



AWS SAFETY AND HEALTH FACT SHEET BUNDLE

FOR CONSTRUCTION AND INFRASTRUCTURE WELDING

Includes the following concise and helpful fact sheets from the American Welding Society's Committee on Safety and Health

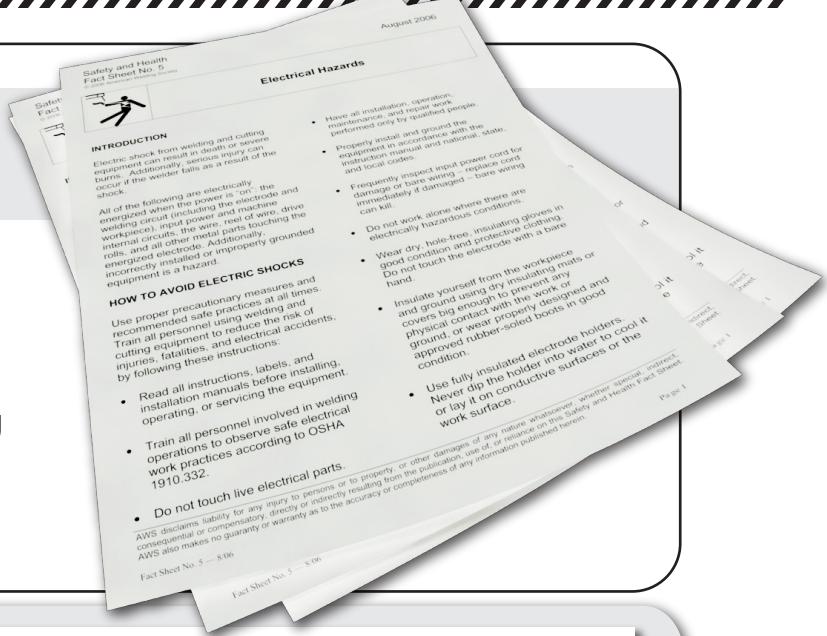
Fact Sheet 5: Electrical Hazards

Fact Sheet 6: Fire and Explosion Prevention

Fact Sheet 9: Tripping and Falling

Fact Sheet 10: Falling Objects

Fact Sheet 11: Confined Spaces



The following safety fact sheets and the complete 66-page ANSI Z49.1 Safety in Welding, Cutting, and Allied Processes are available for free download at www.aws.org/safety:

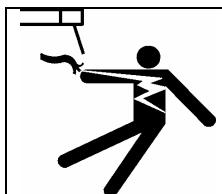
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- 36: Ventilation for Welding & Cutting
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- Z49.1: Safety in Welding, Cutting, and Allied Processes



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Electrical Hazards

INTRODUCTION

Electric shock from welding and cutting equipment can result in death or severe burns. Additionally, serious injury can occur if the welder falls as a result of the shock.

All of the following are electrically energized when the power is "on": the welding circuit (including the electrode and workpiece), input power and machine internal circuits, the wire, reel of wire, drive rolls, and all other metal parts touching the energized electrode. Additionally, incorrectly installed or improperly grounded equipment is a hazard.

HOW TO AVOID ELECTRIC SHOCKS

Use proper precautionary measures and recommended safe practices at all times. Train all personnel using welding and cutting equipment to reduce the risk of injuries, fatalities, and electrical accidents, by following these instructions:

- Read all instructions, labels, and installation manuals before installing, operating, or servicing the equipment.
 - Train all personnel involved in welding operations to observe safe electrical work practices according to OSHA 1910.332.
 - Do not touch live electrical parts.
- Have all installation, operation, maintenance, and repair work performed only by qualified people.
 - Properly install and ground the equipment in accordance with the instruction manual and national, state, and local codes.
 - Frequently inspect input power cord for damage or bare wiring – replace cord immediately if damaged – bare wiring can kill.
 - Do not work alone where there are electrically hazardous conditions.
 - Wear dry, hole-free, insulating gloves in good condition and protective clothing. Do not touch the electrode with a bare hand.
 - Insulate yourself from the workpiece and ground using dry insulating mats or covers big enough to prevent any physical contact with the work or ground, or wear properly designed and approved rubber-soled boots in good condition.
 - Use fully insulated electrode holders. Never dip the holder into water to cool it or lay it on conductive surfaces or the work surface.

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- Do not touch electrode holders connected to two welding machines at the same time since double open-circuit voltage can be present.
- Do not allow the electrode holder or electrode to come in contact with any other person or any grounded object.
- Do not use worn, damaged, undersized, or poorly spliced cables, welding gun cables, or torch cables. Make sure all connections are tight, clean, and dry.
- Do not wrap cables carrying electric current around any part of your body.
- When required by ANSI Z49.1 or other codes, ground the workpiece to a good electrical earth ground. The work lead is not a ground lead. Do not use the work lead as a ground lead. Use a separate connection to ground the workpiece to earth.
- Do not touch an energized electrode while you are in contact with the work circuit.

When using auxiliary power from welding generators, it is recommended that you use a circuit protected by a ground fault circuit interrupter (GFCI) such as receptacles in boxes, extension cords, and the like. Use of an assured grounding system is also acceptable and is equivalent to use of a GFCI protected circuit. (see AWS Safety and Health Fact Sheet No. 29, Grounding of Portable and Vehicle Mounted Welding Generators, for information about assured grounding systems).

Additional safety precautions are required when welding is performed under any of the following electrically hazardous conditions: in damp locations or while wearing wet clothing; on metal floors, gratings, scaffolds, or other metal structures; in cramped positions such as sitting, kneeling, or lying; or when there is a high risk of unavoidable or accidental contact with the workpiece or ground. Where these conditions are present, use one of the following types of equipment presented in order of preference: (1) a semiautomatic DC constant voltage metal electrode (wire) welder, (2) a DC manual covered electrode (stick) welder, or (3) an AC welder with reduced open-circuit voltage. In most situations, use of a DC, constant voltage wire welder is recommended. And, do not work alone!

- Wear a safety harness to prevent falling if working above floor level.
- Turn off all equipment when not in use. Disconnect the power to equipment that will be left unattended or out of service.

Disconnect the input power or stop the engine before installing or servicing the equipment. Lock the input disconnect switch in the “open” (Off) position, or remove the fuses, so that power cannot be turned on accidentally. Follow lockout/tagout procedures (see AWS Safety and Health Fact Sheet No. 18, Lockout/Tagout).

- Use only well maintained equipment. Frequently inspect welding equipment and repair or replace all damaged parts before further use.

- Keep all covers and panels securely in place.

WEARERS OF PACEMAKERS

The technology of heart pacemakers and other electronic devices changes frequently and this may change the way these devices are affected by other electrical devices including welding equipment. Wearers of pacemakers or other electronic devices vital to life should be instructed to check with their doctor and with the device manufacturer to determine if any hazard exists when near welding or cutting operations. See AWS Fact Sheet No. 16, Pacemakers and Welding, for additional information about pacemakers and welding.

PROCEDURES FOR ELECTRIC SHOCK

- Turn off the electric power.
- Use nonconducting material, such as dry wood, to free the victim from contact with live parts or wires.
- If the victim is not breathing, call for emergency services. Administer cardiopulmonary resuscitation (CPR) immediately after breaking contact with the electrical source. Continue CPR until breathing starts or until help arrives.
- Where an automatic electronic defibrillator (AED) is available, use according to instructions.
- Treat an electrical burn as a thermal burn by applying clean, cold (iced) compresses. Prevent contamination, and cover with a clean, dry dressing.

INFORMATION SOURCES

American National Standards Institute (ANSI). *Safety in Welding, Cutting, and Allied Processes* (ANSI Z49.1), published by the American Welding Society, 550 NW LeJeune Road, Miami, FL 33126; telephone 800-443-9353; Web site: www.aws.org.

Occupational Safety and Health Administration (OSHA). *Code of Federal Regulations*, Title 29 Labor, Parts 1910.1 to 1910.1450, available from the U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401; telephone: 800-321-6742; Web site: www.osha.gov

National Fire Protection Association (NFPA). *National Electric Code* (NFPA 70), available from National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101; telephone: 800-344-3555; Web site: www.nfpa.org.

National Fire Protection Association (NFPA). *Standard for Fire Prevention During Welding, Cutting and Other Hot Work* (NFPA 51B), available from National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101; telephone: 800-344-3555; Web site: www.nfpa.org.

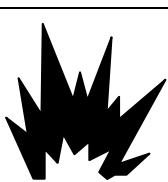
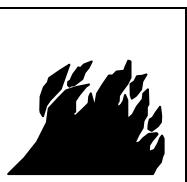
National Fire Protection Association (NFPA). *Standard for Electrical Safety Requirements for Employee Workplaces* (NFPA 70E), available from National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101; telephone: 800-344-3555; Web site: www.nfpa.org.

Mine Safety and Health Administration (MSHA). *Code of Federal Regulations*

Title 30 Mineral Resources, Parts 1 to 199,
available from the U.S. Government
Printing Office, 732 North Capitol Street
NW, Washington, DC 20401; telephone:
202-693-9400; web site: www.msha.gov.

American Welding Society (AWS). *Safety and Health Fact Sheets*, published by the American Welding Society, 550 NW LeJeune Road, Miami, FL 33126; telephone 800-443-9353; Web site: www.aws.org.

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Fire and Explosion Prevention

INTRODUCTION

Welding, cutting, and allied processes produce molten metal, sparks, slag, and hot work surfaces. These can cause fire or explosion if precautionary measures are not followed.

NATURE OF THE HAZARD

Flying sparks are the main cause of fires and explosions in welding and cutting. Sparks can travel up to 35 feet (10.7 meters) from the work area. Sparks and molten metal can travel greater distances when falling. Sparks can pass through or become lodged in cracks, clothing, pipe holes, and other small openings in floors, walls, or partitions.

Typical combustible materials inside buildings include: wood, paper, rags, clothing, plastics, chemicals, flammable liquids and gases, and dusts. Parts of buildings such as floors, partitions, and roofs may also be combustible.

Typical combustible materials outside buildings include dry leaves, grass, and brush.

Welding and cutting can cause explosions in spaces containing flammable gases, vapors, liquids, or dusts. Special precautions are needed for any work on containers (see AWS F4.1).

HOW TO AVOID THE HAZARD

- Develop adequate procedures, and use proper equipment to do the job safely.
- When Required obtain a Hot-Work Permit (See NFPA 51B).
- Remove combustible materials for a minimum radius of 35 feet (10.7 meters) around the work area or move the work to a location well away from combustible materials.
- If relocation is not possible, protect combustibles with covers made of fire-resistant material.
- If possible, enclose the work area with portable, fire-resistant screens.
- Cover or block all openings, such as doorways, windows, cracks, or other openings with fire resistant material.
- Do not weld on or cut material having a combustible coating or internal structure, such as in walls or ceilings, without an appropriate method for eliminating the hazard.
- When needed, have a qualified firewatcher in the work area during and for at least 30 minutes after the job is finished.

- After welding or cutting, make a thorough examination of the area for evidence of fire. Remember that easily visible smoke or flame may not be present for some time after the fire has started.
- Do not dispose of hot slag in containers holding combustible material.
- Keep appropriate fire extinguishing equipment nearby, and know how to use it.
- Make sure all electrical equipment and wiring are installed properly and have recommended circuit protection.
- Do not overload or improperly size input conductors and/or weld output conductors to avoid equipment and building fire hazards.
- Connect the work cable to the work as close to the welding area as practical.
- Do not weld or cut in atmospheres containing reactive, toxic, or flammable gases, vapors, liquids, or dust.
- Do not apply heat to a workpiece covered by an unknown substance or coating that can produce flammable, toxic, or reactive vapors when heated.
- Do not apply heat to a container that has held an unknown substance or a combustible material unless container is made or declared safe. (see AWS F4.1).
- Provide adequate ventilation in work areas to prevent accumulation of flammable gases, vapors, or dusts.

SUMMARY

Remember that sparks can travel up to a radius of 35 feet (10.7 meters) from the work and pass through or become lodged in all kinds of openings and cause fires where least expected. Recognize that sparks can travel well beyond the 35 foot (10.7 meters) radius when falling or during plasma arc cutting and air carbon arc cutting or gouging. Remove combustible materials and prevent flammable gases, vapors, and dusts from accumulating in the work area to reduce the possibility of a fire or explosion. Always have appropriate fire extinguishing equipment nearby, and know how to use it.

Fires and explosions can be prevented by being aware of your surroundings, minimizing the combustibles in them, and taking the appropriate protective precautions.

INFORMATION SOURCES

American National Standards Institute (ANSI). *Safety in Welding, Cutting, and Allied Processes*, Z49.1, available from American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126. Phone 800-443-9353; Web site: www.aws.org.

National Fire Protection Association (NFPA), *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, NFPA 51B, available from the National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, Massachusetts USA 02269-9101. Phone: 617-770-3000; Web site: www.nfpa.org.

Occupational Safety and Health Administration (OSHA). *Code of Federal*

Regulations, Title 29 Labor, Chapter XVII, Parts 1901.1 to 1910.1450, available from Superintendent of Documents, U.S. Government Printing Office, P.O. Box 371954, Pittsburgh, PA 15250-7954. Phone: 866-512-1800; Web site: www.osha.gov.

American Welding Society (AWS). *Safe Practices for the Preparation for Welding and Cutting of Containers or Piping*, AWS F4.1, available from the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126. Phone: 800-443-9353; Web site: www.aws.org.

American Welding Society (AWS). *Fire Safety in Welding and Cutting*, Pamphlet, available from the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126. Phone: 800-443-9353; Web site: www.aws.org.

Mine Safety and Health Administration (MSHA). *Code of Federal Regulations*, Title 30 Mineral Resources, Parts 1-199, available from Superintendent of Documents, U.S. Government Printing Office, P.O. Box 371954, Pittsburgh, PA 15250-7954. Phone: 866-512-1800; Web site: www.msha.gov.

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Safety and Health

Fact Sheet No. 9

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Tripping and Falling

NATURE OF THE HAZARD

Welding, cutting and associated processes take place in a wide variety of locations under many different conditions. Welding and cutting occurs in shops and factories on the floor level, on high steel in skyscraper construction, in pits, vats, mines, tanks, ship compartments, and everywhere metals are joined or cut.

SOME CAUSES OF TRIPS AND FALLS

- Poor housekeeping of materials, equipment, hoses, and tools.
- Scattered parts and pieces either left over or waiting for use.
- Failure to use or correctly use a fall protection system.
- Sudden loud noises or shouts.
- Inadequate or improperly used safety equipment such as ladders, guardrails, scaffolds, and nets.
- Failure to use proper personal protective equipment such as skid-resistant soles on shoes to meet job needs.
- Horseplay or unsafe actions, such as tossing tools to each other or bumping someone in a precarious position.

- Electric shock from faulty equipment.
- Restricted vision caused by needed safety gear such as welding helmets and safety goggles.
- Failure to fully understand the hazards, such as toxic fumes, when entering a pit, tank, or compartment.

HOW TO PREVENT TRIPPING AND FALLING

- Be alert, aware, and focused on the job and the work area; notice any changing conditions.
- Wear and use only the correct, approved equipment for the specific job; be sure it is properly installed and used.
- Do not carry things that obstruct your view or that upset your balance.
- Prohibit horseplay on the job.
- Follow all standard safe practices required by your employer.
- Keep the work area clean and neat – ask your supervisor for help if needed.
- Do not take chances or unnecessary risks – such actions cause accidents.

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Occupational Safety and Health Administration (OSHA). *Code of Federal Regulations*, Title 29 Labor, Parts 1910.1 to 1910.1450, available from the U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401; telephone: 800-321-6742; web site: www.osha.gov.

Mine Safety and Health Administration (MSHA). *Code of Federal Regulations* Title 30 Mineral Resources, Parts 1 to 199, available from the U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401; telephone: 202-693-9400; web site: www.msha.gov.

American Welding Society (AWS). *Safety and Health Fact Sheets*, published by the American Welding Society, 550 NW LeJeune Road, Miami, FL 33126; telephone 800-443-9353; web site: www.aws.org.



Protecting Against Falling Objects

NATURE OF THE HAZARD

Welding, cutting and associated processes often take place in areas where falling objects may be present. Falling objects may seriously injure or kill. Falling objects are common problems on construction and demolition sites, from buildings to bridges, and are often a problem during maintenance work. Even sparks, spatter, and cut-off pieces can fall.

HOW TO PROTECT AGAINST FALLING OBJECTS

- Wear approved head and foot protection (see Information Sources).
- Be alert and aware of your total work environment and any possible overhead objects before you start working.
- Place a safety net or equivalent below overhead work.
- Follow safe work practices when working below overhead activities.
- Notify others of overhead work and any changing job conditions.
- Remember, a welding helmet or goggles restricts vision and may prevent taking the action necessary to avoid falling objects.

- Post areas where falling objects are a hazard.

- Practice safe hot work procedures.

HOW TO PREVENT FALLING OBJECTS

- Be certain that material being welded or cut is secured from falling.
- Do not permit loose objects near the edge of overhead structures.
- Appropriately cover floor and wall openings. Floor hole covers must effectively support two times the weight of employees, equipment, and materials that may be imposed on the covers at any one time.
- Use toe boards with guardrails where work takes place near unprotected edges where materials could fall.
- Do not kick, throw, or push anything off overhead structures – this includes electrode stubs and scrap metal.
- Do not create falling objects for others – be alert to your actions.
- Use fire blankets to prevent, or catch, falling sparks, spatter, and hot pieces.

INFORMATION SOURCES

American National Standards Institute (ANSI). *Safety in Welding, Cutting, and Allied Processes* (ANSI Z49.1), published by the American Welding Society, 550 NW LeJeune Road, Miami, FL 33126; telephone 800-443-9353; web site: www.aws.org.

Occupational Safety and Health Administration (OSHA). *Code of Federal Regulations*, Title 29 Labor, Parts 1910.1 to 1910.1450, available from the U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401; telephone: 800-321-6742; web site: www.osha.gov.

Mine Safety and Health Administration (MSHA). *Code of Federal Regulations* Title 30 Mineral Resources, Parts 1 to 199, available from the U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401; telephone: 202-693-9400; web site: www.msha.gov.

American Welding Society (AWS). *Safety and Health Fact Sheets*, published by the American Welding Society, 550 NW LeJeune Road, Miami, FL 33126; telephone 800-443-9353; web site: www.aws.org.

National Fire Protection Association (NFPA). *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work* (NFPA 51B), available from National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101, telephone: 800-344-3555, web site: www.nfpa.org.

American National Standards Institute (ANSI). *Requirements for Protective Headwear for Industrial Workers*, Z89.1, available from ANSI, 11 West 42nd Street, New York, NY 10036-8002; telephone: 212-642-4900; web site: www.ansi.org.

ASTM International Standards, F2412, *Test Methods for Foot Protection*, and F2413, *Specification for Performance Requirements for Protective Footwear*, available from ASTM International, 100 Bar Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2559 (telephone: 610-832-9585; web site: www.astm.org). (Note: F2412 and F2413 have replaced the former ANSI Z41 standard, which has now been withdrawn.)

Safety and Health Fact Sheet No. 11

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Hot Work in Confined Spaces

NATURE OF THE HAZARD

Many different places require welding, cutting, and other hot work. Some of these places lack room and become "confined spaces." Confined spaces have the following characteristics:

- Limited space, entry, or exit.
- Poor ventilation – lack of safe breathing air and possible buildup of hazardous gases, fumes, and particles.

EXAMPLES OF CONFINED SPACES

Small rooms	Process vessels
Pits	Tunnels
Vats	Furnaces
Storage tanks	Pipelines
Sewers	Silos
Degreasers	Boilers
Reactor vessels	Utility vaults
Compartments of ships	Ventilation ducts
Unventilated room areas	Conveyers

REASONS FOR DEATHS AND SERIOUS INJURIES FROM HOT WORK IN CONFINED SPACES

- Fire
- Electric shock
- Exposure to hazardous air contaminants
- Explosion
- Asphyxiation

ACTIONS REQUIRED BEFORE APPROVING HOT WORK IN A CONFINED SPACE

- Determine if special training or a permit is required to enter the space.
- Open all covers and secure them from closing.
- Test atmosphere for:
 - (1) suitable oxygen content
 - (2) combustibles or reactives
 - (3) toxics

Note: The testing requires special equipment and training.

- Isolate lines by capping or double blocking and bleeding. Keep vents open and valves leak-free.
- Lock out/tagout all systems not required during hot work.
- Provide means for readily turning off power, gas, and other supplies from outside the confined space.
- Protect or remove any hazardous materials or materials which may become hazardous when exposed to hot work.

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REQUIRED ACTIONS DURING HOT WORK IN A CONFINED SPACE

- Continuously ventilate and monitor air to ensure fumes and gases do not exceed safe exposure limits.
- 29 CFR 1910.252(c) and 1926.353(c) require the use of local exhaust ventilation or supplied air respiratory protection when hot work is performed in a confined space where there is a potential for exposure to fluorine compounds (fluxes and rod coatings), zinc, lead, cadmium, or mercury. When beryllium is present, use both local exhaust and a supplied-air respirator.
- 29 CFR 1926.353(c) requires the use of local exhaust ventilation or supplied air respiratory protection when hot work is performed in a confined space where there is a potential for exposure to chromium or when Gas Metal Arc Welding is performed on stainless steel.
- Use NIOSH/MSHA (National Institute for Occupational Safety and Health/Mine Safety and Health Administration) approved breathing device when required by code.
- Keep unnecessary persons and equipment out of, and away from, the confined space.
- Do not allow equipment to block exit or rescue efforts.
- Place as much equipment as possible outside the confined space.
- Do not enter a confined space unless a watchperson, properly equipped and trained for rescue, is outside. Maintain continuous communications with the worker inside.

- When possible, provide means for readily turning off power, gases, and fuel from inside the confined space, even if outside turn-off means are provided.

INFORMATION SOURCES

American National Standards Institute (ANSI). *Safety in Welding, Cutting, and Allied Processes* (ANSI Z49.1), published by the American Welding Society, 550 NW LeJeune Road, Miami, FL 33126; telephone 800-443-9353; web site: www.aws.org.

Occupational Safety and Health Administration (OSHA). *Code of Federal Regulations*, Title 29 Labor, Parts 1910 and 1926, available from the U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401; telephone: 800-321-6742; web site: www.osha.gov.

Mine Safety and Health Administration (MSHA). *Code of Federal Regulations* Title 30 Mineral Resources, Parts 1 to 199, available from the U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401; telephone: 202-693-9400; web site: www.msha.gov.

American National Standards Institute (ANSI). *Safety Requirements for Confined Spaces* (ANSI Z117.1), available from ANSI, 25 West 43rd Street, New York, NY 10036; telephone: 212-642-4900; web site: www.ansi.org.

National Institute for Occupational Safety and Health (NIOSH) Respirator Rule. *Code of Federal Regulations*, Title 42 Public Health, Part 84, available from the U.S. Government Printing Office, 732 North Capitol Street NW, Washington, DC 20401; telephone: 800-356-4674; web site: www.cdc.gov/niosh.

Guide for Strengthening and Repairing Existing Structures

This is a free preview of an AWS technical standard.
AWS publications for your industry are available at
www.awspubs.com



American Welding Society



AWS D1.7/D1.7M:2010
An American National Standard

**Approved by the
American National Standards Institute
July 1, 2009**

Guide for Strengthening and Repairing Existing Structures

1st Edition

Prepared by the
American Welding Society (AWS) D1 Structural Welding Committee

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

This guide provides information on strengthening and repairing existing structures. Included are sections on weldability, evaluation of existing welds, testing and sampling, heat straightening, and damage repair.



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Guide for Strengthening and Repairing Existing Structures

1. General Provisions

1.1 Scope. This document contains basic information pertinent to the welded strengthening and repair of existing steel structures. The information contained in this guide is intended for both Engineers and Contractors with the purpose of providing direction and guidance to perform weld repairs, weld strengthening, and other weld procedures to correct problematic issues with existing structures. This guide contains background information that will be useful to the Engineer who is obligated under AWS D1.1/D1.1M:2008 Clause 8 to provide a comprehensive plan to address projects that involve strengthening and repairing of steel structures. The approach to the strengthening and repairing of these materials is to be developed using the information provided herein.

This guide is intended to apply to the strengthening and repair of existing structures made of the following materials:

- (1) Steel with a minimum specified yield strength of 100 ksi [690 MPa] or less
- (2) Cast iron
- (3) Wrought iron

Strengthening or repairing an existing structure includes modifications to meet new serviceability or load requirements as well as corrections made to repair conditions unsuitable for future use specified by the Engineer. The Engineer should prepare a contract for the work including, but not limited to, design, workmanship, inspection, acceptance criteria, and documentation. Except as modified in this clause, provisions of this guide should apply to the strengthening and repair of existing structures, including heat straightening of distorted members.

1.2 Limitations. This guide is intended to assist in the evaluation of existing structural elements and the development of appropriate procedures for repairing those elements. It does not provide exhaustive coverage of any specific topic.

This guide is intended to apply to the strengthening and repair of existing buildings and other structural systems. It is not intended to apply to:

- (1) Structures made of steels less than 1/8 in [3 mm] thick
- (2) Pressure vessels and pressure piping
- (3) Structures made of materials other than those listed under the scope
- (4) Seismic upgrades
- (5) New construction

Whereas this guide is not intended to apply the application outside the scope, the principles contained in this guide may be applied to other materials and applications. The Engineer is advised to use caution and engineering judgment for application outside the scope of this guide.

More importantly, it is critical to state here that this document does not provide detailed specific procedures and direction to correct any specific strengthening or repair operation regardless of how common or standard the procedure may be. Instead, information supplied herein as well as that material referenced in Annex A is intended to provide users with an overall approach to weld modifications as they pertain to: strengthening and repair; technical resources to develop