

Safe Welding, Cutting, and Hot Work Practices in the Petroleum and Petrochemical Industries

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Safe Welding, Cutting, and Hot Work Practices in the Petroleum and Petrochemical Industries

1 Introduction

1.1 Purpose

Gas and electric welding and cutting operations are important activities to support petroleum and petrochemical operations. Personnel engaged in these operations should have a thorough understanding of the duties they are to perform, and the potential hazards associated with the activity and materials involved. This recommended practice provides information to assist in the safe performance of welding, cutting, and other hot work activities to be done safely in petroleum and petrochemical operations. The understanding of potential hazards, and application of this knowledge, can help reduce the probability and severity of incidents and the risk of harmful health effects from those activities.

1.2 Scope

This recommended practice provides guidelines for safely conducting welding, cutting, or other hot work activities in refineries, gas plants, petrochemical plants, and other facilities in the petroleum and petrochemical industries. It includes specific guidance to evaluate procedures for certain types of work on equipment in service. Not included in the scope are:

- a) guidance for compliance with regulations or codes;
- b) hot tapping (it is the subject of API RP 2201);
- c) welding techniques, craft skills, or qualification of welders. While personnel doing welding and other hot work activities require a high degree of skill and shall be qualified for that work, the qualification process falls outside the scope of this document. Additional guidance relating to welding equipment, techniques, processes, and testing used in the chemical, oil, gas, and pipeline industries is provided by API RP 582 and API 1104;
- d) normal “safe work” practices, such as fall protection, PPE, slip/trip/fall, etc., that are common to all similar industrial work activities;
- e) entry or work in inert environments (see RP 2217A).

The principles and resources provided in this document are widely applicable. Some activities (such as oil drilling or offshore operations) may be subject to specific regulations or unique work requirements that should be considered when developing welding and hot work programs.

API RP 2009 intends to maintain consistency and compatibility with ANSI/AWS Z49.1, which provides much more detail on welding equipment, PPE, and certain procedures, and NFPA 51B, which focuses on fires and explosions, with guidance covering a broad spectrum of applications, including structures.

1.3 Retroactivity

Any provisions in this publication related to procedures or design are intended for new project reference, such as revising procedures or designing new facilities, or when considering major revisions or expansions. It is not intended that any recommendations in this publication be applied retroactively to existing facilities or evaluation of prior practice. This recommended practice should provide useful guidance when there is a desire or need to review programs or facilities.

1.4 Concept of Hazard vs. Risk

Materials such as gasoline or propane have properties such as flammability or toxicity that have the inherent ability to cause harm if not properly safeguarded. Flammability, toxicity, corrosivity, and stored chemical or mechanical energy are hazards associated with various industrial materials. Risk requires exposure. A hot surface or material can cause thermal skin burns and a corrosive acid can cause chemical skin burns, but these can occur only if there is contact exposure to skin. There is no risk when there is no potential for exposure.

Determining the level of risk involves understanding hazards and estimating the probability and severity of exposure that could lead to harm. While the preceding examples relate hazards to the risk to people, the same principles are valid for evaluating property risk. For instance, hydrocarbon vapors in a flammable mixture with air can ignite if exposed to a source of ignition, resulting in a fire that could damage property.

From the National Fire Protection Association (NFPA) *Hot Work Safety* fact sheet:

Ways to minimize hot work hazards:

- Use the “Recognize, Evaluate, and Control” process. This process is covered in NFPA 51B and focuses on the following:
 - Recognize: Determine if fire risks exist before hot work is started.
 - Evaluate: Determine if hazards are present, especially hazards that could fuel a fire (flammable and combustible liquids or gases and simple combustibles).
 - Control: Take appropriate steps to eliminate or minimize the hazards. The hot work permit helps the permit authorizing individual, hot work operator, and fire watch recognize potential hazards. Areas can be protected with the use of welding pads, blankets, or curtains, clearing combustibles from a 35-foot radius space around the hot work, or moving the hot work to an area free of combustibles.
- Identify alternatives to hot work. Hot work hazards can be avoided if there is an alternative method to complete the job. Some options include the following:
 - screwed or clamped piping (in water or air or other non-hydrocarbon service);
 - flanged piping;
 - manual hydraulic shears;
 - mechanical bolting or pipe cutting;
 - compressed air-actuated fasteners.

1.5 General Hot Work Process

The discussion of safe hot work in this publication follows the process flowchart shown in Figure 1. This chart shows a typical flow sequence for welding activities in the petroleum and petrochemical industries. Sections of this document that discuss those steps are indicated. Other facilities may have alternative workflow processes or may combine some steps.

TYPICAL HOT WORK ACTIVITY FLOW

For Equipment Not in Service

Reference Section

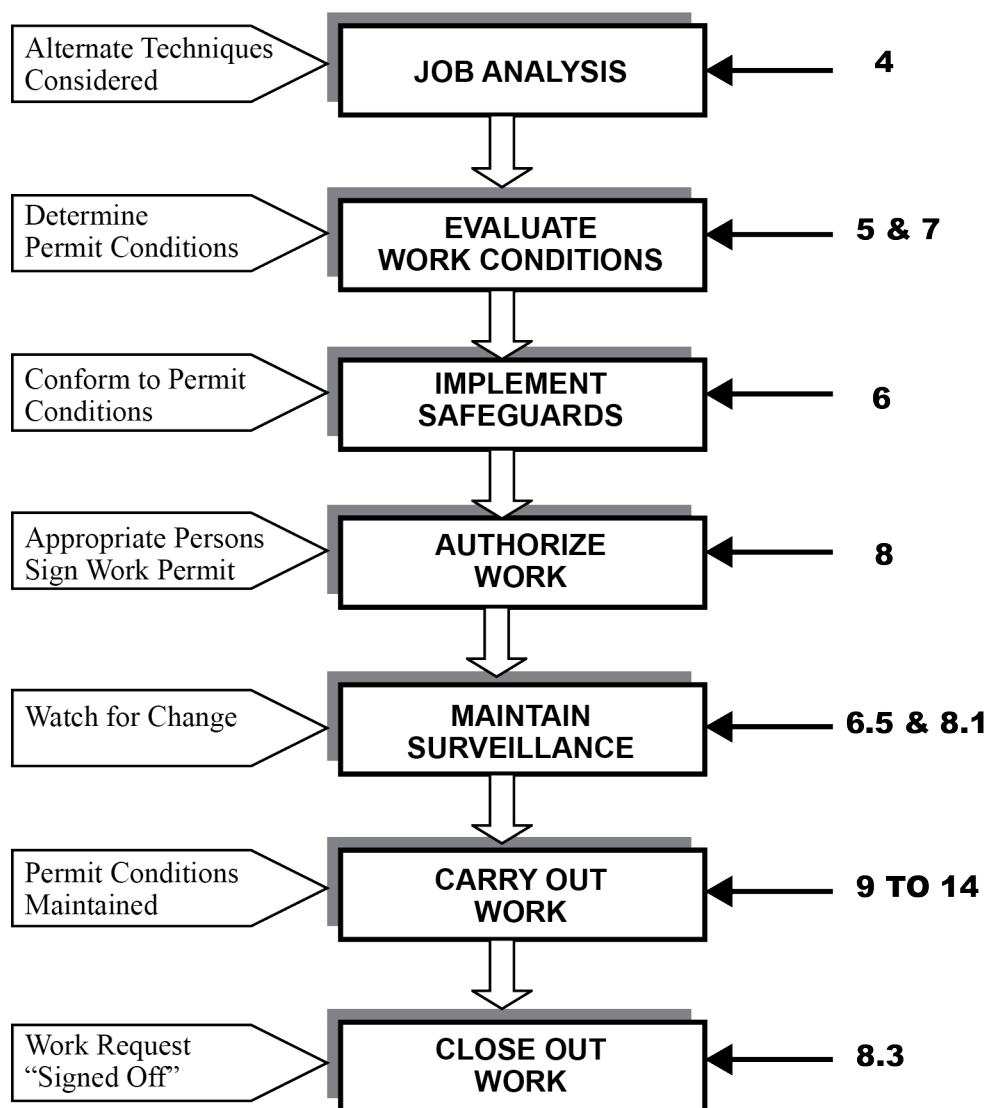


Figure 1—Typical Hot Work Activity Flow for Equipment Not in Service

2 Normative References

The publications listed in this section are specifically referenced in this publication. Additional relevant references are listed in the Bibliography.

API 510, *Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair and Alteration*

API 570, *Piping Inspection Code: Inspection, Repair, Alteration, and Re-Rating of In-Service Piping Systems*

API Recommended Practice 582, *Welding Guidelines for the Chemical, Oil, and Gas Industries*

API Standard 653, *Tank Inspection, Repair, Alteration, and Reconstruction*

API Standard 1104, *Welding of Pipelines and Related Facilities*

API Recommended Practice 2003, *Protection Against Ignitions Arising Out Of Static, Lightning, and Stray Currents*

API Standard 2015, *Safe Entry and Cleaning of Petroleum Storage Tanks*

API Publication 2027, *Ignition Hazards Involved in Abrasive Blasting of Atmospheric Storage Tanks in Hydrocarbon Service*

API Recommended Practice 2201, *Procedures for Welding or Hot Tapping on Equipment in Service*

API Publication 2207, *Preparing Tank Bottoms for Hot Work*

API Publication 2217A, *Guidelines for Work in Inert Confined Space in the Petroleum Industry*

ACGIH¹ *Threshold Limit Values TLVs® and Biological Exposure Indices BEIs®*

ANSI² Z49.1, *Safety in Welding, Cutting and Allied Processes (ANSI/AWS)*

ASSP³ *Guidelines for Hot Work in Confined Spaces*

AWS Safety and Health Fact Sheet 1, *Fumes and Gases*

AWS Safety and Health Fact Sheet 4, *Chromium and Nickel in Welding Fume*

AWS Safety and Health Fact Sheet 13, *Ergonomics in the Welding Environment*

AWS⁴ Safety and Health Fact Sheet 26, *Arc Viewing Distance*

AWS Safety and Health Fact Sheet 36, *Ventilation for Welding and Cutting*

AWS Safety and Health Fact Sheet 38, *Respiratory Protection Basics for Welding Operations*

ANSI/NB-23,⁵ *National Board Inspection Code (Section 23)*

NFPA⁶ 350, *Guide for Safe Confined Space Entry and Work*

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*

NFPA 70, *National Electric Code*

NIOSH⁷ Pub 88-110, *Criteria for a Recommended Standard: Welding, Brazing, and Thermal Cutting*

¹ American Conference of Governmental Industrial Hygienists, 1330 Kemper Meadow Drive, No. 600, Cincinnati, Ohio, 45240, www.asgih.org.

² American National Standards Institute, 25 West 43rd Street, New York, New York 10036, www.ansi.org.

³ American Society of Safety Professionals, 520 N. Northwest Highway, Park Ridge, Illinois 60068, www.assp.org.

⁴ American Welding Society, 8669 NW 36th Street, Doral, Florida 33166, www.aws.org.

⁵ National Board of Boiler and Pressure Vessel Inspectors, 1055 Crupper Avenue, Columbus, Ohio 43229, www.nationalboard.org.

⁶ National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169, www.nfpa.org.

⁷ National Institute for Occupational Safety and Health (NIOSH) Centers for Disease Control and Prevention (CDC) NIOSH/CDC, Patriots Plaza I, 395 E Street, SW, Suite 9200, Washington, DC 20201, www.cdc.gov/niosh.

NIOSH Pub 2005-149, *NIOSH Pocket Guide to Chemical Hazards*

OSHA 1910.146, *Permit-Required Confined Spaces*

OSHA 1910.147, *Control of Hazardous Energy (Lockout/Tagout)*

OSHA 1910.1000 (and following), *Subpart Z, Toxic and Hazardous Substances*

OSHA 1926.32, *Definitions [for OSHA Construction Standards]*

OSHA 1926.354, *Welding, Cutting, and Heating in Way of Preservative Coatings*

3 Terms and Definitions

For the purposes of this document, the following definitions apply.

3.1

acute hazard

Capable of causing effects occurring from exposure over a short time, usually within minutes or hours. An acute exposure can result in short-term or long-term health effects.

3.2

chronic health hazard

Capable of causing adverse health effects resulting from exposure over a long period of time (often at low-level concentrations).

3.3

competent person

A person identified by the employer as being capable of identifying existing and predictable hazards in the surroundings or working conditions that are unsanitary, hazardous, or dangerous to personnel, and who has authorization to take prompt corrective measures to eliminate them (OSHA 1926.32). The concept of “competent person” is performance-based relative to the context of the work to be done.

3.4

confined space

A space that is large enough and so configured that an employee can bodily enter and perform assigned work; has limited or restricted means for entry or exit (tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry); and is not designated for continuous employee occupancy. Further, “non-permit confined space” refers to a confined space that does not contain or, with respect to atmospheric hazards, have the potential to contain any hazard capable of causing death or serious physical harm [OSHA 1910.146(b)].

3.5

exposure limit

For chemical agents, a measure of the maximum airborne concentration limits for toxic substances to which workers may be exposed without protection (e.g., respirators). Exposure limits are usually expressed in parts per million or milligrams per cubic meter. Material safety data sheets (SDSs) from the manufacturer or supplier of the material should list exposure limits.

3.6

flammable and combustible range

A range of vapor-to-air ratios (between the LFL and UFL for a particular material) within which ignition can occur. These ranges can vary widely, as illustrated by flammable ranges for gasoline (1.4 % to 7.6 %) and acetylene (2.5 % to 100 %).

3.7

fume

Small-diameter particulate matter formed when vaporized high-molecular-weight materials condense from the gaseous state. Although solids, fumes are small enough to behave like gases.

3.8

hazard

An inherent chemical or physical property with the potential to do harm (flammability, toxicity, corrosivity, stored chemical or mechanical energy).

3.9

hot work

An operation that can produce enough heat from flame, spark, or other source of ignition, with sufficient energy to ignite flammable vapors, gases, or dust. Hot work includes such actions as electric arc and gas welding, chipping, flaming, grinding, gas cutting, abrasive blasting, brazing, and soldering. Special procedures and permits are required when hot work is to be performed in certain areas (Appendix D of ANSI Z49.1 lists more than 90 welding and allied processes that would qualify as “hot work”).

3.10

hydrogen blister

A bulge in steel caused by high-pressure molecular hydrogen trapped at an internal flaw within steel.

3.11

inerting

The process of eliminating the potential for a flammable atmosphere by using an inert gas such as nitrogen, carbon dioxide, or steam (water vapor) to displace oxygen required for ignition.

3.12

job hazard analysis

A technique that focuses on job tasks to identify hazards before they occur. It focuses on the relationship between the worker, the task, the tools, and the work environment. Ideally, after you identify uncontrolled hazards, you will take steps to eliminate or reduce them to an acceptable risk level.

3.13

lower flammable limit

LFL

The concentration of a vapor in air (or other oxidant) below which propagation of flame does not occur on contact with an ignition source. The lower flammable limit is usually expressed as a volume percentage of the vapor in air. It is sometimes called the lower explosive limit (LEL). In popular terms, a mixture containing a percentage of flammable vapor one below the LFL is too “lean” to burn.

3.14

lower explosive limit

LEL

The minimum concentration of vapor in air below which propagation of a flame does not occur in the presence of an ignition source.

3.15

permissible exposure limits

PELs

A legal limit in the United States for exposure of an employee to a chemical substance or physical agents such as noise. Federal regulations are set by the Occupational Safety and Health Administration and U.S. Department of Labor, and are found in 29 Code of Federal Regulations 1910.1000 and in the substance-specific standards that follow.

3.16**permit**

A written or electronic document authorizing a work activity and defining the conditions under which the work shall be conducted. It is normally signed by both the recipient and an issuing competent person with authority to allow the activity to take place.

3.17**personal protective equipment (PPE)**

Equipment (such as protective clothing, respiratory devices, protective shields, or barriers) worn or used by individuals to protect the eyes, face, head, and extremities from hazards of equipment, processes, or environment that are capable of causing injury or functional impairment.

3.18**purging**

The process of eliminating the potential for a flammable atmosphere by displacing hydrocarbons from a potential hot work area to eliminate the fuel required for ignition.

3.19**qualified person**

A person designated by the employer who, by possession of a recognized degree, certificate, or professional standing, or by extensive knowledge, training, and experience, has successfully demonstrated the ability to identify and solve or resolve problems relating to the subject matter, work, or project, and, when required, is properly licensed in accordance with federal, state, or local laws and regulations.

3.20**risk**

The probability of exposure to a hazard that could result in harm to personnel, property, the environment, or general public.

3.21**risk assessment**

The identification and analysis, either qualitative or quantitative, of the likelihood and outcome of specific events or scenarios with judgments of probability and consequences.

3.22**risk-based analysis**

A review of potential needs based on a risk assessment.

3.23**Threshold Limit Values****TLVs**

Recommended exposure limits published annually by the American Conference of Governmental Industrial Hygienists in Threshold Limit Values and Biological Exposure Indices®. (TLV is a registered trademark of the American Conference of Governmental Industrial Hygienists.)

3.24**upper flammable limit (UFL)**

The maximum concentration of a vapor in air (or other oxidant) above which propagation of flame does not occur on contact with an ignition source. The upper flammable limit is usually expressed as a volume percentage of the vapor in air. It is sometimes called the upper explosive limit (UEL). In popular terms, a mixture containing a percentage of flammable vapor above the UFL is too “rich” to burn.

3.25**welder**

The person operating gas or electric welding equipment; the person physically doing the welding. In some publications, this person is referred to as a welding operator.

4 Job Hazard Analysis

4.1 Job Analysis

The first step in the work process is establishing what needs to be accomplished and how the associated work is to be done. A work scope analysis should be performed to determine if alternatives to performing hot work activities exist within reasonable engineering and economic bounds. This is an appropriate time to consider alternative work procedures, such as cold cutting.

Factors to be considered in setting a priority for analysis of jobs include:

- accident frequency and severity: jobs where accidents occur frequently or where they occur infrequently but result in disabling injuries;
- potential for severe injuries or illnesses: the consequences of an accident, hazardous condition, or exposure to harmful substance are potentially severe;
- newly established jobs: due to lack of experience in these jobs, hazards may not be evident or anticipated;
- modified jobs: new hazards may be associated with changes in job procedures;
- infrequently performed jobs: workers may be at greater risk when undertaking non-routine jobs, and a job hazard analysis provides a means of reviewing hazards.

If, after the general work job hazard analysis review, hot work is indeed required, the following priorities conform to good practice and regulatory requirements:

- a) The work shall be moved to a safe area when possible and practical. Typically, this is an area specifically designated as safe for hot work, such as a maintenance welding shop or an outlying fabricating area.
- b) If the work cannot be moved, the review shall determine whether the fire hazards in the vicinity can be moved to a safe place, such as moving stored material out of the area while the welding is going on.
- c) If the object on which hot work is to be performed cannot be moved, and if all the fire hazards cannot be removed, physical barriers shall be used to confine the ignition sources (such as heat, sparks, and slag) and to protect the immovable fire hazards from ignition. In addition to safeguarding to prevent the hot work from igniting a flammable or combustible material, the hot work process must be done to safeguard the welder from hazards such as inhalation of welding fumes and flash burns to the eyes.

If the work cannot be done except by performing hot work in place, each activity should be closely analyzed for all hazards, such as the potential hazards discussed in this publication or on the SDSs relevant to the materials involved (see Section 5). Along with the safeguards in step c) above, this should minimize the risk that hot work may provide a source of personnel exposure or ignition hazards that could lead to a fire or explosion. The consequences of each hazard should be carefully weighed along with unexpected conditions that might occur during hot work.

Contingency plans should be in place in the event that an emergency occurs in the facility. This would include how the work would be stopped, when workers would remain in place during an emergency (such as to safe up a process opening), or any other stopped work actions necessary to safely conclude the hot work operations.

4.2 Review By Specially Qualified Persons

Work on certain types of equipment must be reviewed and approved by specially qualified persons before the job starts. Hot work, welding, or repairs on vessels, exchangers, and tanks typically require evaluation and approval by qualified persons. These might be experienced engineering personnel, pressure equipment specialists, or licensed inspectors. Typically, this review is used when there may be a requirement for more technical or