

8.3 Site

8.3.1 Site Design. The site shall be constructed, equipped, and operated so as to minimize the possibility of injury to viewers at the site.

8.3.2 Site Location. Materials and equipment on the site shall be located so as not to interfere with evacuation of people during an emergency.

8.4 Fire Protection

E8.4 See also Clause 6, Fire Prevention and Protection.

8.4.1 Extinguishers. Sites shall be provided with portable fire extinguishers of appropriate size and type.

8.4.2 Combustibles. Combustible materials at the site shall be shielded from flames, sparks, and molten metal.

8.4.3 Fire Department. The fire department shall be notified in advance of such use of the site.

8.5 Protection of the Public

E8.5 See also Clause 6, Fire Prevention and Protection.

8.5.1 Flames, Flying Sparks, and Molten Metal. The public shall be shielded from flames, flying sparks, and molten metal.

8.5.2 Radiation. The public shall be shielded from harmful ultraviolet, infrared, and other electromagnetic radiation. Shielding shall protect direct viewers and adjacent passersby.

8.5.3 Fumes and Gases. The public shall be protected from inhalation of hazardous concentrations of fumes and gases.

8.5.4 Electrical Shock. The public shall be protected from contact with live electrical parts.

8.6 Cylinders

E8.6 See also 10.8 and 10.9.

8.6.1 Capacity. Cylinders shall not be charged in excess of one-half their maximum permissible capacity by weight or pressure. Cylinders of non liquefied gases and acetylene shall be charged to not more than one-half their maximum permissible charged pressure in psig (kPa). Cylinders of liquefied gases shall be charged to not more than one-half the maximum capacity in pounds (kilograms).

8.6.2 Storage. Unconnected cylinders, stored at the site, shall be limited to approximately one day's consumption of each gas used. Other cylinders shall be stored in an approved storage area, preferably outdoors but not near a building exit.

8.6.3 Trucks. When transported, cylinders weighing more than 40 pounds (18 kilograms), shall be carried on a hand or motorized truck.

8.6.4 Cylinder Valves. Cylinder valves shall be closed when equipment is unattended.

E8.6.4 Cylinder valves should be closed and capped when equipment is unattended for an extended time, such as for several days. See 8.6.5.

8.6.5 Valve Caps. Where cylinders are designed to be equipped with valve protection caps, the caps shall be in place except when the cylinders are in service or connected ready for service.

8.6.6 Protection. Cylinders shall be located or secured so that they cannot be knocked over.

8.7 Process Hoses, Cables, and Conduits

E8.7 See also 10.6.

8.7.1 Physical Damage. Hoses, cables, and conduits shall be located and protected so that they will not be physically damaged.

8.7.2 Tripping. Hoses, cables, and conduits shall be located and protected to minimize tripping hazard.

9. Precautionary Information

9.1 General. Personnel shall be informed of the potential hazards from fumes, gases, electric shock, heat, radiation, and noise.

E9.1 Refer to Clause 4, Protection of Personnel and the General Area, for additional information on potential hazards. See also OSHA 29 CFR Section 1910.1200.

9.2 Precautionary Information for Arc Welding and Related Processes and Equipment. The information shown in Figure 1, or its equivalent, shall be placed on stock containers of materials such as wires, fluxes, and electrodes and on major equipment such as power supplies, wire feeders, and controls used in arc welding, arc cutting, and allied processes. The information shall be readily visible and may be on a label, tag, or other printed form.

Where noise has been determined to be a hazard, the statement of hazard, "NOISE can damage hearing," shall be placed after the statement of hazard, "ELECTRIC SHOCK can KILL."

When provided, first aid information shall follow the last precautionary measure.

The company name and address shall appear on the label unless it is readily visible elsewhere on the product.

E9.2 This information is a minimum requirement. Additional information and labeling may be required by other standards and regulations. The message is the important thing. This information is intended to get it to the final user. See also the ANSI Z535 series of standards on safety signs and colors.

First aid information is generally recommended only on products that present immediate and major health hazards.

A label identification number should appear on the label.

When materials are determined to be more hazardous than those requiring the use of WARNING as a signal word, the signal word should be changed to DANGER and an appropriate precautionary message should be added.

9.3 Precautionary Information for Oxyfuel Gas Processes and Equipment. As a minimum, the information shown in Figure 2, or its equivalent, shall be placed on stock containers of materials such as rods and fluxes, and on major equipment used in oxyfuel gas welding, cutting, and allied processes. The information shall be readily visible and may be on a label, tag, or other printed form.

Where noise has been determined to be a hazard, the statement of hazard, "NOISE can damage hearing" shall be placed after the statement of hazard, "HEAT RAYS (INFRARED RADIATION) from flame or hot metal can injure eyes." This information shall follow the last precautionary measure. The company name and address shall appear on the label unless it is readily visible elsewhere on the product.

E9.3 See comment for 9.2. Some processes are arcless and flameless. Modify the information in Figure 2 to reflect the proper heat source and appropriate hazards.

9.4 Hazardous Materials Information. When the fume from a product contains a by-product component whose allowable limit will be exceeded before the general welding fume allowable limit, the by-product component shall be identified on the Safety Data Sheet (SDS). These include, but shall not be limited to, byproducts of the materials itemized in 5.5.1.

E9.4 A number of potentially hazardous materials are employed in the fluxes, coatings, coverings, and filler metals used in welding and cutting, or are released to the atmosphere during welding and cutting. Safety Data Sheets (SDSs) are required by federal regulations. See also 9.7.

9.5 Brazing Filler Metals Containing Cadmium. As a minimum, brazing filler metals containing cadmium as a designated constituent shall carry the information shown in Figure 3, or its equivalent, on tags, boxes, or other containers, and on any coils of wire not supplied to the user in a labeled container.

E9.5 See E9.3.

9.6 Brazing and Gas Welding Fluxes Containing Fluorides. As a minimum, brazing and gas welding fluxes containing fluorine compounds shall have precautionary information as shown in Figure 4, or its equivalent, on tags, boxes, or other containers to indicate that they contain fluorine compounds.

E9.6 See E9.3.

WARNING:

PROTECT yourself and others. Read and understand this information

FUMES AND GASES can be hazardous to your health.

ARC RAYS can injure eyes and burn skin.

ELECTRIC SHOCK can KILL.

- Before use, read and understand the manufacturer's instructions, Safety Data Sheets (SDSs), all label information, and your employer's safety practices.
- Keep your head out of the fumes.
- Use enough ventilation, exhaust at the arc, or both, to keep fumes and gases from your breathing zone and the general area. Use breathing protection unless exposures are below exposure limits.
- Wear correct eye, ear, and body protection.
- Do not touch live electrical parts.
- See American National Standard Z49.1, *Safety in Welding, Cutting, and Allied Processes*, published by the American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166; OSHA *Safety and Health Standards*, available from the U.S. Government Printing Office.

DO NOT REMOVE THIS INFORMATION

Figure 1—Precautionary Information for Arc Welding Processes and Equipment

WARNING:

PROTECT yourself and others. Read and understand this information.

FUMES AND GASES can be hazardous to your health.

HEAT RAYS (INFRARED RADIATION) from flame or hot metal can injure eyes.

- Before use, read and understand the manufacturer's instructions, Safety Data Sheets (SDSs), all label information, and your employer's safety practices.
- Keep your head out of the fumes.
- Use enough ventilation, exhaust at the flame, or both, to keep fumes and gases from your breathing zone and the general area. Use breathing protection unless exposures are below exposure limits.
- Wear correct eye, ear, and body protection.
- See American National Standard Z49.1, *Safety in Welding, Cutting, and Allied Processes*, published by the American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166; OSHA *Safety and Health Standards*, available from the U.S. Government Printing Office.

DO NOT REMOVE THIS INFORMATION

Figure 2—Precautionary Information for Oxyfuel Gas Processes and Equipment

DANGER: Contains cadmium.

Protect yourself and others. Read and understand this information.

FUMES ARE POISONOUS AND CAN KILL.

- Before use, read and understand the manufacturer's instructions, Safety Data Sheets (SDSs), all label information, and your employer's safety practices.
- Do not breathe fumes. Even brief exposure to high concentrations should be avoided.
- Use enough ventilation or exhaust, or both, to keep fumes and gases from your breathing zone and the general area. If this cannot be done, use air supplied respirators.
- Keep children away when using.
- See American National Standard Z49.1, *Safety in Welding, Cutting, and Allied Processes*, published by the American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166; OSHA *Safety and Health Standards*, available from the U.S. Government Printing Office.

DO NOT REMOVE THIS INFORMATION

Figure 3—Precautionary Information for Brazing Filler Metals Containing Cadmium

WARNING: Contains fluorides.

Protect yourself and others. Read and understand this information.

FUMES AND GASES CAN BE HAZARDOUS TO YOUR HEALTH. BURNS EYES AND SKIN ON CONTACT. CAN BE FATAL IF SWALLOWED.

- Before use, read and understand the manufacturer's instructions, Safety Data Sheets (SDSs), all label information, and your employer's safety practices.
- Keep your head out of the fume.
- Use enough ventilation or exhaust, or both, to keep fumes and gases from your breathing zone and the general area. Use breathing protection unless exposures are below exposure limits.
- Keep children away when using.
- See American National Standard Z49.1, *Safety in Welding, Cutting, and Allied Processes*, published by the American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166; OSHA Safety and Health Standards, available from the U.S. Government Printing Office.

DO NOT REMOVE THIS INFORMATION

Figure 4—Precautionary Information for Brazing and Gas Welding Fluxes Containing Fluorides

9.7 Safety Data Sheets (SDSs). The suppliers of welding materials shall provide a Safety Data Sheet which identifies the hazardous materials, if any, used in their welding and cutting products.

E9.7 SDSs are required by OSHA 29 CFR Section 1910.1200. It is important for manufacturers to review and understand the requirements for SDS authoring, including the criteria for listing hazardous components in Section 3 of the product SDS. In addition, it is advised to review and understand the requirements for listing hazards and hazardous constituents, arising out of the product's use.

9.8 Graphic Symbols. Graphic symbols shall be permitted in place of text when they present equivalent precautionary information.

E9.8 See also ANSI Z535 and NEMA EW6, *Guidelines for Precautionary Labeling for Arc Welding and Cutting Products*.

9.9 Hazard Communications. Employers shall assure that the information described in this section is communicated to end users of the products (see 3.2.1.2 of this standard).

Part II
Specific Processes

10. Oxyfuel Gas Welding and Cutting Safety

10.1 Scope. This section covers safe practices for users of oxyfuel gas welding, cutting, soldering, brazing, and related materials and equipment. It does not cover specifications for the design and construction of such equipment, nor for the construction or installation of bulk gas supply or piping distribution systems.

E10.1 Note that this applies to USERS, not manufacturers of equipment. See 1.3.

10.2 Terminology

10.2.1 Call Oxygen by Name. Oxygen shall be called by its proper name, oxygen, and not by the word "air."

E10.2.1 Use of this proper name will decrease the probability of misuse.

10.2.2 Call Fuel Gases by Name. Fuels, fuel gases, and liquid fuels shall be called by their proper names, such as, acetylene, propane, natural gas, and not by the word "gas."

E10.2.2 Proper identity is needed to determine the correct hazards.

10.3 Oxygen and Combustibles

10.3.1 Keep Oxygen from Combustibles. Oxygen cylinders, cylinder valves, couplings, regulators, hoses, and apparatus shall be kept free from oil, grease, and other flammable or explosive substances. Oxygen cylinders or apparatus shall not be handled with oily hands or gloves.

E10.3.1 Oxygen will not burn, but vigorously supports and accelerates combustion, causing materials to burn with great intensity. Oil or grease in the presence of oxygen may ignite readily and burn violently.

10.3.2 Prohibited Uses for Oxygen. Oxygen shall not be used as a substitute for compressed air. Oxygen shall not be used in pneumatic tools, in oil preheating burners, to start internal combustion engines, to blow out pipelines, to dust clothing or work, or to create pressure

E10.3.2 These prohibitions decrease the possibility of a raging oxygen-fed fire occurring. Oxygen is not flammable, but vigorously supports combustion. Oxygen can be adsorbed by clothing. A slight spark can result in severe burns.

for ventilation or similar applications. Jets of oxygen shall not be permitted to strike an oily surface, greasy clothing, or enter fuel oil or other storage tanks.

10.3.3 Oxygen Equipment. Oxygen cylinders, equipment, pipelines, or apparatus shall not be used interchangeably with any other gas.

E10.3.3 Contamination of oxygen equipment with combustible substances may lead to spontaneous combustion or explosion in oxygen.

10.4 Attachments for Gas Mixing. No device or attachment facilitating or permitting mixtures of air or oxygen with flammable gases prior to consumption, except at a burner or in a torch, shall be allowed unless approved for the purpose.

E10.4 This prevents the accumulation of explosive mixtures.

10.5 Torches

10.5.1 Approval. Only approved torches, as defined in 2.1, shall be used.

E10.5.1 For additional information on torches, see CGA E-5, *Torch Standard for Welding and Cutting*.

10.5.2 Operation

10.5.2.1 Leak Testing Connections. Connections shall be checked for leaks after assembly and before lighting the torch. Flames shall not be used.

E10.5.2.1 Leak test solutions for use on oxygen connections are commercially available and are recommended. Leak testing should be repeated after the equipment has been used in a manner that could cause leaks.

10.5.2.2 Purging Hoses. Before lighting the torch for the first time each day, hoses shall be purged individually. Hoses shall not be purged into confined spaces or near ignition sources. Hoses shall be purged after a cylinder change.

E10.5.2.2 Purging consists of allowing each gas to flow through its respective hose separately, to purge out any flammable mixture in the hose. It is important to purge before lighting the torch.

10.5.2.3 Lighting Torch. A friction lighter, stationary pilot flame, or other suitable source of ignition shall be used. Matches, cigarette lighters, or welding arcs, shall not be used for lighting torches.

Manufacturers' procedures shall be followed with respect to the sequence of operations in lighting, adjusting, and extinguishing torch flames.

E10.5.2.3 This is to minimize burns of hands and fingers. Do not attempt to light or relight torch from hot metal in a small cavity, hole, furnace, etc., where gas might accumulate. Point the torch away from persons or combustible materials.

10.5.2.4 Confined Space. In confined spaces, the torch valves shall be closed and in addition, the fuel gas and oxygen supply to the torch shall be positively shut off at a point outside the confined area whenever the torch is not to be used, such as during lunch or overnight. Unattended torches and hoses shall be removed from the confined space.

E10.5.2.4 This is to minimize the possibility of gas accumulation in confined space due to leaks or improperly closed valves when gas welding or cutting is completed. See also Clause 7, Confined Spaces, of this standard, for other precautions to be observed in working in confined spaces.

10.6 Hose and Hose Connections

10.6.1 Specification. Hose for oxyfuel gas service shall comply with the Association for Rubber Products Manufacturers IP-7, *Specification for Rubber Welding Hose*.

E10.6.1 Metal-Clad or armored hose is not recommended. However, as part of a machine or an appliance when conditions of use make metal reinforcing advantageous, hose may be used in which such metal reinforcing is exposed to neither the inside gases nor the outdoor atmosphere.

10.6.2 Colors. Hoses for oxyfuel gas service shall be color coded according to the authorities having jurisdiction.

E10.6.2 The generally recognized colors in the United States are red for fuel gas hose, green for oxygen hose, and black for inert-gas and air hose. Other countries some-

times use different colors. International colors generally recognized are described in ISO 3821, *Welding—Rubber Hoses for Welding, Cutting, and Allied Processes*.

10.6.3 Taping. When parallel lengths of oxygen and fuel gas hose are taped together for convenience and to prevent tangling, not more than 4 inches (100 millimeters) in each 12 inches (300 millimeters) shall be covered by tape.

E10.6.3 This leaves 2/3 of the hoses visible for color identification, and provides adequate ventilation to prevent gas entrapment in the event of hose leaks.

10.6.4 Maintenance. Hose showing leaks, burns, worn places, or other defects rendering it unfit for service shall be repaired or replaced.

E10.6.4 Frequency of inspection depends upon the amount and severity of use. Bending areas at the regulator and torch connections are prone to crack and leak because of additional stress.

10.6.5 Hose Connection Specifications. Hose connections shall comply with the standard hose connection specification, CGA Pamphlet E-1, *Regulator Connection Standards*.

Hose connections for welding gas lines shall not be compatible with connections for breathing air.

10.6.6 Hose Connection Quality. Hose connections shall be fabricated in a manner that will withstand, without leakage, twice the pressure to which they are normally subjected in service, but in no case less than 300 psi (2070 kPa). Oil-free air or an oil-free inert gas shall be used for testing.

10.6.7 Devices. Only approved devices as defined in 2.1 shall be used in oxyfuel gas systems.

E10.6.7 When an approved device such as a hose check valve or flash-back arrestor is used in an oxyfuel gas welding and cutting torch system, the device should be used and maintained in accordance with the manufacturers' instructions. Refer to CGA Pamphlet E-2, *Standard Hose Connection Specifications*.

10.6.7.1 The use of suitable approved flashback arrestors shall be permitted.

E10.6.7.1 Flashback arrestors can provide a certain measure of protection against the hazards of flashback. To maintain this protection and to ensure that they have not become damaged or inoperative during use, a routine inspection program should be followed as specified during use. Also, a regular inspection program should be followed as specified in the instructions provided by the manufacturer.

Many years of field experience has shown various oxyfuel gas torches to be reliable and safe apparatus when operated in accordance with instructions recommended by the manufacturer. Under certain circumstances, the user's failure to follow these instructions can cause the backflow (reverse flow) of unwanted gas and/or flashback into the upstream equipment.

10.7 Pressure-Reducing Regulators

10.7.1 Approval. Only approved pressure reducing regulators, as defined in 2.1, shall be used.

E10.7.1 Refer to CGA E-4, *Standard for Gas Regulators for Welding and Cutting*.

10.7.2 Designated Service. Pressure reducing regulators shall be used only for the gas and pressures for

E10.7.2 Contamination can lead to explosions and fire.

which they are labeled. The regulator inlet connections shall comply with ANSI/CGA Standard V-1, *Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections*.

Regulators shall not be interchanged among designated gas services.

10.7.3 Inspection Before Use. Union nuts and connections on regulators shall be inspected before use to detect faulty seats which may cause leakage when the regulators are attached to cylinder valves or hoses. Damaged nuts or connections shall be replaced.

10.7.4 Oxygen Gauges. Gauges used for Oxygen service shall be marked “USE NO OIL.”

10.7.5 Oxygen Regulators. Regulators shall be drained of oxygen before they are attached to a cylinder or manifold, or before the cylinder valve is opened (see also 10.8.4.4 and 10.8.4.11). Oxygen cylinder or manifold valves shall always be opened slowly (see 10.8.4.3 and 10.8.4.4).

E10.7.5 The regulator attached to a cylinder can be drained of oxygen by momentarily opening and then closing the downstream line to the atmosphere with the regulator adjusting screw engaged and the cylinder valve closed. The cylinder valve is then opened slowly. The oxygen cylinder or manifold outlet connection should be wiped clean with a clean cloth, free of oil and lint, and the cylinder valve “cracked” before connecting the regulator. (See 10.8.4.3.)

These steps help reduce the chance of oxygen fed regulator fires when the regulator is pressurized from a high-pressure source.

10.7.6 Maintenance. When regulators or parts of regulators, including gauges, need repair, the work shall be performed by qualified mechanics.

10.8 Compressed and Oxyfuel Gas Cylinders (Containers)

E10.8 Compressed gas cylinders used in welding and cutting processes contain gases generally at pressures approximately 2500 psi (17237 kPa), but sometimes much higher. Gases at these pressures are dangerous if not properly handled. The procedures described in this section are intended to prevent damage or abuse to gas cylinders which might cause them to leak or explode with the consequence of serious damage, injury, or death.

10.8.1 General Cylinder Provisions

10.8.1.1 Approval. All portable cylinders used for storage and shipment of compressed gases shall be constructed and maintained in accordance with 49 CFR 173 regulations of the U.S. Department of Transportation (DOT).

10.8.1.2 Filling Authorization. No one except the owner of the cylinder or person authorized by the owner shall fill a cylinder.

10.8.1.3 Mixing Gases. No person other than the gas supplier shall mix gases in a cylinder or transfill gases from one cylinder to another.

10.8.1.4 Content Identification. Compressed gas cylinders shall be legibly marked with either the chemical or the trade name of the gas in conformance with ANSI/CGA C-7, *Guide to Preparation of Precautionary Labeling and Marking of Compressed Gas Containers*, for the purpose of identifying the gas

content. Cylinders on which the labeling is missing or illegible shall not be used. They shall be returned to the supplier.

10.8.1.5 Changing Markings. The numbers and markings stamped into cylinders shall not be changed except in conformance with 49 CFR 173 U.S. DOT regulations.

10.8.1.6 Connection Threads. Compressed gas cylinders shall be equipped with connections complying with ANSI/CGA V-1, *Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections.*

10.8.1.7 Valve Protection. All cylinders with a water weight capacity over 30 pounds (13.6 kilograms) shall be equipped with a means of connecting a valve protection cap or with a collar or recess to protect the valve.

10.8.1.8 Cylinder Temperature. The storage temperature of the cylinder contents shall not be allowed to exceed 125°F (52°C). The use temperature shall not exceed 120°F (49°C).

E10.8.1.8 Hot gases *may* expand and increase pressures above allowable limits. For additional information, contact the Compressed Gas Association.

10.8.1.9 Damaged Cylinders. Cylinders evidencing severe damage, corrosion, or fire exposure shall not be used.

10.8.2 Cylinder Storage

10.8.2.1 Protection. Cylinders shall be stored where they will not be exposed to physical damage, tampering, or subject to temperatures which would raise the contents above the limits of 10.8.1.8.

E10.8.2.1 Check for overhead combustibles such as overhead lines and piping, suspended ceiling materials, etc., when considering storage location. The storage location should be well ventilated so as to avoid the accumulation of hazardous gases in the event of cylinder leakage.

Cylinders shall be stored away from elevators, stairs, or gangways in assigned places where cylinders will not be knocked over or damaged by passing or falling objects. Cylinders shall be secured in storage to prevent falling.

10.8.2.2 Cylinders Separated from Combustibles. Cylinders in storage shall be separated from flammable and combustible liquids and from easily ignited materials such as wood, paper, packaging materials, oil, and grease by at least 20 feet (6.1 meters), or by a noncombustible barrier at least 5 feet (1.6 meters) high having a fire resistance of at least one-half hour.

E10.8.2.2 Heat can cause pressure to rise and may lead to cylinder rupture or operation of protective devices.

10.8.2.3 Oxygen Separated from Fuel Gas. Oxygen cylinders in storage shall additionally be separated from fuel gas cylinders, or from reserve stocks of calcium carbide, by a distance or barrier as described in 10.8.2.2.

10.8.2.4 Oxygen in Acetylene Generator Buildings. Oxygen cylinders stored in outside acetylene generator houses shall be separated from the generator or carbide storage rooms by a noncombustible partition

having a fire resistance of at least one hour. This partition shall be without openings and shall be gas-tight.

Oxygen shall not be stored inside acetylene generator rooms.

10.8.2.5 Fuel Gas Cylinders Upright. Acetylene and liquefied gas cylinders shall be used valve end up.

E10.8.2.5 This prevents liquid flow into hoses and regulators.

10.8.2.6 Fuel Gas Storage Limits. Fuel gas storage limits shall be in accordance with NFPA 51, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes*.

10.8.3 Cylinder Handling

10.8.3.1 Rough Handling. Cylinders shall not be dropped, struck, or permitted to strike objects violently in a manner which may damage the cylinder, valve, or safety device.

10.8.3.2 Pry Bars. Bars shall not be used under valves or valve protection caps to pry cylinders loose when frozen to the ground or otherwise fixed.

E10.8.3.2 The use of warm (not boiling) water is recommended.

10.8.3.3 Rollers or Supports. Cylinders shall never be used as rollers or supports, whether full or empty.

10.8.3.4 Safety Devices. Safety devices shall not be tampered with.

10.8.3.5 Closed Valves. Cylinder valves shall be closed before moving cylinders.

10.8.3.6 Valve Protection Caps. Valve protection caps, where the cylinder is designed to accept a cap, shall always be in place and handtight (except when cylinders are in use or connected for use).

E10.8.3.6 Cylinder valve protection caps should be kept with the cylinders so they can be reassembled when the regulator is removed.

10.8.3.7 Manual Lifting. Valve protection caps shall not be used for lifting cylinders.

10.8.3.8 Lifting Equipment. When transporting cylinders by a crane or derrick, a cradle or suitable platform shall be used. Slings or electromagnets shall not be used for this purpose.

10.8.3.9 Transporting Cylinders. When cylinders are transported by motor vehicle, they shall be secured and transported in accordance with Department of Transportation regulations, when required.

E10.8.3.9 It is especially hazardous to transport cylinders of fuel gas inside any vehicle, such as an automobile, where gas from a leak can accumulate inside the passenger compartment or trunk. Opening the door or trunk will activate a light switch that acts to ignite the accumulated gas and cause a deadly explosion.

10.8.3.10 Cylinders with Regulators Attached. When cylinders are to be moved with regulators attached, the cylinders shall be secured in position when moved, and cylinder valve closed.

10.8.4 Cylinder Use

10.8.4.1 Pressure Regulator. Compressed gas shall never be used from cylinders without reducing the pressure through a suitable regulator attached to the

cylinder valve or manifold, unless the equipment used is designed to withstand full cylinder pressure.

10.8.4.2 Maximum Acetylene Pressure. Acetylene shall not be utilized at a pressure in excess of 15 psig (103 kPa) or 30 psia (206 kPa). This requirement shall not apply to storage of acetylene dissolved in a suitable solvent in cylinders manufactured and maintained according to Department of Transportation requirements, or to acetylene for chemical use.

E10.8.4.2 Acetylene can dissociate (decompose with explosive violence) above these pressure limits. The 30 psia (206 kPa) limit is intended to prevent unsafe use of acetylene in pressurized chambers such as caissons, underground excavations, or tunnel construction.

10.8.4.3 "Cracking" Cylinder Valve. Before connecting a regulator to a cylinder valve, the valve outlet shall be wiped clean with a clean cloth free of oil and lint, and the valve shall be opened momentarily and closed immediately.

E10.8.4.3 This action, generally termed *cracking*, is intended to clear the valve of dust or dirt that otherwise might enter the regulator.

The valve shall be cracked while standing to one side of the outlet, never in front of it. Fuel gas cylinder valves shall not be cracked near other welding work or near sparks, flame, or other possible sources of ignition.

10.8.4.4 Special Procedure for Oxygen Cylinders. The following shall be done after the regulator is attached to oxygen cylinders:

E10.8.4.4 If oxygen at high pressure is suddenly applied, it is possible to cause ignition of regulator components and injure the operator. See CGA Pamphlet E-4 for additional information.

(1) Engage the adjusting screw and open the downstream line to drain the regulator of gas.

(2) Disengage the adjusting screw and open the cylinder valve slightly so that the regulator cylinder-pressure gauge pointer moves up slowly before opening the valve all the way.

(3) Stand to one side of the regulator and not in front of the gauge faces when opening the cylinder valve.

10.8.4.5 Hammer or Wrench. A hammer or wrench shall not be used to open cylinder valves that are fitted with hand wheels.

10.8.4.6 Special Wrench. Cylinders not having fixed hand wheels shall have keys, handles, or nonadjustable wrenches on valve stems while these cylinders are in service so that the gas flow can be turned off quickly in case of emergency. In multiple cylinder installations, at least one such wrench shall always be available for immediate use.

10.8.4.7 Valve Wide Open. When a high-pressure (nonliquefied) gas cylinder is in use, the valve shall be opened fully in order to prevent leakage around the valve stem.

10.8.4.8 Valve Partially Open. An acetylene cylinder valve shall not be opened more than approximately one and one-half turns and preferably no more than three-fourths of a turn, unless otherwise specified by the manufacturer.

E10.8.4.8 This is so that it may be closed quickly in case of emergency.

10.8.4.9 Interference. Nothing shall be placed on top of a cylinder when in use which may damage the safety device or interfere with the quick closing of the valve.

10.8.4.10 Valves Closed. Cylinder valves shall be closed whenever the equipment is unattended.

10.8.4.11 Draining Regulator. Before a regulator is removed from a cylinder, the cylinder valve shall be closed and the gas released from the regulator.

10.8.4.12 Secure Cylinders During Use. A suitable cylinder truck, chain, or steadying device shall be used to keep cylinders from being knocked over while in use.

10.8.4.13 Fire Protection. Cylinders shall be kept far enough away from actual welding or cutting operations so that sparks, hot slag, or flame will not reach them, otherwise fire resistant shields shall be provided.

10.8.4.14 Electric Circuits. Cylinders shall not be placed where they might become part of an electrical circuit. Contacts with third rails, trolley wires, etc. shall be avoided. Cylinders shall be kept away from radiators, piping systems, layout tables, etc. that may be used for grounding electric circuits such as for arc welding machines. The tapping of electrodes against a cylinder shall be prohibited. Do not strike an arc on cylinders.

E10.8.4.14 Cylinders should not be so grounded, or located, where they can become part of an electric circuit. Arc damaged cylinders may leak or explode.

10.8.4.15 Fuel Gas Cylinder Withdrawal Rates. Withdrawal rates from gas cylinders shall not exceed manufacturers' recommendations.

E10.8.4.15 In the case of acetylene, excessive withdrawal rates can lead to acetone depletion from the cylinder. Some materials may be damaged by acetone and create leaks. The stability of acetylene may be reduced. In the case of liquefied fuel gases, excessive withdrawal rates will cause refrigeration.

10.8.5 Cylinder Emergencies

10.8.5.1 Fuel Valve Packing Leak. If a leak is found around the valve stem of a fuel gas cylinder, the packing nuts shall be tightened, or the cylinder valve closed.

E10.8.5.1 Leaks can lead to oxygen deficient or explosive atmospheres.

10.8.5.2 Fuel Gas Leaks Which Cannot be Stopped. If tightening the packing nut does not stop a valve stem leak, or if a fuel gas valve is leaking at the seal and cannot be stopped by closing the valve firmly, or if a leak should develop at a cylinder fuse plug or other safety device, then the fuel gas cylinders shall be moved to a safe location outdoors, away from any source of ignition, marked properly, and the supplier advised.

When a leaking cylinder cannot be moved safely to a location outdoors, the area or building shall be immediately evacuated and the fire department notified of the emergency.

E10.8.5.2 Outdoors, the cylinder valve may be opened slightly to gradually discharge the contents.

A precautionary sign shall be posted not to approach the leaking cylinder with a lighted cigarette or source of ignition.

10.8.5.3 Fuel Cylinder Fires. Small fires at fuel gas cylinders, usually resulting from ignition of leaks described in 10.8.5.1 and 10.8.5.2, shall be extinguished, if possible, by closing the cylinder valve or by the use of water, wet cloths, or fire extinguisher. The leaks shall then be treated as described in those sections.

In the case of a large fire at a fuel gas cylinder, such as from the functioning of a fuse plug or safety device, personnel shall be evacuated from the area, and the cylinder kept wet with a heavy water stream to keep it cool.

E10.8.5.3 It is usually better to allow the fire to continue to burn and consume the escaping gas, otherwise it may reignite with explosive violence. If circumstances permit, it is often better to allow the cylinder fire to burn out in place rather than attempt to move the cylinder.

If the cylinder is located where the fire should not be allowed to burn out in place, attempts may be made to move it to a safer location, preferably outdoors. Personnel should remain as distant as possible, and the cylinder should be kept cool with a water stream.

10.9 Cylinder Manifolding

10.9.1 Approval. Fuel gas manifolds and high-pressure oxygen manifolds for use with oxygen cylinders having a DOT service pressure above 250 psig (1724 kPa) shall be approved either separately for each component part or as an assembled unit.

10.9.2 Gas Service. All manifolds and parts shall be used only for the gases for which they are approved.

10.9.3 Fuel Gas Manifold Capacity Limits and Locations. Fuel gas manifold capacity limits and locations shall be in accordance with NFPA 51.

E10.9.3 NFPA 51 has established a 3000 cubic foot (84 cubic meters) total nonliquefied gas capacity as an indoor limit for fuel gas cylinders connected to one manifold. The rationale for this limit is that a typical building of 100 feet by 100 feet with a 15 feet ceiling (150 000 cubic feet, 4200 cubic meters) could contain a leak of 3000 cubic feet of acetylene and not exceed the lower explosive limit if uniformly distributed. Acetylene has the lowest explosive limit of the commonly used fuel gases. See NFPA 51 for additional details.

10.9.4 Oxygen Manifold Capacity Limits and Locations. Oxygen manifold capacity limits and locations shall be in accordance with NFPA 51.

10.9.5 Manifold Requirements. Fuel gas and oxygen manifolds requirements shall be in accordance with NFPA 51.

10.9.6 Manifold Installation and Operation. Manifold installation and operation shall be in accordance with NFPA 51.

11. Arc Welding and Cutting Equipment Safety

11.1 General

11.1.1 Scope. This section contains safety precautions specific to the installation and operation of arc welding and cutting equipment.

11.1.2 Equipment. Arc welding and cutting equipment shall be chosen as specified in 11.2 and shall be installed as specified in 11.3.

E11.1.2 Gas equipment used in arc welding should be handled as described in Clause 10, Oxyfuel Gas Welding and Cutting Safety. See 11.5.5.

11.1.3 Personnel. Persons in charge of the equipment or designated to operate the arc welding and cutting

equipment shall have been properly instructed and qualified to maintain or operate such equipment and approved as competent for their work responsibilities. Rules and instructions covering the operation and maintenance of the arc welding and cutting equipment shall be readily available.

11.2 Safety Aspects in Selection of Arc Welding Equipment

11.2.1 Safety Standards. Safety in design of arc welding equipment shall be in compliance with applicable NEMA and ANSI standards. Special purpose machines not covered by the above listed standards shall conform in all aspects to the standards set forth in this publication.

11.2.2 Environmental Conditions. When using alternating current (ac) or direct current (dc) arc welding machines, the welding operator shall take special care to prevent electrical shock, when working under environments with increased risk of electric shock.

E11.2.2 Water or perspiration can create environments with increased risk of electric shock. Electrical shock can be prevented by the use of nonconductive gloves, clothing, and shoes and avoiding contact with live electrical parts.

Other examples of environments with increased risk of electric shock are locations in which the freedom of movement is restricted so that the operator is forced to perform the work in a cramped (kneeling, sitting, lying) position with physical contact with conductive parts, and locations that are fully or partially limited by conductive elements and in which there is a high risk of unavoidable or accidental contact by the operator. These hazards can be minimized by insulating conductive parts near the vicinity of the operator.

If a significant amount of work time is spent in environments with increased risk of electric shock, the use of automatic controls is recommended to reduce the no-load voltage to a value not to exceed 38 volts rms ac or 50 volts direct current (dc) at rated input voltage.

This recommendation also applies to 11.2.3.1. Environments with increased risk of electric shock are defined in ANSI/ IEC 60974-1, *Arc Welding Equipment – Part 1: Welding Power Sources*.

11.2.3 Other Conditions

11.2.3.1 Open-Circuit Voltage (Special Processes). When special welding and cutting processes require open-circuit voltages higher than those specified in ANSI/ IEC 60974-1, *Arc Welding Equipment – Part 1: Welding Power Sources*, adequate insulation or other means shall be provided to protect the operator from making contact with hazardous voltage.

E11.2.3.1 Some processes such as plasma arc cutting may utilize open-circuit voltages as high as 400 volts dc. Precautionary labeling, workplace placards, or special employee training should be considered when high open-circuit voltage is present. See 11.2.2.

11.2.3.2 Work Terminal to Grounded Enclosure. The work shall be grounded in accordance with 11.3.2. In the case of installations that have followed the practice of grounding the work lead at a power source

E11.2.3.2 The practice of connecting the work terminal to the power source enclosure is not recommended and should be avoided. It is likely for a welding operator to inadvertently remove the connection

terminal, that itself is grounded by a connection to the grounded power source enclosure, the power source terminal shall be connected to the grounded power source enclosure by a conductor smaller in diameter (at least two wire gages higher) than the power source enclosure grounding conductor, and the terminal shall be marked to indicate that it is grounded. In no case shall a connection between the work lead terminal and the grounded power source enclosure be intentionally used instead of the work lead to carry welding current.

between the work clamp and the work piece and thereby cause welding current to flow through the grounding conductors of the electrical system. Measures must be taken to prevent the flow of welding current through grounding conductors. Grounding conductors are sized for other purposes. Welding currents may be too high for some grounding conductors in the welding area or the power network.

11.2.3.3 Welding Terminals. Terminals for welding leads shall be protected from accidental electrical contact by personnel or by metal objects, for example, vehicles, crane hooks.

E11.2.3.3 Protection may be obtained by the use of dead front construction utilizing receptacles for plug connections, by locating terminals in a recessed opening or under a nonremovable hinged cover, by heavy insulating sleeves or by other equivalent mechanical means to satisfy the requirements.

11.2.3.4 Portable Control Devices. No connections for portable control devices, such as push buttons, to be carried by the operator shall be connected to an ac circuit of higher than 120 volts. Exposed metal parts of portable control devices operating on circuits above 50 volts shall be grounded by a grounding conductor in the control cable.

E.11.2.3.4 See NFPA 79.

11.2.3.5 Autotransformers. Autotransformers or ac reactors shall not be used to draw welding current directly from any primary ac power source having a voltage exceeding 80 volts.

11.2.3.6 Equipment Loading. Care shall be taken in applying arc welding equipment to ensure that the ampere rating chosen is adequate to handle the job. Welding machines shall not be operated above the ampere ratings and corresponding rated duty cycles as specified by the manufacturer and shall not be used for applications other than those specified by the manufacturer.

E11.2.3.6 Using welding machines beyond ampere or duty cycle ratings causes overheating which results in premature deterioration of insulation and increases the electrical shock hazard. Consideration should be given to the fact that actual welding currents may be higher than shown by indicators on the machines if welding is done with short leads or low arc voltages. Particularly high over-currents are likely on general purpose welding machines when used with low arc voltage processes such as gas tungsten arc welding.

11.2.3.7 Welding Cables. Welding cables shall be of the flexible type designed especially for the rigors of welding service and of a size adequate for reasonably expected current and duty cycles. Special attention shall be paid to the insulation of cables used with equipment which includes high-voltage, high-frequency oscillators.

E11.2.3.7 See also 11.2.3.6. Refer to 11.5.4 for additional information. See AWS F4.2, *Safety Guidelines for Proper Selection of Welding Cables.*

11.3 Installation of Arc Welding Equipment

11.3.1 Code Requirements. Installation including grounding, necessary disconnects, fuses, and type of incoming power lines shall be in accordance with the requirements of the current NFPA 70, *National Electrical Code*®, and all local codes.

11.3.2 The Work. The workpiece or metal upon which the welder welds shall be grounded independent of the welding leads to a good electrical ground unless a qualified person assures it is safe to work on an ungrounded workpiece.

E11.3.2 When the work terminal is grounded, care should be taken to see that the workpiece is not separately grounded. Refer to 11.3.2.1. Before welding is attempted the operator should check to be sure that the worklead is properly connected. This will eliminate the chance of welding current being misdirected into the grounding conductor system of other equipment. Misdirected welding current can damage conductors which do not have adequate ampacity. See Article 630.15 of NFPA 70, *National Electrical Code*®.

11.3.2.1 Grounding. Grounding shall be done by locating the work on a grounded metal floor or platen, or by connection to a grounded building frame or other satisfactory ground. Care shall be taken to avoid the flow of welding current through a connection intended only for safety grounding since the welding current may be of a higher magnitude than the grounding conductor can safely carry.

E11.3.2.1 The work lead and work lead clamp are sometimes incorrectly referred to as “ground lead” and “ground clamp.” The work lead and the ground lead are not the same. The work lead should not be referred to as the grounding lead. It is preferable to connect the work lead directly to the work. Hence, it is inappropriate to refer to the lead as “ground lead” or the connection as “ground clamp.” The work clamp should never be stored by clamping it to any part of the grounded power source frame. Grounding of electrical systems and circuit conductors is done to limit voltages due to lightning, line voltage surges, or unintentional contact with higher voltage lines, and to stabilize voltage to ground during normal operations.

It also facilitates over-current device operation in case of ground faults. (See Article 250.4 of NFPA 70, *National Electrical Code*®.) Grounding of workpieces, equipment housings, metal cabinets and frames, or other conductive material that form part of the equipment is done to limit the voltage to ground on these items. Limiting the voltage by grounding helps to prevent accidental shocks when equipment is misconnected or insulation fails. (See Article 250.4 of NFPA 70, *National Electrical Code*®.)

Equipment used with ungrounded supply systems, such as is used in naval shipboard systems, should be connected in accordance with the requirements of the authority having jurisdiction.

Special radio frequency grounding may be advisable for equipment using high-frequency arc stabilizers. (See *Recommended Installation and Test Procedures for High Frequency Stabilized Arc Welders*, 1970, Arc Welding Section of NEMA.)

11.3.2.2 Work Lead. Welding current shall be returned to the welding machine by cable with sufficient current capacity. However, connection of a cable from the welding machine to a common conductor or properly bonded structure on which the work rests, or to which the work is connected, shall be a permissible alternate procedure. Single-phase alternating current machines in groups of three with their inputs connected in delta to a three-phase supply circuit connected in wye on the secondary circuits shall be permitted to use a single work

E11.3.2.2 Refer to 11.3.6 for voltage and shock consideration. With the permissible alternate procedure, care should be taken that no other electrical connection or path exists.

lead from the neutral of the three units to the structure being welded.

The work lead shall use a single cable of a size suitable for the current rating of at least one machine.

11.3.3 Conduit and Pipe Ground Limitations. Conduits containing electrical conductors shall not be used for completing a work lead circuit. Pipelines shall not be used as a permanent part of a welding circuit, but may be used during construction, extension, or repair providing the current is not carried through threaded joints, flanged bolted joints, or caulked joints. In addition, special precautions shall be used to avoid sparking at the connection of the work lead cable.

E11.3.3 Current which passes through joints which are not intended for such use can cause hot spots to develop. These hot spots can lead to the development of hidden fires or explosions. For other precautions, see 11.4.

11.3.4 Prohibited Work Lead Connection. Chains, wire ropes, cranes, hoists, and elevators shall not be used to carry welding current.

E11.3.4 See 11.4.9.2.

11.3.5 Electrical Continuity in Structures. When during construction or modification, a building or any other fabricated metal structure is used for a welding current return circuit, it shall be checked to ascertain whether proper electrical contact exists at all joints. Sparking or heating at any point shall be cause for rejection of the structure as a return circuit.

E11.3.5 Approval should be obtained from the owner or responsible person before proceeding.

11.3.6 Connections to Minimize Shock Hazard. Where welders are working on one structure, sufficiently close to each other, and someone is likely to touch the exposed parts of more than one electrode holder simultaneously, machines shall be connected to minimize shock hazard as follows:

11.3.6.1 DC Machines. Unless required by special cases, all dc machines shall be connected with the same polarity.

E11.3.6.1 A test lamp or voltmeter may be used to determine whether the connections are correct. See 11.3.6.3.

11.3.6.2 AC Machines. Unless required by special cases, all single-phase ac machines shall be connected to the same phase of the supply circuit and with the same instantaneous polarity.

E11.3.6.2 A voltmeter can be used to determine whether the connections are correct. See 11.3.6.3.

11.3.6.3 Special Cases. The operator and other area personnel shall be instructed on the importance of avoiding simultaneous contact of the exposed parts of more than one electrode holder.

E11.3.6.3 When operations on one structure involve several welding machines, the dc welding process requirements may require the use of both polarities, or supply circuit limitations for ac welding may require distribution of machines among the phases of the supply circuit. No-load voltages between electrode holders will be two times normal in dc or 1, 1.41, 1.73, or two times normal on ac machines. Similar voltage differences will exist if both ac and dc welding are done on the same structure.

11.4 Operation

E11.4 This section applies to all arc welding and cutting processes.

11.4.1 Worker Instruction. Workers assigned to operate or maintain arc welding equipment shall be acquainted

E11.4.1 Those sections of particular interest are Clause 4, Protection of Personnel and the General Area;

with those parts of this standard applicable to their work assignments.

11.4.2 Checking Connections. After assembling any connection to the machine, each assembled connection shall be checked before starting operations to ascertain that it is properly made. In addition, the work lead shall be firmly attached to the work; magnetic work clamps shall be freed from adherent metal particles and spatter on contact surfaces.

11.4.3 Machine Frame Grounding. Grounding of the welding machine frame shall be checked. Special attention shall be given to safety grounding connections of portable machines. See NFPA 70, *National Electrical Code*®, Article 250, *Grounding*.

11.4.4 Leaks. There shall be no leaks of cooling water, shielding gas, or engine fuel that can adversely affect the welder's safety.

11.4.5 Safe Operating Instructions. Written rules and instructions covering the safe operation of equipment shall be made available to the welder and shall be strictly followed.

11.4.6 Work Interruptions. When the welder leaves the work or stops for an appreciable time, the equipment or machine output shall be turned off or de-energized.

11.4.7 Moving the Machine. When the machine is to be moved, the input power supply to the equipment shall be electrically disconnected.

11.4.8 Equipment Not in Use. When not in use, metal and carbon electrodes shall be removed from holders to eliminate danger of electrical contact with persons or conducting objects. When not in use, electrode holders shall be so placed that they cannot make electrical contact with persons, conducting objects, such as metal or wet earth, flammable liquids, or compressed gas cylinders. When not in use, guns of semiautomatic welding machines shall be placed so that the gun switch cannot be operated accidentally.

11.4.9 Electric Shock. The welder shall be trained to avoid shock. Unexplained shocks shall be reported to the supervisor for investigation and correction prior to continuing. Safe procedures shall be observed at all times when working with equipment having voltages necessary for arc welding.

11.4.9.1 Live Metal Parts. The welder shall never permit the live metal parts of an electrode, holder, or other equipment, to touch bare skin or any wet covering of the body.

Clause 5, Ventilation; and Clause 6, Fire Prevention and Protection.

E11.4.2 Clean and tight connections are necessary to prevent local heating. Properly insulated and dry connections are necessary to prevent stray electrical currents and possible shock or short circuits.

Coiled welding cable should be kept to a minimum and any excess is to be spread out before use to avoid overheating and damage to insulation. Jobs alternately requiring long and short cables should be equipped with insulated connectors so that idle lengths can be disconnected when not needed.

E11.4.4 Moisture can carry electric current and increase the chance of electric shock, shielding gases can cause asphyxiation, and fuels can cause explosions or fires.

E11.4.9 Conductive articles of jewelry and clothing (such as watch bands, bracelets, rings, key chains, necklaces, metalized aprons, cloth with conductive thread, or metal headgear) should not be worn if they might contact exposed energized parts. However, such articles may be worn if they are rendered nonconductive by covering, wrapping, or other insulating means.

11.4.9.2 Insulation. Welders shall protect themselves from electrical contact with the work or ground by dry insulating material; particularly, they shall be protected against large area contacts by insulation when working in a sitting or prone position.

E11.4.9.2 When the worker is required to be on a ladder while welding or cutting, the ladder should be nonconductive or otherwise insulated from work and ground. Dry shoes in good condition should be worn. Rubber soled shoes or boots should be worn in damp areas. Workers should wear protective boots when working in standing water or other wet areas.

To reduce the possibility of welding current arcing through the suspension wire rope when performing welding from suspended scaffolds, use an insulated thimble to attach each suspension wire rope to its hanging support (such as cornice hook or outrigger). Insulate excess suspension wire rope and insulate any additional independent lines from grounding. Cover the suspension wire rope with insulating material extending at least 4 feet above the hoist. Insulate the tail line below the hoist to prevent contact with the platform. Guide or retain the portion of the tail line that hangs free below the scaffold so that it does not become grounded (see 29 CFR 1926.451(f)(17)).

11.4.9.3 Gloves. Dry gloves in good condition shall be used.

E11.4.9.3 Use of damp or wet gloves may lead to electric shock. Where moisture or perspiration is a problem, rubberized gloves or other insulating means should be used. See also 4.3.2 and E11.2.2.

11.4.9.4 Holders and Guns. Electrode holders and guns shall be well insulated and kept in good repair.

11.4.9.5 Water Immersion. Electrode holders and guns shall not be cooled by immersion in water.

11.4.9.6 Water-Cooled Holders. Water-cooled holders and guns shall not be used if any water leak or condensation exists which would adversely affect the welder's safety.

11.4.9.7 Changing Electrodes. Except for shielded metal arc welding, the output of the welding machine shall be electrically de-energized when electrodes or contact tips are changed.

11.4.9.8 Other Practices to Avoid. The welder shall not coil or loop welding electrode cable around parts of the body. Precautions shall be taken to prevent shock induced falls when the welder is working above ground level.

11.4.9.9 Wearers of Pacemakers. Wearers of pacemakers or other electronic equipment vital to life shall check with the life support manufacturers and their clinician to determine whether a hazard exists.

E11.4.9.9 Welders and other persons who must work in a welding environment should inform their doctors prior to undergoing device installation procedures.

11.5 Maintenance

11.5.1 General. All arc welding equipment shall be maintained in safe working order at all times. The welder or maintenance personnel shall report any equipment

E11.5.1 Periodic inspections are strongly recommended.

defect or safety hazard to the supervisor, and the use of such equipment shall be discontinued until its safety has been assured. Repairs shall be made by qualified personnel only.

11.5.2 Welding Equipment. Welding equipment shall be maintained in good mechanical and electrical condition to avoid unnecessary hazards. On rotating electrical equipment, commutators shall be kept clean to prevent excessive flashing.

11.5.2.1 Inspection. Welding equipment shall be inspected frequently to detect accumulations of foreign matter that would interfere with ventilation or insulation. Electrical coil ventilation ducts shall be similarly inspected and cleaned. Fuel systems on engine-driven machines shall be inspected and checked for possible leaks and accumulations of water that might cause rusting. Rotating and moving components shall be kept properly shielded and lubricated.

E11.5.2.1 Dirt on electrical equipment can increase temperature, decrease service life, and possibly lead to short circuiting.

It is good practice to blow out the entire welding machine with clean dry compressed air using adequate safety precautions.

11.5.2.2 Welding in the Open. Welding equipment used in the open shall be protected from inclement weather conditions. Protective covers shall not obstruct the ventilation necessary to prevent overheating of the machine.

E11.5.2.2 Air filters in the ventilating system of the electrical components should not be used unless provided by, or approved by, the manufacturer of the welding machine. The reduction of air flow resulting from the use of an air filter on equipment not so designated can subject internal components to an overheating condition and subsequent failure.

11.5.2.3 Modifications. When it is necessary to modify equipment, such as in order to meet noise level requirements, it shall be determined that the modifications or additions to the equipment do not cause the electrical or mechanical ratings to the equipment to be exceeded or overloaded.

E11.5.2.3 Modifications should only be performed by the equipment manufacturer or a qualified service technician.

11.5.3 Wet Machines. Machines which have become wet shall be thoroughly dried and properly tested before being used. When not in use, the equipment shall be adequately protected or stored in a clean, dry place.

11.5.4 Welding Cable. Welding cable shall be inspected for wear or damage. Cables with damaged insulation or connectors shall be replaced or repaired to achieve the mechanical strength, insulating quality, electrical conductivity, and water tightness of the original cable. Joining lengths of cables shall be done by methods specifically intended for the purpose. The connection methods shall have insulation adequate for service.

E11.5.4 Disconnected welding cable leads should be properly stored to prevent inadvertent completion of electrical circuits.

11.5.5 Compressed Gases. Use of compressed gases for shielding in arc welding operations shall follow the applicable provisions of Clause 10, Oxyfuel Gas Welding and Cutting Safety.

12. Resistance Welding Safety

12.1 General

12.1.1 Scope. The scope of this section is limited to welding equipment using resistance welding principles as defined in the AWS publication entitled AWS A3.0M/A3.0, *Standard Welding Terms and Definitions*. Users are further referred to Part I herein which is applicable to general safety in welding and cutting.

12.1.2 Selection. All resistance welding equipment shall be selected for safe application to the work intended. The personnel safety aspects of resistance welding shall be given consideration when choosing equipment for the work to be performed.

12.1.3 Operator Training. Workers designated to operate resistance welding equipment shall have been properly instructed and judged competent to operate such equipment.

E12.1.3 Refer to OSHA 29 CFR 1910.225.

12.2 Installation. All equipment shall be installed in conformance with NFPA 79, *Electrical Standard for Industrial Machinery*, NFPA 70E, *Standard for Electrical Safety in the Workplace®*, and NFPA 70, *National Electrical Code®* or their equivalent in protection based on advances in technology. The equipment shall be installed by qualified personnel under the direction of a technical supervisor.

E12.2 Refer to OSHA 29 CFR 1910 Subpart S, Electrical.

12.3 Guarding

12.3.1 Control Initiating Devices. Control initiating devices such as push buttons, foot switches, retraction systems, and dual schedule switches on all welding equipment including manual guns shall be arranged or guarded to prevent the operator from inadvertently activating them.

12.3.2 Stationary Equipment

12.3.2.1 General. All chains, gears, operating linkages, and belts associated with welding equipment shall be protected in accordance with ANSI B15.1, *Safety Standard for Mechanical Power Transmission Apparatus.*

12.3.2.2 Single-Ram and Single-Point Equipment. On stationary single-ram welding machines, unless the workpiece size, configuration, or tooling (e.g., jig or fixture) occupies both of the operator's hands remotely from the point of operation during the machine cycle, operations shall be in a manner preventing injury to the operator by one or a combination of the following:

(1) Machine guards or fixtures preventing the operator's hands from passing under the point of operation,

(2) Two-handed controls,

(3) Latches,

(4) Presence sensing devices, or

(5) Any similar device or mechanism preventing operation of the ram while the operator's hands are under the point of operation.

12.3.2.3 Multi-Gun Equipment. All multi-gun welding machine operations, when the operator's fingers can be expected to pass under the point of operation, shall be effectively guarded by the use of a device, such as but not limited to, presence sensing devices, latches, block, barriers, or two-handed controls.

12.3.3 Portable Equipment

12.3.3.1 Support System Safety. All suspended manual gun equipment, with the exception of the manual gun assembly, shall be equipped with a support system capable of supporting the total impact load in the event of failure of any component of the supporting system. The system shall be designed to be fail safe. The use of devices such as cables, chains, clamps, etc. shall be permitted.

12.3.3.2 Moving Holder. Where it enters the gun frame, the moving holder mechanism shall be designed so as to present no shear points to the fingers placed on the operating movable holder, otherwise guarding shall be provided. If suitable guarding cannot be achieved, the use of two handles, one for each hand with one or two operating switches located at appropriate holding points shall be permitted to be used. These handles and operating switches shall be sufficiently remote from the shear or pinch point, or both, to eliminate the possibility of any finger entering the shear or pinch point when the hands are on the controls.

12.4 Electrical

12.4.1 Voltage. All external weld-initiating control circuits shall operate not over 120 volts ac rms for stationary equipment, and not over 36 volts ac rms for portable equipment.

12.4.2 Stored Energy Resistance Welders

12.4.2.1 Maintenance and Service. When servicing stored energy welding machines, maintenance personnel shall not rely on the existence of energy dissipation means or energy indicators and shall always use a safe method to verify the stored energy has been dissipated before servicing the equipment.

12.4.2.2 Stored Energy Resistance Welders, Equipment and Controls. Resistance welding equipment and control panels containing devices such as capacitors, inductors, and batteries for stored energy resistance welding shall have suitable insulation and protection by complete enclosures, all doors of which

shall be provided with suitable interlocks and contacts wired into the control circuit (similar to elevator interlocks). Such interlocks or contacts shall be so designed as to effectively interrupt power and ensure the stored energy is dissipated (for inductors and capacitors) or isolated (for batteries) as appropriate when the enclosure door is open.

A manually operated switch or suitable positive device shall be installed in addition to the mechanical interlocks or contacts, as an added safety measure assuring absolute discharge of all capacitors.

The stored energy welder shall contain a means to determine the condition of stored energy such as insulated test points. Appropriate precautionary labeling regarding this stored energy shall be used.

The control panel itself is considered an enclosure and capacitors located inside such a panel box shall not need further enclosure when the other requirements of the paragraph are met.

12.4.3 Inverter-Based Welding Machines

12.4.3.1 Maintenance and Service. When servicing medium frequency direct current (MFDC) resistance welding controls and high frequency direct current welding (HFDC) resistance welding controls, maintenance personnel shall not rely on the existence of filter capacitor dissipation means and shall always use a safe method to verify that the capacitors have been dissipated before servicing the equipment.

12.4.3.2 Inverter-based Controls. Machines incorporating MFDC resistance welding controls and HFDC resistance welding controls may incorporate large filter capacitors, which store hazardous amounts of energy. These controls must comply with the requirements of NFPA 79, *Electrical Standard for Industrial Machinery.* The MFDC and HFDC controls shall contain a means to determine the condition of the filter capacitors such as insulated test points. Appropriate precautionary labeling shall also be used to advise of this voltage hazard.

12.4.4 Locks and Interlocks

12.4.4.1 Doors. The doors and access panels of all resistance welding machines and the control panels, accessible at production floor level, shall be kept locked or interlocked to prevent access by unauthorized persons to live portions of the equipment. A door or access panel shall be considered locked if a key, wrench, or other instrument is required to open it.

12.4.4.2 Remotely Located Control Panels. Control panels located on overhead platforms or in separate rooms shall be either locked, interlocked, or

guarded by a physical barrier and signs, and the panels closed when the equipment is not being serviced. Signs shall be in accordance with ANSI Z535 Standards.

For flash welding equipment, flash guards of suitable fire resistant material shall be provided to control flying sparks and molten metal.

12.4.5 Spark Shields. Protection shall be provided from the hazard resulting from flying sparks by methods such as the installation of a guard of suitable fire resistant material or the use of approved personal protective eye wear. The variations in resistance welding operations are such that each installation shall be evaluated individually.

E12.4.5 The primary intent is the protection of personnel other than the operator whose protection is discussed in Clause 4, Protection of Personnel and the General Area. Suitable precautions shall be taken to avoid fires as set forth in Clause 6, Fire Prevention and Protection.

12.4.6 Stop Buttons. One or more safety emergency stop buttons shall be provided on all welding machines that have the following characteristics:

(1) require three or more seconds to complete a sequence,

(2) have mechanical movements that can be hazardous to persons if guards were removed, and

(3) installation and use of these emergency stop buttons will not in themselves create additional hazards to persons.

E12.4.6 The term *sequence* as used here means the action and time required by the machine from the time the run buttons are locked in (interlocked) and can be released, until the machine stops of its own accord.

12.4.7 Grounding

E12.4.7 Undesirable circulating currents can flow through the fixture or workpiece when permanent grounding is employed within systems incorporating multiphase primary supplies, different secondary voltages, or both. Such situations will require use of a grounding reactor (for ac machines), a grounding resistor (for dc machines) or isolation contactor (when there is no human interaction with the secondary circuit or its associated tooling).

12.4.7.1 General Grounding of Resistance Welders. The welding transformer secondary shall be bonded to a protective ground by one of the methods in (1), (2), (3) below, or an alternative means of protection shall be provided as in (4) below:

(1) Permanent grounding of the welder secondary circuit using an appropriately sized conductor.

(2) Bonding of the dc welder secondary circuit through a properly sized resistor.

(3) Connecting a grounding reactor across the secondary winding with reactor tap(s) to ground.

(4) As an alternative, on machines where, under normal operation, there is no human interaction with the secondary circuit or its associated tooling, provide for an isolation contactor to open both sides of the line to the primary of the welding transformer. When this method is employed, appropriate care shall be taken during maintenance procedures, such as the welding of test coupons, to ensure that personnel are protected from fault currents.

12.4.7.2 Grounding of Portable Transguns. In addition to the requirements of 12.4.7.1, manual guns incorporating an integral resistance welding transformer with primary voltage in excess of 120 volts require supplemental means to ensure operator protection. Such supplemental means shall include as a minimum:

(1) Ground fault detection which will disconnect the supply in the event of a fault.

(2) Ground connection verification.

(3) A grounded shield primary cable to provide supplemental mechanical and electrical protection.

(4) A means to verify the operation of the safety systems.

E12.4.7.2 Operators and maintenance personnel will require additional training on the operation and maintenance of this equipment and there should be a regular schedule of inspection to ensure the safety equipment is operating as intended.

12.5 Static Safety Devices. On large welding machines incorporating a platen, electrically interlocked safety devices such as pins, blocks, or latches, shall be provided where the platen or the head can move. The device, when used, shall cause the energizing circuit to be broken, and the device itself will prevent movement of the platen or head under static load. More than one device may be required, varying with machine size or accessibility, but each device alone shall be capable of sustaining the full static load involved.

E12.5 The intent is to require these devices when the machine area is so large that the maintenance or setup would require the insertion of more than hands into the closure area.

12.6 Ventilation. Ventilation shall be provided in accordance with Clause 5.

12.7 Maintenance. Periodic inspections and necessary repairs shall be made by authorized personnel. The operators or maintenance personnel shall report any equipment defects to supervisory personnel.

13. Electron Beam Welding and Cutting Processes (EBW and EBC)

13.1 General. These safe practice recommendations are abstracted from the AWS C7.1, *Recommended Practices for Electron Beam Welding*.

E13.1 AWS C7.1 should be consulted for a complete treatise of the subject. Also, refer to Part I of this standard for general safety considerations associated with welding and cutting processes and equipment.

13.2 Potential Hazards. The following potential hazards associated with electron beam welding shall be guarded against:

(1) Electric Shock (13.2.1)

(2) Gases and Fumes (13.2.2)

(3) X-Radiation (13.2.3)

(4) Visible Radiation (13.2.4)

(5) Vacuum (13.2.5)

13.2.1 Electric Shock. Appropriate precautionary signs shall be affixed to the equipment. All doors and

E13.2.1 The typical primary voltage to an electron beam welding machine is 440 volts. Voltages used in the

access panels on electron beam welding equipment shall be properly secured and interlocked to prevent accidental or unauthorized access. All high-voltage conductors shall be fully enclosed by grounded, conductive barriers that are also interlocked. A grounding probe shall be used before servicing the electron beam gun and high-voltage power supplies.

electron beam welding processes are much higher than those in most welding processes.

Whenever servicing (especially on energized systems) is done on this equipment, a second person should be in the area in case of accidental shock. The primary input voltage is stepped up to several thousand volts for the electron beam gun and also for the vacuum (ionization) gauge(s). These voltages, and their associated currents, are lethal.

13.2.2 Gases and Fumes. Positive exhaust ventilation and filtering from the medium and nonvacuum EB processes shall be provided. In high-vacuum EB welding, extra care shall be taken while cleaning the interior of the vacuum chamber to ensure that vapors from the solvents and cleaning solutions do not reach hazardous levels.

E13.2.2 Ozone, nitrogen oxides, and metal fumes are generated by electron beam welding. See 3.2.1.2 for more information on handling of hazardous substances, Clause 5, Ventilation, for a detailed description of adequate ventilation systems, and Clause 7, Confined Spaces, for information on working in confined spaces.

Before welding any unfamiliar materials or using any unfamiliar cleaning materials, the Safety Data Sheet (SDS) shall be read to determine whether any hazards exist.

13.2.3 X-Radiation. Proper shielding of EBW equipment is required to eliminate, or reduce to acceptable levels, x-radiation in the workplace. Any modifications to radiation shielding shall be performed only by the equipment manufacturer or a qualified service technician. A radiation survey shall be done after modifications are completed by the equipment manufacturer or qualified technicians.

E13.2.3 X-radiation is produced when electrons collide with a substance (such as a gas or metal). The intensity of the x-rays produced increases with increasing beam voltage, beam current, and the atomic number of the material being struck by the beam. The electron beam equipment should be inspected and a radiation survey made periodically with the results documented and posted. Publications such as ANSI N43.3, *General Safety Standards for Installations Using Non-Medical X-Ray and Sealed Gamma Ray Sources, Energies Up to 10 MeV*, and AWS C7.1M/C7.1, *Recommended Practices for Electron Beam Welding*, should be consulted for typical precautions and survey procedures that should be followed in order to provide adequate protection.

13.2.4 Nonionizing Radiation. The leaded glass used in the viewing ports shall provide sufficient optical viewing protection from the UV and IR radiation, and appropriate filters shall be selected and used to reduce the visible light to a comfortable viewing level.

E13.2.4 Direct viewing of the weld zone during electron beam welding can be harmful to the eyesight since visible, infrared (IR), and ultraviolet (UV) radiation are produced. See also 4.2.2. ANSI/ISEA Z87.1, *Occupational and Educational Personal Eye and Face Protection Devices*, should be consulted for guidance in the selection of optical filters.

13.2.5 Vacuum. Users of the electron beam welding process shall be aware of the precautions required for working with vacuum systems.

E13.2.5 All electron beam welding machines require a high vacuum for beam generation. In addition, most machines require some level of vacuum environment for the workpiece. User should be aware that high levels of noise can be generated by EBW vacuum systems. A detailed description of these precautions is provided by the American Vacuum Society publication *Vacuum Hazards Manual*.

14. Laser Beam Cutting and Welding

14.1 General. Cutting and welding operations using laser beam technology shall follow the applicable sections of this standard and ANSI Z136.1, *Safe Use of Lasers*.

15. Brazing and Soldering Safety

15.1 General. This section addresses safe practices for brazing and soldering.

E15.1 The hazards encountered with brazing and soldering are similar to those associated with the welding and cutting processes. The safe practices implemented for welding and cutting are equally applicable to brazing and soldering regarding the Protection of Personnel and the General Area, Ventilation, Fire Prevention and Protection, and Confined Spaces (see Clauses 4, 5, 6, and 7).

15.2 Potential Hazards. When conducting brazing and soldering operations, the following potential hazards shall be guarded against:

(1) flammable and corrosive substances (see 15.2.1),

(2) burns (see 15.2.2),

(3) fluxes and filler metals (see 15.2.3),

(4) gases and fumes (see 15.2.4), and

(5) equipment maintenance (see 15.2.5).

15.2.1 Flammable and Corrosive Substances. Operators shall isolate containers of alcohol-based or alcohol-containing flux solutions from open flames and heat sources during assembly as well as when in storage. As fluxes are corrosive substances, they shall be stored, transported, and disposed of in accordance with regulatory practices for acidic materials. Operators shall wear proper eye protection, face guard, and protective clothing during the transport, handling, and use of fluxes. The safety data sheets for flammable and corrosive substances shall be consulted before these substances are used.

E15.2.1 Numerous fluxes for structural and electronic applications contain alcohol as the vehicle or as a diluting agent, causing the fluxes to be highly flammable. Moreover, fluxes are corrosive materials. The level of corrosivity ranges from very mild (e.g., pure rosin) to highly active (e.g., solutions of hydrochloric acid, nitric acid, and so forth); however, even the mild acids can cause burn injuries to the operator. Some stop-off materials, cements, and binders contain solvents and are flammable.

Brazing furnace atmospheres shall be purged using safe procedures before the introduction of flammable gases (these include fuel gases, hydrogen, and dissociated ammonia) often used as atmospheres (see 5.5.6).

15.2.2.1 Marking Hot Materials. Operators shall label all assemblies, tools, and surfaces that are at high temperatures with the appropriate sign (see 3.2.3.4).

E15.2.2.1 High temperatures are those temperatures at which the particular item cannot be carried by the bare hand.

15.2.2.2 Dip Brazing. When dip brazing, assemblies and fixtures to be immersed in the molten salt bath shall be completely dry.

E15.2.2.2 Any presence of moisture on the assemblies or fixtures will cause an instantaneous generation of steam that may expel the contents of the dip pot with explosive force to create a serious burn hazard.

15.2.2.3 Aluminum. Operators shall take precautions when handling aluminum to prevent serious burns from very hot assemblies.

E15.2.2.3 When aluminum is very hot, it does not change color like steel does; thus, hot aluminum is deceptive.

15.2.2.4 Hydrogen. Operators shall take precautions when using hydrogen as a fuel gas to prevent burns to the personnel.

E15.2.2.4 Flames of burning hydrogen are almost invisible.

15.2.3 Fluxes and Filler Metals. Operators shall remove all food (including coffee, soft drinks, and other beverages) from the work area in which brazing filler metals, solder alloys, and fluxes are being handled. Casual contact between the hands, face, nose, or mouth shall be avoided when handling filler metals, solder, fluxes, or base materials. Gloves shall be worn when

E15.2.3 Solder typically contains heavy metals (e.g., antimony, lead, silver, and so forth) that are toxic to humans. The ingestion of small amounts of these metals over extended periods can cause chronic health complications.

possible. The safety data sheets for brazing fluxes and filler metals shall be consulted before these substances are used.

15.2.4 Gases and Fumes. Operators shall use adequate ventilation during brazing and soldering procedures (see Clause 5). Nonevacuated furnaces shall be purged following brazing or soldering processes to remove harmful fumes prior to the removal of assemblies.

E15.2.4 Temperatures can be used that cause some elements in the filler metal to vaporize. Elements, such as antimony, beryllium, cadmium, lead, or mercury are toxic materials. Zinc fumes can cause metal fume fever. Some filler metals contain suspected carcinogens such as nickel and chromium. These can oxidize at high temperature and create hazardous fumes. Fluxes that contain chemical compounds of fluorine or chlorine are harmful if they are inhaled or they contact the skin. The application of heat to fluxes and filler metals can generate toxic gases and fumes. Stop-off materials are generally fine ceramics and should be considered a dust particulate material.

15.2.5 Equipment Maintenance

15.2.5.1 Cleaning. Suitable eye, face, and body protection shall be worn by operators when cleaning assemblies with any solvent, including tap water. Gloves shall be worn to prevent injury from acidic or caustic residues generated in the cleaning agent as well as the possible ingestion of metals rubbed off joints and base material.

Operators shall dispose of all cleaning solutions in accordance with environmental regulations and corporate procedures.

E15.2.5.1 Protection is especially important when cleaning the assembly. Even though the solvent may be harmless (e.g., tap water), it quickly becomes contaminated with flux residues, thereby forming caustic or acidic solutions that can impair vision or cause skin burns. This danger is especially prevalent during the drying phase of the cleaning step, which may use high-pressure gases (e.g., compressed air or nitrogen) to displace the liquid cleaning agent from the assembly.

15.2.5.2 Removal of Magnesium Buildup. The buildup of magnesium from brazing furnaces shall be removed periodically. Protective clothing (i.e., fire-resistant jackets, pants, and gloves) shall be used as well as adequate ventilation or respirators (see 5.4) to prevent the inhalation of magnesium and magnesium oxide dust accumulated during the scraping operation.

Nonsparking tools shall be used to scrape the magnesium and magnesium oxide off the walls and other internal parts of the furnace. At regular intervals, the accumulated debris shall be put into a metal box and removed from the furnace area to prevent igniting the magnesium by an accidental spark.

The area around the furnace shall be kept clean at all times. Several pails of sand and the proper fire extinguisher shall be available to extinguish possible magnesium fires. Under no circumstances shall water be used to extinguish a magnesium fire. At no time shall any one person work alone on this removal procedure. Another person shall always be present in the immediate area in case of an accidental fire.

E15.2.5.2 Magnesium, a highly flammable metal, is added to brazing filler metals to facilitate aluminum brazing.

Annex A (Informative)

American Welding Society Safety and Health Standards List

This annex is not part of this standard but is included for informational purposes only.

A3.0M/A3.0	*Standard Welding Terms and Definitions, Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*
C7.1M/C7.1	*Recommended Practices for Electron Beam Welding*
F1.1M	*Methods for Sampling Fumes and Gases Generated by Welding and Allied Processes*
F1.2	*Laboratory Method for Measuring Fume Generation Rates and Total Fume Emission of Welding and Allied Processes*
F1.6	*Guide for Estimating Welding Emissions for EPA and Ventilation Permit Reporting*
F2.2	*Lens Shade Selector*
F2.3M	*Specification for Use and Performance of Transparent Welding Curtains and Screens*
F3.2	*Ventilation Guide for Weld Fume*
F4.1	*Safe Practices for the Preparation of Containers and Piping for Welding and Cutting*
F4.2	*Safety Guidelines for Proper Selection of Welding Cables*

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Annex B (Informative)
List of Other Sources

This annex is not part of this standard but is included for informational purposes only.

The following codes, standards, specifications, pamphlets, and books contain information which may be useful in meeting the requirements of this standard. Inquiries as to the availability and cost of any of these publications should be addressed directly to the publishers in Annex C.

ACGIH		*Threshold Limit Values (TLVs®) for Chemical Substances and Physical Agents in the Workroom Environment*
		Industrial Ventilation Manual
AGA		*Purging Principles and Practices*
ANSI	A13.1	*Scheme for the Identification of Piping Systems*
	B11.1	*Safety Requirements for Construction, Care and Use of Mechanical Power Presses*
	B15.1	*Safety Standard for Mechanical Power Transmission Apparatus (with ASME)*
	B31.1	*Power Piping (with ASME)*
	Z535.4	*Standard for Product Safety Signs and Labels*
ANSI/IEC	60974-1	*Arc Welding Equipment – Part 1: Welding Power Sources*
API	1104	*Welding of Pipelines and Related Facilities*
	PUBL 2009	*Safe Welding, Cutting, and Other Hot Work Practices in the Petroleum and Petrochemical Industries*
	PUBL 2013	*Cleaning Mobile Tanks in Flammable or Combustible Liquid Service*
	STD 2015	*Safe Entry and Cleaning of Petroleum Storage Tanks*
	PUBL 2201	*Safe Hot Tapping Practices in the Petroleum and Petrochemical Industries*
ARPM	IP-7	*Specification for Rubber Welding Hose*
AVS		*Vacuum Hazards Manual*
CGA	C-7	*Guide to Preparation of Precautionary Labeling and Marking of Compressed Gas Containers*
	E-1	*Standard Connections for Regulator Outlets, Torches, and Fitted Hoses for Welding and Cutting*
	E-2	*Hose Line Check Valve Standards for Welding and Cutting*
	G-7.1	*Commodity Specification for Air*
	P-1	*Safe Handling of Compressed Gases in Containers*
	V-1	*Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections*

ISEA	Z87.1	*Occupational and Educational Personal Eye and Face Protection Devices*
	Z89.1	*Industrial Head Protection*
NEMA	EW4	*Graphic Symbols for Arc Welding and Cutting Apparatus*
	EW6	*Guidelines for Precautionary Labeling for Arc Welding andCutting Products*
NFPA	50	*Standard for Bulk Oxygen Systems at Consumer Sites*
	51	*Standard for the Design of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes*
	51B	*Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*
	70	*National Electrical Code®*
	70E	*Standard for Electrical Safety in the Workplace®*
	79	*Electrical Standard for Industrial Machinery*
	306	*Standard for Control of Gas Hazards on Vessels*
	326	*Standard for the Safeguarding of Tanks and Containers for Entry, Cleaning, or Repair*
	701	*Standard Methods of Fire Tests for Flame Propagation of Textiles and Films*
NIOSH	78–138	*Safety and Health in Arc Welding and Gas Welding and Cutting Certified Equipment List*
NSC		*Accident Prevention Manual*
		Fundamentals of Industrial Hygiene
OSHA		*Occupational Safety and Health Standards for General Industry (29 CFR Part 1910, Subpart Q)*
		Occupational Safety and Health Standards for General Industry (29 CFR Part 1910.134
		Occupational Safety and Health Standards for General Industry (29 CFR Part 1910.146
		Occupational Safety and Health Standards for Construction (29 CFR Part 1926, Subpart J)
UL	252	*Standard for Compressed Gas Regulators*
	551	*Standard for Transformer-Type Arc Welding Machines*

Annex C (Informative)
List of Publishers

This annex is not part of this standard but is included for informational purposes only.

ACGIH: American Conference of Governmental Industrial Hygienists, 1330 Kemper Meadow Drive, Cincinnati, OH 45240 (telephone: 513-742-2020; website: www.acgih.org)

AGA: American Gas Association, 400 N Capitol Street, NW, Suite 450, Washington, DC 20001 (telephone: 202-824-7000; website: www.aga.org)

ANSI: American National Standards Institute, 25 West 42nd Street, 4th Floor, New York, NY 10036 (telephone: 212-642-4980; website: www.ansi.org)

API: American Petroleum Institute, 200 Massachusetts Avenue NW, Suite 1100, Washington, DC 20001 (telephone: 202-682-8000; website: www.api.org)

ARPM Association for Rubber Products Manufacturers, 7321 Shadeland Station Way, Suite 285, Indianapolis, IN 46256 (telephone 317-863-4072; website: www.arpminc.com)

ASME: ASME International, 2 Park Avenue, New York, NY 10016 (telephone: 800-843-2763; website: www. asme. org)

ASTM: ASTM International, 100 Bar Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2559 (telephone: 610-832-9500; website: www.astm.org)

AVS American Vacuum Society, 125 Maiden Lane, Suite 15B, 15th Floor, New York, NY 10038 (telephone: 212-248-0200; website: www.avs.org)

AWS: American Welding Society, 8669 NW 36 Street, # 130, Miami, FL 33166 (telephone: 800-443-9353; website: www.aws.org)

CGA: Compressed Gas Association, 14501 George Carter Way, Chantilly, VA 20151 (telephone: 703-788-2700; website: www.cganet.com)

ISEA International Safety Equipment Association, 1901 N Moore Street, Suite 808, Arlington, VA 22203 (telephone: 703-525-1695; website: www.safetyequipment.org)

MSHA: Mine Safety and Health Administration, 201 12th Street S, Suite 401, Arlington, VA 22202 (telephone: 202-693-9400; website: www.msha.gov)

NEMA: National Electrical Manufacturers Association, 1300 North 17th Street, Suite 900, Arlington, VA 22209 (telephone: 703-841-3200; website: www.nema.org)

NFPA: National Fire Protection Association, One Batterymarch Park, Quincy, MA 02169-7471 (telephone: 800-344-3555; website: www.nfpa.org)

NIOSH: National Institute for Occupational Safety and Health, 4676 Columbia Parkway, Cincinnati, OH 45226 (telephone: 800-356-4674; website: www.cdc.gov/niosh)

NSC: National Safety Council, 1121 Spring Lake Drive, Itasca, IL 60143-3201 (telephone: 800-621-7615; website: www.nsc.org)

OSHA: Occupational Safety and Health Administration, 200 Constitution Avenue NW, Washington, DC 20210 (telephone: 800-321-6742; website: www.osha.gov)

RWMA: Resistance Welding Manufacturing Alliance, 8669 NW 36 Street, # 130, Miami, FL 33166 (telephone: 800-443-9353; website: http://www.aws.org/rwma)

UL: Underwriters Laboratories, Incorporated, 333 Pfingsten Road, Northbrook, IL 60062 (telephone: 847-272-8800; website: www.ul.com)

US: U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401 (telephone: 202-512-0000; website: www.gpo.gov)

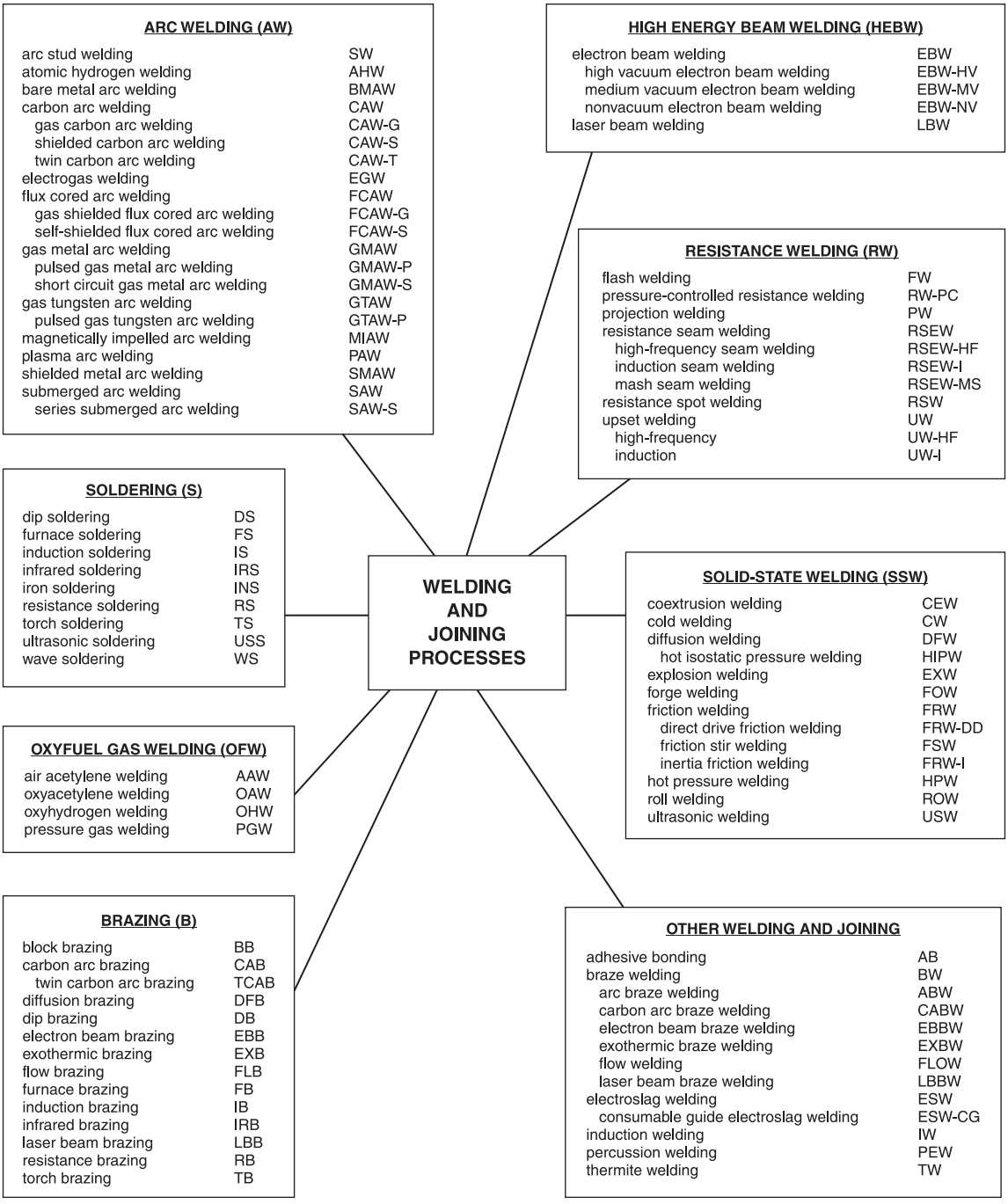
Annex D (Informative)

Master Chart of Welding and Joining Processes and Master Chart of Allied Processes

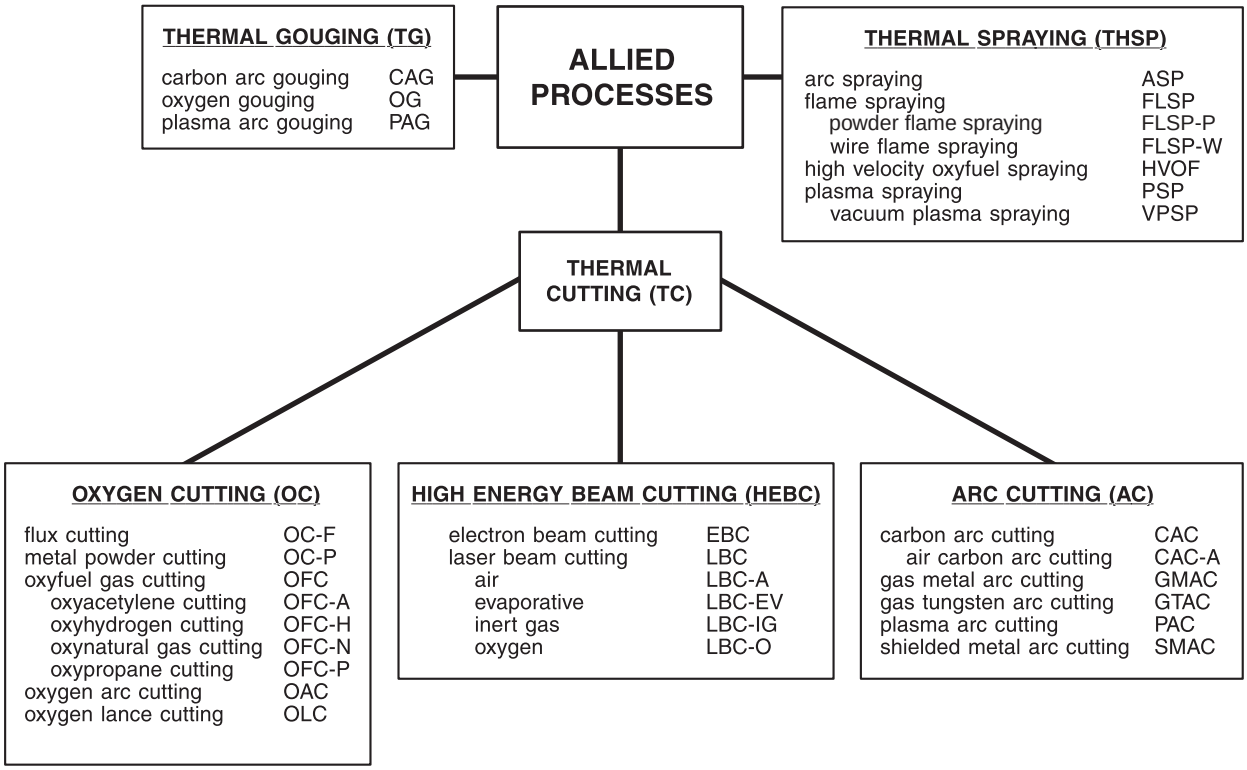
(from AWS A3.0M/A3.0:2020, *Standard Welding Terms and Definitions*)

This annex is not part of this standard but is included for informational purposes only.

Master Chart of Welding and Joining Processes



Master Chart of Allied Processes



Annex E (Informative)

Requesting an Official Interpretation from ASC Z49

This annex is not part of this standard but is included for informational purposes only.

E1. Introduction

The following procedures are here to assist standard users in submitting successful requests for official interpretations to AWS standards. Requests from the general public submitted to AWS staff or committee members that do not follow these rules may be returned to the sender unanswered. AWS reserves the right to decline answering specific requests; if AWS declines a request, AWS will provide the reason to the individual why the request was declined.

E2. Limitations

The activities of the ASC Z49 regarding interpretations are limited strictly to the interpretation of provisions of standards prepared by the committee. Neither AWS staff nor the committee are in a position to offer interpretive or consulting services on (1) specific engineering problems, (2) requirements of standards applied to fabrications outside the scope of the document, or (3) points not specifically covered by the standard. In such cases, the inquirer should seek assistance from a competent engineer experienced in the particular field of interest.

E3. General Procedure for all Requests

E3.1 Submission. All requests shall be sent to the Managing Director, AWS Standards Development. For efficient handling, it is preferred that all requests should be submitted electronically through standards@aws.org. Alternatively, requests may be mailed to:

Managing Director
Standards Development
American Welding Society
8669 NW 36 St, # 130
Miami, FL 33166

E3.2 Contact Information. All inquiries shall contain the name, address, email, phone number, and employer of the inquirer.

E3.3 Scope. Each inquiry shall address one single provision of the standard unless the issue in question involves two or more interrelated provisions. The provision(s) shall be identified in the scope of the request along with the edition of the standard (e.g., Z49.1:2012) that contains the provision(s) the inquirer is addressing.

E3.4 Question(s). All requests shall be stated in the form of a question that can be answered ‘yes’ or ‘no’. The request shall be concise, yet complete enough to enable the committee to understand the point of the issue in question. When the point is not clearly defined, the request will be returned for clarification. Sketches should be used whenever appropriate, and all paragraphs, figures, and tables (or annexes) that bear on the issue in question shall be cited.

E3.5 Proposed Answer(s). The inquirer shall provide proposed answer(s) to their own question(s).

E3.6 Background. Additional information on the topic may be provided but is not necessary. The question(s) and proposed answer(s) above shall stand on their own without the need for additional background information.

E4. AWS Policy on Interpretations

The American Welding Society (AWS) Board of Directors has adopted a policy whereby all official interpretations of standards are handled in a formal manner. Under this policy, all official interpretations are approved by the technical committee that is responsible for the standard. Communication concerning an official interpretation is directed through the AWS staff member who works with that technical committee. The policy requires that all requests for an official interpretation be submitted in writing. Such requests will be handled as expeditiously as possible, but due to the procedures that must be followed, some requests for an official interpretation may take considerable time to complete.

E5. AWS Response to Requests

Upon approval by the committee, the interpretation is an official interpretation of the Society, and AWS shall transmit the response to the inquirer, publish it in the *Welding Journal*, and post it on the AWS website.

E6. Telephone Inquiries

Telephone inquiries to AWS Headquarters concerning AWS standards should be limited to questions of a general nature or to matters directly related to the use of the standard. The *AWS Board Policy Manual* requires that all AWS staff members respond to a telephone request for an official interpretation of any AWS standard with the information that such an interpretation can be obtained only through a written request. Headquarters staff cannot provide consulting services. However, the staff can refer a caller to any of those consultants whose names are on file at AWS Headquarters.

Annex F (Informative)

A Brief History of Precautionary Information

This annex is not part of this standard but is included for informational purposes only.

The present format of Clause 9, *Precautionary Information*, was developed by the combined efforts of the American Welding Society (AWS) and the National Electrical Manufacturers Association (NEMA). In the 1970s some members of these organizations determined it would be beneficial if the *Precautionary Labels*, in Clause 8 of the 1967 edition of ANSI Z49.1, *Safety in Welding and Cutting*, were supplemented with additional precautions.

The 1967 label only addressed *Fumes and gases hazardous to health.* Other hazards, such as *Electric Shock, Arc Rays, and Noise* were of concern. Independently, AWS and NEMA Committees began to develop additional label information. Members of both organizations alerted each other of their own committee's work. As a result, it was decided to form an *AWS/NEMA Joint Committee on Precautionary Labels (ANJCOPL).* After years of work by committee members, a consensus was reached. The new format was presented to American National Standards Institute (ANSI) for inclusion in Clause 9 of the 1983 edition of ANSI Z49.1, *Safety in Welding and Cutting.*

For the first time the precautionary information was written with vocabulary control. Readability levels were assigned to different parts of the label information using FOG INDEX and UNDERSTANDABILITY LEVEL techniques. The label text was designed as follows:

Fourth Grade Understandability:

WARNING:

PROTECT yourself and others. Read and understand this information

FUMES AND GASES can be hazardous to your health.

ARC RAYS can injure eyes and burn skin.

ELECTRIC SHOCK can KILL.

Then Sixth Grade Understandability (with occasional eighth grade word):

- Before use, read and understand the manufacturer's instructions, Safety Data Sheets (SDSs), all label information, and your employer's safety practices.
- Keep your head out of the fumes.

Use enough ventilation, exhaust at the arc, or both, to keep fumes and gases from your breathing zone and the general area. Use breathing protection unless exposures are below exposure limits.

Wear correct eye, ear, and body protection.

Do not touch live electrical parts.

See American National Standard Z49.1, *Safety in Welding, Cutting, and Allied Processes*, published by the American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166; OSHA *Safety and Health Standards*, available from the U.S. Government Printing Office.

DO NOT REMOVE THIS INFORMATION

Figure 1—Precautionary Information for Arc Welding Processes and Equipment

The new *Precautionary Information* clause was successfully adopted by the ASC Z49 Committee. This new label concept, literally, has met the collective approval of the millions of members of the participating ANSI Organizations. If, and when, in the future, label text changes are to be considered, the understandability levels of the respective label text should be preserved.

NOTE: The changes in this edition preserve the understandability levels.