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

API RECOMMENDED PRACTICE 2009
EIGHTH EDITION, JANUARY 2021

For Committee Use Only

American
Petroleum
Institute

Special Notes

API publications necessarily address problems of a general nature. With respect to circumstances, local, state, and federal laws and regulations should be reviewed.

API is not undertaking to meet the duties of employers, manufacturers, or suppliers to warn and properly train and equip their employees, and others exposed, concerning health and safety risks and precautions, nor undertaking their obligations under local, state, or federal laws.

Information concerning safety and health risks and proper precautions with respect to particular materials and conditions should be obtained from the employer, the manufacturer or supplier of that material, or the material safety data sheet.

Nothing contained in any API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. Sometimes a one-time extension of up to two years will be added to this review cycle. This publication will no longer be in effect five years after its publication date as an operative API standard or, where an extension has been granted, upon republication. Status of the publication can be ascertained from the API Standards Department, [telephone (202) 682-8000]. A catalog of API publications and materials is published annually and updated quarterly by API, 200 Massachusetts Ave, Suite 1100, N.W., Washington, D.C. 20001.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API standard. Questions concerning the interpretation of the content of this standard or comments and questions concerning the procedures under which this standard was developed should be directed in writing to the API Standards Department, American Petroleum Institute, , 200 Massachusetts Ave, Suite 1100, N.W., Washington, D.C. 20001. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the general manager.

API standards are published to facilitate the broad availability of proven, sound engineering and operating practices. These standards are not intended to obviate the need for applying sound engineering judgment regarding when and where these standards should be utilized. The formulation and publication of API standards is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

For Committee Use Only

All rights reserved. No part of this work may be reproduced, stored in a retrieval system, or transmitted by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission from the publisher. Contact the Publisher,

AP! Publishing Services, 200 Massachusetts Ave, NW, Suite 1100, Washington, DC 20001.

Copyright © 2002 American Petroleum Institute

Foreword

This publication provides guidelines for the protection of personnel and property when performing welding, cutting or other hot work in the petroleum and petrochemical industries. This recommended practice distinguishes between normal hot work activities (such as in a welding or maintenance shop) and those which involve hot work on equipment in service and out of service in the field. It provides guidance for certain of these special "in-service" activities.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to assure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any federal, state, or municipal regulation with which this publication may conflict.

Suggested revisions are invited and should be submitted to the general manager of the API Standards Department, American Petroleum Institute, 200 Massachusetts Ave, NW, Suite 1100, Washington, DC 20001.

INFORMATION CONCERNING SAFETY AND HEALTH HAZARDS AND PROPER PRECAUTIONS WITH RESPECT TO PARTICULAR MATERIALS AND CONDITIONS SHOULD BE OBTAINED FROM THE EMPLOYER, THE MANUFACTURER OR SUPPLIER OF THAT MATERIAL, OR THE MATERIAL SAFETY DATA SHEET.

For Committee Use Only

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 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 requires a high degree of skill and those personnel 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, API 1104.

d) Normal "safe work" practices such as fall protection, PPE, slip/trip/fall, etc. which 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 which 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 that 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.

For Committee Use Only

1.4 Concept of Hazard vs. Risk

Materials such as gasoline or propane have properties such as flammability or toxicity with the inherent ability to cause harm, if not properly safeguarded. Flammability, toxicity, corrosivity, and stored chemical or mechanical energy all are hazards associated with various industrial materials. Risk requires exposure. A hot surface or material can cause thermal skin burns or 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 “Recognize, Evaluate, and Control” Process. One process to reduce hot work hazards is called “Recognize, Evaluate, and Control.” 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 flow chart 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.

For Committee Use Only

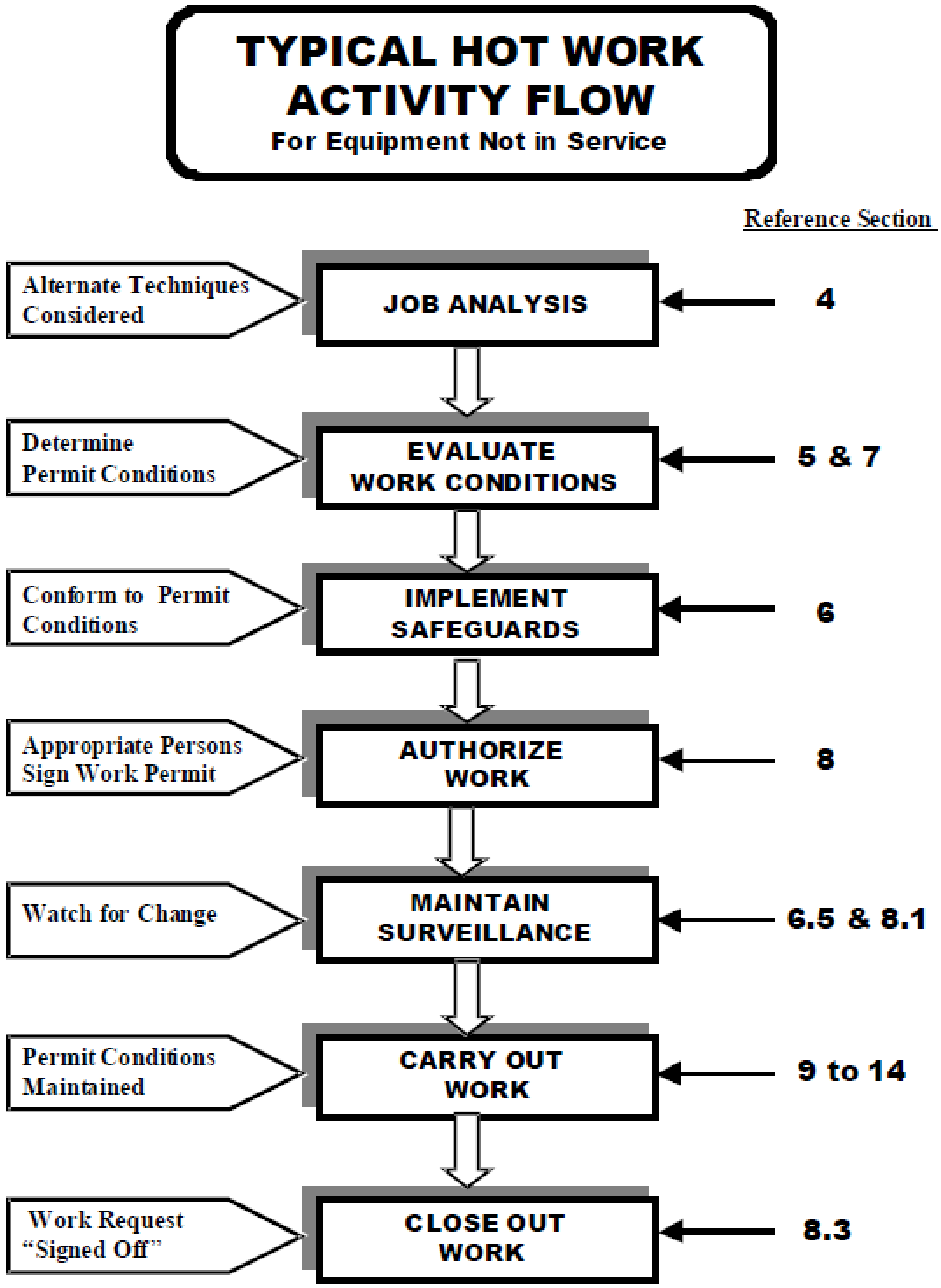

Figure 1—Typical Hot Work Activity Flow for Equipment Not in Service

2 Referenced Publications

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

API

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*

RP 582, *Welding Guidelines for the Chemical, Oil, and Gas Industries*

Std 653, *Tank Inspection, Repair, Alteration, and Reconstruction*

Std 1104, *Welding of Pipelines and Related Facilities*

RP 2003, *Protection Against Ignitions Arising Out Of Static, Lightning, and Stray Currents*

Std 2015, *Safe Entry and Cleaning of Petroleum Storage Tanks*

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

RP 2201, *Procedures for Welding or Hot Tapping on Equipment in Service*

Publ 2207, *Preparing Tank Bottoms for Hot Work*

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

ACGIH[1]

Threshold Limit Values TLVs® and Biological Exposure Indices BEIs®

ANSI[2]

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

ASSE[3]

Guidelines for Hot Work in Confined Spaces

AWS[4]

AWS Fact Sheet 26, *Arc Viewing Distance*

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*

AWS Fact Sheet 1, *Fumes and Gases*

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

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

For Committee Use Only

---

[1] American Conference of Governmental Industrial Hygienists, 6500 Glenway Avenue, Building D-5, Cincinnati, Ohio 45211, www.asgih.org.

[2] American National Standards Institute, 25 West 43rd Street, New York, New York 1036, www.ansi.org.

[3] American Society of Safety Engineers, 33477 Treasury Center, Chicago, Illinois 60694-3400, www.asse.org.

[4] American Welding Society, 550 NW LeJeune Road, Miami, Florida 33126, www.aws.org.

National Board[5]

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

NFPA[6]

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

70, *National Electric Code*

NIOSH[7]

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

Pub 99-115, *Pocket Guide to Chemical Hazards and Other Databases* (CD-ROM)

OSHA[8]

1910.119, *Process Safety Management of Highly Hazardous Chemicals*

1910.146, *Permit-Required Confined Spaces*

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

1910.251-7, Subpart Q, *Welding, Cutting, and Brazing*

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

1910.1200, *Hazard Communication*

1926.32, *Definitions [for OSHA Construction Standards]*

1926.350, *Gas Welding and Cutting*

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

3 Terms and Definitions

Terms used in this publication are defined in this section.

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.

For Committee Use Only

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

[6] National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269, www.nfpa.org.

[7] National Institute for Occupational Safety and Health (NIOSH) Centers for Disease Control and Prevention (CDC) NIOSH/CDC, 4676 Columbia Parkway, Cincinnati, Ohio 45226, www.cdc.gov/niosh.

[8] U.S. Department of Labor, Occupational Safety and Health Administration, 200 Constitution Avenue, NW, Washington, DC 20210, www.osha.gov.

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 which 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; and has limited or restricted means for entry or exit (for example 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” means 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%-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 things 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
Bulge in steel caused by high pressure molecular hydrogen trapped at an internal flaw within steel.

For Committee Use Only

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. Sometimes called 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 set by the Occupational Safety and Health Administration, U.S. Department of Labor, and found at 29 Code of Federal Regulations 1910.1000 and in the substance-specific standards which follow.

3.16
permit
A written document, or electronic document, authorizing a work activity and defining the conditions under which the work shall be conducted. 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 eyes, face, head and extremities from hazards of equipment, processes or environment 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 ability to identify and solve or resolve problems relating to the subject matter, the work, or the 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 which could result in harm to personnel, property, the environment or general public.

For Committee Use Only

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. 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 alternates 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. To help identify potential hazards, the job analyst may use questions such as these:

— Can any body part get caught in or between objects?

— Do tools, machines, or equipment present any hazards?

— Can the worker make harmful contact with moving objects?

— Can the worker slip, trip, or fall?

— Can the worker suffer strain from lifting, pushing, or pulling?

— Is the worker exposed to extreme heat or cold?

— Is excessive noise or vibration a problem?

— Is there a danger from falling objects?

— Is lighting a problem?

— Can weather conditions affect safety?

— Is harmful radiation a possibility?

For Committee Use Only

— Can contact be made with hot, toxic, or caustic substances?

— Are there dusts, fumes, mists, or vapors in the air?

NOTE This is not a totally inclusive list.

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 JHA 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, then 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, then 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 safety and health 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 which 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 would occur 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 engineering knowledge or a regulatory or code requirement. This review should be conducted as part of the job analysis.

For Committee Use Only

5 Hazard Evaluation and Risk Reduction

5.1 General

Hazards are inherent properties that relate to specific materials, activities or situations. While these properties cannot be changed, with knowledge of the hazards a hazardous material might be removed, activities restructured, or an alternate work approach substituted. Thus, an exposure-dependent risk can be reduced or eliminated. A careful job analysis (see 4.1) should be made of potential hazards and the operations to be performed prior to starting work. This will help determine the appropriate safeguards, required engineering controls and/or personal protective equipment necessary to perform the work.

This health and safety analysis can be part of the normal permit procedure.

The following sections discuss hazards (including employee physical safety and health concerns as well as fire safety) that could be associated with welding and hot work activities. Section 6 discusses additional risk reduction techniques. Special hazards both physical and health hazards are presented by abrasive blasting activities and special precautions and permitting requirements must be developed to safeguard those types of activities.

5.2 Physical Hazards

Many of the hazards present in the normal workplace exist in the welding environment. Normal use of workplace PPE and precautions against slip/trip/fall hazards are the same and are not addressed here. Although, they must be added in the workplace and as part of the hot work permitting process. Similarly, if work is done at heights, the facility (or organization) fall protection procedures and equipment should be used. Arc welding requires electric power, and work in confined spaces needs lighting. Suitable electrical work practices should be followed for whatever electrical equipment is in use, especially in wet or moist conditions (including perspiration) where there is potential for contact with metal parts which are "electrically hot" (see 5.11).

In the welding environment, especially in confined spaces, the work area is often congested because of the number of cables, hoses and lines required. While normal procedures are applicable, it is good to review the placement of equipment to reduce exposure to tripping hazards.

Because hot work and welding are heat-generating processes, there should be pre-job plans to use appropriate protective clothing to avoid thermal burns. Injuries have occurred due to sparks or hot metal falling into pockets, folds of rolled up sleeves, pants-cuffs or work boots. Frayed clothing is more easily ignited.

Eye and face injuries can be caused by flying particles, molten metal, liquid chemicals, acids or caustic liquids, or chemical gasses or vapors. Safe work practices should protect persons against falling sparks, chips and slag when working below welding being done at elevation.

5.3 Potential Acute Health Hazards and Risk Reduction

Acute health hazards affect people during or shortly after exposure. The effects may be transient or longer lasting. Typically, these short-term exposure effects are reversible when removed from exposure. Examples are irritation of the eyes or respiratory system caused by inhalation exposure over a short time to vapors, gases or from welding fumes. Although transient, these effects are undesirable and should be avoided.

Other materials used or stored in the hot work environment may represent acute hazards (such as hydrogen sulfide, chlorine, or ammonia) which could be released and reach personnel.

Even without this potential, the welding operation itself can create acute health hazards. Arc flash (ultraviolet radiation) can cause eye irritation or burns. Fumes from vaporized zinc (such as created while welding galvanized steel) can cause "metal fume fever." Work in hot environments can cause heat stress, and oxygen deficiency from any source can have acute effects.

Understanding and mitigating hazards, and preventing exposure using proper protective equipment and good ventilation are successful techniques for reducing personnel risk during welding.

For Committee Use Only

5.4 Potential Chronic Health Hazards and Risk Reduction

Chronic health hazards require repeated or extended exposure and may not evidence effects for a long time after exposure. Materials for which such exposures are of interest when welding are discussed in the following sections. The risk associated with welding fumes relates to inhalation exposure. Since welding fumes must be inhaled to constitute a risk the emphasis on monitoring, ventilation and respiratory protection become key factors in risk reduction.

Noise can be expected in the welding work environment. As in the non-welding work environment, good practice and regulatory requirements dictate precautionary attention to noise exposure and hearing protection.

Noise is a hazard to welders, and especially in confined spaces. Sources of noise include:

a) Welding machines.

b) Air movers.

c) Air compressors.

d) Some welding processes (such as air-arc cutting).

e) Power tools.

It may be possible to reposition equipment or personnel to reduce proximity to noise sources such as welding equipment, power sources, ventilation equipment, air compressors and process equipment. A hearing conservation program may be required depending on noise exposures.

Hearing protection should be a standard part of the personal protective equipment available for routine use during welding by welders and support personnel in the area. (For personnel working below welders, ear-muff type protectors have the added benefit of keeping sparks or slag from falling in their ears.)

Some studies have related cataracts to chronic exposure to UV radiation. This possible effect reinforces the wisdom of using proper welder's eye protection.

5.4.1 Welding Fume

The hazard associated with welding fumes involves the toxicity of their constituents and their concentration. The composition and quantity of fumes are determined by:

a) The materials being welded.

b) The composition of the electrodes or filler metals.

c) The process being used.

d) The presence of any coatings or paints (coatings should be removed for at least 4 in. from the area of heat application).

e) The circumstances of use (open environment or confined space).

Toxic fumes can be generated from welding on metals coated with (or containing alloys of) lead, zinc, cadmium, beryllium, chromium, manganese, nickel, and certain other metals. Some paints may produce toxic fumes when heated. The potential health effects vary in type and severity depending on many factors, and some effects can be serious. USA federal regulatory exposure limits are provided in OSHA 1910 Subpart Z (and following sections), while recommended exposure limits are provided by ACGIH TLVs and in NIOSH documents such as Pub 88-110.

Understanding the fume-generating potential of materials and processes being used provides the basis for atmospheric monitoring, ventilation and (when appropriate) choice of additional control measures such as air-supplied respirators. In some cases, alternate materials or welding processes may be used to reduce the potential for exposure

For Committee Use Only

and restrictive control measures. Reducing exposure to welding fumes can be achieved by following this suggested hierarchy of control:

a) Using alternate equipment, procedures or welding materials.

b) Using local fume-capture ventilation.

c) Using administrative controls to limit potential welder exposure.

d) Teaching welders how to minimize exposure (stay upwind and keep head out of plume).

e) Using personal protective respiratory protection.

Review of potential fume exposure should consider and provide appropriate protection for helpers or others working in the area. See American Welding Society's Safety and Health Fact Sheet 36.

5.4.2 Other Toxic Substances

Atmospheric testing and monitoring requirements should be determined by the job hazard analysis or maybe required by regulations or company requirements. Results of monitoring should satisfy each safety need through job design, engineering controls, procedural controls or other safeguards, such as personal protective equipment. Appropriate measures should be implemented to keep personnel exposures below OSHA Permissible Exposure Limits (PELs) and/or ACGIH Threshold Limit Values (TLVs). Persons evaluating atmospheres should consider both fire hazards and health hazards, using appropriate limits for each. Specialized monitoring and testing for health hazard materials are required if possibilities exist for exposures above the relevant limits. Personnel doing this testing should recognize that health-related exposure limits can be significantly lower than limits due to fire safety concerns. For example, the ACGIH time weighted average (TWA) for gasoline is 300 ppm, while the LFL would be 14,000 ppm (1.4%.)

5.5 Flammable Liquids, Vapors, Solids, or Dusts

Normally, the work area should be hydrocarbon vapor and gas free. Hot work should not be permitted:

a) While adjacent equipment that contains flammable liquid, vapor, solids, or dust is connected (without isolation) to the equipment on which welding is being done, or

b) Where adjacent equipment is being opened, disassembled, steamed, ventilated, or flushed of sediment without considering how such actions might affect the hot work.

Attention should be given to drums or other portable containers holding flammable or combustible materials. Hot work performed in areas where tanks are receiving flammable liquids or gases should be continuously monitored to ensure that the atmosphere is safe. In areas where hot work is approved, process operators should be made aware of the work in process and take necessary precaution to prevent release of flammable liquids or vapor until the hot work has stopped.

Under specific conditions, and with special review as discussed in Section 12, hot work may be performed on equipment in service containing hydrocarbon vapors or gases. Figure 2 in Section 12 is a flow chart outlining one approach for work on equipment in service. This is discussed in more detail in that section.

At many work sites with multiple hazards, management and health and safety personnel need to focus on identifying and communicating the health and safety hazards and risks in these situations. For example, on a job site you may have abrasive blasting, welding and coating tasks all taking place at the same time. We often focus on the individual tasks and hazards and focus on controlling the hazard for that task and the individual(s) involved. But on a busy job site there is typically numerous activities going on. Employers must protect their workers for the sum of the hazards on the job site regardless of which work group introduces a hazard.

For Committee Use Only

5.6 Combustible or Flammable Materials

Combustible materials should be removed from the work area or protected from welding sparks or slag. Noncombustible covers or "wetting down" are traditionally used (see 6.4). Wooden scaffolding and pallets are examples of vulnerable combustibles.

5.7 Ignition Sources

5.7.1 Welding Machines as Ignition Sources

Welding machines can be an ignition source and must be treated as such. Care must be taken to ensure that welding machines are properly grounded to the power source. With power from power lines, the electrical ground is tied in at the breaker box. For portable generator sets, the unit should be grounded locally to the frame. Portable generator sets can be staked to form an earth grounding system or grounded to a facility ground system. Welding cables should be bonded to the piece being welded to avoid stray currents. The welding machine and its electrical grounding connection should be located in an area free of flammable vapors or gases. Grounding and bonding should be consistent with the equipment manufacturer's instructions and applicable national and local electrical wiring codes (such as NFPA 70). Welding machines should be inspected before use to ensure that:

a) There are no frayed or broken wires.

b) All connections are tight, (Alligator clips should not be used to establish the bond or ground connection. The connection should be a securely attached bolting/clamping device) and

c) The machine functions properly.

Welding leads should be protected from insulation chafing and exposing the conductor. Potential areas of vulnerability include when passing through openings, across access ways, scaffolding, or other electrically grounded equipment or piping systems. Welding cables should be inspected at each contact point with grounded equipment, piping, etc., to prevent unwanted arcing at locations remote from the hot work being performed. When possible, cables should be located in manways or openings other than those being used for entry.

5.7.2 Other Ignition Sources

Any spark-producing or high-temperature object or activity can be a potential source of ignition. Motor vehicles, drilling, cutting, abrasive blasting and electrical equipment (including cellular or digital phones, two-way radios or digital cameras) should be evaluated before being allowed in an area where flammable vapors may be present. Static electricity can be generated by flow of fluids such as air and steam.

Bonding and grounding procedures along with the avoidance of non-metallic static-accumulating equipment are used to prevent static discharge. API RP 2003 provides guidance for prevention of static accumulation and discharge. API RP 2027 addresses ignition hazards associated with abrasive blasting.

5.8 Open Drain Systems

Hot work should not be permitted over drainage basins, separators, open ditches, streams, bayous or bodies of water where there is the potential for release of combustible or flammable materials upstream of the work which could flow downstream and reach the work area.

5.9 Wind

Hot work should not be permitted in areas into which flammable vapors could be blown, for example, from leaking process piping or equipment in adjacent areas or in the event of a pressure-relief valve discharging into the atmosphere. Wind can also carry sparks from hot work into process areas in close proximity and potentially ignite vapors (such as might be present from leaking flanges, valve packings, sewer catch basins, vents or gauging hatches). If combustible materials catch fire, they can produce embers which blow away and represent an ignition risk in other areas, sometimes at substantial distances.

For Committee Use Only

5.10 Equipment with Liners, Blisters, or Patch Plates

5.10.1 Lined Equipment and Trapped Hydrocarbons

Careful inspections must be performed, and special precautions taken on any vessels, tanks, piping, or other equipment, which is lined, and which could have void spaces (e.g., vessels with stainless steel liners). This inspection should ensure that no product or vapors are trapped between the layers. This includes situations involving equipment like tanks with double bottoms, fiber-glass-lined tanks, double-walled tanks and piping, single bottom tanks whose contents may have leaked onto their foundation and tank roof supports which may have product inside them (see 10.3). These areas should be drilled and checked. If found to contain flammable or combustible materials, they should be purged or inerted prior to and during hot work (see 6.2.1 and Appendix B).

5.10.2 Hydrogen Blisters

If equipment inspection identifies hydrogen blistering, then the proposed work warrants special review before conducting hot work in the area. The blisters themselves may represent a personnel hazard since they can contain hydrogen at very high pressure. Hydrogen blistering may be accompanied by other equipment damage phenomena such as hydrogen induced cracking (HIC). Historically, equipment in contact with amines, hydrogen fluoride or "sour" (hydrogen sulfide containing) materials has been susceptible to HIC or hydrogen blistering. These phenomena appear more often in areas which have been welded. Evaluation by a qualified person (such as a metallurgist) should be included in a determination of whether it is safe to continue hot work as many factors are involved. Nondestructive examination may be useful as part of this evaluation. If a qualified person determines that it is safe to continue, then one traditional approach has been to vent hydrogen blisters by drilling with non-sparking tools prior to any hot work.

5.10.3 Patches

Equipment with patch plates should be inspected to be sure the patch plate has not leaked product into the void between the patch plate and the equipment pressure boundary prior to any hot work being performed on the patch plate.

5.11 Electrical Hazards to Personnel

Safe work practices and procedures should be implemented to reduce electrical hazard exposure for personnel, along with the precautions discussed in 5.7.1 to prevent electrical sources of ignition. These include:

a) Keeping the work area as dry as possible (which may not be possible where the area is kept wet to reduce potential for ignition).

b) Insulating the welder from work and ground using dry insulation (rubber mat or wooden platform).

c) Wearing dry, hole-free gloves when welding or handling electrical equipment.

d) Avoiding contact with (touching) the electrode holder or other "electrically hot" parts with bare hands.

e) Keeping electrode holder, cables and insulation in good condition, and withdrawing from service all defective equipment.

f) Keeping electrical leads and cables out of water and protected from mechanical damage. (Some facilities use temporary supports to elevate cables.)

g) Use of GFCI where water is present (when appropriate for the equipment being served).

6 Implementation of Safeguards

6.1 General Concepts of Safeguards and Risk Reduction

The evaluation of the work conditions should identify potential hazards. Hot work can be conducted safely when hazards are recognized, and proper procedures are used.

For Committee Use Only

Implementation of safeguards based on this evaluation aims to protect against exposure to potential hazards. These safeguards include:

a) Knowing hazards in the work area.

b) Reviewing SDSs when questions arise regarding materials being used.

c) Sharing hazard information with all affected personnel. Affected workers are all personnel who are performing work authorized by the hot work permit and others in the immediate area of the hot work.

d) Using a rigorous and detailed Hot Work Permit System.

e) Posting permits where required by procedures.

f) Adhering to site-specific safe work conditions, including use of engineering controls, ventilation and site preparation, including flammable or combustible location.

g) Protecting personnel physical safety (fall protection, lockout/tagout, personal protective equipment).

h) Preventing employee exposure to chemical substances and physical agents (monitoring, controlling environment, PPE).

i) Avoiding unintended oxygen deficiency (work location, monitoring, ventilation).

j) Preventing uncontrolled ignition of flammable or combustible materials.

   — maintaining containment of flammables

   — eliminating ignition sources (see 5.7)

   — controlling access to the work area

   — using continuous monitoring in areas with higher risk of flammable vapor release

   — Becoming familiar with the equipment and the instructions for use.

6.2 Equipment Purging and Ventilation

6.2.1 Purging

Purging is usually used to decontaminate smaller confined spaces. One approach uses air, steam or inert gas from an electrically bonded hose, blown through an opening into the enclosed space and vented out another opening. Typically, an electrically bonded vent is used to remove the vapors. Placement of the exhaust vent should avoid work areas. Inert gas or steam is preferred. If air is used for purging a fuel-rich space, there is a high probability that a flammable mixture will be formed. Special risk mitigation and management approval should be considered prior to this practice being used. Steam can be used to purge equipment prior to starting work.

Once the purge has been removed care must be taken to assure that the space does not pull contaminates back inside as it cools (see Appendix B.2).

Another purging approach uses dry ice placed in the enclosed space. As the ice sublimes, it releases carbon dioxide which can dilute and displace both air and vapors. This avoids static electricity concerns.

Water displacement can also purge a space. Water is directed into the confined space until it fills the volume, displacing any flammables (unless they are trapped in spatial subdivisions). This method is generally effective but brings with it the need to address environmental concerns associated with water disposal.

There is potential for continued release of hydrocarbon vapors from sludge or pockets in corroded metal. This reinforces the importance of continued monitoring and ventilation after purging.

For Committee Use Only

6.2.2 Dilution Ventilation

Ventilation for welding, cutting and other hot work operations aims to minimize the worker's exposure to hazardous fumes, gases, and vapors while maintaining a non-flammable work environment. Dilution ventilation adds fresh air to the work environment while removing contaminated air. Natural ventilation may be sufficient in some outside work. Mechanical (or forced) ventilation is almost always needed in confined spaces. The OSHA requirement for dilution air ventilation is 2,000 cfm for each welder.

Mechanical ventilation requires an air mover. Typically, these are either fans or venturi devices. Although "explosion-proof" electric fans are commercially available, most facilities prefer air- or steam-driven equipment. Since there is no electricity, this eliminates any possible personal or ignition hazards should there be difficulties or deterioration of the equipment. Removing the electrically driven device removes the hazards of electricity but does not eliminate any possible static electricity hazards.

Where possible, the air mover should be mounted in a position to move vapors or fumes away from all working personnel. When ventilating to eliminate flammable vapors, the preferred method is to blow air into the confined space. This is more effective in mixing the confined space contents and achieving more uniform contaminant removal. Venting at the top of vertical vessels (such as tanks) is preferred to reduce the possibility of exposure to personnel working at ground level and to maintain flow of potentially hazardous or flammable vapors away from workers in the confined space. Flowing air generates static electricity. The air movers should be bonded to the confined space container and both should have a good electrical path to ground. If non-metallic fans or ducts are used, they should be designed to be electrically conductive.

6.2.3 Local Ventilation

Local exhaust ventilation is sometimes used for fume capture and control. In general, local ventilation is more suitable for use in shops or non-confined spaces. This approach uses relatively high velocity airflow at (or very close to) the hot work. Fume capture requires 100 cfm of airflow at the site of the fume generation. To achieve this the ventilation duct pickup must be within one or two duct diameters from the work. Some types of welding equipment is designed with "built in" local exhaust ventilation. However, this increases the size of the equipment and makes portable equipment more cumbersome to use. For this reason, local ventilation is more frequently used on fixed or automated equipment. Local ventilation is only suited to some welding technologies. See Safety and Health Fact Sheet No. 36.

6.3 Protection of Personnel

Taking appropriate action during (or before) hot work operations can protect personnel from potential and actual safety and health hazards. Table 1 describes some approaches. See AWS Safety and Health Fact Sheet 13.

For Committee Use Only

Table 1—Welding Hazards and Possible Protection

Hot Work or Welding Hazard	Possible Protection
Skin burns from hot metal, sparks, slag, hot chips, and welders flash (UV radiation).	Long sleeve shirts and pants (without cuffs), welders' aprons, neck protection, fire-retardant clothing[a], and ear protection if welding is being done overhead.
Heat stress or radiation skin burns (infrared radiation).	Heat-barrier clothing for welder. Barriers between welding and personnel. Additional distance between the work and personnel
Flying particles during chipping and slag removal.	Safety glasses, face shields, ear protection.
Ultraviolet light rays from electric welding.	Welders' helmets, face shield or goggles for personnel in close proximity (including welder's helpers). See ANSI Z49. Additional distance between the work and personnel See AWS Safety and Health Fact Sheet No. 26
Welding fumes. See 5.4.1.	Use of alternate materials and electrodes; ventilation; respiratory protection. See AWS Safety and Health Fact Sheet No. 1
Other toxic substances. Lead paint. Materials used in area.	Use of alternate materials; ventilation; respiratory protection; paint removal; chemical containment control.
Oxygen deficiency or hazardous gas accumulation in poorly ventilated spaces.	Move work to less confined location. Provide adequate ventilation. Continuous area or personal gas monitoring. See AWS Safety and Health Fact Sheet No. 38
Setting combustible materials, oil-soaked insulation or workers' outer clothing on fire from sparks or slag.	Surveillance and work environment control. Use of spark containment (i.e., welding boxes). Removal/relocation/protection of any flammable/combustible materials near the hot work site (e.g. NFPA 51B requires this be done for a 35 ft. radius.)
Oxygen or gas from welding equipment leaking into confined spaces.	Disconnect hoses from gas source when not in use, store compressed gases outside of confined space. Continuous oxygen level monitoring
Oxygen content rising to unsafe levels in inerted confined spaces.	Continuous oxygen level monitoring.
Accumulation of flammable vapor or gas.	Locate work to avoid low spots; ventilate; remove sludge and corroded metal "pockets"; flammable gas monitoring.
Ignition of flammable materials from or in catch basins, drainage ditches, containment basins or separators.	Relocate work; cover potential sources; flush hydrocarbons away with water; flammable gas monitoring.
Toxic coating exposure.	Strip away sufficient coating to bare metal, such that no fume can be generated from hot surfaces (OSHA 1926.354).
Flash fire (from potential ignition of hydrocarbons).	Flammable vapor monitoring; fire-retardant clothing.
Ignition of temporary anti-contamination protective clothing.	Use of fire-retardant anti-contamination clothing appropriate for welders.
Ignition of "fire blankets" or tarpaulins.	Use of welding blankets of known fire-resistant performance. Replacing oil-contaminated tarps and blankets.

[a]It should be noted that some synthetic fiber garments which function for protection against flash fire exposure may be penetrated by hot particles and alternative protection may be needed for welders.

For Committee Use Only

6.4 Safeguards Against Ignition Hazards

The following precautions have been used successfully as safeguards against ignition. Whichever precautions are chosen should be in place before welding, cutting or other hot work is performed.

Above or near surfaces contaminated with hydrocarbons or other potential fuels (including combustible materials), the area should be:

a) Wiped clean and flushed with water, or

b) Steam cleaned, or

c) Covered with clean dirt or sand, or

d) Protected by other precautions which isolate fuel contaminated surfaces from ignition sources.

Tarpaulins are traditional tools to help make areas fire safe. However, tarpaulins made of traditional materials can burn. Covers specifically intended for use as “fire blankets” should be used. A U.S. Department of Energy facility performed a series of temperature tests on over 50 samples of fire blankets after an incident prompted concerns related to “off gassing” when fire blankets were directly impinged by a welding torch flame. They concluded with a preference for fire blankets made from silica or glass fibers which had low off-gassing and which may melt—but not burn—when contacted by flames, welding slag or splatter. Similar conclusions were reached by industrial facilities where hot metal contact caused holes in some fabrics.

Holes in the ground or cracks in pavement should be protected in a manner similar to hydrocarbon contaminated surfaces by:

a) Flushing.

b) Covering.

All sewer manholes and catch basins in the vicinity of the work area should be covered, plugged, isolated or secured:

a) To prevent hydrocarbon vapors or gases from exiting the sewer or drain and reaching an area of hot work.

b) To prevent sparks from getting into the sewer.

A catch basin equipped with a trap should be flushed continuously with water.

If sewer manholes or drains are covered in preparation for hot work, the covers must be removed when the work has been completed or if work stops at the end of the day or shift. If the work is not completed, the covers must be replaced before work starts again.

If wood scaffolding or other combustibles are being used or are in the area, appropriate precautions should be taken to protect them against ignition. Covering with fire resistant blankets or periodic wetting with water are techniques sometimes used. Welding in process areas should be done within the confines of a welding box constructed of fire-resistant materials in a manner to contain sparks, block the view of the welding arc from passersby, and isolate any nearby combustible fuel source from the welding operation. Welding curtains are commercially available. Traditional curtains are opaque and stop both ultraviolet and infrared radiation. Some are transparent and stop ultraviolet radiation better than infrared. Both are expected to contain sparks. Grounding of metallic hose nozzles can reduce the potential for static electricity discharge generated by flow of fluids such as air and steam. This is especially significant if these hoses are used to purge confined spaces containing hydrocarbons.

6.5 Fire Watch Personnel

Use of a properly trained and equipped fire watch should be considered whenever hot work is performed. At a minimum they should be used when hot work is performed in locations where flammable vapors or gas may be present, where fire might develop from igniting flammable or combustible liquids, or combustible materials (wood, cardboard, paper, plastic), or when special conditions may warrant the use of fire watch personnel. The person assigned as a fire watch

For Committee Use Only

shall have no other duties that would distract from the primary safety surveillance and response function (monitoring for change); observing general safety in the immediate work area is acceptable. One should consider having fire watch personnel wear special vests or clothing so that they can be easily recognized. Fire watch personnel equipment and knowledge shall include:

a) Understanding and being able to recognize hazards.

b) Having appropriate functional fire extinguishing equipment readily available.

c) Being trained in the equipment's use and incipient firefighting.

d) Being familiar with facilities for sounding an alarm in the event of a fire.

e) Being able to communicate effectively with the workforce.

Fire watch duties include:

a) Watching for fires in all exposed areas.

b) Trying to extinguish a fire only when obviously within the capacity of the equipment available.

c) Sounding the fire "alarm" when available equipment is not sufficient to suppress a minor fire; in accordance with facility procedures this may include activating the Emergency Response System using a handheld radio or other communications device.

d) Maintaining a watch for at least 1/2 hour to 1 hour after completion of welding/cutting or other hot work until the area has been inspected and found to be free of fires or smoldering materials.

New NFPA 51B updated requirements

A study by the NFPA which is outlined in the annex of NFPA 51B highlight many large fires which were caused by hot work as the ignition source. Most of the incidents involved Class A type ignition materials, not Class B ignition materials as are found in a petrochemical facility. When the permit is issued and the conditions of work set, the risk associated with the hot work and the surrounding workplace shall be assessed and how long the fire watch should be maintained shall be determined.

This RP suggests that "Maintaining a watch for at least 30 minutes to 1 hour after completion of welding/cutting or other hot work or until the area has been inspected and found to be free of fires of smoldering materials"

Additionally, NFPA 51B now includes a "Fire monitoring option as outlined in the definitions (3.3.1) and outlined when the fire monitoring should occur (5.6.3) The fire monitoring function is set-up when the permit issuer considers that additional monitoring of the area should occur beyond the fire watch duties after the job is completed.

7 Testing and Monitoring for Hazards

7.1 Flammability Testing

7.1.1 A competent person using an appropriate combustible-gas detector should perform tests to determine flammable vapor concentrations before hot work is started. An oxygen reading is needed before doing flammability testing for confined spaces. As discussed in 7.2, low oxygen levels (below about 10%) can cause combustible gas test instruments to give false readings. Combination oxygen/combustible test equipment is commercially available and in wide use.

7.1.2 A combustible-gas detector will detect hydrocarbons only in the vapor phase and may not detect the presence of oils with flash points substantially above ambient temperatures, such as gas oil or distillates and other hydrocarbons sometimes found in catalyst beds during unit shutdowns. The heat generated by hot work may vaporize such hydrocarbons and introduce a previously undetected hazard. Such materials must be found and removed before cutting or welding is started. If steam is used for decontamination of a confined space, then detector tests should be

For Committee Use Only

conducted only after steaming operations have been completed so steam vapors will no longer affect detector results. Tanks, vessels and piping that have been steamed should be checked to assure that flammable vapors have not been drawn back into them as they cool. Nitrogen, argon, steam and hot gases may affect some types of combustible-gas instruments, possibly causing inaccurate readings. Calibrating meters with incorrect calibration gas and/or not applying appropriate correction factors will also cause inaccurate readings.

7.1.3 The surrounding area and equipment and containers that might contain flammable vapors must be thoroughly checked, even if such equipment has been steamed, flushed, or otherwise cleaned. All hydrocarbon vapors (other than methane) are heavier than air at ambient temperature. Gas testing should include all low points (such as sumps, drains, liquid boots) and all confined areas (such as floating roof pontoons on aboveground storage tanks, piping and vessels). Long runs of piping should be tested at multiple locations. The combustible gas detector must be properly maintained, adjusted, and calibrated.

7.1.4 Portions of equipment which seal flammable materials can have higher potential for leaks and may warrant special monitoring attention. These include flanges, valves, pump seals and clamps on lines.

7.2 Oxygen Testing and Monitoring

The oxygen percentage in the atmosphere being tested has significance because:

a) Procedures and protection for workers depend on oxygen level. (As noted in 9.2, if the oxygen level varies from normal atmospheric, the reason should be investigated.)

b) Many combustible gas detectors require a minimum of about 10% oxygen to provide proper readings.

Anytime the possibility exists for an oxygen-deficient atmosphere the oxygen level could be below the level required by the instrument manufacturer to give a correct flammability reading. This could occur where a tank, vessel, or piping has been purged with (or contains) an inert gas such as nitrogen or carbon dioxide. An oxygen reading must be taken using a properly maintained and adjusted oxygen meter before the flammable vapor test. Consult the instrument manufacturer’s literature for information for the specific test equipment being used.

If a test registers an excess or lack of oxygen or the presence of vapors resulting in a measurable LFL reading, work should be stopped immediately, and the source of vapor or oxygen variance should be located and controlled.

The hot work permit should specify the type and frequency of testing (see 8.2).

7.3 Testing and Monitoring for Toxic Substances

Monitoring for potential presence of toxic materials should be based on the job analysis. Review of SDSs for materials used or stored in the proposed work area may indicate the possible presence of materials with defined exposure limits.

In this case, evaluation of the work environment should be done before work starts. If the area is free of such materials, then the job analysis should determine what monitoring is required based on the composition of the base metal, electrodes, and any solvents, fluxes or coatings. Prior monitoring data for the same work may be used to characterize potential exposures if the job hazard review indicates comparable conditions. For similar (but not comparable) operations, confirming industrial hygiene monitoring should be conducted. See AWS Safety and Health Fact Sheet No. 4. Frequency of Monitoring the Atmosphere

Periodic combustible gas and oxygen retests (or continuous monitoring) may be required while hot work is proceeding; this is always important and especially for work in a confined space. The permit should specify the monitoring frequency.

8 Hot Work Permits

8.1 General

Petroleum and petrochemical facilities typically use a formal system to authorize and control all covered hot work. These work authorization systems normally require a written hot work permit before doing any welding or spark

For Committee Use Only

producing work in areas processing, using or storing flammable or combustible materials. The permit process should indicate who is responsible for inspecting the work site, conducting gas testing, and approving the permit allowing hot work to be done.

Authorization of hot work permits should be vested in designated "competent" personnel and include those in charge of operating the affected process or storage equipment. Operations personnel should immediately notify workers engaged in hot work of actual or imminent changes in conditions which may endanger their safety so that the hot work can be stopped (e.g., a release of material from a pressure-relief valve). This field-level "Stop Work Authority that every person has" ~~philosophy~~ should be emphasized in permit procedure training.

A hot work permit normally is not required for work done in designated "hot work" areas such as maintenance welding shops or outlying fabricating areas which are separate from areas where hydrocarbons may be present. However, NFPA statistics record a history of fires in these work areas. This suggests that designated areas should be checked periodically to confirm that the "safe for hot work" status hasn't changed.

8.2 Permit Requirements

Except in areas specifically designated as safe for hot work, a hot work permit shall be obtained before starting any work that can involve a source of ignition. (Equipment such as vessels and piping should be gas free and cleared of potentially toxic substances and liquid hydrocarbons before being brought into weld shops or the designated safe areas.) Particular care must be taken for equipment that has voids and boxed areas that may still be contaminated. Each hot work permit should state precautions necessary for the specific job.

The permit shall be documented (written or electronic) and should include the following information and conditions:

a) The equipment on which work is to be performed and the location of work.

b) Identification and location of relevant SDSs (where appropriate).

c) The type of work to be performed (e.g., cutting, welding, grinding).

d) The protective equipment and protective measures required, including rescue equipment for work in confined spaces.

e) Standby fire protection equipment and/or personnel required.

f) The area/equipment required to be tested with an oxygen and combustible gas detector and, if required, tested for toxic materials, plus the test results.

g) Frequency of atmospheric testing and whether continuous monitoring is required.

h) Any special precautions which are necessary to complete the job safely, including conditions for stopping work.

i) Indication that affected personnel have been notified.

j) Signatures of authorized individuals including (as a minimum) the competent person issuing the permit.

k) Signature of the permit recipient (who in some instances may be a contract worker).

l) The date and time the permit was issued.

m) The permit's expiration date and time.

If hot work is to be performed in a confined space, the confined space permit should be supplemented or combined with a hot work permit in accordance with facility and regulatory requirements. In some facilities, two permits are required, one for the hot work and one for the confined space entry.

Once the safe work procedures and permit requirements and conditions have been determined, and before the permit is issued, a careful hazard analysis and inspection shall be made (see Section 5). This shall include oxygen and

For Committee Use Only

flammable vapor tests (see Section 7), to determine that unconfined flammable vapors or gases or combustible materials are not present in the work area or equipment and that no reasonable probability exists of any such material entering the area while hot work is performed. The authorizing individual, who must be a competent person, may then issue a permit for the work to proceed. The permit system should provide a mechanism for adequate communication if several work groups are involved in the work process. A copy of the permit shall be kept on site until the work is completed or as required by applicable regulations (for instance, Cal-OSHA historically has required 6 months retention of hot work permits). OSHA standards (29 *CFR* 1910.147) address specific requirements for written procedures associated with locking out and tagging out equipment and other energy sources.

CAUTION: The fact that a permit has been issued for the performance of certain work does not relieve those doing the work of their personal responsibility and accountability for the safe execution of their assigned tasks in accordance with permit requirements. If any unsafe condition arises, work should be stopped, and the condition reported immediately.

8.3 Issuing and Closing Out the Permit

Facility procedures often require the responsible personnel (competent person) to issue the hot work permit to welders and other hot work personnel at the physical job site where the work is to be done. This provides the following benefits:

a) The welders/hot work personnel know who is in charge of the equipment and can ask equipment related questions.

b) The operating personnel know who is working on their equipment.

c) The specific equipment to be worked upon can be identified.

When the work is completed, a follow-up job site visit should be done by operations and craft personnel to see that:

a) The work is complete, and

b) That no safety hazards have been introduced during the work activity.

c) The site has been appropriately cleaned and is ready to return to operations. This includes removal of covers from sewers and drains. See 6.4

8.4 Interrupted Work

For situations where the work is delayed or suspended in an area that has previously been pronounced gas-free, the permit system shall specify the length of time beyond which oxygen and flammability detector tests must be repeated or the permit reissued. Work for which permits have been issued but not started within a prescribed time may need to be rechecked and repermitted before work begins. Some petrochemical businesses require reissuing of the hot work permit, if work is interrupted for more than 1 hour. Permits should be reissued or updated with the needed rechecking of conditions including oxygen, toxics and flammability tests anytime the work is stopped due to unplanned disruptions such as an emergency, power failure or injury to workers in the area.

8.5 Extending the Permit

When it is necessary to continue the work beyond the original designated permit expiration time, an authorizing individual on each succeeding day or shift shall ensure that conditions are satisfactory for work to continue and may then reissue or extend the permit. If conditions have changed, it may be necessary to issue a new permit or amend the existing permit. Permits which involve “permit-required confined space entry” or “Lockout/Tagout” or are in areas covered by Process Safety regulations may have specific regulatory requirements for extension or reissuance. Extensions should conform to any relevant state or local codes and requirements.

For Committee Use Only

9 Hot Work in Confined Spaces

9.1 Confined Space Entry

If hot work requires entry into a confined or enclosed space, the permit system should address both the potential hazards of entry and of doing hot work in a confined space/enclosed space. OSHA "permit-required confined-space entry" procedures (29 *CFR* 1910.146) frequently apply. Reviews of regulatory requirements for confined space work should ensure that the proper regulation is consulted (for instance, marine or Coast Guard confined space regulations differ in detail from those used for general industry). Before entry and during work, the atmosphere inside should be repeatedly monitored as well as continuously purged using an appropriate air mover if natural ventilation is inadequate.

NOTE Working in an inert confined space involves a highly hazardous environment. This work can be accomplished safely only if very special procedures and precautions are followed. Such work is outside the scope of this document; guidance for work in an inert atmosphere is provided in API RP 2217A.

Further, "non-permit confined space" means 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.

NOTE NFPA 350 details recommendations involving hot work in confined spaces.

9.2 Oxygen Content in Confined Spaces

Although some U.S. OSHA regulatory provisions cite oxygen levels of 19.5%–23.5% as permissible, further consideration is warranted. When the oxygen percentage of air in the vicinity of workers differs significantly from general ambient levels the person doing the monitoring should determine why, or alert the hot work operator, then the permit authorizing individual in addition to determining the cause of the of the deviation in oxygen percentage. . OSHA 1910.134(b) states that an Oxygen Deficient Atmosphere means an atmosphere with an oxygen content below 19.5% by volume. Lower-than-ambient oxygen concentration may warn of the presence of toxic or flammable air contaminants. The 1.5% between 19.5% "permissible" and 21% "normal" equals a variance of 15,000 ppm that could be "something else" undesirable displacing oxygen in the work environment. Special precautions must be taken in the event that oxygen levels increase above 23.5% as this affects the flammable limits of materials present, and the LFL will be lowered. As with low oxygen concentrations, if oxygen is higher than atmospheric, the reason should be determined. This may indicate an oxygen leak from the welding equipment or gas supplies, if oxy-acetylene gas welding or cutting is being done in the area.

9.3 Flammable Vapor Concentration

In a normal oxygen-content confined space entry, the maximum concentration of flammable vapors present must always be less than 10% of the LFL, regardless of the type of respiratory protection required, in order to permit entry. If hot work is to be done there should be no (0%) detectable flammable concentration. Any source of detectable flammable vapors should be found and eliminated before hot work begins.

9.4 Confined Space Ventilation

Provisions should be made to ensure that adequate ventilation is provided to each welder or hot work person and that cutting or welding operations inside a confined space do not create an additional hazard to personnel (see OSHA 1910.252, 1910.146 and ANSI Z49.l).

Examples of potential hazards are:

a) Flammable vapors—the acceptable limit is zero percent of the LFL or not detectable (note that heavy hydrocarbons can be vaporized by welding heat).

b) Depletion of oxygen caused by burning in an insufficiently ventilated confined space.

c) A toxic atmosphere caused by welding or cutting on surfaces which are galvanized or lead contaminated. Look at Chromium and Nickel in Welding Fume.

For Committee Use Only

d) Fumes generated during welding which can be of concern depending on their composition and concentration (a function of metal or electrode composition).

e) An increase in oxygen or flammable gas concentrations caused by a leak from an unattended torch attached to oxygen/acetylene hoses and their gas source.

f) Exhaust gases from internal combustion engines used by welding machines, generators, or vehicles reaching confined spaces (perhaps through the ventilation system).

If the work does not require air-supplied breathing apparatus for respiratory protection then precautions must be taken to ensure that the atmosphere at all times meets legal, corporate or accepted industry standards for oxygen (see 9.2) and toxic contaminant (see 5.4) requirements. General ventilation may satisfy this need. Information on equipment ventilation is available in 6.2. When the oxygen and toxic concentration criteria are not within the specified acceptable limits the personnel should be removed from exposure. The reason for the variance should be investigated and appropriate measures taken to prevent exposure before work continues.

The American Society of Safety Professional book “Guidelines for Hot Work in Confined Spaces” provides a useful review of ventilation and other confined space issues.

9.5 Frequency of Monitoring in Confined Spaces

Atmospheric monitoring is especially significant for confined space work. Confined spaces provide greater potential for oxygen depletion or accumulation of contaminants. The permit should specify the monitoring frequency (see 8.2) or whether continuous monitoring is needed. If a test indicates a variance from initial conditions the work should be stopped, and the reason determined and controlled.

9.6 Pyrophoric Iron Precautions

When tanks or vessels have held sulfur-containing (sour) materials and have been inert gas blanketed there is potential for the presence of pyrophoric iron sulfide. Special precautions should be followed when equipment potentially containing pyrophoric deposits is being taken out of service. These vessels should be purged with gas containing low (ca 5%) levels of oxygen and kept wet if possible. This approach essentially involves keeping the pyrophoric deposits wet until the atmosphere is non-flammable and the deposits are either oxidized or removed. A similar concern occurs onboard ships when the inert blanket in cargo tanks is replaced by atmospheric air. (This situation arises frequently when unloading tank ships.) To avoid potential pyrophoric ignition, the international Safety of Life at Sea (SOLAS) guidelines recommend purging the tank until the hydrocarbon concentration in the vapor space is stabilized at less than 2%, before introducing air. This is intended to ensure that the atmosphere in the tank won’t burn (is fuel lean) even if iron sulfide reacts with air and becomes a potential source of ignition.

10 Work Inside Vessels, Exchangers, and Tanks

10.1 Preparations

Hot work inside vessels, exchangers and tanks is a special case of confined space entry since these may be connected to other equipment. As in Section 9, a confined-space entry permit indicating the requirements and conditions for entry shall be issued before any work is done. Before entry into a vessel, exchanger, or tank, the space should be completely isolated from active and potential energy sources by:

a) Blinding, blanking and/or disconnecting all lines connected to the space, or by other approved means (A connection is considered properly blinded when the correct blind, gaskets, and all bolts are properly installed to ensure that no leakage occurs.), and

b) Blinding open ends of connecting piping, and

c) Disconnecting or locking/tagging-out any energized connections to internal equipment (such as mixers).

After isolation, the vessel should be thoroughly cleaned. Additional precautions are necessary if the vessel has a nonmetallic liner or an internal coating; these normally need to be removed from the heat-affected areas to avoid

For Committee Use Only

generation of potentially toxic or flammable vapors or fumes. API 2015 provides special advice for entering and cleaning tanks used in leaded gasoline or other toxic material service.

If welding will be done on tank floors, then the job analysis should recognize the potential for hydrocarbon to have leaked under the floor. RP 2207 addresses this specific case. Often the area under the tank floor is purged to avoid combustion. Any welding on equipment of this type requires prior evaluation and approval of a qualified person (an "authorized inspector" or experienced and qualified engineering personnel).

API 510, 570, 653 and the National Board's ANSI/NB-23 state specific requirements relevant to some types of equipment. Any needs related to these requirements should be identified during the job analysis phase.

10.2 Maintaining a Safe Work Environment

The criteria for monitoring and vapor-freeing the confined space work environment defined in Section 9 should be observed and followed. An overall review should ensure that a precautionary procedure does not introduce a different hazard (such as inerting under tank floors forcing vapors into the workspace). If work is interrupted, there may be a need to retest the environment for combustible gas and oxygen as discussed in 8.4.

10.3 Inspection of Internals

An inspection should be made to ensure that oil, residue, vapor, and other flammable and combustible materials have been removed or protected from ignition by sparks or pyrophoric iron sulfide. This includes areas such as bubble-cap trays, weirs, internal pans, mist extractors, vapor seals, sparging lines, gauge floats, double bottoms, pontoons, linings, under floors, or roof drain piping. If any doubt exists about the cleanliness of internal equipment, the equipment should be removed, cleaned, or suitably protected.

11 Work on the Exterior of Vessels, Exchangers, and Tanks Not in Service

When hot work is limited to the outside surface of an empty vessel that has been isolated and gas freed, internal surfaces in the vicinity of the hot work can be expected to become heated. The job analysis should review this potential. Normal practice is to remove oil, wax or pyrophoric iron sulfide deposits from these surfaces prior to starting hot work.

Where hot work is being done on the outside surface of a vessel, adequate provisions, such as venting, should be made to protect against overpressure due to thermal expansion of the contents. Serious overpressure incidents have resulted from hot work heating residual water in closed equipment which then generated steam.

The job analysis should determine whether the proposed work requires review by a qualified person. This could be the case when nonferrous metals (titanium, aluminum) are involved or where the vessel has sensitive (such as polymeric) insulation.

12 Work on Equipment in Service

12.1 Decision Process for Work on Equipment in Service

Figure 2 illustrates a decision process where hot work is to be performed on equipment in service. The steps outlined in the chart emphasize that this is a special case warranting additional precautions. Work on equipment in service should never be considered "routine," even though successful precedents exist. A review should confirm that the prior experience is relevant to the specific current work under consideration. Essentially, this requires an expansion of the job analysis evaluation of work conditions discussed in Section 4. This evaluation includes consideration of procedures and whether or not they exist or need to be created. It also requires planning input from knowledgeable personnel and those with the appropriate organizational position to authorize this nonroutine work.

Hot work shall not be performed on one vessel or piece of equipment within a unit while other parts of the same unit are in operation unless:

a) It is determined that no unconfined flammable or combustible material is present in the work area, and

b) No reasonable probability exists of any such material entering the area while hot work is being done.

For Committee Use Only

Precautions could include isolating the vessel or equipment from the remaining units, covering common drains, and/or keeping a steady flow of water on any adjacent leaks, flows, or drips that could result in flammable vapors.

The job analysis should determine whether a review by a qualified person is required as discussed in 4.2.

12.2 Hot Work with Hydrocarbons Present

Under specific permit conditions, hot work may be performed on equipment in service containing hydrocarbon vapors or gases present, provided that:

a) Hot work is performed while the hydrocarbon is contained in an oxygen deficient atmosphere. This can be achieved when a pipe, vessel or tank volume is inerted to exclude oxygen during the welding operation, or

b) Hydrocarbon vapor or gas concentrations within the equipment are controlled to remain within a predetermined percent of the LFL, too rich or too lean to burn, or

c) The equipment is in a well-ventilated area, and precautions have been taken to ensure that, in the event of leakage, there is no accumulation of hydrocarbon vapors or flammable gases to create an explosive atmosphere or major fire hazard, and

d) Precautions are taken to prevent burn-through to the hydrocarbons.

As indicated in 9.3, there should be no (0%) detectable hydrocarbons where normal hot work is conducted.

For Committee Use Only

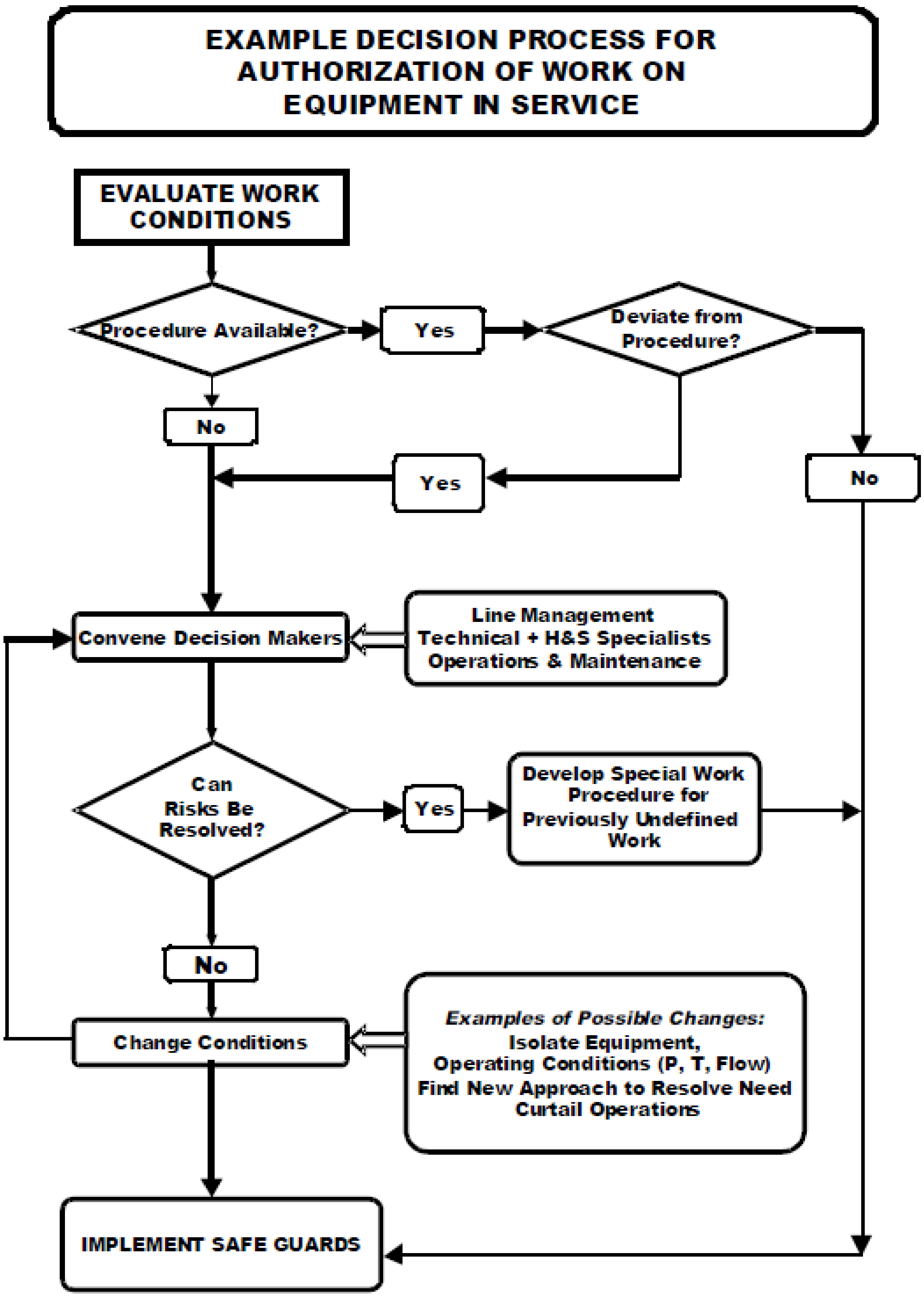

Figure 2—Example Decision Process for Authorization of Work on Equipment in Service

12.3 Work on the Exterior of Atmospheric Pressure In-Service Vessels

Under certain conditions, welding can be done on the outside of vessels which are still in service, but not in pressurized service. Additional review and procedures beyond those for welding on out-of-service gas-free vessels are required.

Welding should not be conducted on a vessel which is double walled and/or which has an internal lining such as glass, polymeric, or alloy until inspection and analysis are made to determine whether it is possible to perform the work safely. Hot tapping and welding on pressurized equipment are outside the scope of this document (see 14.5).

If welding is to be done on the outside surface of a vessel, and if the area is otherwise safe for the use of an open flame, the vessel need not be gas freed if one of the following procedures is employed or conditions maintained:

a) The vessel is not pressurized.

b) In a vessel that is partly filled with liquid, welding may be done 3 ft. or more below the level of the liquid if adequate precautions have been taken to prevent burning through the tank or vessel wall.

c) Welding may be permitted (in very limited situations) if chemical analysis or other reliable evidence indicates that the petroleum-product vessel contains an atmosphere incapable of being ignited because it is too rich or too lean or is non-combustible or non-reactive and that adequate precautions have been taken to prevent burning through the vessel wall.

d) If under a vacuum, the additional evaluations and precautions in 12.4 should be addressed.

12.4 Hot Work on Equipment Under Vacuum

Hot work shall not be performed on vessels under vacuum (less than atmospheric pressure) unless a qualified person(s) concurs after performing an engineering evaluation. Related concerns are:

a) Heat from welding might cause the wall of the vessel to buckle locally and deform inward at the hot work location.

b) Deformation or buckling could cause the vessel to rapidly collapse.

c) If welding penetrates the vessel wall, the reduced pressure could draw in oxygen and allow the contents of the vessel to react at potentially violent rates. (Some experts believe that there is a high probability of introducing air, along with flame, when welding on vessels under vacuum.)

Prior to approving welding on vessels under vacuum an engineering evaluation should determine:

a) What temperature would be reached during the hot work.

b) What the Lower Flammable Limit (LFL) will be in the vessel at the calculated temperature (fuel lean is preferred since inadvertent introduction of air caused by breakthrough could bring portions of a fuel-rich mixture into the combustible range).

c) Whether the vessel contains materials which have temperature-sensitive chemical reactivity, and whether the calculated hot work temperature could trigger a reaction.

d) What precautions are necessary to prevent burning through the vessel wall.

Some facilities choose to prohibit welding on live vacuum equipment. Others use engineering evaluation to determine what constitutes adequate precautions to prevent burn through (welding heat input controls) and to maintain internal vessel conditions outside explosive limits (in some cases using process control by inerting). This choice by any specific facility may depend on the availability of qualified persons to do the required job analysis.

12.5 Leak Repair

Engineering evaluation and consideration should be utilized for any leak repair situation when the repair involves work on equipment in service. With appropriate knowledge, experience, equipment, and procedures certain types of leaks

For Committee Use Only

can be repaired safely while a process unit remains in operation. Some examples are work on the catalyst section of fluid catalytic cracker units (FCCU) or below the liquid level in some storage tanks. With appropriate review and procedures, such repairs have been accomplished safely by welding on temporary patch plates and/or using a prefabricated enclosure.

Some small leaks can be repaired safely and simply when proper precautions are taken. Larger leaks may require more elaborate procedures, such as use of nitrogen to flush gas or liquids away from the leak through a line to a discharge location remote from the point of welding. The exact techniques vary considerably as there are many considerations involved, including the size and location of the leak, piping contents, the configuration of the equipment and operating pressures.

Improper repairs can worsen a leak condition and increase hazardous situations. The job analysis review should ask, “Why do we have leaks, and could the planned activity increase the probability of cracking?”

When repair procedures contemplate welding or hot work on equipment in service, it is essential to take additional appropriate precautions which consider the safety of all personnel involved. Before work starts, there should be written procedures (either existing or specially developed) in place. A briefing to review the procedures should occur prior to the start of the job, and a hot work permit issued consistent with facility and regulatory requirements (see Section 8). Any special oxygen and combustible gas tests or monitoring for toxic materials should be specified.

Specific factors to consider regarding the on-stream repair decision process and precautions to be taken include the following:

a) Metal thickness.

b) Amount of possible thinning due to corrosion or erosion.

c) Metallurgy.

d) Susceptibility of the material to potential cracking.

e) Potential for the planned work activity to increase the probability of cracking.

f) Post Weld Heat Treatment requirements, if any.

g) Size of weld or heat-affected zone.

h) Whether the equipment contains materials which have temperature-sensitive chemical reactivity, and whether a calculated hot work temperature could trigger a reaction.

i) Proximity of weld to heat sensitive equipment.

j) Need for inerting (and potential impact on personnel).

k) Potential for release.

l) Other work in area.

Additional considerations if the work is for leak repair:

a) Size, location and type of the leak.

b) Existence of cracks.

c) Location, length, and depth of any cracks.

d) Whether cracks are in the parent metal, weld, heat-affected zone, or all three.

For Committee Use Only

13 Work in Buildings and Pits

Precautions should be taken when hot work is to be done in buildings such as compressor rooms, manifold and pump houses, pits, receiving houses, and blending and container filling rooms, while any equipment within these areas or buildings is in operation. If hot work is done within buildings or pits, the equipment to be worked on shall be isolated and freed from gas and oil. If necessary, other equipment shall be depressurized. The area shall be ventilated until gases or vapors are eliminated and appropriate toxic gas and/or combustible-gas tests show that the area is safe for hot work. Air movers, approved for service in hazardous locations, may be used to assist in ventilation. Confined space permit and safe work requirements shall be followed where applicable.

Any combustible materials shall be protected or moved to another area if there is any chance of heat transfer or contact with sparks or hot slag. When performing hot work on the outside of buildings, care should be taken to isolate downspout drains, plumbing vents and exhaust fans. This is intended to protect against flammable or toxic materials released from the building from reaching the welding area. This is especially relevant for work in pits that could accumulate heavier-than-air vapors. Exhaust fans removing flammable gases from labs or plant operations can quickly change the concentration of gas present in the work area around buildings.

14 Work on Piping

14.1 General Considerations for Work on Piping

The job analysis should determine whether work on piping requires a review by a qualified person as discussed in 4.2. API Publ 570 contains information on repairs, alterations, and rerating of in-service piping systems. API Std 1104 discusses pipeline welding (which can involve specific regulatory requirements).

The need to free piping of flammable gases or liquids should be determined on the same basis used for vessels. The presence of flammable vapor can be established with a properly calibrated combustible-gas detector. Periodic retests or continuous monitoring may be necessary as the work proceeds. Other hazardous materials (for example, combustible liquids, corrosives, or toxics) may be present which could be harmful to personnel performing the work. Appropriate precautions must be taken to monitor exposures and to protect personnel.

14.2 Piping Isolation

An important precaution before welding or cutting piping is to properly isolate the piping (e.g., blinding, disconnecting or double blocking and bleeding). The type of isolation used will depend on the contents, pressure, or piping configuration. A single valve may be used, depending on conditions and if isolation is not required (e.g., welding on inert gas piping, water lines). If using a single isolation valve, the OSHA Lockout/Tagout energy control measures must be met. Unless certain regulatory standards (such as OSHA confined space or Lockout/Tagout standards) are met, a single closed valve is not likely to be an acceptable means of isolation.

14.3 Venting of Piping

Adequate provisions, such as venting, should be made to protect against overpressure due to thermal expansion of the contents. The actual determination that a pipe is safe is a step-by-step procedure that must be followed closely prior to issuing a hot work permit.

14.4 Piping Contamination and Coating

Piping that has contained compressed air from a lubricated compressor may have an internal film of oil. Welding should not begin until the oil film has been removed or the pipe inerted.

Preservative coatings are another important issue involving welding, cutting, and heating pipes and other surfaces. OSHA describes the precautions that should be taken for preservative coatings in 29 *CFR* 1926.354. The standard requires that when welding, cutting, or heating a surface with a preservative coating, a flammability test shall be made by a competent person. If the coating is known to be not flammable or the coating has been removed, this flammability determination is not required. If flammable, coating “shall be stripped from the area to be heated in order to prevent ignition.” (The standard notes that “Preservative coatings shall be considered to be highly flammable when scrapings burn with extreme rapidity” giving one type of simple field evaluation test.) It is also necessary to determine if toxic

For Committee Use Only

gases or vapors are released from heating the coating. Typical practice is to remove coatings as they may interfere with good welding practice.

Further, OSHA states that in enclosed spaces, "all surfaces covered with toxic preservatives shall be stripped of all toxic coatings for a distance of at least 4 in. from the area of heat application, or the employees shall be protected by airline respirators." Also, "the preservative coatings shall be removed a sufficient distance from the area to be heated to ensure that the temperature of the unstripped metal will not be appreciably raised. Artificial cooling of the metal surrounding the heating area may be used to limit the size of the area required to be cleaned."

14.5 Hot Tapping

Under certain conditions (never to be considered routine) it may be necessary to weld or hot tap a pressurized pipe while the line is in operation, but this work is outside the scope of this publication. Hot tapping is specifically addressed in RP2201. It requires specially qualified personnel using special equipment and strict precautions, both in preparation and in execution.

For Committee Use Only

Annex A
(informative)

Inerting Vessels

A.1 General Inerting Considerations

Several broad issues deserve consideration if a tank, vessel, piping or other workspace is to be inerted in preparation for hot work:

a) Recognition and control of personnel risks where there may be potential exposure to oxygen deficiency hazards associated with inert gas.

b) Prevention of static electricity buildup and discharge.

c) The relative weight of the inerting gas compared to air.

d) Flammability meters do not function in oxygen deficient atmospheres (below about 10% oxygen) so a chemical analysis may be required.

e) Steam or inert gas should not be vented from vessels or piping in the vicinity of personnel or potential ignition sources.

A.2 Steam

Prevention of static electricity buildup and discharge is a major consideration when using steam as an inerting medium. Appropriate bonding and grounding is necessary.

If steam is used as a means of displacing oxygen, every part of the vessel should be heated by the steam to a temperature of at least 170 F (77 C). This successful historic practice reduces the oxygen level and introduces ca 40% water vapor as a quenching medium. The temperature of the steam should not exceed the flash point of the material contained in the tank. The rate of steam supply into the tank must exceed the rate of condensation. This may be difficult on large tanks or during cold weather. Workers should recognize that there is still a possibility for pockets of air or vapors to be present. Steam and heat will work to vaporize and mechanically remove heavier hydrocarbons from the walls of the inerted vessel or tank.

Visible discharge of steam from an opening is insufficient evidence that the atmosphere within is not explosive. A chemical analysis may be required, and sampling should recognize that samples taken near the vessel opening may not represent all points in the vessel.

If the temperature is cooled to atmospheric and airfow is used after steaming, the process has become one of purging (which will be incomplete if all potential fuels have not been removed). Further testing should be conducted to ensure that the atmosphere in the vessel has not re-entered the flammable range.

A.3 Other Inert Gas

If carbon dioxide, nitrogen or another inert gas is used as the displacing medium, it shall be introduced so that the atmosphere in all parts of the vessel is completely displaced. Carbon dioxide gas should be introduced using a fixed-pipe system electrically bonded to the container to avoid a buildup of static electricity or a static-charged cloud. In small vessels, subliming dry ice placed directly in the enclosed space may be a suitable source of carbon dioxide which eliminates static electricity concerns.

A.4 Flammability vs. Oxygen Content

Even if the oxygen content has been reduced by inerting to less than 10% by volume it is not safe to assume that the vessel does not contain an ignitable mixture. The flammable component must be known (e.g., hydrogen's and carbon

For Committee Use Only

monoxide's limiting oxygen index is less than 10%). More extensive data is available in *Flammability Characteristics of Combustible Gases and Vapors*, Bureau of Mines Bulletin 627 NTIS AD701576 and *Investigation of Fire and Explosion Accidents in the Chemical, Mining, and Fuel Related Industries—A Manual*, Bureau of Mines Bulletin 680 NTIS PB87113940.

For Committee Use Only

Bibliography

API

[1] RP 12R1, *Setting, Maintenance, Inspection, Operation and Repair of Tanks in Production Service*

[2] RP 1604, *Closure of Underground Petroleum Storage Tanks*

[3] Publ 2216, *Ignition Risk of Hydrocarbon Vapors by Hot Surfaces in the Open Air*

[4] Std 2610, *Design, Construction, Operation, Maintenance, and Inspection of Terminal and Tank Facilities*

AGA[9]

[5] XK1801, *Purging Manual*

ANSI

[6] Z244, *Lockout/Tagout of Energy Sources*

ASTM[10]

[7] D6413, *Standard Test Method for Flame Resistance of Textiles (Vertical Test)*

[8] F1002, *Standard Performance Specification for Protective Clothing and Materials for Use by Workers Exposed to Specific Molten Substances and Related Thermal Hazards*

[9] F1449, *Standard Guide for Industrial Laundering Care and Maintenance of Flame Resistant or Arc Related Clothing*

[10] F 1506, *Standard Performance Specification for Flame Resistant and Electric Arc Rated Protective Clothing Worn by Workers Exposed to Flames and Electric Arcs*

[11] F1959, *Standard Test Method for Determining Arc Rating of Materials for Clothing*

AWS

[12] F1.1, *Method for Sampling Airborne Particulates Generated by Welding and Allied Processes*

[13] F1.3, *A Sampling Strategy for Evaluating Contaminants in the Welding Environment*

[14] F4.1, *Safe Practices for the Preparation of Containers and Piping for Welding, Cutting and Allied Processes*

[15] *Safety and Health Fact Sheet No. 4*

[16] *Chromium and Nickel in Welding Fume*

[17] *Fire Safety in Welding and Cutting*

For Committee Use Only

---

[9] American Gas Association, 400 N. Capitol Street, NW, Washington, DC 20001. www.aga.org.

[10] American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428-2959, www.astm.org.

[18] *Characterization of Arc Welding Fumes*

[19] *Arc Welding and Cutting Noise*

[20] F2.2, *Lens Shade Selector*

[21] *Safe Practices*

AWS Safety and Health Fact Sheets		
Number	**Title**	**Date**
1	Fumes and Gases	Dec 2018
2	Radiation	Aug 2018
3	Noise	Aug 2018
4	Chromium and Nickel in Welding Fume	Oct 2019
5	Electrical Hazards	Aug 2018
6	Fire and Explosion Prevention	Dec 2018
7	Burn Protection	Dec 2018
8	Mechanical Hazards	Aug 2018
9	Tripping and Falling	Aug 2018
10	Falling Objects	Aug 2018
11	Confined Spaces	April 2020
12	Contact Lens Wear	Aug 2018
13	Ergonomics in the Welding Environment	Aug 2018
14	Graphic Symbols for Precautionary Labels	Sept 2018
15	Style Guidelines for Safety and Health Documents	Dec 2018
16	Pacemakers and Welding	Feb 2015
17	Electric and Magnetic Fields (EMF)	Sept 2015
18	Lockout/Tagout	Dec 2018
19	Laser Welding and Cutting Safety	Dec 2018
20	Thermal Spraying Safety	Dec 2018

BMUSDI[11]

[22] Bulletin 627, *Flammability Characteristics of Combustible Gases and Vapors*

[23] Bulletin 680, *Investigation of Fire and Explosion Accidents in the Chemical, Mining, and Fuel Related Industries—A Manual*

[24] *CSB Report No. 2012-03-I-CA*

[25] *Key Lessons for Preventing Incidents When Preparing Process Equipment for Maintenance*

NFPA[12]

For Committee Use Only

[11] The United States Bureau of Mines of the Department of the Interior was established in 1910 by the Department of the Interior and abolished on March 30, 1996. Bureau of Mines documents are available through the U.S. Department of Commerce, National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161. http://www.ntis.gov/support/orderingpage.htm. ONLY NTIS order numbers can be used on the NTIS web site to locate products received from government organizations before 1990.

[12] National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02019. www.nfpa.org

[26] 10, *Standards for Portable Fire Extinguishers*

[27] 30, Flammable and Combustible Liquids Code

[28] 70, *National Electrical Code*

[29] 325, *Guide to Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids*

[30] 326, *Safeguarding of Tanks and Containers for Entry, Cleaning or Repair*

OSHA[13]

[31] Publ 8-1.5, *Guidelines for Pressure Vessel Safety Assessment*

United Kingdom—Health and Safety Executive

[32] HSG253, *The safe isolation of plant and equipment*

For Committee Use Only

[13] U.S. Department of Labor, Occupational Safety and Health Administration, 200 Constitution Avenue, NW, Washington, DC, 20210. OSHA regulations are posted on, and can be downloaded from, the OSHA website, www.osha.gov.

For Committee Use Only