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BALLOT # 7084

Safe Hot Tapping Practices in the Petroleum and Petrochemical Industries

API RECOMMENDED PRACTICE 2201

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Safe Hot Tapping Practices in the Petroleum and Petrochemical Industries

1 Scope

Hot tapping is the technique of attaching a 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. The fitting may be attached through in-service welds or mechanical means. Since bolted or mechanical fittings are not common practice in oil processing and petrochemical facilities, 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;
- elements to consider during the hot tap process from job analysis through completion;
- suggestions on "what to do if things go wrong."

This recommended practice is intended for use in new facilities and for major modifications or expansions of existing facilities, or when establishing new programs. It is not intended that the provisions of this document be applied retroactively to existing facilities. This document may be used as guidance when reviewing existing procedures, programs, or facilities.

1.1 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.

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2 Normative References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any addenda) applies.

No normative references.

3 Terms and Definitions

For the purposes of this standard, the following terms and definitions apply

3.1 acute hazard

The low momentum mixing of a gas or vapor with air.

NOTE: The mixing is the result of turbulent energy exchange, which is a function of wind (mechanical eddy formation) and atmospheric temperature profile (thermal eddy formation).

3.2

Acute health hazard - 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.

NOTE: 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.

3.3

bleed off valve

A valve provided to release, vent, equalize or drain pressure or fluid from piping or equipment.

3.4

chronic health hazard

Capable of causing effects occurring from exposure over a long period of time (often at low-level concentrations). 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 many petroleum or petrochemical vapors, risk relates to inhalation exposure. Emphasis on monitoring, ventilation and respiratory protection become key factors in risk reduction.

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3.5

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.

NOTE (OSHA 1926.32) The concept of “competent person” is performance based and relative to the context of the work to be done.

3.6 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.

NOTE Examples of confined spaces in the petroleum industry include: process vessels, vessel tower skirts, flare stacks, boilers, 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).

3.7

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).

NOTE 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.

3.8

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.

3.9

hot tap valve

A full-opening isolation valve installed on a hot-tap fitting that allows a hot-tapping machine to be attached, permits the cutter and coupon to pass through the valve bore without obstruction, and provides isolation after the tapping operation is completed.

3.10

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.

NOTE Special procedures and permits are required when hot work is to be performed in certain areas. (Annex D of ANSI Z49.1 lists more than 90 welding and allied processes that can qualify as “hot work”).

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3.11

hydrogen blister

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

3.12

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.

3.13

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.

3.14

Line stopping

The line stopping is a means of temporarily plugging a pressurized pipe without stopping pressure of service upstream of the line stop. A hot tap is first made into the main, allowing insertion of the line stop-plugging device into the main under pressure, ASTM PCC-2 - Repair of Pressure Equipment and Piping PCC-2 – 2022 details the line stopping process.

3.15

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 lock-out device is removed” (from OSHA 1910.147).

3.16

lockout/tagout

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

3.17

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).

3.18

particulate

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

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3.19

permissible exposure limits (PELs)

Federal workplace chemical exposure regulations set by the Occupational Safety and Health Administration, U.S. Department of Labor.

NOTE found at 29 Code of Federal Regulations 1910.1000 and in the substance-specific standards which follow.

3.20

permit

A written document authorizing a work activity and defining the conditions under which the work shall be conducted.

NOTE Normally signed by both the recipient and an issuing competent person with authority to allow the activity to take place.

3.21

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.

3.22

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.

3.23

risk

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

3.24

risk assessment

The identification and analysis, either qualitative or quantitative, of the likelihood and out- come of specific events or scenarios with judgements of probability and consequences.

3.25

risk-based analysis

A review of potential needs based on a risk assessment.

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3.26

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.

3.27

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).

3.28

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.

3.29

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.

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 should conform to Recognized And Generally Accepted Good Engineering Practices (RAGAGEP):

- 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.

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- d) The job analysis shall identify task-specific risks and verify that appropriate mitigation measures are implemented, including justified deviations from standard safety minimums when necessary. (Reference Annex A, B and C, for standard checklists and/or standard request documents.)

Since hot tapping work cannot 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 firefighting, personnel evacuation, and/or alternate methods (such as changes in plant operations) to finish the hot work without incident. Annex C provides an example of a hot tap emergency action contingency plan.

4.2 Reviewing 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 should 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

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 Annex C). 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).

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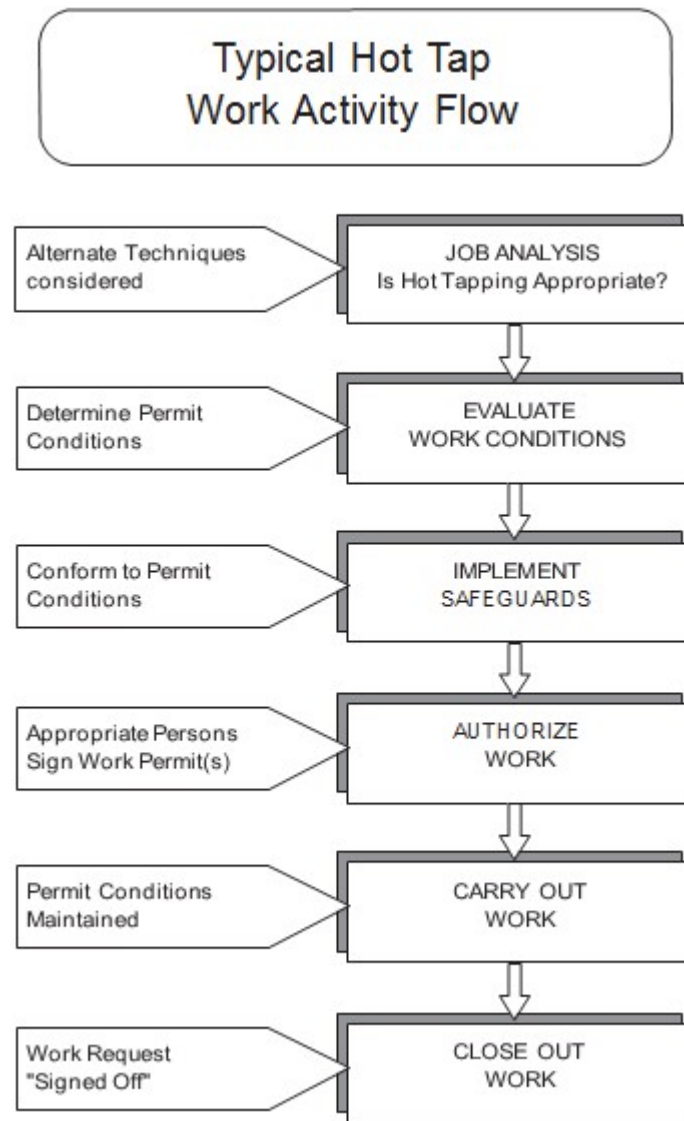


Figure 1—Typical Hot Tap Activity Flow

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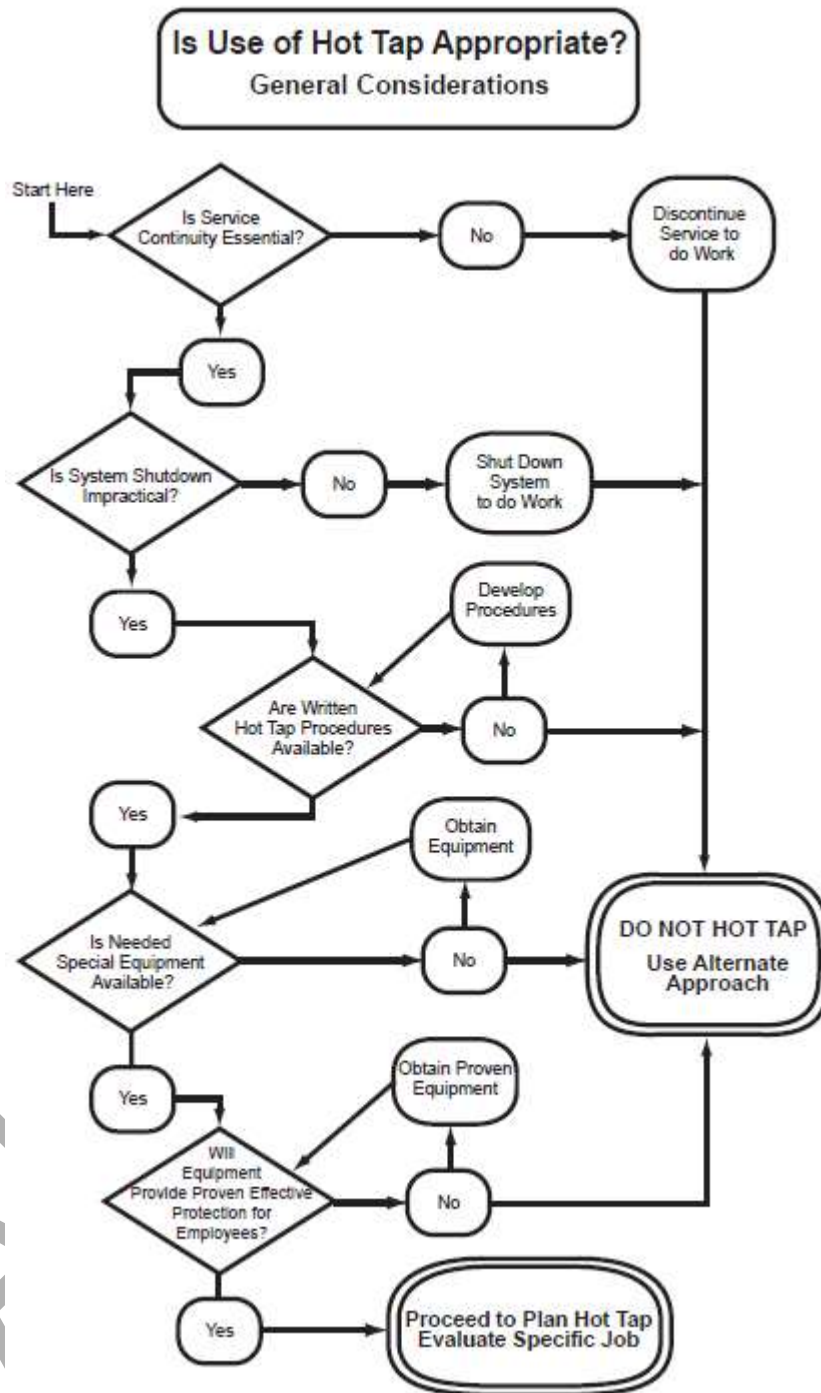


Figure 2—Example Process to Review Whether Hot Tapping is Appropriate

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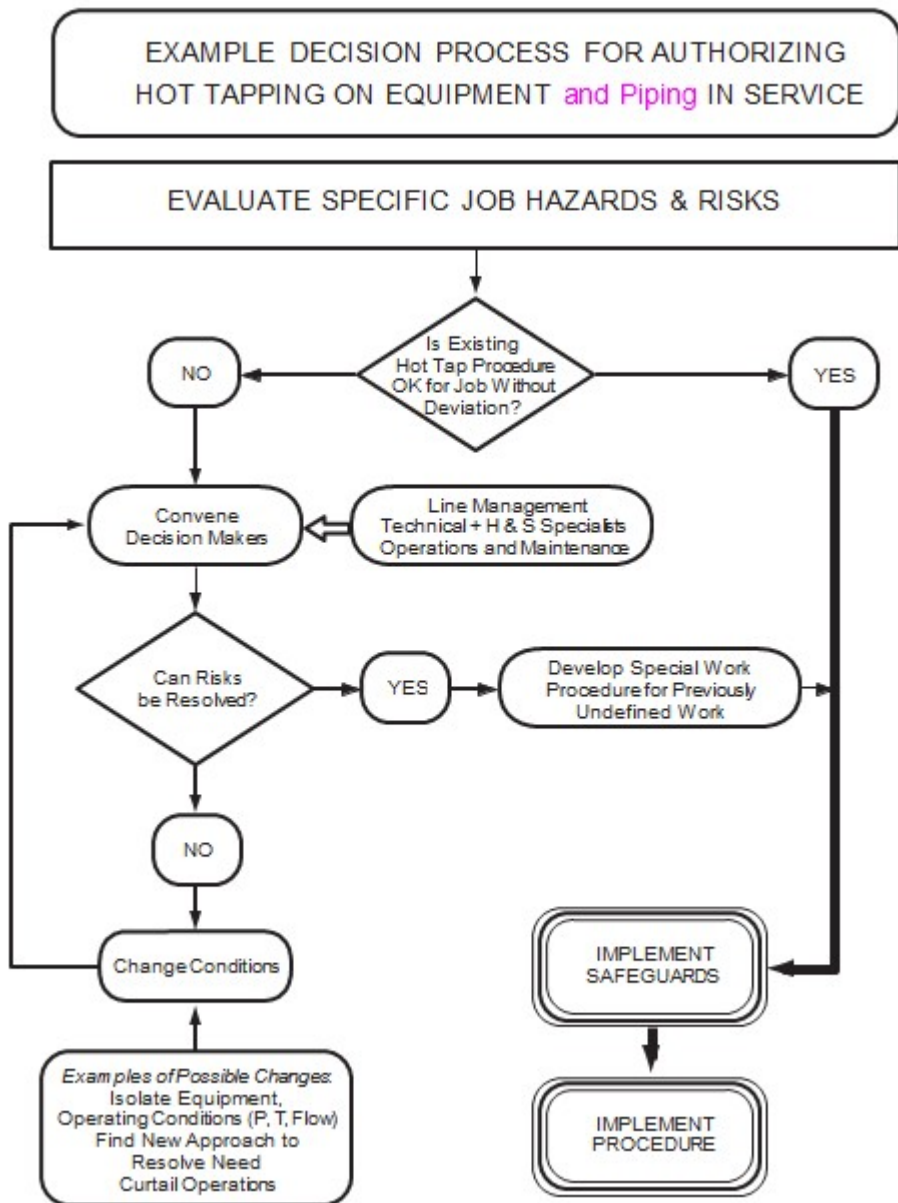


Figure 3—Example Decision Process for Authorizing Hot Tapping

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.

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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

In-service welding and 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 complex" 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 in-service welding associated with the hot tap can stress metal and heat fluids in vessels and piping.

5.3 Thermal Burn Hazards to Personnel and Risk Reduction

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.

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, which can be removed prior to the hot work associated with a hot tap.

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

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

- c) Consider halting transfer operations in areas where tanks are receiving flammable liquids or gases and could vent into the hot tap area;
- d) continuous monitoring to ensure that the atmosphere is free of flammable material;

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.

6 Welding and Hot Tap Metallurgy Considerations

6.1 General

In service welding procedures are typically qualified to either API 1104 Annex B or ASME IX with ASME PCC-2 depending on the design code. When performing in-service welding, there are three issues that need to be considered as part of the welding procedure: burn-through, weld cracking, and in some cases, metallurgical changes.

First, weld burn-through can occur when the area beneath the weld pool can no longer contain the internal pressure during welding. This risk of burn-through occurring increases as the wall thickness decreases, the pressure increases, or the flow decreases. The risk of burn through is elevated on material less than 0.250", particularly when coupled with no-flow conditions. Prior to welding, UT should be performed where the in-service weld is planned to measure the minimum wall thickness and to look for laminations that might be unacceptable. To minimize the risk of burn-through, use low hydrogen welding process or consumables, smaller diameter electrodes, and by limiting the welding heat input.

Second, weldment cracking can occur in several different forms depending on the metallurgy. In carbon and low alloy steel, hydrogen-induced cracking is the most common cracking risk. Factors that can affect cracking are the amount of diffusible hydrogen, high stress, and a susceptible microstructure. The operating conditions and product can lead to accelerated cooling rates during in-service welding resulting in harder, more crack-prone microstructures. The material and fitting chemistry as well as control of the weld heat input or the use of temper bead welding procedures are effective ways of producing a less susceptible microstructure.

Welding consumables are the primary source of diffusible hydrogen in welds. Low hydrogen welding process's and consumables are recommended for all in-service welding procedures. Adherence to manufacturers recommended consumable control plans are recommended to minimize the risk of hydrogen cracking. Additionally, other potential sources of hydrogen include surface contamination (e.g. hydrocarbon-based grease, surface moisture etc.), and the internal service environment (e.g. gaseous hydrogen) may need to be considered in some situations. Hydrogen cracking is also known as delayed cracking and may not manifest immediately after welding is complete. Delayed inspection shall be employed as the final inspection of the weldment to ensure delayed hydrogen cracking risk is addressed. A shorter delay time can be appropriate if additional engineering assessment is performed and qualified.

Other forms of cracking can occur such as hot cracking due to weld contamination or low melting eutectic phases such in austenitic stainless steel. An engineering evaluation shall be performed when hot tapping on these alloys.

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Third, in some limited cases, the internal material metallurgy may be affected by the internal product during in-service welding. For example, this may include the formation of local carburized region or a eutectic phase formation on the ID surface. This phenomenon is typically limited to thin wall applications with higher heat input welds.

The burn through and cracking can both be managed by defining the allowable welding heat input window where both items are acceptable. The weld cracking risk is usually defined by the minimum heat input allowed to avoid microstructures that are hydrogen to hydrogen cracking. The maximum heat input is defined to manage the burn through risk.

The in-service weld cooling rates are influenced by the contents and flow conditions inside the piping or equipment, which actively removes heat from the weldment. Careful evaluation of heat transfer during welding is essential to define the allowable heat input range of in-service welding. This includes determining the appropriate maximum heat input and welding variables to prevent burn-through and the minimum heat input or temper bead procedure to minimize the formation of crack-susceptible microstructures in the weld and heat-affected zones.

API, Edison Welding Institute, Battelle Laboratories, DNV (Det Norske Veritas), E2G (Equity Engineering Cloud), and PRCI (Pipeline Research Council International) documents (included in the Bibliography references) contain information regarding approaches to determine weld cooling rate evaluations used to select weld heat inputs.

An engineering evaluation should be conducted before in-service welding. Piping and equipment to be welded and hot tapped must also be inspected for adequate wall thickness, laminations, and injurious defects. To minimize the risk of burn-through, the metal thickness should be adequate for the pressure/vacuum, temperature, and welding heat input. A determination should be made of the metal chemistry. The metallurgy of the weld materials, the hot tap fitting, and the welding (rod) electrode should 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 to avoid weld or environmental cracking and the need for post weld heat treatment (PWHT). Refer to ASME PCC-2 or API 1104 Annex B for guidance for welding procedure testing.

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 such as the Battelle, PRCI, E2G model, or equivalent. 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 smaller diameter welding electrode to limit both the welding current (penetration) and the heat input. Minimum base thickness requirements shall be stated in the written documentation for the job and must be allowed by the welding procedure specification. The actual minimum thickness is a function of the thickness required for strength, plus a safety factor. In most situations, the use of low hydrogen rods is preferred as they have less penetration than cellulosic electrodes.

NOTE The use of low heat input levels can increase the risk of cracking in high carbon equivalent materials with a fast-cooling rate. Consider a temper bead sequence to prevent cracking on these materials.

6.3 Flow Conditions in Lines

For metal thickness less than $\frac{1}{4}$ in. (6.4 mm), flow during welding affects the potential for burn-through or metallurgical changes but flow is not required for all conditions. The welding parameters, specifically the heat input, need to be selected to balance the flow induced cooling rate effects along with the burn-through and hydrogen cracking concerns. User needs to confirm that the expected cooling rate caused by the flow will produce acceptable cooling rates within the range of the weld procedure selected.

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For metal thickness between $\frac{1}{4}$ in. (6.4 mm) and $\frac{1}{2}$ in. (12.7 mm), the burn-through risk is low but the flow impacts the weld cooling rate and risk of hydrogen cracking. 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 Base Metal Integrity

The piping or equipment base metal thickness must provide support for the new connection and the hot tapping machine. Alternately, reinforcement or auxiliary support of the hot tapping machine may be provided. The base metal should be free of deleterious indications including but not limited to laminations, hydrogen attack, or stress corrosion cracking. Imperfections which might prevent a sound weld from being made must be evaluated by a engineering analyses prior to in-service welding.

A lamination is a non-sloping mid wall indication which results in a complete loss of the back wall reflection. It is abrupt, unlike internal corrosion which will be more gradual. Indications that do not result in complete loss of the back wall reflector are considered inclusions or stringers.

Inclusions and stringers are to be considered non-relevant for welding, unless their total area of the indication exceeds 7 in² (45 cm²) of the inspected area.

In the event the 7 in² (45 cm²) criteria are exceeded, perform the following:

Measure the carrier pipe or vessel wall thickness to ensure it is not below 0.500 inch. Other guidance requiring in-service welding calculations applies if wall thickness below 0.250 inch is identified.

Follow a temper bead welding procedure which combines low heat input and the application of a buttering layer. Ensure welders use a freshly opened can of E7018- H4R electrodes and do not exceed manufacture recommendations for electrode exposure.

Perform typical NDE and appropriate visual inspection, including after application of buttering pass. .

6.5 Fittings

Many types of mechanical and welded fittings are available, such as welded outlet fittings, weld-ends, split tees, saddles and nozzles. The appropriate fitting shall be selected in accordance with the governing design specification. Fittings must be properly sized to accommodate the hot-tapping machine, ensure full cutter penetration within the machine's travel limits, and allow unobstructed valve closure during retrieval of the cutter and coupon. The chemical composition of the fitting should also be considered as it will impact the maximum hardness produced during in-service welding.

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, a specialized welding procedure to negate the requirement of stress relief, mechanically attached fittings or taking the equipment out of service should be considered. Refer to ASME PCC-2.

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

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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 so the appropriate metal temperature can be achieved. The metal should be preheated by the appropriate heating method to the requirements stated with in the design code or standard and the welding procedure specification.

Preheating may or may not be achievable based off operating conditions. Preheating may be required by the welding procedure to avoid cracking whenever the base metal has high carbon equivalency or high tensile strength. Consider preheating controls to ensure the preheat temperature can be maintained during welding.

Post-heating may also be applied after the welding is complete. Post-heating is different post-weld heat treatment since post-heating shall only promote hydrogen diffusion and should not affect the weld microstructure.

Note: In many in-service applications, preheating and post-heating may not be practical as the product flow will constantly cool the weldment down to the product temperature.

6.8 Welding and Hot Tap Connection Design

Hot tapping should not be permitted closer than 6" (150mm) or 8 times the wall thickness of the header or pressure equipment for weld seams unless determined by an engineering analysis is acceptable.

Choice of hot tap location should ensure 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 must be designed to the applicable code or standard (see references in Bibliography). Where construction codes intended for new piping, such as ASME B31.3, do not address in-service modifications, they should not be used as the sole basis for design. In such cases, additional applicable standards that address post-construction activities, such as ASME PCC-2, ASME B31.4, or ASME B31.8, should be used to supplement the design, including for encirclement or split tee type fittings used for hot tapping and line stopping operations.

The design shall cover the specification of gaskets, valves, and bolts. Reinforcing pads or saddles shall be included in the design when required by the applicable code.

6.9 Hot Tapping Equipment Under Vacuum

There are concerns with performing hot-tapping under vacuum. Potential concerns include but are not limited to:

- a) Heat from welding might cause the wall of the vessel to buckle locally and deform inward at the hot work location. Deformation or buckling could cause the vessel to rapidly collapse.
- b) If welding penetrates the vessel wall the reduced pressure could draw in oxygen and allow the contents of the vessel to react. (There is a risk of introducing air, along with flame, when welding on vessels under vacuum.)

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 flammable limits (in some cases using process control by purging the hot tap equipment with inert gas prior to tapping). Prior to approving welding or hot tapping on vessels under vacuum an engineering evaluation should, at a minimum, determine:

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- a) Evaluate the internal metal temperature vs. the autoignition temperature of the contents.
- b) What flammable mixture of materials the vessel contains (fuel lean mixture is preferred since inadvertent introduction of air caused by breakthrough could bring portions of a fuel- rich mixture into the combustible range).
- c) What precautions are necessary to prevent burning through the vessel wall.

6.10 Piping and Equipment Contents

Welding and hot tapping should not be performed on piping or equipment containing the following products unless and engineering evaluation has been performed to verify the activities can be performed safely.

- a) Vapor/air or vapor/oxygen mixtures near or within their flammable or explosive range.
- b) Oxygen or oxygen enriched atmosphere. The oxygen may cause a vapor mixture to enter the flammable range and may affect the base metal being welded.
- c) Compressed air systems, unless known to be free of flammables and combustibles such as lubricating oil residues.
- d) Hydrogen, since carbon and ferritic alloy steels are susceptible to high-temperature hydrogen attack during process operations. Therefore, the engineering evaluation must ensure that the equipment has been operated within the Nelson curve for the particular steel involved. This includes hydrogen sulfide equipment.
- e) Temperature-sensitive, chemically reactive materials which might violently decompose or become hazardous from the heat of welding such as peroxides, chlorine, or other chemicals).
- f) The combination of process conditions, medium, materials, welding, current integrity of the equipment to be welded upon, should be assessed for active, in-active and the possible introduction of new degradation mechanisms. For example, high temperature applications, the risk of graphitization should be considered. Refer to API-571 – (Damage Mechanisms Affecting Fixed Equipment in the Refinery Industry).
- g) Caustics, amines, and acids (such as HF acid), if the concentrations and temperatures are such that the original fabrication specifications require PWHT. These services may cause cracking in the weld area or heat affected zone.
- h) Certain unsaturated hydrocarbons (such as ethylene) may experience exothermic decomposition due to elevated temperatures caused by welding, creating localized hot spots on piping or equipment walls that could lead to failure.
- i) Special considerations shall be performed to hot tap on systems with hydrogen/hydrogen-rich content, air/oxygen mixtures, or those which do not need oxygen to burn such as ethylene oxide, acetylene or propylene oxide.

Note: The higher temperature from the heat of welding may cause a vapor mixture to enter the flammable range with the welding or subsequent hot tapping providing a source of ignition.

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7 Hot Tapping Machines

7.1 General

Although commercial hot tapping machines are available, some companies prefer to build their own. Hot tapping machines may be powered by hand, air, hydraulic fluid, or electricity. These machines must be able to retain and remove the blank or coupon. The seals and materials of construction of the hot tapping machine must be compatible with the contents in the piping or vessel. The material of the drill or cutter must be suitable for effective penetration of the metal of the piping or vessel being tapped. Hot tapping machines must be designed and constructed to withstand the temperatures, pressures, and mechanical stress which may be imposed during their operation. The hot tap machine must be "special equipment which will provide proven effective protection for employees." This provision is in accordance with U.S. Federal OSHA requirements in 1910.147.

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.

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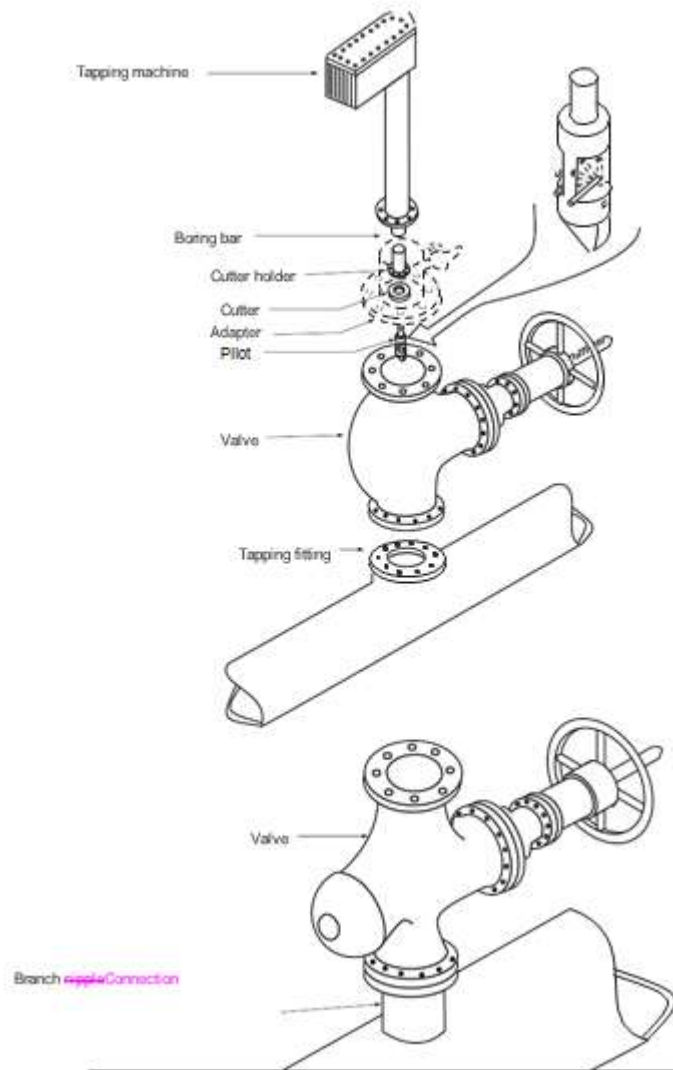


Figure 4—Hot Tapping Machine and Typical Hot Tap Connection

8 Preparations

8.1 Written Plans

Prior to conducting welding or hot tapping on piping or equipment in service, a written plan should be prepared which includes at least the following:

- a) Connection design, location and carrier thickness.
- b) Hot tap procedure.
- c) Detailed written welding procedure (qualified in accordance with the applicable code) documenting heat input, as appropriate.

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- d) Health, safety, fire protection, emergency response, and other appropriate procedures and instructions, including owner and user requirements.

Additional information when developing a written plan may be obtained from relevant codes and standards for qualification of welders and the fundamental ASME Code welding procedures to be employed. ASME PCC-2 provides guidance on hot tapping and address qualification of welders and the welding procedures. Some of these may be found in Section IX of the ASME Boiler and Pressure Vessel Code. For pipelines, API 1104 also address qualification of welders and the welding procedures to be employed when welding on new and in-service pipelines containing flammable and combustible liquids.

8.2 Management of Change (MOC)

During the Job Analysis and associated review by qualified persons, consideration shall be given to hazards that may be introduced to the process system as the result of planned use of the hot tap connection. This "Management of Change (MOC) review should conform to facility and regulatory requirements. The review should address any potential longer-term concerns related to the revised equipment as well as possible short-term effects during the hot tapping and in-service welding. Many companies require a higher level of management review and approval for hot tap authorization due to the risk involved as part of their MOC or hot work permitting process.

8.3 Personnel Competency and Qualifications

Personnel, including in-service welders and operators of hot tap and line stopping equipment must be qualified in accordance with applicable codes and specifications. They should be thoroughly familiar with the welding, hot tap equipment and procedures to be used. Only skilled competent personnel should mount and assemble the hot tapping machine. These skills may be achieved either through on-the-job training or by a formal training program provided by the manufacturer of the hot tapping machine. As noted in previous sections, certain aspects of the job analysis and planning involve participation and approval by both competent and qualified persons.

9 Special Conditions

9.1 Hot Tapping and Welding on Atmospheric Tanks

Welding on the exterior of tanks in-service shall not be conducted unless controls are established and in place to prevent flammable vapors from reaching the area of welding. Work must be stopped immediately should any flammable vapors be detected in the welding area.

Hazards associated with welding or hot tapping on tanks in operation include (but are not limited to) the following:

- a) Tank venting, with vapors reaching the work area where welding is taking place.
- b) Product within the tank rising and overflowing.
- c) Inadvertently allowing the liquid level within the tank to fall below the point of welding, thereby losing the heat sink provided by the liquid and exposing the vapor space within the tank to an ignition source.

Welding should not be conducted above the liquid level or on a tank which is double walled and/or which has an internal lining such as glass, polymeric or alloy cladding until inspection and analysis are made by a qualified person to determine whether it is possible to perform the work safely. If in-service welding and hot tapping is to be done on the outside surface of a tank, and if the area is otherwise safe for the use of an open flame, the following precautions should be employed:

- a) Pressure within the vessel shall be maintained in a range determined to be acceptable by a qualified person during the job analysis.

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- b) Atmosphere within the tank shall be incapable of being ignited because it is too rich or too lean or is non-combustible or non-reactive as determined during job analysis and associated reviews based on chemical analysis or other reliable evidence.
- c) Welding should not be performed on metal in the vapor space.
- d) Liquid level in the tank should be maintained at least 3 ft (1 m) above the area where the work is being performed when welding or hot tapping on atmospheric tanks in service (because of the potential danger of creating an explosive atmosphere inside the tank vapor space). This is to prevent welding on vessels or tanks in the vapor space.
- e) The tank should be static with no flow in or out. Never pump into or out of a tank during hot work. Turn off all mixers and heaters.
- f) Measurements of atmospheric tank levels should be verified by a hand tape gauge to verify the accuracy of automatic or remote reading gauges.
- g) Adequate precautions shall be taken to prevent burning through the tank or vessel wall during welding associated with hot tapping.
- h) Additional hazards associated with welding or hot tapping on tanks in operation include (but are not limited to) the following:
 - i) Tank venting, with vapors reaching the work area where welding is taking place.
 - j) Product within the tank rising and overflowing.
 - k) Inadvertently allowing the liquid level within the tank to fall below the point of welding, thereby losing the heat sink provided by the liquid and exposing the vapor space within the tank to an ignition source.
 - l) If under a vacuum the additional evaluations and precautions in 6.9 should be addressed.

9.2 Welding or Hot Tapping on the Decks of Floating Roof Tanks is Prohibited

Welding shall not be permitted on the decks of floating roof tanks in service. Floating roof tanks are subject to unique flammability hazards in the following specific locations:

- a) Inside the pontoons.
- b) Between the deck and liquid surface near the tank roof gauge float compartment.
- c) Near the roof seal vent.
- d) Near the floating roof lift leg vent.
- e) Between the primary and secondary seal.
- f) Near the roof drain.

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9.1 Welding or Hot Tapping Above or Below Grade

For hot tapping (and the associated welding work) above or below grade, provisions shall be made for an easily accessible means of egress. To assure that the atmosphere in excavations and confined spaces is safe for entry and hot work, tests shall be conducted for oxygen, flammable vapors and toxic air contaminants, and permit(s) issued listing the requirements and approving the entry into the confined space and hot work therein. The job analysis should determine if regulatory "Permit Required Confined Space" provisions (such as OSHA 1910.146), training (such as OSHA 1926.21) or ventilation [OSHA 1926.353(b)] apply. API 2015 and API 2016 provide useful guidance for confined space entry and work. Welding in any confined space introduces contaminants. An in-depth review is provided in the ASSE book "Guidelines for Hot Work in Confined Spaces". Special review should consider the personnel safety aspects of any proposed hot tapping in confined spaces or other areas from which rapid escape may be difficult. If there is a release of material the potential for exposure and injury will be significantly increased.

If oxygen deficiency, flammable vapors, or hazardous air contaminants are present, an air mover or other positive means of ventilation shall be provided. Respiratory equipment may also be required to provide protection from hazardous contaminants, vapors, or fumes emitted as a result of welding. Air monitoring may also be required during work activity to assure that air quality remains within the permitted safe work levels.

9.4 Hot Tapping and Welding on Pressurized Tanks or Vessels

Hot tapping on pressurized tanks and vessels requires a strict, engineered approach to prevent blowouts, explosions, and catastrophic failures. Welding on the exterior of pressurized tanks or vessels in-service shall not be conducted unless controls are established as outlined below:

- a) Conducting an engineering analysis, verifying minimum wall thickness is within the requirements outlined in the recommended practice.
- b) Maintaining controlled flow to dissipate heat or maintain an environment which is too lean (by inerting) or too rich (100% flammable without any oxygen) to support combustion. Atmosphere within the tank vessel shall be incapable of being ignited because it is too rich or too lean or is non-combustible or non-reactive as determined during engineering analysis and associated reviews based on chemical analysis or other reliable evidence.
- c) Avoid welding on seams, defects, or heavily corroded areas. All existing welds impacted with welding or hot tapping shall be inspected in accordance with the company's nondestructive examination requirements to ensure that no injurious defects are present. All relevant imperfections shall be evaluated and included in the engineering evaluation.
- d) In-Service vessel, maintain a minimum, consistent flow rate to dissipate welding heat, but avoid excessive velocities that cause rapid cooling and cracking.
- e) Closed systems where welding will increase pressure through thermal expansion. Pressure within the vessel shall be maintained in a range determined to be acceptable by a qualified person during the job analysis.

9.5 Welding or Hot Tapping on Lined Piping, Lined Equipment, or Cased Lines

Welding or hot tapping is not recommended on in-service lines or equipment with cladding, or with glass, lead, refractory, plastic or strip linings, unless specifically authorized by specialized procedures or following an engineering evaluation.

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When welding or hot tapping on underground lines which run through casings, care must be taken to assure that the annular space is gas free and that the work is performed on the pipeline and not on the casing.

9.6 Hot Tapping and Welding on Blocked-In Piping

Blocked-in piping consists of non-flowing fixed volume of product. Hot tapping on pipelines may have specific regulatory requirements (such as DOT for pipelines). Flow should be established in the pipeline to carry heat away from the weld site (see 6.10) and an open flow path should be maintained to prevent buildup of hydrostatic pressure due to liquid expansion in static "blocked-in" piping. No-flow can be performed with an acceptable engineering analysis (see 6.3). Reviews of piping and consumable welding material should be included in the job analysis. This review should determine potential personnel hazards associated with the material contained in the piping.

9.7 "No Flow" hot tapping exceptions

"No flow" hot tapping can be managed when the chance of burning through is low and the risk of other aspects of the hot tapping such as hardness is a greater concern. Hot tapping on "No flow" piping can be safely performed only when the pipe material is sound (i.e. Vessel wall integrity, corrosion issues reviewed, and size and thickness of pipe or vessel wall) (minimum 5 mm thickness), the pressure and temperature is low, and proper welding procedures are used to manage heat. It is critical that the pipe does not require post-weld heat treatment, is not corroded, and is free of internal linings. In addition, doing hot tapping on flammable or combustible liquids or gases without a flow to carry away the heat caused by the welding process requires all of the above listed conditions and additional specialized precautions to ensure that there is no burn through and loss of primary containment.

9.8 Hot Tapping Upstream of Equipment and Valves

Avoid hot tapping upstream of rotating equipment or automatic control valves, unless such equipment is protected from the cuttings by filters or traps.

10 Hot Tap Operations

10.1 Preliminary Requirements

Before proceeding with hot tapping or welding, the following conditions shall be satisfied:

- a) A MOC or hot tap management review has occurred and the hot tap has been evaluated and approved per company policies such as are outlined in this recommended practice by appropriate company engineering and management personnel.
- b) A competent and/or qualified person is committed to be present during the hot tapping and line stopping operations when applicable.
- c) The area where the connection is to be made has been identified and physically marked.
- d) The metal thickness has been verified and any metal imperfections that might prevent a proper weld have been completely evaluated and approved by a competent and/or qualified person. The measurements must be recent enough to represent the current metal condition (some facilities achieve this by requiring measurements no older than 28 days).
- e) All existing welds impacted with welding or hot tapping shall be inspected in accordance with the company's nondestructive examination requirements to ensure that no injurious defects are present. All relevant imperfections shall be evaluated and included in the engineering evaluation.

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- f) A plan has been prepared to monitor and control process variables within their required limits while hot tapping or welding is being performed.
- g) A contingency plan is in place. (This may include an Emergency Action Plan such as shown in the example in Annex C.)
- h) All necessary testing for flammable vapors, oxygen, and hazardous air contaminants has been conducted.
- i) Potential safety and health hazards have been assessed, and personnel protective equipment (including fire retardant clothing) is available for use as necessary.
- j) Appropriate hot work, hot tapping (and confined space entry if required) permits have been obtained and approved.
- k) A dedicated fire watch has been established and equipped with a suitable fire extinguisher or pressurized fire hose. This person shall understand fire watch duties, be able to communicate with the personnel working in the area and competent person trained in the use of the equipment. (See example list of duties in Table 2 of Annex A.)
- l) Egress plans need to be identified and addressed prior to work commencing.
- m) Signs and barriers have been provided when warranted to isolate the job site from unauthorized personnel or the public.
- n) Procedures have been prepared and are in place to isolate the work area (for example: isolating the process and depressuring the equipment/piping being worked on) in the event of an emergency. Attach field sketch of isolation points to be used in the event of emergency situations (isolation points must be tagged). List action steps to be taken in the event of an emergency (provide reference sketch when appropriate and specify PPE).

10.2 In-service Welding in Preparation for Hot Tapping

The following requirements are applicable to the in-service welding operation used as the first step in hot tapping:

- a) Select and use a welding procedure which is qualified for the specific application and design code, and allows appropriate welding heat input to manage the burn through and weld cracking risks, as determined by a qualified person.
- b) Assure that the welder is qualified for the specified procedure and appropriate code.
- c) Assure that the fitting is positioned and supported before welding, so that misalignment of the hot tapping machine will not occur.
- d) Ensure the gap between the fitting and the piping or equipment is within the limits of the in-service welding procedure.
- e) Ensure that the consumable control plan is followed
- f) Protect the weld area during cleaning, preparation, welding, and weld inspection if blowing dirt, snow, or rain is present.

10.3 Inspecting the Weld

Visually inspect all attachment welds after welding. Dye penetrant, ultrasonic, or magnetic particle inspection should be performed. Delayed inspection and/or post-weld hydrogen bakeout for hydrogen cracking risks should be a part of the engineering evaluation, users may refer to Pipeline Research Council – Post-Heating as an Alternative to

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Delayed Nondestructive Examination, PR-186-184508. If these are interim tests conducted after the first weld pass, the weld area must be thoroughly cleaned of any foreign material or residues before doing any more welding passes. These procedures should not be relied upon to replace the need for hydrostatic or pneumatic testing.

NOTE 1 If reinforcing is specified, either the hot tap machine operator or the owner of the in-service equipment may wish to pressure-test the nozzle prior to installing the reinforcing pad.

NOTE 2 The design code or standard may require additional NDE.

10.4 Installing the Hot Tapping Machine

When installing the hot tapping machine follow the manufacturer's instructions and the following items.

- a) Engineering analysis should be performed for weight loads and/or existing supports of the equipment to determine if additional support is required for the weight of the hot tapping machine.
- b) The hot tap valve to be used must be of adequate size and rating, be of proper metallurgy, and be a full opening valve. The hot tap valve should be tested for seat leakage prior to installation (see API Std 598).

NOTE Some process streams may require different valve types to minimize valve seat leakage.

- c) During installation the valve should be centered on the nozzle flange or fixture.
- d) Run the boring bar through the valve opening to be sure the cutter does not jam or drag. The pilot drill and cutter travel shall be specified in the hot tapping procedure. Ensure that the hot tap coupon will be retrieved and not obstruct the hot tap valve operation.
- e) Carefully calculate the travel distance of the cutter to ensure that the tap can be completed within the dimensional limits, that the cut will be stopped before the cutter or pilot drill touches the opposite side of the tapped pipe or vessel unless fitting design and tapping equipment allow such as a full bore line stop installation, and that the retrieved cut-out coupon can be retracted far enough to allow unimpeded closure of the tapping valve.
- f) Confirm that the bleed-off valve operates functionally and is not plugged.
- g) Ensure that precautions have been established for safe bleed off and disposal of material collected in the machine above the hot tap valve.

10.5 Pressure Testing

The hot tap machine, valve, and fitting should be pressure tested before the cutting is started. Testing procedures before cutting should include, but are not limited to the following

- a) Check tightness of bolts, packing, packing nuts, and any bypass line to avoid possible leakage.
- b) Confirm that the temperature of the line or vessel during testing is suitable for the required pressure tests. Users should consider, at a minimum, hydrotest medium suitability, and brittle fracture risks. In situations where a hydrostatic test is impracticable, a pneumatic test may be considered if agreed to by the owner and an appropriate engineering evaluation is performed. Due to the increased stored energy hazard present during pneumatic tests, users can refer to ASME PCC-2 Article 501 for in depth guidance.

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- c) The test pressure should be greater than or equal to the test pressure required by the applicable construction code of the equipment to be tapped, but not greater than the maximum test pressure allowed by the hot tap fitting and to ensure buckling of the piping does not occur. The maximum test pressure of the hot tap fitting can be determined per ASME PCC-2 Article 216.

10.6 Hot Tap Completion

Once work has started it should proceed without interruption until the hot tap has been completed and the valve closed:

- a) It is often possible to know when the cut is complete by the reduced resistance to hand cranking or when the drive motor speeds up.
- b) The manufacturer's instructions should be followed when retracting the bore and closing the valve. If the blank or coupon is lost, no attempt should be made to retrieve it with the hot tapping machine. If recovery of the blank or coupon is necessary, a retrieval plan shall be developed.
- c) Provisions should be made to ensure that adequate containment is available to control liquids and vapors trapped within the hot tapping machine which will be released upon removal of the machine after work is completed.

“Closing out the job” should follow normal facility permit procedures along with any special follow-up observation requirements established during the job analysis. The fire watch should remain at the site for 30 min. after hot work is complete. Special emphasis should be placed on checking for leaks in the hot tapped area.

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Annex A (informative)

Example Hot Tap Checklists

Tables A.1 through A.7 provide example hot tap checklists that may be used to assist in the planning and execution of hot tap operations. These checklists are intended as examples only and may be adapted to meet facility-specific requirements. A completed checklist may be retained as part of the records for the hot tap operation.

Table A.1—Before Starting the Welding and Hot Tap

	Each of the following considerations should be satisfied before starting the welding and hot tapping	Date	Time	Initials Checked by
1	Does the hot tapping equipment have suitable pressure, temperature ratings, and adequate cutter travel for the job?			
2	Has the hot tap valve been tested for proper operation (opened/closed) and operable for all intended hot tapping?			
3	Has the valve been leak tested (at minimum) prior to the hot tap operation?			
4	Has the hot tap location been positively identified and marked?			
5	Have the products been assessed, and SDS's reviewed for health hazards, to assure procedure is appropriate?			
6	Is the product stable under heated conditions, as applicable?			
7	Has the fitting or connection been designed per the particular design code requirements?			
8	Is the welding procedure specification suitable for the application?			
9	Are the welders qualified for the identified weld procedure[s] for the job?			
10	Are the hot tapping technician [s] qualified for the hot tapping and line stopping operations?			
11	Prior to welding, has the fitting been fit up to applicable WPS and manufacturer specifications and positioned to prevent damage to the fitting during the hot tapping process?			
11	Have approved work permits (e.g., Hot Work, Hot Tap, Entry) been obtained?			
12	Have the flow conditions been verified to meet the job requirements?			
13	If welding on an atmospheric tank, is the liquid level of the tank within a safe level for welding?			

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14	Has the area of hot tapping and welding been evaluated by non-destructive testing that is acceptable to the company, engineering analysis and code requirements?			
15	If laminations or defects have been found, has an engineering evaluation been performed to determine if and how to proceed with the work?			
17	Has the metallurgy and pressure class (rating) of the fitting or connection been verified?			
18	Can the tapping area support the weight of the fitting and hot tapping/line stopping/completion equipment, and is there adequate hoisting and support for the hot tapping/line stopping/completion equipment?			
19	Have the hot tap valve and fitting been visually inspected for damage and/or debris?			
20	Is there sufficient external clearance to install the hot tapping/line stopping/completion equipment, as required, and extract that equipment through the valve?			
21	Has the hot tap valve been tested for proper operation (opened/closed; record number of turns, as applicable) for all intended hot tapping/line stopping/completion operations?			
22	Does the hot tapping equipment include a coupon retention mechanism integrated into the pilot bit (e.g. U-wires)?			
23	Has the cutting depth been properly calculated for the job and does the tapping machine have enough travel complete the hot tapping operation?			
24	Is there sufficient internal clearance in the tapping housing to retract the cutter and coupon through the valve?			
26	Has atmospheric testing (LEL, oxygen and any health hazards) been completed prior to issuing the hot work permit?			
27	Has a dedicated Fire Watch person been assigned with the appropriate training and has firefighting equipment provided?			
28	Has the Fire Watch person been provided with a list of duties as outlined in Table 2?			
29	Are all personnel in the area equipped with appropriate personal protective equipment?			
30	Is there adequate egress in the event of an emergency?			
31	Has a contingency procedure been prepared and in place to isolate the work area?			
32	Are personnel trained to implement the contingency procedure?			

Table – A.2 Fire Watch Duties

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	Fire watch duties include:	Date	Time	Initials Checked by
1	Being able to communicate effectively with personnel in the 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	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 A.3 – Before Cutting

	Each of the following considerations should be satisfied before cutting:	Date	Time	Initials Checked by
1	Has the weld been visually inspected?			
2	Has the weld been non-destructively inspected when applicable?			
3	Have gauges been installed to verify pressure in pipeline and within hot tapping equipment?			
4	Has the hot tap fitting been leak tested (at minimum)?			
5	Have the hot tap valve, packing, gasket, and bolts been checked for leakage?			
6	Has the hot tapping machine been checked and bleed valve (if equipped) verified to be fully operational and unobstructed, per manufacturer or company specifications?			
7	Have the pilot and cutter been inspected and attached per manufacturer specifications?			
8	Is the coupon retention mechanism installed on the pilot bit?			
9	Have the hot tapping machine and valve been purged, if required?			

Table A. 4—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

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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, confirming number of turns, when applicable?			
3	Have provisions been made to contain or control any liquid or gas in the hot tapping machine?			
4	Has the bleeder valve been opened?			
5	Has all of the pressure been bled from the hot tapping machine before removing the bolts from the flange?			

Table A.5—After Removing the Hot Tapping Machine

	After removing the hot tapping machine	Date	Time	Initials Checked by
1	Has the hot tap machine been cleaned, removing the hydrocarbons, chemicals and Naturally Occurring Radioactive Material (NORM) when applicable from equipment?			
2	If the hot tap valve is to be removed, has the hot tap fittings primary plug been confirmed to be installed and completed to manufacturer specifications? (e.g. Installation blind flange or completion cap)			
3	If hot tap valve is left in place, has it been confirmed to be completed to company's specification?			
4	If hot tap / line stop job will not be completed and will continue at a later time and the hot tap valve is still in place, has a blind flange and/or threaded fitting been installed to prevent unexpected pressure release (e.g. leaking hot tap valve, unauthorized opening)?			
5	Has a leak test been completed on all hot tap fitting assemblies?			

Table A.6—Line Stopping Through Previously Installed Fittings

	Each of the following considerations should be satisfied before line stopping:	Date	Time	Initials Checked by
1	Has the velocity of the product been verified to not exceed the line stopping equipment manufacturer's specified limitations?			
2	Is the line stopping equipment compatible with the product and service conditions?			
3	Have gauges been installed to verify pressure in pipeline and within the line stopping equipment?			
4	Prior to removing blind flange / completion cap, has the area between completion plug and blind flange / completion cap been depressurized?			

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5	Has the hot tap valve been tested for proper operation (opened /closed) and operable for all intended line stopping operations?			
6	Has the equipment been checked and bleed / purge valve verified to be fully operational for completion plug extraction?			
7	Has the manufacturer's instructions been followed to be sure that the equipment has been assembled and installed correctly for completion plug extraction?			
8	Has leak testing been performed on the affected connections of the equipment for completion plug extraction?			
9	After removal has the completion plug been inspected?			
Line Stopping (applies to new and existing fittings)				
1	Has approval been issued to perform work on area to be isolated?			
2	Has the line stopping equipment been checked and bleed / purge valve verified to be fully operational?			
3	Have the manufacturer's instructions been followed to validate sufficient travel of the line stopping equipment and verify equipment has been assembled and installed correctly for operations?			
4	Have gauges been installed to verify pressure in pipeline and within equipment?			
5	Has leak testing been performed on the affected connections of the equipment?			
6	Has pressure been equalized from the pipeline to the equipment prior to opening hot tap valve?			
7	After inserting, has it been verified the line stop is holding pressure?			

Table A.7—After Line Stopping

	Each of the following considerations should be satisfied after line stopping:	Date	Time	Initials Checked by
1	After work was completed, has the isolated area been confirmed safe to remove line stopping equipment?			
2	Has the pressure of the isolated area been equalized?			
3	Have the manufacturer's instructions been followed to retract equipment and return pipeline to service?			
4	After bleeding down the equipment, has the hot tap valve been confirmed to hold pressure?			
5	If required, have pressure gauges been monitored while installing completion plug?			
6	Has all pressure been bled from the equipment above the hot tap valve prior to removal?			

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7	Has the completion plug been confirmed to hold pressure?			
8	Has the blind flange / completion cap been installed and leak tested?			

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Annex B (informative)

Example Hot Tapping Request Forms

Figures B.1 and B.2 provide example hot tapping request forms that may be used for equipment in service

NOTE Before initiating this request, refer to Facility "HOT TAP PROCEDURES" for more information. A separate request is required for each individual hot tap.

To _____ Date _____
(Operations Manager of equipment involved)

The following hot tap or hot work is proposed for your approval on piping, vessels, tanks, etc., in service in your area, or in an area affecting your operations:

Unit or Area _____

Location _____

Project Description _____

Alternate Solution or Remarks _____

Management of Change Review Completed by: _____ Date _____

From (Initiator) _____ Department _____

Approved by Operations Manager Involved _____ Date _____

Return this form with both sides filled out to the Initiator, who will obtain approvals as follows:

Pressure Equipment Supervisor _____ Date _____

Health and Safety Representative _____ Date _____

The Initiator handling this work will use this form to secure Fire and Safety Permits ("Hot Work"). In all cases, the operating department involved is responsible to positively identify the exact location of the hot tap or associated welding work.

Return this completed form to the inspector or person providing oversight for pressure equipment in the area where work is to be performed.

Figure B.1 - Hot Tap Request for Equipment in Service (1)

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TO BE FILLED OUT BY INITIATOR:

TYPE OF PROPOSED INSTALLATION:

HEADER OR VESSEL INFORMATION

LINE SIZE (in.) _____ MATERIAL _____

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 _____ NDT _____

2. PROCEDURE _____ NDT _____

3. PROCEDURE _____ NDT _____

INSPECTOR: _____

PRESSURE TESTS:

(A) NOZZLE _____ PSIG MEDIUM _____

(B) NOZZLE _____ PSIG MEDIUM _____

(C) BLOCK VALVE: HYDROSTATICS AT 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 _____

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Figure B.2 - Hot Tap Request for Equipment in Service (2)

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Annex C (informative)

Example In-service Hot Tap Emergency Action Plan

Figure C.1 is not intended to replace the facility's established emergency action plan; rather, it supplements the emergency planning requirements applicable to hot tap operations. The plan identifies potential issues that may arise during hot tap activities and the actions to be taken in response to unexpected conditions

Examples leaks; losing the hot tap coupon; hot tap machine becoming "stuck" and unable to be withdrawn; cutting through the opposite side of a pipe or vessel; or, significant loss of containment of process materials.

1. This plan has been communicated to all parties involved:
 Operations Craft persons Firewatch Site Emergency Response Leadership

2. Firewatch has been familiarized with equipment on site:
 Firewatch equipment Contractor equipment Facility Equipment Emergency PPE

3. Emergency action plan:
 - A. Emergency equipment description, including personal protective equipment for emergency response (such as SCBA, specific gloves, bunker gear, chemical suit, etc.):

 - B. Exact Location: _____

 - C. Process Material: _____ MSDS Hazard Ratings
Temperature: _____ Fire ____ Reactivity _____
Pressure: _____ Health _____ Other _____

 - D. Attach field sketch of isolation points to be used in the event of emergency situation (isolation points must be tagged) _____

 - E. List action steps to be taken in the event of an emergency (provide reference sketch which identified all actions needed to isolate the leak such as valves to be isolated and equipment that will need to be shutdown. This may involve a complete shutdown of the process unit and must be preplanned and staffed when appropriate and specify PPE) _____

 - F. If storage tank, note isolation valves to be chained and locked on sketch:
Is liquid level 3 ft above weld location? Yes No

4. Facility representative coordinating emergency action plan response
Name of facility emergency response representative: _____ Phone _____
Alternate facility emergency response representative: _____ Phone _____

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Figure C.1 - Hot Tap Emergency Action Plan

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Bibliography

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

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

API Std 570, *Piping Inspection Code: Inspection, Repair; Alteration, and Rerating of In-Service Piping Systems*

API Std 571 *Damage Mechanisms Affecting Fixed Equipment in the Refinery Industry*

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

API Std 598, *Valve inspection and Testing*

API Std 650, *Welded Steel Tanks for Oil Storage*

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

API RP 750, *Management of Process Hazards*

API Publ 941, *Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants*

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

API RP 2009, *Safe Welding, Cutting, and Hot Work Practices in the Petroleum and Petrochemical Industries*

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

API RP 2016, *Recommended Practice for Entering and Cleaning Petroleum Storage Tanks*

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

ACGIH *Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment and Biological Exposure Indices*

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

ANSI Z244, *Lockout/Tagout of Energy Sources (ANSI/NSC)*

ASME *Boiler and Pressure Vessel Code, Section VIII, Pressure Vessels and Section IX, Welding & Brazing Qualifications*

ASME B31.3, *Piping*

ASME B31.4, *Pipeline Transportation Systems for Liquids and Slurries* B31.8, *Gas Transmission Pipelines*

ASME *PCC-2 - Repair of Pressure Equipment and Piping (PCC-2 – 2022)*

ASSE *Guidelines for Hot Work in Confined Spaces*; Martin H. Finkel, CIH, CMCASSE Press, 1999

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AWS F 3.1, *Guide for Welding Fume Control*

Battelle Institute - *Investigation and Prediction of Cooling Rates During Pipeline Maintenance Welding and Battelle's Hot Tap Thermal Analysis Modes*

Det Norske Veritas *Project PP082753, Development of Industry Best Practices for Hot Tap Connections*

Edison Welding Institute - *Project J6176, Qualification and Selection of Procedures for Welding Onto In-Service Pipelines and Piping Systems*

ANSI/NB-23, *National Board Inspection Code*

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

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

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

Pipeline Research International - *Thermal Analysis Model for Hot-Tapping Welding*

USDOT 49, *Code of Federal Regulations, Parts 190–199*

USDOT 192.55, *Welded Branch Connections*

USDOT 192.151, *Tapping*

USDOT 192.627, *Tapping Pipelines Under Pressure*

U.S. OSHA 29, *Code of Federal Regulations, Parts 1910.252(d)(vi)*

U.S. OSHA 29, *Code of Federal Regulations, Part 1926 Subpart J (Welding and Cutting)*

U.S. OSHA 1910.119, *Process Safety Management of Highly Hazardous Chemicals*

U.S. OSHA 1910.146, *Permit-Required Confined Spaces*

U.S. OSHA 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)*

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

49 CFR 192.627