

Safe Hot Tapping Practices in the Petroleum and Petrochemical Industries

Downstream Segment

API RECOMMENDED PRACTICE 2201
FIFTH EDITION, JULY 2003

REAFFIRMED, OCTOBER 2010



AMERICAN PETROLEUM INSTITUTE

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Safe Hot Tapping Practices in the Petroleum & Petrochemical Industries

SECTION 1—GENERAL

1.1 PURPOSE

This publication provides information to assist in safely conducting hot tapping operations on equipment in service in the petroleum and petrochemical industries. No document can address all situations nor answer all potential questions. However, the understanding of potential hazards, and application of this knowledge, can help reduce the probability and severity of incidents.

1.2 SCOPE

Hot tapping is the technique of attaching a welded branch fitting to piping or equipment in service, and then creating an opening in that piping or equipment by drilling or cutting a portion of the piping or equipment within the attached fitting. (In certain specific situations a bolted or mechanical fitting may be used. This approach is not common practice in oil processing and petrochemical facilities and this document does not address any considerations unique to “hot tapping without welding”.) Hot tapping is usually performed when it is not feasible, or is impractical, to take the equipment or piping out of service, or to purge or clean it by conventional methods. With proper review to determine that a hot tap is appropriate, and development and conformance to job-specific procedures, many hot tap connections have been safely made without interfering with the process operation.

This publication covers the safety aspects to be considered before and during hot tapping on in-service piping or equipment. It provides:

- aids to recognize, review, and address safety concerns;
- a review of potential hot tapping concerns based on industry experience;
- guidance on planning hot taps;
- application of “hazard versus risk” concepts applied to hot tapping;
- elements to consider during the hot tap process from job analysis through completion;
- suggestions on “what to do if things go wrong.”

This publication is not:

- a substitute for job-specific planning;
- a set of work procedures.

Virtually every hot tapping job is different. A detailed, written, job-specific hot tap procedure should be available before starting each job to help ensure that appropriate measures are addressed. If there are standing procedures for hot tapping they should be reviewed for applicability to the specific job to be done. These procedures may need revision in

response to unique job specific problems or situations that may arise concerning the safety of personnel and facilities.

The hot tap approach described in this publication applies to piping and equipment fabricated from ferritic and austenitic steel. Other materials, such as aluminum, copper, plastic, and cast iron may be unsuitable for hot tapping or welding or may require special procedures.

Hot tapping is a “change” subject to review based on facility “management of change” processes or procedures.

1.3 RETROACTIVITY

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

1.4 CONCEPT OF HAZARD VS. RISK

Hazards are properties of materials with the inherent ability to cause harm. Flammability, toxicity, corrosivity, 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 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 which could damage property.

1.5 CONCEPT OF COMPETENT AND QUALIFIED PERSONS

OSHA uses the term “competent person” in dozens of standards for persons serving a variety of roles. In other standards the term “qualified person” is used. Sometimes both terms are used in the same standard. This recommended practice also uses these terms. The following sections explain this usage. In both cases it is the employer who has the responsibility for designating the person.

Essentially the decision of who is a “competent person” or a “qualified person” becomes a performance oriented management decision, evaluating varied experience, skills and knowledge needed for each category.

1.5.1 Competent Person

The concept of relying on the experience and judgement of a “competent person” is used in this document as it is in many standards and regulations. In street terms this means “someone who knows enough to make the right decisions to do a job properly”. One definition [from 1926.32(f)] says a competent person “means one who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.”. In other standards the requirements to qualify as a “competent person” are expanded to include training in subject specific courses defined by OSHA or EPA. This document does not specify training requirements or courses.

1.5.2 Qualified Person

The concept of “qualified person” implies knowledge or education (which may be technical) beyond, or different from, that of a competent person. One definition describes a qualified person as “one who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training and experience, has successfully demonstrated ability to solve or resolve problems relating to the subject matter, the work, or the project.”

For craft personnel, an OSHA formal interpretation puts the burden on the employer, stating “OSHA does not require tests to assess craft technical skills and knowledge. It is the responsibility of the employer to assure that their employees possess the skills and knowledge necessary to perform their tasks safely.” Facility or regulatory requirements may require welders to perform certain tests to qualify as a “code welder,” but the mandatory need for this qualification may be restricted to work on specific equipment; it may, or may not, be relevant to hot tap work depending on the equipment being hot tapped.

For engineers a “qualified person” may be characterized as having relevant education, experience and specialized knowledge for the specific subject or activity.

SECTION 2—REFERENCED PUBLICATIONS

The latest editions of the following documents are referenced in this publication:

API

RP 12R1	<i>Setting, Maintenance, Inspection, Operation and Repair of Tanks in Production Service</i>
Std 510	<i>Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration</i>
Std 570	<i>Piping Inspection Code: Inspection, Repair; Alteration, and Rerating of In-Service Piping Systems</i>
RP 582	<i>Welding Guidelines for the Chemical, Oil, and Gas Industries</i>
Std 598	<i>Valve inspection and Testing</i>
Std 650	<i>Welded Steel Tanks for Oil Storage</i>
Std 653	<i>Tank Inspection, Repair Alteration, and Reconstruction</i>
RP 750	<i>Management of Process Hazards</i>
Publ 941	<i>Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants</i>
Std 1104	<i>Welding of Pipelines and Related Facilities</i>
RP 1107	<i>Pipeline Maintenance Welding Practices</i>

RP 2009	<i>Safe Welding, Cutting, and Hot Work Practices in the Petroleum and Petrochemical Industries</i>
Std 2015	<i>Safe Entry and Cleaning of Petroleum Storage Tanks</i>
RP 2016	<i>Recommended Practice for Entering and Cleaning Petroleum Storage Tanks</i>
Publ 2216	<i>Ignition Risk of Hydrocarbon Vapors by Hot Surfaces in the Open Air</i>
ACGIH ¹	<i>Threshold Limit Values for Chemical Substances and Physical Agents In the Work Environment and Biological Exposure Indices</i>
ANSI ²	
Z49.1	<i>Safety in Welding, Cutting and Allied Processes (ANSI/AWS)</i>
Z244	<i>Lockout/Tagout of Energy Sources (ANSI/NSC)</i>

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

²American National Standards Institute, 1430 Broadway, New York, New York 10018. www.ansi.org

ASME ³		NFPA ⁹	
ASME Boiler and Pressure Vessel Code		51B	<i>Standard for Fire Prevention During Welding, Cutting, and Other Hot Work</i>
Section VIII “Pressure Vessels”			
Section IX “Welding & Brazing Qualifications”		NIOSH ¹⁰	
B31.3 <i>Chemical Plant and Petroleum Refinery Piping</i>		Pub 88-110	<i>Criteria for a Recommended Standard: Welding, Brazing, and Thermal Cutting</i>
B31.4 <i>A Liquid Transportation Systems for Hydrocarbons, LPG, etc.</i>		Pub 99-115	<i>Pocket Guide to Chemical Hazards and Other Databases (CD-ROM)</i>
B31.8 <i>Gas Transmission Pipelines</i>		U.S. DOT ¹¹	
ASSE ⁴		49 Code of Federal Regulations Parts 190 – 199	
<i>Guidelines for Hot Work in Confined Spaces</i> ; Martin H. Finkel, CIH, CMC ASSE Press 1999		192.55	<i>Welded Branch Connections</i>
		192.151	<i>Tapping</i>
		192.627	<i>Tapping Pipelines Under Pressure</i>
		U.S. OSHA ¹²	
		29 Code of Federal Regulations Parts 1910 and 1926	
AWS ⁵		1910.119	<i>Process Safety Management of Highly Hazardous Chemicals</i>
F 3.1 <i>Guide for Welding Fume Control</i>		1910.146	<i>Permit-Required Confined Spaces</i>
Battelle Institute ⁶		1910.147	<i>Control of Hazardous Energy (Lockout/Tagout)</i>
<i>Investigation and Prediction of Cooling Rates During Pipeline Maintenance Welding and Battelle’s Hot Tap Thermal Analysis Models</i>		1910.251-7	<i>Subpart Q Welding, Cutting, and Brazing (and following) Subpart Z, “Toxic and Hazardous Substances”</i>
Edison Welding Institute ⁷		1910.1000	<i>Hazard Communication</i>
Project J6176 <i>Qualification And Selection Of Procedures for Welding Onto In-Service Pipelines and Piping Systems</i>		1910.1200	<i>Definitions (for OSHA Construction Standards)</i>
National Board ⁸		1926.32	<i>Gas Welding and Cutting</i>
ANSI/NB-23 <i>National Board Inspection Code</i>		1926.350	<i>Welding, Cutting, and Heating in Way of Preservative Coatings</i>
		1926.354	

³American Society of Mechanical Engineers, 345 E. 47th Street, New York, New York 10018. www.asme.org

⁴American Society of Safety Engineers, 1800 E. Oakton Street, Des Plaines, Illinois 60018. www.asse.org

⁵American Welding Society, 550 N.W. LeJeune Road, Miami, Florida 33126. www.aws.org

⁶Joe Sheldrick, Publisher, Battelle Press Bookstore, 505 King Avenue, Columbus, Ohio 43201-2693. www.battelle.org

⁷Edison Welding Institute, 1100 Kinnear Road, Columbus, Ohio 43212. www.ewi.org

⁸National Board of Boiler and Pressure Vessel Inspectors, 1055 Crupper Avenue, Columbus, Ohio 43229. www.nationalboard.org

⁹National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269. www.nfpa.org

¹⁰National 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

¹¹U.S. Department of Transportation, 400 7th Street, S.W. Washington, D.C. 20590. www.dot.gov

¹²U.S. Department of Labor, Occupational Safety and Health Administration, 200 Constitution Ave., N.W., Washington, D.C. 20210. (OSHA Regulations are posted on, and can be downloaded from, the OSHA web site.) www.osha.gov

SECTION 3—DEFINITIONS

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

3.2 chronic health hazard: Capable of causing effects occurring 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 and relative to the context of the work to be done. (see 1.5.1)

3.4 confined space: An enclosure with known or potential hazards and restricted means of entrance and exit, which is not normally occupied by people, and is usually not well ventilated. Examples of confined spaces in the petroleum industry include: process vessels, vessel tower skirts, flare stacks, boil-

ers, storage tanks, tank cars and trucks, vaults, large-diameter piping, and under certain circumstances, spaces located below ground level, such as pits. (OSHA 1910.146).

3.5 exposure limit: For chemical agents are a measure of the maximum airborne concentration limits for toxic substances to which workers may be exposed without protection (for example, respirators). Exposure limits are usually expressed in parts per million or milligrams per cubic meter for a defined period of time. Material Safety Data Sheets (MSDSs) from the manufacturer or supplier of the material should list exposure limits.

3.6 hot tapping: The technique of attaching a mechanical or welded branch fitting to piping or equipment in service, and creating an opening in that piping or equipment by drilling or cutting a portion of the piping or equipment within the attached fitting.

3.7 hot work: An operation that can produce 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, 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 can qualify as "hot work").

3.8 hydrogen blister: Bulge in steel caused by high pressure molecular hydrogen trapped at an internal flaw within steel.

3.9 IDLH: The NIOSH traditional definition is the maximum concentration of an air contaminant from which one could escape within 30 min. without a respirator and without experiencing any escape-impairing or irreversible health effects.

3.10 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.

3.11 lockout: "The placement of a lockout device on an energy isolating device, in accordance with an established procedure, ensuring that the energy isolating device and the equipment being controlled cannot be operated until the lockout device is removed" (from OSHA 1910.147).

3.12 lockout/tagout: Use of either a lockout or tagout procedure conforming to OSHA 1910.147.

3.13 lower flammable limit (LFL): The minimum 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).

3.14 particulate: Inhalable materials considered by ACGIH to be hazardous when deposited anywhere in the respiratory tract.

3.15 permissible exposure limits (PELs): Federal workplace chemical exposure 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 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.

3.18 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. (see 1.5.2)

3.19 risk: The probability of exposure to a hazard which could result in harm to personnel, the environment or general public.

3.20 risk assessment: The identification and analysis, either qualitative or quantitative, of the likelihood and outcome of specific events or scenarios with judgements of probability and consequences.

3.21 risk-based analysis: A review of potential needs based on a risk assessment.

3.22 tagout: The placement of a tagout device on an energy isolating device, in accordance with an established procedure, to indicate that the energy isolating device and the equipment being controlled may not be operated until the tagout device is removed.

3.23 threshold limit values (TLV[®]s): 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 and one below the LFL is too “lean” to burn.

3.25 vapor: The gaseous state of materials; vapor release requires elevated temperature for materials which are liquid or

solid at ambient temperature. Materials can burn only when in their vapor state.

3.26 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.

SECTION 4—JOB ANALYSIS

4.1 JOB ANALYSIS

The first step in the hot tapping work process is establishing what needs to be accomplished, how the associated work is to be done, and whether hot tapping is appropriate. The general review process is shown in Figure 1. It is important to recognize that hot tapping “by definition” involves hot work on equipment in service. A work scope analysis should be performed to determine if alternates to hot tapping exist within reasonable engineering and economic bounds, and whether hot tapping is appropriate (see 4.2).

If, after review, hot tapping is indeed required, the following approach conforms to good practice and regulatory requirements:

- a. Since the work cannot be moved, a review shall determine whether fire hazards in the vicinity can be moved to a safe place.
- b. Essentially the decision of who is a “competent person” becomes a performance oriented management decision, evaluating varied skills and knowledge for each category.
- c. All precautions used for hot work should be followed.

Since hot tapping work can not be done except by performing hot work in place, the work area and each activity should be closely analyzed for hazards, such as the potential hazards discussed in this publication or on the MSDSs 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 put into place for fire fighting, personnel evacuation, and/or alternate methods (such as changes in plant operations) to finish the hot work without incident. Appendix D provides an example of a hot tap emergency action contingency plan.

4.2 REVIEWING WHETHER HOT TAPPING IS APPROPRIATE

4.2.1 Determining Whether Hot Tapping is Appropriate

The example flow chart in Figure 2 shows some of the thought required in making the decision that use of hot tapping is appropriate. OSHA 1910.147 “Control of Hazardous Energy” (Lockout/Tagout) provides a specific exemption for performing hot tapping, with several criteria which must be met to satisfy that this is both needed and safe. These criteria are:

- a. continuity of service is essential;
- b. shutdown of the system is impractical;
- c. documented procedures are followed;
- d. special equipment is used which will provide proven effective protection for employees.

As indicated in Figure 2, if all four of these criteria cannot be met then hot tapping should not be done and the work must be performed in conformance with the requirements of the OSHA Lockout/Tagout regulation. For work on equipment subject to other regulations (federal or state OSHA Process Safety or DOT) there may well be other regulatory requirements.

4.3 JOB-SPECIFIC HOT TAPPING REVIEW FOR WORK AUTHORIZATION

4.3.1 Decision Process for Authorizing Hot Tapping

The analysis associated with Figure 2 covers both good practice and addresses the OSHA regulatory aspects relative to Lockout/Tagout. Figure 3 emphasizes the facility decision-making process. First, as a special subset of work on equipment in service, the immediate safety considerations must be considered for accomplishing the work. Potential emergency response needs can be reviewed (see Appendix D). Then, since this process emphasizes communication among knowledgeable decision makers, the potential immediate and longer term impact on other parts of the organization can be judged. For instance, this review prior to authorizing the hot tap work provides opportunity for review of “change” which might be subject to “management of change” requirements or whether the equipment change warrants a Process Hazards Analysis (PHA).

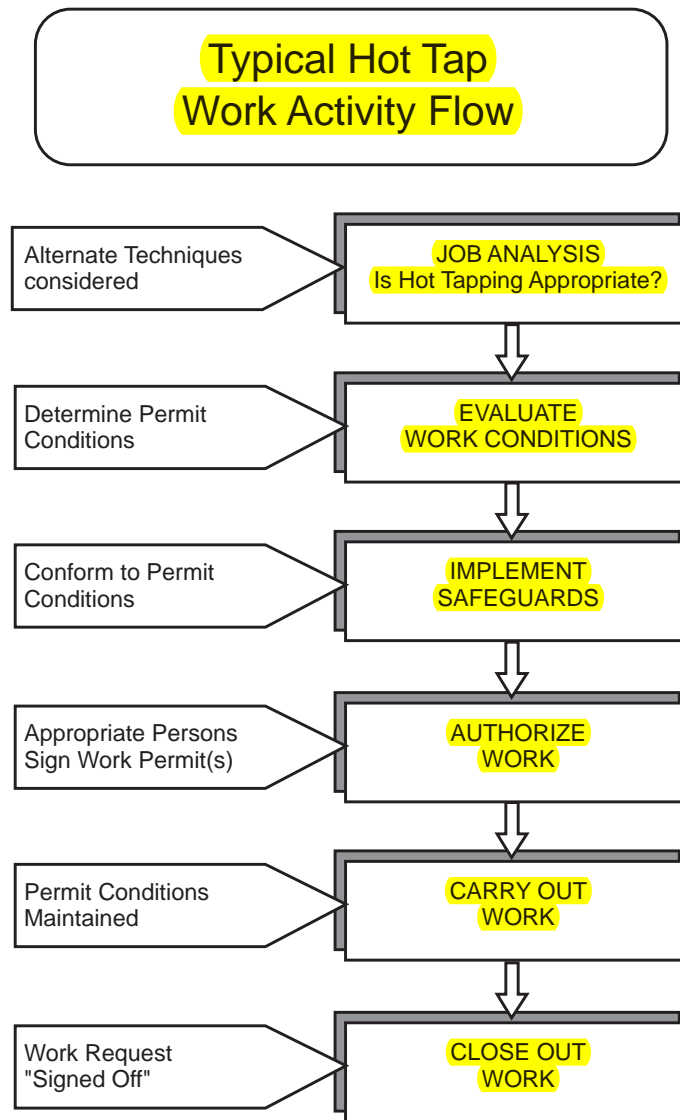


Figure 1—Typical Hot Tap Activity Flow

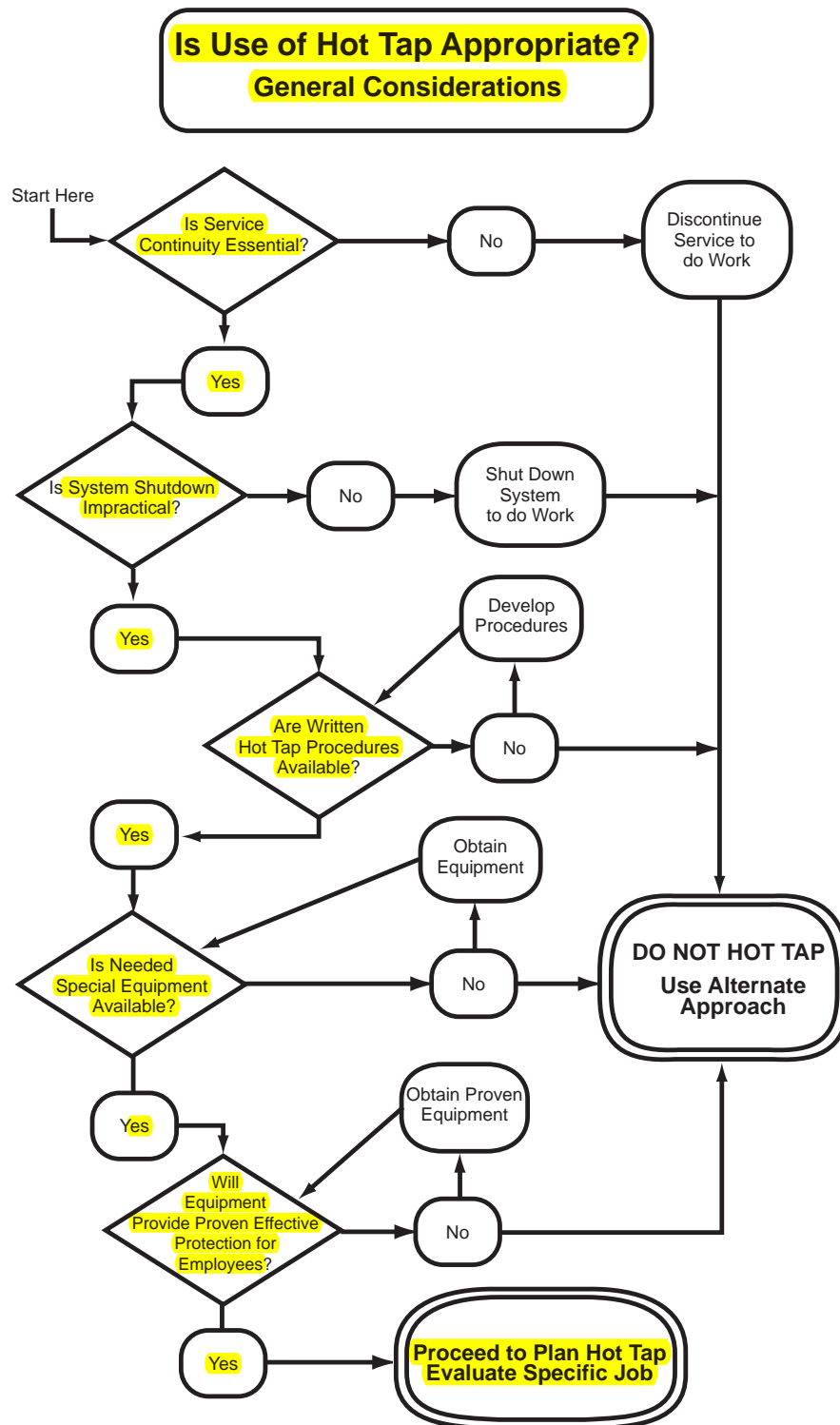


Figure 2—Example Process to Review Whether Hot Tapping is Appropriate

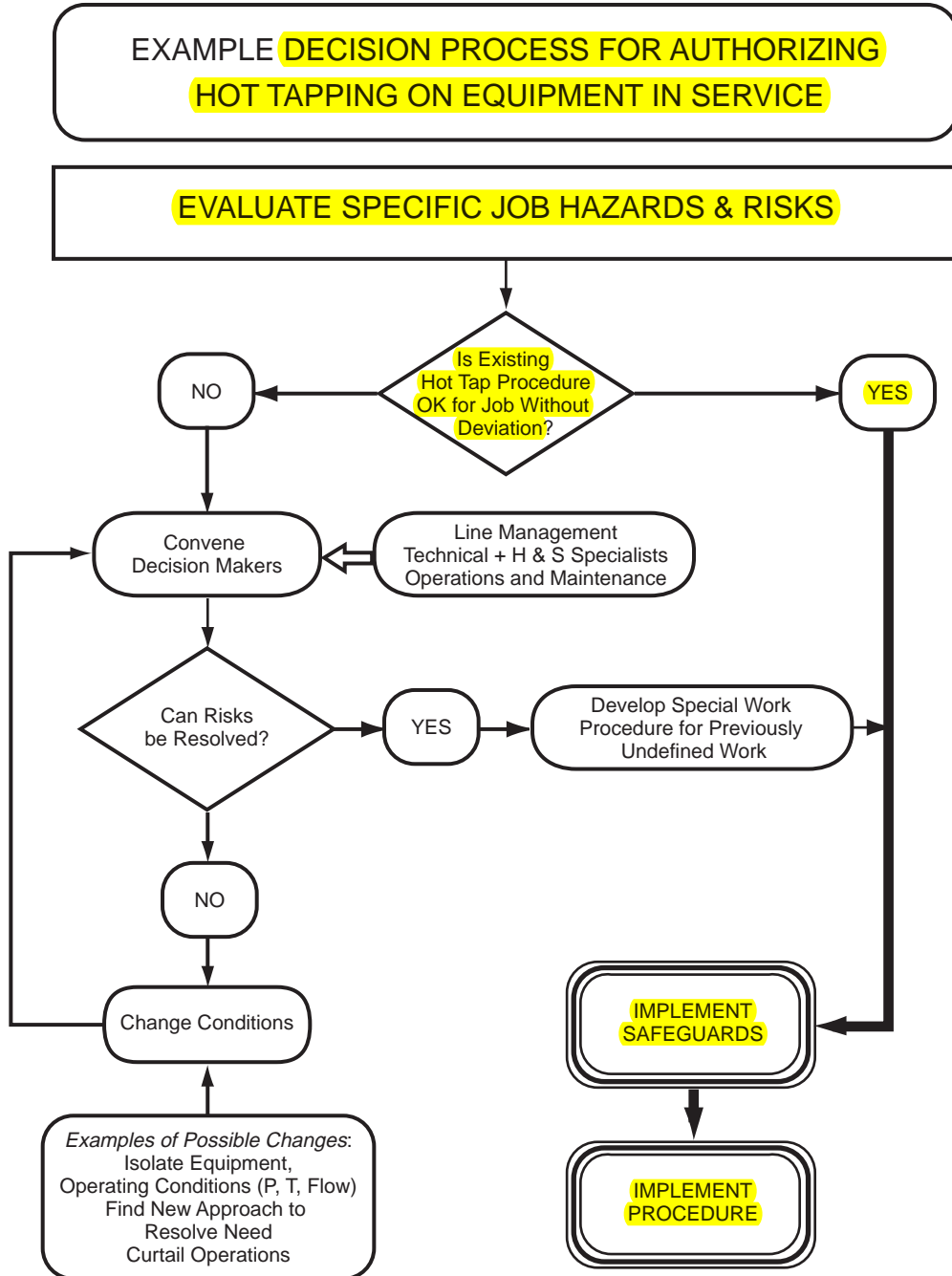


Figure 3—Example Decision Process for Authorizing Hot Tapping

The final product of the review process should be a written procedure specific to the hot tapping job to be done. If the specific job is reviewed and existing procedures are found to conform to the project needs, then they can appropriately be used. If they don't address the specifics, then a revised procedure

should be written. If several hot taps are to be done then each needs to have a separate procedure and permit.

The decision to authorize hot tapping should include a review of metallurgy and line contents as discussed in Section 6 to ensure that hot tapping is appropriate.

SECTION 5—HAZARD EVALUATION AND RISK REDUCTION FOR HOT TAPPING ON IN-SERVICE EQUIPMENT

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) and determination of whether hot tapping should be used should be made of potential hazards and the operations to be performed prior to starting work. This will help determine the appropriate procedures, safeguards, required engineering controls and/or personal protective equipment necessary to perform the work (see 4.3). This safety analysis includes elements of a normal hot work 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 subsequent hot tap activities. Section 6 discusses additional risk reduction techniques.

5.2 HOT TAPPING OVERVIEW

Hot tapping involves both welding on equipment in service and cutting through the containment material. Both of these introduce significant elements which are different from normal "hot work". Welding on equipment in service is addressed as a special case in API RP 2009, along with general welding safe work practices. Hot tapping is an even "more special" case of working on equipment in service. Hot tapping should never be considered "routine".

Knowledge, experience and planning along with good procedures, competent personnel with appropriate skills who perform their work in conformance to procedures, and proper equipment are keys to safe and successful hot tapping. Hot tapping should not be emergency work—if precautions cannot be established in advance and accommodated then the unit or equipment should be taken out of service or shut down. This is because:

- a. there is typically a significant inventory of flammable material in vessels or equipment and thus containment is very important.
- b. the welding associated with the hot tap can stress metal and heat fluids in vessels and piping.

5.3 PHYSICAL HAZARDS

Many of the hazards present in the normal workplace exist in the welding and hot tapping environment. Normal precautions not specifically addressed here include:

- a. protection against slip-trip-fall hazards in work areas with cables, hoses and lines;
- b. use of normal workplace PPE (head, foot, eye, respiratory and thermal protection in accordance with facility requirements for the work environment);
- c. fall protection procedures and equipment;
- d. protection from electric hazards associated with welding machines or electric lighting in the area (use of bonding, grounding, low voltage or GFI are the same as for other maintenance);
- e. protection against eye and face injuries caused by flying particles, molten metal, liquid chemicals, acids or caustic liquids, or irritating chemical gases or vapors.

5.4 THERMAL BURN HAZARDS TO PERSONNEL AND RISK REDUCTION

High temperature contact exposure can cause serious burns. This hazard is familiar to those who do welding work. Risk reduction is provided through avoidance of contact by using good work practices and protective clothing. Injuries have occurred due to sparks or hot metal falling into pockets, folds of rolled up sleeves, pants-cuffs or work boots. And, frayed clothing is more easily ignited.

Because hot tapping often involves cutting into contained flammable or combustible materials, the potential for a release is greater than in normal welding. The use of fire resistant clothing is especially prudent for personnel working in the hot tap area.

5.5 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 welding fumes.

Other materials used or stored in the vicinity of the work may represent acute hazards which could be released (substances such as hydrogen sulfide, chlorine or ammonia) and reach personnel. Even without this potential, the welding operation can create acute health hazards. Arc flash (ultraviolet radiation) can cause eye irritation or burns. Fumes from zinc 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 risk during welding.

5.6 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. An effective hazard communication program should identify materials warranting special attention which may be associated with the specific workplace. Material Safety Data Sheets (MSDSs) should be available to aid in identifying materials in the area and contained in the piping or equipment to be hot tapped or welded upon. Some materials for which repeated or prolonged exposures are of interest when welding or hot tapping are discussed in the following sections. Risk is associated with exposure. For welding fumes, and many petroleum or petrochemical vapors, risk relates to inhalation exposure. 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. 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.

5.6.1 Welding Fumes

Toxic fumes can be generated during welding. Fumes from welding on metals containing alloys of lead, zinc, cadmium, beryllium, and certain other metals are recognized hazards.

Virtually all metals are worthy of review. Some paints, particularly those containing lead, can produce toxic fumes when heated or burned. While toxicity is an independent property of the hazardous material, risk depends on the composition and quantity of fumes in conjunction with exposure. The composition of the welding consumables, any coatings or paints, the process used, and the circumstances and condition of use will also affect toxicity. The general hierarchy of control is:

- Where electrode material concerns are identified investigate whether an engineering-approved acceptable material substitution is available.
- For coatings the area should be cleaned.
- In all cases appropriate ventilation should be considered.
- Respiratory protection may be necessary if monitoring experience indicates a need.

5.6.2 Other Toxic Substances and Risk Reduction.

If potential for exposure is possible, provide appropriate control measures, including the following:

- Determine the level of exposure through measurement and/or analysis, or directly applicable prior experience.
- Minimize skin contact and breathing of vapors or fumes through engineering or administrative controls, or by providing appropriate personal protective equipment.
- Keep work areas clean and well ventilated; clean up spills promptly.
- Use soap and water or approved cleaner to remove materials which contact skin. Do not use gasoline or similar solvents.
- Promptly remove and wash oil-soaked clothing, and do not use oil soaked leather gloves, aprons, or other materials.

There is a growing body of information on welding hazards and appropriate protective measures. NIOSH has done research, often in conjunction with the welding community. OSHA and some other federal or state regulations address operations associated with petroleum and petrochemical facilities.

5.7 FLAMMABLE LIQUIDS, VAPORS, SOLIDS, OR DUSTS

Normally, the general work area around the hot tap work site should be hydrocarbon vapor and gas free. Attention should be given to drums or other portable containers containing flammable or combustible materials.

Hot tapping may be proposed for work on a vessel or piece of equipment within a unit while other parts of the same unit are in operation. The Job Analysis (see Section 4) shall determine that no unconfined flammable or combustible material will be present in the work area and that no reasonable probability exists of any such material entering the area while hot

work is being done. Possible precautions may include, but are not limited to:

- a. covering common drains;
- b. ensuring all sewer traps are full and functional, using a steady flow of water when necessary;

Note: Caution must be taken to ensure that hydrocarbon does not enter the work area from sewers.

- c. halting transfer operations in areas where tanks are receiving flammable liquids or gases;
- d. continuous monitoring to ensure that the atmosphere is free of flammable material;
- e. blocking off any relief valves (RVs) in the area.

In areas where hot tapping and associated welding are approved, process operators should be made aware of the

work in process and must not release flammable liquids or vapor until the hot work has stopped. Hot work should not be permitted where adjacent equipment is being opened, disassembled, steamed, ventilated, or flushed without considering how such actions might affect the hot work.

5.8 COMBUSTIBLE MATERIALS AND RISK REDUCTION

Combustible materials should be removed from the work area or protected from welding sparks or slag. Noncombustible covers or “wetting down” are traditionally used. Wooden scaffolding is an example of a vulnerable combustible. Embers from burning wood can be blown some distance downwind and provide an ignition source in remote areas.

SECTION 6—WELDING AND HOT TAP METALLURGY CONSIDERATIONS

6.1 GENERAL

The two primary concerns when welding on in-service piping and equipment are burn-through and cracking. Burn-through will occur if the unmelted area beneath the weld pool can no longer contain the pressure within the pipe or equipment. Weld cracking results when fast weld cooling rates produce a hard, crack-susceptible weld microstructure. Fast cooling rates can be caused by flowing contents inside the piping and equipment which removes heat quickly.

Consideration should be given to evaluating heat transfer during welding to determine the heat input and related welding variables in order to prevent overheating and burn through of the in-service piping or equipment. Also, consideration should be given to evaluating the expected cooling rate of the weld to determine the heat inputs required to produce welds (and heat affected zones) which are free of cracking. API, Edison Welding Institute and Battelle Laboratories documents (included in the Section 2 references) contain information regarding these evaluations.

An engineering evaluation should be conducted before in-service welding is performed on materials which contain laminations or other imperfections. Vessels or lines to be welded and hot tapped must also be inspected for adequate wall thickness and absence of imperfections. To minimize the risk of burn-through, the metal thickness should be adequate for the pressure (vacuum) and temperature involved so that the hot tapping machine, equipment, and personnel can be safely supported and operated.

A determination shall be made of the metal chemistry. The metallurgy of the weld materials, the hot tap fitting, and the welding (rod) electrode must be compatible with the metallurgy of the equipment to be welded or hot tapped. For example, a low-hydrogen process and electrodes are often

advisable to minimize weld cracking problems. Special welding considerations may be needed for high tensile strength steels to avoid weld cracking and the need for post weld heat treatment (PWHT).

6.2 BURN-THROUGH PREVENTION

To avoid overheating and burn-through, the welding procedure specifications should be based on experience in performing welding operations on similar piping or equipment, and/or be based on heat transfer analysis. To minimize burn through, the first weld pass to equipment or piping less than $\frac{1}{4}$ in. (6.4 mm) thick should be made with a $\frac{3}{32}$ in. (2.4 mm) or smaller diameter welding electrode to limit heat input. Subsequent passes should be made with a $\frac{1}{8}$ in. (3.2 mm) diameter electrode, or smaller if the metal thickness does not exceed $\frac{1}{2}$ in. (12.7 mm).

Note: The use of low heat input levels can increase the risk of cracking in high carbon equivalent materials.

For equipment and piping wall thicknesses greater than $\frac{1}{2}$ in. (12.7 mm), where burn-through is not a primary concern, larger diameter electrodes may be used. Where burn-through is of concern, care should be taken by avoiding the use of excessive welding current. In many situations, the use of low hydrogen rods may be preferable to reduce the possibility of burn-through and cracking when welding on high carbon-equivalency components. Some facilities avoid use of penetration electrodes to minimize the potential for burn-through.

6.3 FLOW IN LINES

For metal thickness less than $\frac{1}{4}$ in. (6.4 mm), some flow during hot tapping minimizes the potential for several unde-

sirable conditions. Overheating liquids, burn-through caused by elevated metal temperatures, and fluid thermal expansion in closed systems are less likely when flow is maintained. However, higher flow increases the weld cooling rate and the risk of cracking. Therefore, when welding, it is desirable to provide some minimum level of flow while avoiding high flow rates. The need for a minimum level of flow is a trade-off between the need to minimize the risks of burn-through and cracking (see the Battelle Institute report Investigation and Prediction of Cooling Rates During Pipeline Maintenance Welding and Battelle's Hot Tap Thermal Analysis Models or Edison Welding Institute Project J6176).

For metal thickness between $\frac{1}{4}$ in. (6.4 mm) and $\frac{1}{2}$ in. (12.7 mm), flow also increases the weld cooling rate and risk of cracking. Minimizing the flow rate reduces the risk of cracking and keeps the risk of burn through low. For metal thickness greater than $\frac{1}{2}$ in. (12.7 mm), the effect of flow on both weld cooling rates and the risk of burn-through may be negligible.

Under certain conditions, such as when welding or hot tapping on a flare line, there may be insufficient or interrupted flow which can result in a flammable mixture during the welding operation. In these circumstances it may be necessary to purge or flood the line with steam, inert gas, or hydrocarbon gas to prevent the formation of flammable mixtures.

6.4 METAL THICKNESS

The piping or equipment base metal thickness must provide support for the new connection and the hot tapping machine. Alternately, reinforcing pads or auxiliary support of the hot tapping machine may be provided. The base metal must be free of laminations, hydrogen attack, or stress corrosion cracking. Imperfections which might prevent a sound weld from being made must be evaluated by a qualified person or competent person with appropriate experience to conduct the evaluation.

Minimum base thickness requirements shall be stated in the written documentation for the job. A minimum base metal thickness of $\frac{3}{16}$ in. (4.8 mm) is recommended for most applications of welding and hot tapping. The actual minimum thickness is a function of the thickness required for strength, plus a safety factor, usually $\frac{3}{32}$ in. (2.4 mm), to prevent burn through. Exceptions to the recommended thickness may be permitted when metallurgical requirements and pressure (vacuum) limitations specified by a qualified company specialist are met.

6.5 FITTINGS

Many types of mechanical and welded fittings are available, such as welded outlet fittings, weld-ends, split tees, saddles and nozzles. A qualified or competent person shall select the proper fitting for the connection. Fittings must be properly

sized to accommodate the hot tapping machine, to allow for full depth of cutter penetration within the travel limits of the machine, and to allow for uninterrupted tapping valve closure when the cutter and cut out coupon are retrieved.

6.6 POST WELD HEAT TREATMENT (PWHT)

Some equipment and piping is unsuitable for welding in service, because the metallurgy or thickness of the metal and/or the contents require Post Weld Heat Treatment (PWHT) which normally cannot be done while the equipment or piping is pressurized. In such cases, mechanically attached fittings or taking the equipment out of service should be considered.

If PWHT is performed, the work should be reviewed to identify potential ignition sources and provide the appropriate permits and procedures.

6.7 METAL TEMPERATURE

The job analysis should include considering whether heating the weld area before welding is needed when the metal temperature is low enough (below the atmospheric dew point) so that moisture forms on the metal surface. Generally, welding should not be performed on lines or equipment when atmospheric temperature is colder than -50 °F (-45 °C) unless special precautions, such as providing temporary shelter, space heaters, and so forth, are taken. API Std 570 notes that pipe material temperatures from $+32$ °F to $+50$ °F require restrictive welding measures including the use of specific electrodes.

Preheating may be required by the welding procedure to avoid cracking whenever the base metal has high carbon equivalency or high tensile strength.

6.8 WELDING AND HOT TAP CONNECTION DESIGN

Welding or hot tapping should not be permitted closer than 18 in. (46 cm) to a flange or threaded connection, or approximately 3 in. (8 cm) to a welded seam (including a longitudinal seam of welded piping) unless determined by an engineering review to be acceptable.

Choice of hot tap location should assure that the connection is positioned to allow for the installation, operation, and removal of the hot tapping machine. Access and egress in case of a potential release or emergency should be established and communicated to recognize concern for workers and to address emergency response needs.

Welding and hot tap connections and repairs and alterations must be designed to the applicable code (see references in Section 2) such as the following:

- a. For piping designed to ASME B3 1.3, refer to API Std 570.
- b. For piping designed to ASME B31.4 and B 31.8, refer to ASME/ANSI B31.4.

7.2 HOT TAPPING MACHINE CONSIDERATIONS

Before hot tapping is attempted, the machine, cutter, and pilot bit should be carefully inspected to ensure that they are in satisfactory condition and capable of being left in service (if necessary) in the event of mechanical problems or hot tap valve leakage. All hot tapping machines have maximum and minimum working pressure, and high and low temperature

ratings. During hot tapping, consideration must be given to the possibility of operational upsets which may alter the process temperature or pressure. It must also be remembered that the hot tapping machine may have to remain in place for an extended period of time if removal of the machine is not successful. Figure 4 shows one type of hot tapping machine and a typical hot tap connection.

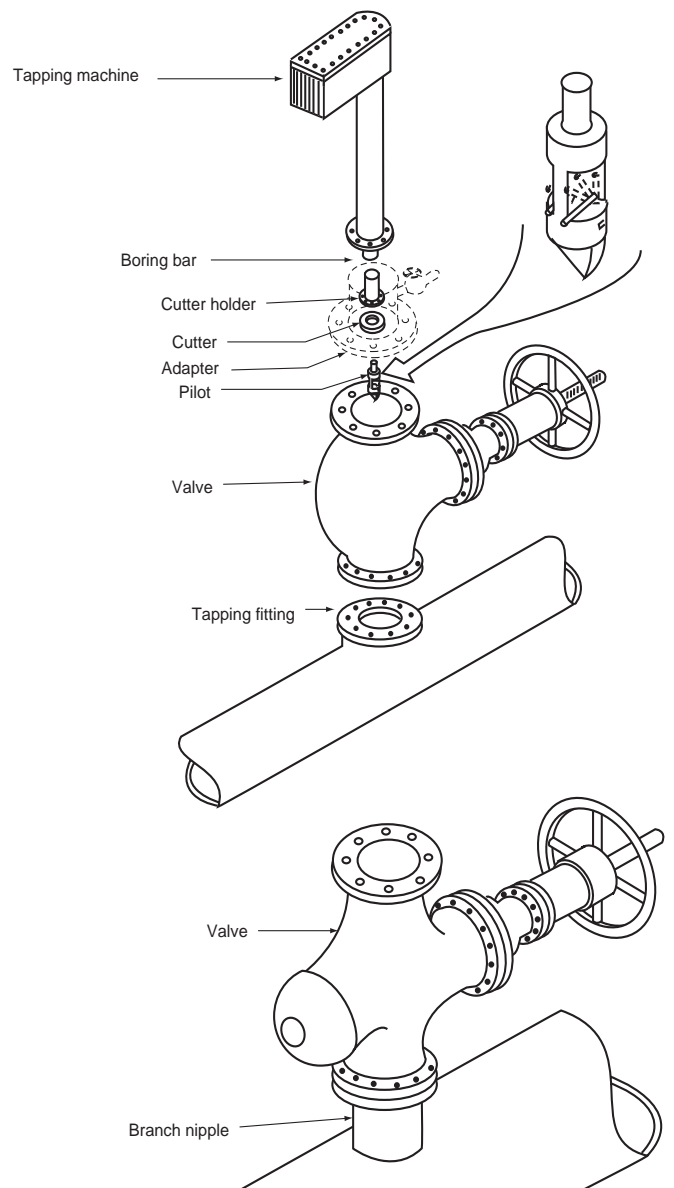


Figure 4—Hot Tapping Machine and Typical Hot Tap Connection

APPENDIX A—EXAMPLE HOT TAP CHECKLISTS

This checklist is an example of a type of aid some facilities use as a reminder to accomplish the steps involved in hot tap operations in an orderly manner. Particular circumstances of jobs may dictate additional preparatory steps. A checklist like this may be retained as a record of the job.

Location _____

Date _____

Job _____

Prepared by _____

Table 1—Before Starting the Hot Tap

	Each of the following considerations should be satisfied BEFORE STARTING THE HOT TAP	Date	Time	Initials Checked by
1	Review/follow hot tap machine manufacturer's operating instructions.			
2	Have the contents of the line or vessel to be hot tapped or welded been assessed, and MSDSs reviewed for health hazards, to assure procedure is appropriate?			
3	Is the material in the line or vessel stable under heated conditions?			
4	Has the connection been designed per Section 6 requirements?			
5	Do the flanges, bolts, gaskets, pipe, and valve to be installed meet the code for the line or vessel to be hot tapped?			
6	Has the welding procedure specification been developed as covered in this standard?			
7	Have approved work permits (e.g., Hot Work, Hot Tap, Entry) been obtained?			
8	Review manufacturer's instructions to ensure that the hot tapping machine has suitable pressure, temperature ratings, and adequate cutter travel for this job.			
9	Has the valve been pressure tested and the cover fitted to assure that it will work and fit properly?			
10	Has the exact location of the hot tap been identified and marked on the line or equipment?			
11	Is the area to be hot tapped located on a line in which flow has been established or below the liquid level of the tank or vessel?			
12	Has the area to be welded been inspected for thickness and freedom from existing welds, laminations, hydrogen attack, or other metallurgical imperfections?			
13	Are tests and inspections current?			
14	If laminations or defects have been found, has a thorough engineering evaluation been made by a qualified person to determine if and how to proceed with the work?			
15	Has the metallurgy of the line or vessel been established, and is it compatible with the connecting fitting?			
16	Can the welding and tapping area support the weight of the hot tapping machine, and is there adequate hoisting and support for the hot tapping machine and subsequent piping?			
17	If PWHT of the welded area is required, was an appropriate review conducted in accordance with 6.6.			
18	Is there sufficient external clearance to install the hot tapping machine and extract the cutter through the valve?			
19	Is there sufficient internal clearance to retract the cutter and coupon through the valve?			
20	Is the hot tap fitting of the proper length to accommodate operation of the hot tapping machine?			
21	Have oxygen, combustible gas, and atmosphere contamination tests been conducted in the hot tap area?			
22	Has a dedicated fire watch person been assigned and appropriate training and fire fighting equipment provided?			
23	Has the Fire Watch person been provided with a list of duties as outlined in Table 2?			
24	Are all personnel in the area equipped with appropriate personal protective equipment?			
24	Is there adequate storage area and room for operational needs and emergency access or egress?			
25	Has a procedure been prepared and in place to isolate the work area in the event of a failure and material release?			
26	Are personnel trained to implement the contingency procedure?			
27	Have the requirements been defined for weld inspection and for pressure testing, and is all of the testing equipment on hand and in good working condition?			

Table 2—Example of Fire Watch Duties

	FIRE WATCH DUTIES INCLUDE:	Date	Time	Initials Checked by
1	Being able to communicate effectively with personnel in area			
2	Watching for fires in all exposed areas			
3	Knowing how to use the assigned fire suppression equipment			
4	Knowing how to activate the facility fire alarm			
5	Trying to extinguish a fire only when obviously within the capacity of the equipment available (extinguisher or hose)			
6	Activating the fire alarm when available equipment is not sufficient to suppress minor fire.			
7	Maintaining a watch for at least 1/2 hour after completion of welding, hot tap or other hot work until the area has been inspected and found to be free of leaks and ignition sources (fires, hot spots or smoldering materials)			

Note: Facilities may choose to require subsequent follow-up observations to check for leaks.

Table 3—Before Welding

	Each of the following considerations should be satisfied BEFORE WELDING:	Date	Time	Initials Checked by
1	Are the welders qualified for the approved welding procedure (specification) to be used?			
2	Is a preheat of the weld area required?			
3	Is the fitting properly positioned to prevent misalignment of the hot tapping machine?			
4	Have the pressure and temperature of the contained materials been reduced as much as the process operation will allow?			
5	Have the flow, pressure, and level considerations of 6.3, 6.9 and 9.1 been considered?			

Table 4—Before Cutting

	Each of the following considerations should be satisfied BEFORE CUTTING:	Date	Time	Initials Checked by
1	Has the weld been inspected and tested?			
2	Has the hot tap fitting been pressure tested?			
3	Have the hot tap valve, packing, gasket, and bolts been checked for leakage?			
4	Have the packing or seals on the hot tapping machine been checked?			
5	Has the bleed off valve been checked to assure it will hold, is operable, and is not obstructed?			
6	Are all bolts on the pilot and cutter bit tight? (e.g., torqued to specification)			
7	Is the coupon catcher on the pilot bit?			
8	Is the valve centered on the flange?			
9	Has cutting depth been calculated to avoid cutting the opposite side of the pipe?			
10	Has the boring bar been run through the valve to assure free passage?			
11	Have the hot tapping machine and valve been purged, if recommended?			

Table 5—Before Removing the Hot Tapping Machine

	Each of the following considerations should be satisfied BEFORE REMOVING THE HOT TAP MACHINE:	Date	Time	Initials Checked by
1	Have the manufacturer's instructions been followed to be sure that the boring bar is fully retracted before closing the hot tap valve?			
2	Has the hot tap valve been closed?			
3	Has the bleeder valve been opened?			
4	Has all of the pressure been bled from the hot tapping machine before removing the bolts from the flange?			
5	Have provisions been made to contain or control any liquid or gas in the hot tapping machine?			

Table 6—After Removing the Hot Tapping Machine

	AFTER REMOVING THE HOT TAPPING MACHINE	Time	Initials	Date Checked by
1	The hot tap machine should be cleaned, removing the hydrocarbons/chemicals from the line or equipment.			
2	All rags, absorbent pads, and other cleaning materials must be disposed of properly			
3	When the work is completed a follow-up job site visit may be done by operations and craft personnel to see that:			
3a)	The work is complete,			
3b)	No safety hazards have been introduced during the work activity.			

Note: All of the checklists included in these tables are provided only as examples. They are not intended for adoption without review and customizing for individual circumstances. The titles and responsibilities used in these checklists are representative of practice used by some facilities in the petroleum and petrochemical industry. Facilities choosing to adopt a similar list should base it on their own organization structure, titles, assigned responsibilities, and specific hot tap and work permitting procedures.

EXAMPLE OF HOT TAP REQUEST FOR EQUIPMENT IN SERVICE (Page 2 of 2)

TO BE FILLED OUT BY INITIATOR:

TYPE OF PROPOSED INSTALLATION

HEADER OR VESSEL INFORMATION

LINE SIZE (in.) _____ METALLURGY _____
 OPERATING PRESSURE _____ PSIG TEMPERATURE _____ F
 PROCESS DESCRIPTION _____

BRANCH CONNECTION INFORMATION

LINE SIZE (in.) _____ FLANGE RATING _____ PSI
 GASKET MATERIAL _____ METALLURGY _____
 INITIATOR _____ DATE _____

A location sketch of the proposed hot tap is recommended. The hot tap location must have scaffolding (where required for access), insulation must be removed and the equipment must be marked for the exact hot tap location prior to notifying Pressure Equipment Inspection.

TO BE FILLED OUT BY THE AREA INSPECTOR AND PRESSURE EQUIPMENT ENGINEER

WALL THICKNESS AT HOT TAP LOCATION _____ (in.) DETERMINED BY: _____ DATE: _____

WELD DETAIL NUMBER:

1. PROCEDURE _____ X-RAY _____
2. PROCEDURE _____ X-RAY _____
3. PROCEDURE _____ X-RAY _____

INSPECTOR: _____

TESTS REQUIRED:

- (A) NOZZLE _____ PSIG MEDIUM _____
 (B) REINFORCING PAD _____ PSIG MEDIUM _____
 (C) BLOCK VALVE: HYDROSTATIC SEAT EACH SIDE AT _____ PSIG

AREA INSPECTOR _____ DATE _____

PRESSURE EQUIPMENT ENGINEER _____ DATE _____

TO BE FILLED OUT BY THE MAINTENANCE DEPARTMENT

HOT TAP MACHINE:

MAKE _____ MACHINE RATING _____ PSIG AT _____ F

MODEL _____ PRESSURE TESTED AT _____ PSIG

SERIAL NO. _____ BY _____ DATE _____

MAINTENANCE DEPARTMENT REPRESENTATIVE _____ DATE _____

Note: The titles and responsibilities used in this form are representative of practice by some facilities in the petroleum and petrochemical industry. Facilities choosing to adopt a similar form should base it on their own organization structure, titles, assigned responsibilities and specific hot tap and work permitting procedures.

APPENDIX C—EXAMPLE OF WELDERS INSTRUCTIONS PRIOR TO HOT TAPPING

WELDING SAFETY TASK REVIEW (WSTR)—PREPARATION FOR HOT TAPPING

Review the Hot Tap plan and verify that all workers understand their duties. (All members of the crew are to be present for the Welding Safety Task Review (WSTR) including pipe foreman, welding foreman, pipe welder, pipefitter, and helper.)	
Discuss proper clearance for hot tap machine	
Discuss hot tap request form information and requirements (thickness of pipe to be welded, temperature of pipe to be welded, pressure in line and product in line to be welded).	
Discuss proper welding procedure with welder or welders that are going to be involved with welding process (location of machine plus setting of amperage on machine).	
Verify that the right location or area was ultrasonic tested for thickness and marked for weld attachment of hot tap fitting.	
Discuss how to clean area to be welded, prior to welding.	
Discuss required tools to be used for cleaning pipe, grinding tacks, grinding stringer. (If power tools are not recommended, what alternative tools must be used.)	
Discuss gap needed for root pass between stub and existing header.	
Discuss need to electrically bond (ground) ground cable to hot tap fitting	
Discuss amount of penetration needed on stringer bead. (Avoid excess amount of weld penetration which could interfere with drilling of hot tap; don't back weld fittings.)	
Discuss requirement to clean out Hot tap stub and remove all debris at completion of weld.	

Note: WELDING SUPERVISOR MUST BE PRESENT FROM WSTR MEETING THROUGH WELDING OF STRINGER BEAD.

The above is a generic example of instructions used with welders preparing for a hot tap. It is not intended for adoption without review and conforming to specific facility needs. Facilities choosing to adopt a similar list should base it on their own organization structure, titles, assigned responsibilities and specific hot tap and work permitting procedures.