Chapter 10
Welding and Cutting

10-1. References.

a. American Welding Society (AWS) (https://www.aws.org/) (10-1.a)

b. ANSI/AWS F4.1, Safe Practice for the Preparation of Containers and Piping for Welding, Cut, and Allied Processes (https://webstore.ansi.org/) (10-1.b)

c. ANSI/AWS Z49.1, Safety in Welding, Cutting, and Allied Processes (https://webstore.ansi.org/) (10-1.c)

d. ANSI/ISEA Z87.1, American National Standard for Occupational and Educational Personal Eye and Face Protection Devices (https://webstore.ansi.org/) (10-1.d)

e. NFPA 51, Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes (https://www.nfpa.org/Codes-and-Standards) (10-1.e)

f. NFPA 70, National Electrical Code (NEC) (2020) (https://www.nfpa.org/Codes-and-Standards) (10-1.f)

g. NFPA 326, Standard for the Safeguarding of Tanks and Containers for Entry, Cleaning, or Repair (https://www.nfpa.org/Codes-and-Standards) (10-1.g)

h. 29 CFR 1910, Subpart Q Welding, Cutting and Brazing (https://www.govinfo.gov/content/pkg/CFR-2019-title29-vol5/pdf/CFR-2019-title29-vol5-part1910-subpartQ.pdf) (10-1.h)

i. 29 CFR 1926, Subpart J Welding and Cutting (https://www.govinfo.gov/content/pkg/CFR-2019-title29-vol8/pdf/CFR-2019-title29-vol8-part1926-subpartJ.pdf) (10-1.i)

j. 49 CFR 192, Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards (https://www.govinfo.gov/content/pkg/CFR-2019-title49-vol3/pdf/CFR-2019-title49-vol3-part192.pdf) (10-1.j)

10-2. Definitions.

a. Arc Welding. A welding process that joins work pieces by heating them with an arc. (10-2.a)

b. Bonding. The permanent joining of metallic parts to form an electrically conductive path that will ensure electrical continuity and capacity to safely conduct any expected current. (10-2.b)

c. Brazing. A welding process that joins ferrous metals materials by heating them to a temperature that will not melt them but will melt a filler material which adheres to them and forms a joint. (10-2.c)

d. Cable. A conductor with insulation, or a stranded conductor with or without insulation and other coverings (for example, single-conductor cable), or a combination of conductors insulated from one another (for example, multiple-conductor cable). (10-2.d)

e. Competent Person (CP). See paragraphs 1-2 or 2-2, as applicable. (10-2.e)

f. Confined Space. See paragraphs 34-2. (10-2.f)

g. Employee. See paragraphs 1-2 or 2-2, as applicable. (10-2.g)

h. Flashback. A backfire of the flame in a mixing chamber of the oxy-fuel gas torch that may progress through the torch and hoses. (10-2.h)

i. Fuel Gas. A gas (for example, acetylene, hydrogen, natural gas, propane) used with oxygen in the oxyfuel process and for heating. (10-2.i)

j. Gas Metal Arc Welding. An arc welding process that uses an arc between a continuous filler metal electrode and the weld pool. Shielding from the atmosphere is provided by an externally supplied gas. (10-2.j)

k. Grounding. See paragraph 11-2. (10-2.k)

l. Hot Tapping. A procedure of attaching connections to equipment in service by welding and drilling. (10-2.l)

m. Hot Work. Hot work is considered any activity that generates or has the potential to generate, heat, sparks, open flame, or explosion (for example, hot riveting, welding, burning, abrasive blasting, brazing, cutting, grinding, powder-actuated tools, soldering). Grinding, drilling, abrasive blasting, or similar spark-producing operations are also considered hot work except when such operations are isolated physically from any atmosphere containing more than 10% of the LEL of a flammable or combustible substance. (10-2.m)

n. Hot Work Permit. Written authorization to perform hot work operations. (10-2.n)

o. Oxyfuel Gas Cutting. An oxygen cutting process that uses heat from an oxyfuel gas flame. (10-2.o)

p. Oxyfuel Gas Welding. A welding process that joins work pieces by heating them with an oxyfuel gas flame. (10-2.p)

q. Qualified Person (QP). See paragraphs 1-2 or 2-2, as applicable. (10-2.q)

10-3. Personnel Required Qualification/Training.

a. General. Train welders, cutters, and their supervisors in the safe operation of their equipment, safe welding/cutting practices, proper respirator use, and fire protection procedures to follow when welding/cutting. See chapter 5 for respiratory protection and chapter 9 for fire protection. (10-3.a)

b. Welders. Welders must be designated in writing for the job functions they are expected to perform. Proof of qualification must be attached to the designation. (10-3.b)

c. Structural Welding. Persons performing structural welding or inspections on critical items must be trained and certified according to AWS standards (for example, Certified Senior Welding Inspector (CWSI), Certified Welding Inspector (CWI), or equivalent inspector). (10-3.c)

d. Hot Tap. Only competent personnel may hot tap, weld, or cut on active flammable gas, liquid transmission, or distribution pipeline. (10-3.d)

10-4. Roles and Responsibilities.

a. Critical Weld Inspectors. CWSI, CWI, or equivalent inspector must inspect all welds on critical items. (10-4.a)

b. Competent Person (CP). A CP must evaluate hazards to determine what controls are needed for welding, cutting, and heating operations that do not involve conditions or materials described in this chapter. (10-4.b)

10-5. Inspection Requirements.
Inspect all welding equipment before each use to ensure that all required safety devices and ancillary equipment are in place and properly functioning. Remove defective equipment from service, replace or repair it, and re-inspect it before placing back in service. Inspect these and similar items:

a. Torches. (10-5.a)

b. Cables. (10-5.b)

c. Shut-off valves. (10-5.c)

d. Couplings. (10-5.d)

e. Tips. (10-5.e)

10-6. Activity Hazard Analysis (AHA) Requirements.
Develop AHAs according to paragraphs 1-6 or 2-6, as applicable, for all activities involving hot work. Include the following in the AHA:

a. Type of metals being used. (10-6.a)

b. Type of welding process. (10-6.b)

c. Type of extinguishing method for each operation or process. (10-6.c)

d. Identify the CP for welding and fire watch. Employer will determine how long a fire watch is required to stay in place, but it must be a minimum of thirty (30) minutes after the exposure has ended and documented in the AHA. (See chapter 9) (10-6.d)

e. PPE required (see chapter 5). (10-6.e)

10-7. Minimum Plan Requirements.
A written Housekeeping Plan is required for all welding, cutting, brazing, or heating operations that involve toxic materials. Develop the plan according to chapter 35 of this manual, to include the following:

a. Detailed description of the activity being performed, to include the frequency, type, and volume of hot work activities. (10-7.a)

b. Description of anticipated hazards or concerns and the control measures that will be implemented to control to an acceptable level, to include routine maintenance and housekeeping procedures and schedule. For example, frequency that all surfaces need to be regularly high efficiency particulate air vacuumed and wet wiped so that they are free of contamination. (10-7.b)

c. Assignment of personnel and their roles and responsibilities. Include necessary information/documentation to support qualification/training of such persons. (See para 10-3) (10-7.c)

d. Inspection and oversight methods to ensure adherence to the plan. (10-7.d)

10-8. General Requirements.

a. General. (10-8.a)

(1) All welding and cutting equipment and operations must be according to standards and recommended practices of ANSI Z49.1.

(2) Before heat is applied to a drum, container, or hollow structure, a vent or opening must be provided for the release of any built-up pressure generated during the application of heat. Do not use heat or spark producing tools to create or provide venting.

(3) Keep cable, hoses, and other equipment clear of passageways, ladders, and stairways.

b. Electrical and Pressurized System Requirements. Maintain and use welding cylinders according to paragraph 10-8.g. (10-8.b)

c. Personal Protective Measures. A CP must evaluate hazards to determine what controls are needed for welding, cutting, and heating operations that do not involve conditions or materials described in this chapter. (10-8.c)

(1) Eye and Face Protection. Protect the eyes and face of welders and those exposed to such tasks from UV and infrared radiation and flying objects during welding, grinding, and chipping operations. (See chapter 5)

(a) Protect personnel performing or exposed to work that produces UV, blue, or infrared light from these hazards according to the following requirements:

(a-1) Select shaded lenses based on the type of equipment and work (see chapter 5).

(a-2) Protective helmets must have non-reflective surfaces and be free of cracks or openings.

(a-3) Do not use lenses that are cracked or pitted.

(a-4) All filter lenses must meet ANSI/ISEA Z87.1 requirements.

(a-5) Welding helmets and ANSI Z87.1 rated safety glasses with top and side protection must always be used.

(b) Do not use electronic-shading welding helmets for welding processes requiring a higher shade rating than the helmet can give. Most auto-darkening helmets are not suited for welding processes requiring a filter shade of 14 or higher.

(2) Naturally or mechanically vent all welding, cutting, and heating operations so that personnel exposures to hazardous concentrations of airborne contaminants are within acceptable limits. Provide local exhaust ventilation whenever welding, cutting, or heating is performed in a confined space. (See chapter 6)

(3) Protect other persons exposed to the same atmosphere as welders or cutters in the same manner as welders or cutters.

(4) Arc and Gas Cutting. Employ local mechanical exhaust ventilation or other means to adequately remove the fumes generated during oxygen cutting that involves either an iron powder or chemical flux, gas-shielded arc cutting, or plasma cutting.

d. Fire Protection. (10-8.d)

(1) Suitable fire extinguishing equipment of sufficient capacity must be provided in the immediate vicinity of welding or cutting operations and maintained in a state of constant readiness for immediate use.

(2) Hot work permits are required on federal installations when hot work operations are performed, unless otherwise indicated by the USACE supervisor/KO or COR (see chapter 9).

(3) Before conducting welding or cutting operations, survey the area to ensure it is free of the following hazards:

(a) Combustible materials located close to the operation (for example, within 35 feet (10.7 m).

(b) The presence or possible generation of potentially explosive atmospheres (for example, flammable gases, vapors, liquids, dusts).

(c) The presence or nature of an oxygen-enriched atmosphere.

(4) Hierarchy of fire control. Objects to be welded, cut, or heated must:

(a) Move object(s) to a location free of dangerous combustibles.

(b) If the work cannot be moved, take all moveable fire hazards in the vicinity to a safe place (for example, moved at least 35 feet (10.7 m) horizontally from the welding or cutting area) or protect the combustible material and construction from the heat, sparks, and slag of welding.

(c) When welding or cutting must be done in a location where combustible or flammable materials are located, the USACE supervisor/KO or COR must inspect the operations and authorize an exception before the work may begin. A fire watch must stand with readily available fire extinguisher equipment and be available to sound an

alarm in the event of a fire. Employer will determine how long a fire watch is required to stay in place, but it must be a minimum of thirty (30) minutes after the exposure has ended and documented in the AHA. (See chapter 9)

(5) When an operation is such that normal fire prevention precautions are not sufficient, assign additional fire watch personnel to guard against fire and instruct them in anticipated fire hazards and use of the firefighting equipment (see chapter 9).

(6) When welding or cutting is to be done over combustible flooring, protect the flooring with fire-resistant shielding covered with damp sand, or kept wet. Where flooring is wet or damp, protect personnel operating arc welding or cutting equipment from potential shock hazards.

(7) Install noncombustible barriers below welding or burning operations in a shaft or raise.

(8) Tightly cover openings or cracks in walls, floors, or ducts within 35 feet (10.7 m) of the site of welding or cutting operations to prevent the passage of sparks to adjacent areas.

(9) Where welding or cutting is to be done near walls, partitions, ceilings, or roofs of combustible construction, use fire resistant guards to prevent ignition.

(10) Where welding or cutting is to be done on a metal wall, partition, ceiling, or roof, take precautions to prevent ignition due to heat conduction or radiation of combustibles on the other side.

(11) Do not weld or cut on a metal partition, wall, ceiling, or roof with a combustible covering, nor on walls or partitions of combustible sandwich-type panel construction.

(12) Before welding or cutting drums, tanks, or other containers and equipment that have contained HAZMAT, thoroughly clean the containers according to NFPA 326 and ANSI/AWS F4.1.

(13) When welding or cutting is to be conducted near a sprinkler head, use a wet cloth or equivalent protection to cover the sprinkler head and then remove the cloth at the completion of the welding or cutting operation.

(14) When welding or cutting in areas protected by fire detection and suppression systems, take precautions to avoid accidental initiation of these systems.

e. Welding and Cutting Hazardous Materials (HAZMAT). (10-8.e)

(1) Perform welding, cutting, and heating operations on pipelines according to 49 CFR 192.

(2) Test all surfaces covered by a preservative coating whose flammability is not known to determine its flammability before starting to weld, cut, or heat them. Preservative coatings are considered highly flammable when scrapings burn with extreme rapidity.

(a) Remove preservative coatings a sufficient distance from the area to be heated to ensure any temperature increase of the un-stripped metal will not result in visually observable decomposition or degradation of the coatings. Artificial cooling of the metal surrounding the heated area may be used to limit the area to be stripped.

(b) When welding, cutting, or heating toxic surface coatings (for example, paints, preservatives, surface stripping chemicals) in enclosed spaces, strip all surfaces covered with the coatings a distance of at least 4 inches (10.2 cm) from the area of heat application or use airline respirators as deemed necessary by a CP assessment and according to chapter 6.

(3) Materials of toxic significance. Perform welding, cutting, or heating operations that involve or generate any of the toxic substances listed below according to the following requirements: antimony, arsenic, barium, beryllium, cadmium, chromium, chromium (VI), cobalt, copper, lead, manganese, mercury, nickel, ozone, selenium, silver, or vanadium.

(a) Whenever these materials are encountered in confined space, use intrinsically safe local exhaust ventilation and PPE.

(b) Whenever these materials, except beryllium or chromium (VI), are encountered in indoor operations, use, and maintain local mechanical exhaust ventilation systems that are sufficient to reduce and maintain personal exposures to within acceptable limits according to the manufacturer's instructions. Ensure that replacement filters are from the same manufacturer and are the correct filter for the exhaust system. When either beryllium or chromium (VI) is encountered in indoor operations, use approved local mechanical exhaust ventilation systems and personal respiratory protection. (See chapter 6)

(b-1) In areas where only welding is conducted, use a general exhaust system ventilation rate of at least 2,000 cubic feet per minute (CFM) (0.9 m^3/s) per welder in open welding areas.

(b-2) Local exhaust ventilation must have a capture velocity of 100 fpm (0.5 m/s), as measured from the farthest distance from the work, and a duct transport velocity of at least 1,000 fpm (5.1 m/s). Local exhaust ventilation systems that filter and return the air back into the work environment are allowed for welding if the work is not located in a confined space or does not involve beryllium or chromium and if the provisions of chapter 6 are followed.

(c) Whenever these materials, except beryllium or chromium (VI), are encountered in outdoor operations, and local mechanical exhaust ventilation systems sufficient to reduce and maintain personal exposures to within acceptable limits are not provided, appropriate respiratory protective equipment must be used (see chapter 6).

(d) Whenever beryllium or chromium (VI) are encountered in outdoor operations, base the justification for and the implementation of engineering and work practice controls and respiratory protection on the results of an initial worker exposure assessment and an exposure determination (see para 10-8.i and chapter 6).

(e) Workers may be exposed to hazardous concentrations of chromium (VI) while welding, cutting, or performing hot work on stainless steel, high chrome alloys or chrome coated metal, or during the application and removal of chromate-containing paints, and other surface coatings (see chapter 6).

(f) When working with materials of toxic significance, workers must remove outer clothing, vacuum off, and wash before taking a break, drinking, smoking, or leaving for the day.

(4) Perform welding, cutting, or heating operations that involve or generate fluorine or zinc compounds according to the following:

(a) In confined spaces, use local mechanical exhaust ventilation and personal respiratory protection sufficient to maintain exposures within acceptable limits (see chapter 6).

(b) In open spaces, perform sampling and testing according to the procedures in chapter 6 to determine concentrations of fluorides or zinc compounds and the need for local exhaust ventilation and personal respiratory protection sufficient to maintain exposures within acceptable limits.

f. Critical Items. (10-8.f)

(1) All structural welding performed on critical items (for example, scaffolding, shoring, forms, ladders, piling), as well as other critical items as determined by QP, must only be performed by certified welders (see para 10-3.c).

(2) Welds on critical items must be inspected by either a current CSWI, a CWI, or equivalent welding inspector trained to AWS standards (see paras 10-3.c and 10-4.a).

g. Oxyfuel Gas Welding and Cutting. (10-8.g)

(1) Oxyfuel gas welding and cutting equipment must be approved by NRTL.

(2) Oxygen Cylinders and Apparatuses.

(a) Keep oxygen cylinders and apparatus free from oil, grease, and other flammable or explosive substances. Do not handle them with oily hands or gloves.

(b) Do not use oxygen cylinders and apparatus interchangeably with any other gas.

(c) Do not place oxyfuel cylinders in a confined space with the workers.

(3) Hose and Hose Connections.

(a) Fuel gas hose and oxygen hose must be readily distinguishable from each other.

(b) Oxygen and fuel gas hoses are not interchangeable. Do not use a single hose having more than one gas passage.

(c) Do not use hose couplings of the type that can be unlocked or disconnected without a rotary motion.

(d) Test hoses that have been subjected to flashback or that shows evidence of severe wear or damage to twice the normal pressure to which it is subjected. In no case test with less than 300 psi (2068.4 kPa) gauge. Do not use damaged hose and hose connectors, or hose and hose connectors in questionable condition.

(e) When parallel runs of oxygen and fuel gas hose are taped together, not more than 4 inches out of every 12 inches (10.2 cm out of every 30.4 cm) may be covered by tape.

(f) Properly ventilate all boxes used for the storage of gas hoses and all enclosed spaces containing gas hoses.

(g) Clamp or otherwise securely fasten hose connections in a manner that will withstand, without leakage, twice the pressure to which they are normally subjected in service, but not less than 300 psi (2,068 kPa) gauge.

(4) Torches.

(a) Inspect torches before each use for leaking shutoff valves, hose couplings, tip connections, and damaged torch tips. Do not use defective torches.

(b) Hoses must be purged individually before lighting the torch for the first time each day. Do not purge hoses into confined spaces or near ignition sources.

(c) Clean clogged torch tip openings with suitable cleaning wires, drills, or other devices designed for such purposes.

(d) Light torches with friction lighters or other approved devices; not by matches or from hot work.

(e) Close torch valves and shut off the gas supply whenever work is suspended.

(f) Remove the torch and hose from confined spaces whenever work is suspended.

(5) Protective Equipment.

(a) Unless indicated otherwise by the manufacturer's instructions, install a reverse-flow check valve and a flash arrestor in the hose at each torch when using oxyfuel gas or other oxygen-fuel gas welding and cutting systems that use a cylinder regulator-hose-torch.

(b) When oxygen-fuel gas systems are manifolded together, perform according to NFPA 51.

(6) Do not connect multiple sets of oxyacetylene hoses to a single regulator on a single set of oxyacetylene tanks unless a commercially available fitting that complies with CGA standards and is listed by a NRTL is installed. Install the fitting in the output side of the regulator and include a built-in shut-off valve and reverse-flow check valve on each branch.

(7) Do not adjust acetylene regulators to permit a discharge greater than 15 psi (103.4 kPa) gauge.

h. Arc Welding and Cutting. Install, maintain, and operate all electric welding apparatuses according to the NEC. (10-8.h)

(1) Manual Electrode Holders.

(a) Use only manual electrode holders specifically designed for arc welding and cutting of a capacity capable of safely handling the maximum rated current required by the electrodes.

(b) Fully insulate the current carrying parts passing through the gripped portion of the holder and the outer surfaces of the jaws of the holder against the maximum voltage encountered to ground.

(2) Welding Cables and Connectors.

(a) Cables must be completely insulated, flexible, capable of handling the maximum current requirements of the work in progress, and in good repair. Do not use damaged or defective cables.

(b) Inspect welding cables for wear or damage before each use. Replace or repair cables with damaged insulation or connectors to achieve the same mechanical strength, insulating quality, electrical conductivity, and water tightness of the original cable. Do not use cables containing splices or repaired insulation within a minimum distance of 10 feet (3 m) from the end of the cable to which the electrode holder is connected.

(c) Where it becomes necessary to connect or splice lengths of cable together, use insulated connectors of a capacity at least equivalent to that of the cable. When connecting with cable lugs, securely fasten them together to give good electrical contact and completely cover the exposed metal parts of the lugs. When connecting or splicing lengths of cable together, use methods specifically intended for that purpose and adequately insulate the connections for the service conditions.

(3) Grounding. See chapter 11.

(a) Ground the frames of arc welding and cutting machines either by a third wire in the cable connected to the circuit conductor or by a separate wire that is grounded at the source of the current.

(b) Do not bond either of the welding generator terminals to the frame of the welder.

(c) Do not use pipelines containing gases or flammable liquids or conduits carrying electrical conductors for a ground return circuit.

(d) Ground the circuits from welding machines used for other than welding tools.

(4) Do not place welding supply cables near power supply cables or other high-tension wires.

(5) Do not allow welding leads to contact metal parts supporting suspended scaffolds.

(6) Locate the switching equipment for shutting down the welding machine on or near the welding machine.

(7) Shut down the equipment when the leads are unattended.

(8) Shield arc welding and cutting operations by noncombustible or flameproof screens to protect employees and other persons working within 35 feet (10.7 m) from the direct rays of the arc, sparks, molten metal, spatter, and chipped slag.

(a) Select welding curtains that are suitable for the welding process and amperage.

(b) Welding curtains must be fade resistant and flame retardant.

(9) Spread out coiled welding cable before use to avoid overheating and damage to insulation.

i. Gas Metal Arc Welding. (10-8.i)

(1) Keep chlorinated solvents at least 200 feet (61 m) away from the exposed arc.

(2) Dry surfaces prepared with chlorinated solvents before welding is permitted on such surfaces.

(3) Protect those less than 35 feet (10.7 m) from the arc and not protected from the arc by screening with filter lenses. When two or more welders are exposed to each other's arc, each welder must wear filter lens goggles under their welding helmets. Use hand shields to protect the welders against flashes and radiant energy when either the helmet is lifted, or the shield is removed.

(4) Protect welders and other persons who are exposed to radiation by adequately covering the skin to prevent burns and other damage from UV rays. Welding helmets and hand shields must be in good working order and free of defects, cracks, opening, and highly reflective surfaces. Set up screens around welding work area to protect personnel outside of the immediate work zone from being exposed to UV rays.

(5) When gas metal arc welding is performed on stainless steel, chrome alloy steel, or chrome-coated metal, ventilate the area using an approved local exhaust system to protect personnel against dangerous concentrations of nitrogen dioxide and other air contaminants such as chromium (VI). The exhaust system must be capable of reducing and maintaining personal exposures to within permissible limits. If not sufficient, augment the exhaust system ventilation by changing the work practices and engineering controls, such as by using an argon-rich (> 75% argon) shielding gas with gas metal arc welding or flux cored arc welding operations. Wherever engineering and work practice controls are not sufficient to reduce employee exposures below permissible limits, the employer must use them to reduce employee exposures to the lowest levels achievable and must supplement them by using respiratory protection that complies with the requirements of this chapter and chapter 5.

j. Plasma Cutting. Install, maintain, and operate plasma arc cutting equipment according to the NEC and manufacturer’s instructions. (10-8.j)

(1) Verify that all consumables (for example, nozzles, electrodes) are installed according to the manufacturer’s instructions before each use.

(2) All torches used in plasma cutting must contain a trigger safety device to prevent accidental contact.