

DEP SPECIFICATION

HOT-TAPPING ON PIPELINES, PIPING AND EQUIPMENT

DEP 31.38.60.10-Gen.

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DESIGN AND ENGINEERING PRACTICE

DEM1



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the planning and execution of welded "hot-tap" branch connections onto piping systems and pipelines containing hydrocarbons under operating conditions. It has been developed to reflect current understanding of the technology and to improve safe practices in the field.

It is intended to cover hot-tapping on carbon, carbon-manganese and high-strength low-alloy steels (e.g., ISO 3183 L-245 to L485 or API Spec 5L grades B to X70), though many aspects may be relevant for other applications. Hot-tapping on other materials requires special consideration.

This DEP is not intended to cover subsea hot-tapping but many aspects are still relevant for such applications, subject to agreement from the Principal.

Due to the distinction made in the relevant standards between on-plot piping and off-plot pipelines or flowlines, a similar distinction is sometimes made within this DEP, but this has been avoided wherever possible.

This DEP assumes that the piping systems are designed and operated in accordance with ASME B31.3 and pipeline systems are designed and operated in accordance with ISO 13623, ASME B31.4, or ASME B31.8, or a combination thereof. The use of alternative standards is not expected to conflict with any of the principles adopted in this DEP or most of the specific requirements. However, see (1.2) below.

This DEP refers to DEP 30.10.60.30-Gen. for welder qualification, welding procedure qualification, welding and weld inspection. It is assumed that all hot-tap branch connections will be welded.

This DEP does not address the use of a non-welded system. Such systems require special considerations, including long-term integrity aspects and fire survivability.

This DEP mainly considers hot-tapping on pipes but it is possible to perform hot-taps on tanks and other equipment as outlined in (7).

This DEP is relevant to the hot-tapping aspects of "stoppling" operations; although the specific stoppling activities are excluded from the scope of this DEP, they should be subject to similar procedural detail as the hot-tapping activities described herein.

This DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual (DEM) 1 – Application of Technical Standards.

This is a revision of the DEP of the same number dated February 2016; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them.

Any authorised access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to oil and gas exploration and production and oil refining, but may also be applied in gas handling, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be

acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

It should be noted that hot-tapping often requires the approval of the relevant statutory authorities.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

The word **may** indicates a permitted option.

1.3.2 Specific definitions

Term	Definition
Asset operator	The individual within the Principal's organisation who is responsible for the operation of the pipeline, piping or equipment to be hot-tapped.
Branch pipe	The pipe which is to be connected to the run-pipe by means of the hot-tap.
Burn-through	The unmelted area beneath the weld pool can no longer contain the pressure within the pipe or equipment
Coupon	Section of pipe cut out during the hot-tap cutting operation
DN	Nominal Pipe Diameter
HAZ	Heat Affected Zone
HFW line pipe	High-frequency welded line pipe
Hot-tapping	A method of making connections to piping (or other equipment) by attaching a fitting to the system, usually by welding, followed by cutting through the pipe wall at the point of attachment utilising an appropriate (hot-tapping) machine. This operation is generally carried out on a live (hot) system without decommissioning or interrupting flow.
Lock plug	Plug which can be set into position inside a hot-tap connection flange in order to retain internal pressure.

Term	Definition
NPS	Nominal Pipe Size
O-ring type flange	Flange with internal segments which can be moved from the outside to lock into the circumferential recess of a plug that locks the O-ring type flange
Off-plot Pipeline	Pipeline designed in accordance with a recognized pipeline design standard e.g., ISO 13623, ASME B31.4 or B31.8. Parts of a piping system that were designed in accordance with ISO 13623, ASME B31.4 or ASME B31.8 are considered to be off-plot in this DEP, even if those parts are physically located on-plot such as inside the boundaries of a refinery or chemical manufacturing complex.
On-plot Piping	Piping system designed in accordance with ASME B31.3. Parts of a pipeline system that were designed in accordance with ASME B31.3 are considered to be on-plot in this DEP, even if those parts are physically located off-plot
Operating conditions	All conditions of piping and equipment when containing hydrocarbons under a positive internal pressure.
Run pipe	The pipe into which a hot-tap is to be made.
SAW line pipe	Submerged arc-welded line pipe
SME in Welding	Subject Matter Expert in welding as accepted by the Principal.
Stoppling	A hot-tapping operation which includes the insertion and setting of a sealing plug in the pipe in order to stop flow and withstand a certain fluid pressure.
WPS	Welding Procedure Specification

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (10).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated February 2016. This is an administrative update only to correct references to DEPs that have been involved in either a merge or a split.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the "Give feedback" link, fill in the online form and submit.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://swwww.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.
DEP Standard Form (other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

2. GENERAL CONSIDERATIONS

2.1 JUSTIFICATION FOR HOT-TAPPING

1. A decision on whether hot-tapping is to be applied shall be based on careful considerations including at least the following aspects:
 - a. safety;
 - b. condition of the pipe/equipment under consideration;
 - c. configuration of the connection;
 - d. code/statutory requirements;
 - e. operating conditions;
 - f. technical capabilities of the drilling equipment under the operating conditions (pressure, temperature, nature of product);
 - g. related welding problems;
 - h. economic aspects;
 - i. environmental/pollution aspects.
2. If hot-tapping is to be applied under conditions approaching the technical or operational limits as defined in this DEP, specialist advice shall be obtained.

2.2 RESPONSIBILITIES

Hot-tapping is a multi-disciplinary activity, usually involving several departments, all bearing their own responsibilities. Coordination between departments and planning of activities is therefore of vital importance.

1. A case specific hot-tapping procedure shall be adopted, including a hot work permit procedure, which is to be approved by the authorised asset representative.
 - a. This specific procedure shall include a form containing all relevant details, which shall be signed by all parties involved to indicate that all requirements have been fulfilled.
2. The person accountable in the operating asset shall sign the form as final authorisation for the execution of the hot tap.
3. Overall responsibility for preparation and execution of the work shall be assigned to a single individual.
4. Responsibilities for dedicated activities required to assure the safety of personnel and integrity of plant should rest with the typical functions indicated below.
 - a. Design office
 - i. technical design of the modification;
 - ii. set-up of procedures;
 - iii. documentation;
 - iv. hot-tap register.
 - b. Inspection
 - i. gaining approval of the statutory authority (if applicable);
 - ii. condition of equipment/piping to be welded;
 - iii. inspection/testing of the construction;

- iv. testing/checking of materials, welding documentation, procedure and performance qualifications, welding parameters and heat input, quality control, welding, consumables;
- v. recording in the hot-tap register.
- c. Field organisation
 - i. suitability and condition of the drilling equipment to be used;
 - ii. selection of welding personnel, process and procedures;
 - iii. safety of the operation from an engineering point of view;
 - iv. overall coordination of work execution, QA/QC;
 - v. hot work/site entry permits.
- d. Operating staff
 - i. the assurance that the operating conditions laid down in the procedure will be maintained during the hot-tap operation;
 - ii. suitability of the process fluids for the envisaged operation;
 - iii. safety of the hot-tapping activity from an operational standpoint;
 - iv. contingency planning;
 - v. emergency procedures.

2.3 DOCUMENTATION

1. The supporting documentation for a hot-tap operation shall consist of the following:

2.3.1 Design calculations

1. Design calculations shall be based on the requirements of (4).

2.3.2 Drawings and records

1. The hot-tap design package shall, as a minimum, include a cross-sectional general arrangement to define the hot-tap connection.

2.3.3 Safety plan

1. A safety plan shall be prepared for each hot-tapping operation by the Principal's field organisation and shall be agreed beforehand with other relevant departments and the Contractor.
 - a. The safety plan should be brief, otherwise it becomes self-defeating.
API RP 2201 provides guidance on safe practices for hot-tapping operations.
2. Safety plan topics to be addressed shall include the following:
 - a. access to and around the hot-tap location for personnel and the welding and hot-tapping equipment, including requirements for scaffolding;
 - b. roles of involved personnel and their responsibilities on site;
 - c. monitoring of operating conditions (flow rate, pressure, welding temperature, metal temperature due to welding heat input) and gas levels;
 - d. foreseeable hazards and contingency actions;
 - e. communications on site;
 - f. warning system and emergency shutdown;
 - g. means of escape;
 - h. firefighting equipment and personnel;

- i. safety equipment and services;
 - j. first-aid facilities;
 - k. clearance requirements.
3. Emergency procedures shall be specifically addressed, either in the safety plan or in a separate document.

2.3.4 Work procedures

1. Procedures shall be prepared for all aspects of the physical work, including items such as:
 - a. site preparation;
 - b. pipe preparation, including a integrity statement of the pipe;
 - c. welding;
 - d. NDT of hot tap welding;
 - e. hydro-testing;
 - f. drilling/perforation;
 - g. reinstatement

2.3.5 Hot-tap check list

1. The hot-tap procedure shall be supported by a checklist based on that given in (Appendix B).
2. The hot-tap checklist shall be completed at each step by the relevant action party.

2.3.6 Final documentation

1. Final documentation shall include material certificates, test reports, updated as-built drawings and relevant design/operating manuals.

3. RESTRICTIONS ON APPLICATIONS AND OPERATIONAL CONDITIONS

3.1 GENERAL

1. This DEP is relevant only to hot-tapping on carbon, carbon-manganese and high-strength low-alloy steels (e.g., ISO 3183 L245 to L485 or API Spec 5L grades B to X70).
2. Procedures for welding of X70 (L485) grade materials and higher shall be developed in consultation with an SME in welding.
3. Materials for pipelines and on-plot piping shall comply with the requirements of the applicable piping classes in DEP 31.38.01.14-Gen., and DEP 31.38.01.23-Gen..
 - a. If it is proposed to hot-tap on piping materials other than defined above in (3.1), specialist materials engineers and SME in welding shall be consulted and a specific procedure developed.
4. The Welding Procedure Specification developed for the hot tap activity SHALL [PS] be confirmed by an SME in welding to limit the welding parameters so that the material in the region of the weld pool retains sufficient wall thickness to contain the internal pressure and avoid a burn-through.
5. Fitting and branch material shall be of a type and grade compatible with the material of the run-pipe to be hot-tapped, including sour service requirements where applicable.

6. Hot-tap welding should not be performed on materials that require post-weld heat treatment.
 - a. If stress relieving or post-weld heat treatment is required, a Welding Subject Matter Expert (SME) shall be consulted to assess whether it is feasible to make the specific hot-tapping operation with post-weld heat treatment.

Stress-relieving may be required if a material is susceptible to stress corrosion cracking and post-weld heat treatment may be specified by the design code if the wall thickness is greater than a certain limit.
7. Welding shall not be performed on lined, clad or internally coated pipe.

For internally flow coated pipes, welding is allowable.
8. Hot-tap welding shall not be performed on the following materials:
 - a. any material with a maximum allowable operating temperature greater than 370 °C (700 °F);
 - b. pipelines and on-plot piping where the minimum allowable operating temperature is less than -20 °C (-5 °F).
9. For hot-taps on materials with minimum allowable operating temperatures between -20 °C (-5 °F) and 0 °C (30 °F), adequate material toughness shall be ensured.
10. As noted in API STD 570, material operating in the temperature range from 0 °C (+32 °F) to 10 °C (+50 °F) shall be subject to restrictive welding measures, including the use of specific electrodes.
11. Welding SHALL [PS] not be carried out if the metal surface is wet (e.g., due to dewing conditions).
12. In case of dewing conditions, the metal temperature on the surface of the pipe shall be kept above 70 °C (158 °F) during the welding operation to prevent wetting of the metal surface and risk of (delayed) hydrogen cracking.

3.2 PROCESS FLUIDS

1. Hot tapping SHALL [PS] only be performed when all of the following conditions are met:
 - a. the process fluids remain stable when in contact with air during drilling and perforation operations;
 - b. components of the contained fluid will not decompose or react chemically during welding (e.g., leading to explosion, ignition, exothermic reaction), see (3.3);
 - c. the fluid and the hot containment will not react chemically during welding (e.g., leading to burning, (stress) corrosion, embrittlement).

These restrictions mean that welding operations cannot be carried out on equipment which contains:

- *Mixtures of gases or vapours within their flammable range that may become flammable as a result of heat input during welding operations.*
- *Oxygen-enriched atmospheres in the presence of hydrocarbons which may be present either in the atmosphere or deposited on the inside surface of the equipment or pipe.*
- *Compressed air in the presence of hydrocarbons that may be present either in the air or deposited on the inside surfaces of the equipment or pipe.*
- *Gaseous mixtures in which the partial pressure of hydrogen exceeds 700 kPa (ga), (100 psig); except where evidence from tests has demonstrated that hot-tapping can be done safely.*

- *Substances that may undergo reaction or decomposition leading to a dangerous increase in pressure, explosion or attack on metal. With certain combinations of concentration, temperature and pressure, acetylene, ethylene and other unsaturated hydrocarbons may decompose explosively, initiated by a welding hot spot.*
2. Welding SHALL [PS] only be performed on equipment or pipe confirmed to be free of hazardous substances (even at trace quantities) or conditions listed in Table 1.
 3. The list in Table 1 is not exhaustive; the responsible signatories for the hot-tap shall determine the fitness of the system for welding based on the process fluid, chemical reactivity and operating condition of the system.
 4. Hot-tapping SHALL [PS] not be performed on equipment at sub-atmospheric pressures.

Table 1 Hazardous substances or conditions that prevent Hot-Tap operations

Substances:
Acetylene
Acetonitrile
Butadiene
Caustic soda* / Sodium Hydroxide
Chlorine
Compressed air at a pressure in excess of 3 000 kPa (ga) (435 psig)
Elemental Sulphur
Ethylene
Ethylene oxide
Fat/lean Amine Solvents
Steam at a pressure in excess of 5 000 kPa (ga) (725 psig)
Hydrogen (partial pressure in excess of 700 kPa (ga) (100 psig))
Hydrogen sulphide*
Hydrofluoric acid
Oxygen
Propene (Propylene)
Propene oxide
Sulphuric acid
"Very toxic - acute" substances (as defined in DEP 01.00.01.30-Gen.).*
Conditions:
Dissolved hydrogen in the pipe wall (e.g., due to service history)
Pyrophoric scale deposits

NOTE: 1. *Constraint based on general hazard in the event of line puncturing during welding, not the welding process.

3.3 PROCESS CONDITIONS

3.3.1 General

1. The pipe wall temperature, welding penetration depth, fluid pressure and fluid velocity within the pipe shall be controlled during welding in order to avoid:
 - a. Burn-through;
 - b. Deterioration of the micro-structure of the pipe material due to:
 - i. excessive heat input resulting in excessive metal temperature;
 - ii. too rapid cooling of pipe during or after welding.

3.3.2 Maximum temperature of the pipe wall

1. An estimate of the maximum temperature of the inside of the pipe wall attained during welding shall be derived from (Appendix C) or (Appendix D), using the actual wall thickness of the pipe at the hot tap location and the expected heat input as Equation 3.1.
 - a. (Appendix C) and (Appendix D) cover the more usual pipe wall temperatures of 25 °C (77 °F) and 150 °C (300 °F), being the temperatures without and with preheat, respectively.
 - b. For initial pipe wall temperatures above 150 °C (300 °F), advice shall be obtained from a welding SME.
2. The maximum allowable temperature of the parent pipe at time of welding shall be determined, taking into account possible chemical reactions in the process fluid.
3. The maximum allowable temperature of the parent pipe at time of welding shall be no greater than 350 °C (660 °F). See also BS 6990.
4. For a specific hot-tap, the permitted ranges of voltage, current and welding speed shall be defined in the WPS and in accordance with DEP 30.10.60.30-Gen.
5. A simulation test shall be performed for pipelines, see DEP 30.10.60.30-Gen.
 - a. The simulation test shall consist of performing the proposed welding operation on an empty pipe and measuring the maximum temperature attained on the inside surface of the pipe using a temperature probe.
 - b. Materials, wall thickness, welding process, weld configuration, weld preparation and essential welding parameters shall be identical to the proposed hot-tap operation.

Ideally, the simulation test should be made using materials from the same Manufacturer and in the same supply conditions (e.g., controlled rolled or normalised pipe/plate) as the main run-pipe and branch-pipe.
 - c. Afterwards, the simulation weld shall be sectioned at its most critical locations with respect to burn-through and rapid cooling.
 - d. Weld penetration and maximum hardness value shall be measured on a macro of the actual weld.
 - e. The depth of penetration shall be checked against that predicted in (Appendix C) or (Appendix D) to assess whether there is an adequate safety margin.
 - f. The acceptance criteria for hardness shall be as specified in the pipe specification. Hardness shall be measured by the Vickers (HV 10) method in accordance with ISO 6507-1.

6. For manual shielded metal arc butt and fillet welds, the total heat input shall be calculated using Equation 3.1:

$$HI = K \cdot \frac{V \cdot A}{S}$$

Eqn 3.1

where:

- HI = heat input (Joules per mm)
K = net factor = 0.85 for butt welds
V = voltage (volts)
A = current (amperes)
S = travel speed (mm/s)

This formula is in SI units to match the graphs in (Appendix C) and (Appendix D), which are only available in SI.

7. Values of V, A and S shall be either:
- the actual values used in the welding procedure qualification, or
 - the mid-range values from the WPS.
8. Substitute the calculated value of HI in the relevant graph in (Appendix C) or (Appendix D) to estimate the weld penetration and maximum inner pipe wall temperature.
9. For materials other than those in (3.1) or conditions outside the range of (Appendix C) and (Appendix D), the minimum required pipe thickness may be determined based on either specific previous experience and/or data from trials, recognizing material properties and operating/design conditions.
- Such cases shall be subject to the approval of the Principal's Technical Authority.
10. If the estimated values are unacceptable or marginal (at the Principal's discretion) then a full-scale simulation test should be performed to determine actual temperature and penetration values.

It may be possible to reduce the maximum temperature attained during welding by modifying the WPS.

3.3.3 Pressure of process fluid

3.3.3.1 General

- For general safety reasons, at any time during the hot-tap operation the pressure of fluid inside the run-pipe shall not exceed 7 000 kPa (ga) (1 000 psig)
- The fluid pressure inside the run-pipe SHALL [PS] remain below the maximum working pressure of the hot-tap equipment at any time during the hot-tap operation.
- During hot-tap welding, the pressure of fluid inside the run-pipe shall not exceed the maximum allowable pressure as calculated using one of the following methods:
 - Temperature derating (3.3.3.2) which allows for reduction in strength of the pipe wall at welding temperature. This is applicable to both on-plot and off-plot pipes.
 - Fracture toughness (3.3.3.3). This is intended to prevent unstable crack propagation in pipelines.
- For off-plot pipeline applications, maximum pressures shall be calculated by both methods in (3.3.3.2) and (3.3.3.3), and the lower value taken as the maximum allowable pressure during the welding operation.