

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

MANUAL

HOT-TAPPING ON PIPELINES, PIPING AND EQUIPMENT

PTS 31.38.60.10

FEBRUARY 2010



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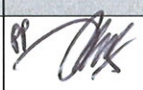
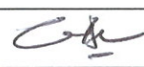
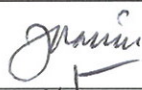
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This revision of **PTS 31.38.60.10– Hot Tapping on Pipelines, Piping and Equipment** has been updated incorporating PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards. All updates in the document are highlighted in *italic font*.

The previous version of this PTS (**December 1999**) will be removed from PTS binder/ e-repository from herein onwards.

Document Approval

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PREFACE

PETRONAS Technical Standards (PTS) publications reflect the views, at the time of publication of PETRONAS OPU/Divisions.

They are based on the experience acquired during the involvement with the design, construction, operation and maintenance of processing units and facilities. Where appropriate they are based on, or reference is made to, national and international standards and codes of practice.

The objective is to set the recommended standard for good technical practice to be applied by PETRONAS' OPU in oil and gas production facilities, refineries, gas processing plants, chemical plants, marketing facilities or any other such facility, and thereby to achieve maximum technical and economic benefit from standardisation.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where PTS may not cover every requirement or diversity of condition at each locality. The system of PTS is expected to be sufficiently flexible to allow individual operating units to adapt the information set forth in PTS to their own environment and requirements.

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1. INTRODUCTION

1.1 SCOPE

This PTS specifies requirements and gives recommendations for the planning and execution of "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 5L grades B to X70), though many aspects may be relevant for other applications. Hot-tapping on other materials requires special consideration.

This PTS is not intended to cover subsea hot-tapping but many aspects are still relevant for such applications.

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 PTS, but this has been avoided wherever possible. Additionally, it is assumed 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 (or other recognized pipeline design code e.g. ASME B31.4, B31.8), or a combination thereof. The use of alternative standards is not expected to conflict with any of the principles adopted in this PTS or most of the specific requirements. However, see (1.2) below.

It is assumed that all hot-tap branch connections will be welded.

NOTE: Where in accordance with the requirements of this DEP, or for other reasons, welding is not permitted, consideration may be given to the use of a non-welded system. Such systems are becoming increasingly available but require special considerations, including long-term integrity aspects.

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

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

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

This PTS is a revision of the previous publication of the same number dated December 1998; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS, the distribution of this PTS is confined to PETRONAS Group and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them.

This PTS is intended primarily for use in exploration/production facilities and oil refineries, but it may also be applied in chemical plants, gas plants and supply/marketing installations.

When PTSs are applied, a Management of Change (MOC) process should 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 may be more stringent than in this PTS, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this PTS 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 with the object of obtaining agreement to follow this PTS as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party which 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 which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. 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 word **should** indicates a recommendation.

1.3.2 Specific definitions and abbreviations

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.
Coupon	Section of pipe cut out during the hot-tap cutting operation.
HAZ	Heat Affected Zone
HFW linepipe	High-frequency welded linepipe
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-O-Ring flange	Flange with internal segments which can be moved from the outside to lock into the circumferential recess of a Lock-O-Ring plug.
Lock-O-Ring plug	Plug which can be set into position inside a hot-tap connection flange in order to retain internal pressure.
DN	Nominal Pipe Diameter
Off-plot Pipeline	Pipeline designed in accordance with a recognized pipeline design standard e.g. ISO 13623, ASME B31.4 or B31.8 (see Note below).
On-plot Piping	Piping system designed in accordance with ASME B31.3 (see Note below).

NOTE: Some parts of a pipeline system, although physically located "off-plot", may be designed in accordance with ASME B31.3. For the purposes of this DEP, such piping shall be considered to be on-plot. Similarly, some refinery piping, although physically located "on-plot", may be designed in accordance with ISO 13623, ASME B31.4 or B31.8. For the purposes of this DEP, such piping shall be considered to be 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 linepipe	Submerged arc-welded linepipe
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 PTS are made, the referenced section number is shown in brackets. Other documents referenced in this PTS are listed in (10).

1.5 SUMMARY OF MAIN CHANGES SINCE THE LAST REVISION

Only minor changes have been made to the previous revision, mainly to reflect the transition to ISO standards and a general updating of references.

2. GENERAL CONSIDERATIONS

2.1 JUSTIFICATION FOR HOT-TAPPING

Hot-tapping is potentially hazardous and therefore should only be undertaken when continuity of service is essential or shutdown of the system is impractical and when it is shown to be technically feasible and to offer a clear advantage over alternatives. The advantage may be economic and, in some situations, the safety and environmental risks may be less than those associated with more conventional methods.

A decision on whether hot-tapping is to be applied shall be based on careful considerations including at least the following aspects:

- safety;
- condition of the pipe/equipment under consideration;
- configuration of the connection;
- code/statutory requirements;
- operating conditions;
- technical capabilities of the drilling equipment under the operating conditions (pressure, temperature, nature of product);
- related welding problems;
- economic aspects;
- environmental/pollution aspects.

If hot-tapping is to be applied under conditions approaching the technical or operational limits as defined in this PTS, specialist advice should be sought.

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.

There should therefore be a general procedure for hot-tapping, including a hot work permit procedure, which shall be approved by the asset operator.

Subsequently, this general procedure shall form the basis for the specific procedure which shall be used for each particular application. 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.

Finally, the authorization from the asset operator is required for the actual execution.

Responsibilities for dedicated activities required to assure personnel and plant safety, integrity of the work performed etc. will normally rest with the typical functions indicated below. It is however important that overall responsibility for the work is clearly assigned to a single individual.

- | | |
|---------------------------|--|
| Design Office | <ul style="list-style-type: none">- technical design of the modification;- set-up of procedures;- documentation;- hot-tap register. |
| Inspection | <ul style="list-style-type: none">- gaining approval of the statutory authority (if applicable);- condition of equipment/piping to be welded;- inspection/testing of the construction;- testing/checking of materials, welding, consumables, etc.;- recording in the hot-tap register. |
| Field Organization | <ul style="list-style-type: none">- suitability and condition of the drilling equipment to be used;- selection of welding personnel, process and procedures;- safety of the operation from an engineering point of view;- overall coordination;- hot work/site entry permits. |

- Operating Staff**
- the assurance that the operating conditions laid down in the procedure will be maintained during the hot-tap operation;
 - suitability of the product for the envisaged operation;
 - safety of the operation from an operational standpoint;
 - contingency planning;
 - emergency procedures.

2.3 DOCUMENTATION

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

2.3.1 Design calculations

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

2.3.2 Drawings and records

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

Upon completion of the task, all drawings and manuals shall be updated according to the established standards of the Principal.

2.3.3 Safety plan

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. The safety plan should be brief, otherwise it becomes self-defeating. API RP 2201 provides additional guidance on safe practices for hot tapping operations.

Topics to be addressed shall include:

- access to and around the hot-tap location for personnel and the welding and hot-tapping equipment, including requirements for scaffolding;
- roles of dedicated personnel and their responsibilities on site;
- monitoring of operating conditions (flow rate, pressure, welding temperature) and gas levels;
- foreseeable hazards and contingency actions;
- communications on site;
- warning system and emergency shutdown;
- means of escape;
- fire fighting equipment and personnel;
- safety equipment and services;
- first-aid facilities.

Emergency procedures shall also be specifically addressed, either in the safety plan or in a separate document.

2.3.4 Work procedures

Procedures shall be prepared for all aspects of the physical work, including items such as:

- site preparation;
- pipe preparation;
- welding;
- NDT;
- hydro-testing;
- drilling/perforation;
- reinstatement.

2.3.5 Hot-tap check list

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

2.3.6 Final documentation

This shall include material certificates, test reports, updated as-built drawings and relevant design/operating manuals, etc.

3. RESTRICTIONS ON APPLICATIONS AND OPERATIONAL CONDITIONS

3.1 MATERIALS

This PTS 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 5L grades B to X70). Materials for pipelines and on-plot piping shall comply with the requirements of the piping classes PTS 31.38.01.12-Gen. and PTS 31.38.01.15 Gen. If it is proposed to hot-tap other materials, specialist materials/welding engineers shall be consulted and a specific procedure shall be developed. Current experience is limited to L450 (X65) materials (see also BS 6990) and therefore special attention should be given to procedures to be developed for higher grade materials.

It shall be ensured that during the welding operation the material in the region of the weld pool has sufficient strength to contain safely the internal pressure and avoid a blow-out. The risk of blow-out is dependent upon a complex interaction of welding conditions, pipe material, pipe thickness, pipe temperature and hoop stress. For materials of yield strength not greater than 450 N/mm^2 , operating at temperatures of not greater than 350°C and with a hoop stress of not greater than 72 % of the specified minimum yield stress, blow-out can be prevented during welding provided the minimum pipe thickness is not less than 5 mm. The actual minimum wall thickness shall be determined by ultrasonic testing. For other materials or conditions, a minimum pipe thickness shall be determined, based on either specific previous experience and/or data from trials.

NOTE: For some products, due to chemical reaction, the safe pipe temperature might be much lower than 350°C (See also BS 6990).

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.

Hot-tap welding should not normally be performed on materials which require post-weld heat treatment. However, if stress relieving or post-weld heat treatment is required, a specialist shall be consulted to assess whether it is feasible to make the specific hot-tapping operation with post-weld heat treatment.

Note: 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.

Welding shall not be performed on lined, clad or internally coated pipe.

Hot-tap welding shall not be performed on the following materials:

- any material with a maximum allowable operating temperature greater than 370°C ;
- pipelines and on-plot piping where the minimum allowable operating temperature is less than -20°C . For minimum allowable operating temperatures between -20°C and 0°C , additional attention shall be given to ensuring adequate material toughness.

3.2 PROCESS FLUIDS

Hot tapping shall only be performed under the following conditions:

- the contained process fluids remain stable when subjected to the high metal temperatures (see 3.3) during welding;
- the process fluids remain stable when in contact with air during drilling and perforation operations;
- there shall be no decomposition or chemical reaction between components of the contained fluid (explosion, ignition, exothermic reaction);
- there shall be no chemical reaction between the fluid and the hot containment wall (burning, (stress) corrosion, embrittlement).

These requirements lead to a number of situations in which welding operations are prohibited on equipment which contains:

- Mixtures of gases or vapours within their flammable range or which may become flammable as a result of heat input in welding operations.
- Substances which may undergo reaction or decomposition leading to a dangerous increase in pressure, explosion or attack on metal. In this context, attention is drawn to the possibility that under certain combinations of concentration, temperature and pressure, acetylene, ethylene and other unsaturated hydrocarbons may decompose explosively, initiated by a welding hot spot.
- 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 which 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), except where evidence from tests has demonstrated that hot-tapping can be done safely.

Based on the above, welding on equipment or pipe which contains hazardous substances or conditions as listed below (even in small quantities) shall not be performed unless positive evidence has been obtained that welding/hot tapping can be applied safely.

Substances:

- Acetylene;
- Acetonitrile;
- Butadiene;
- Caustic soda;*
- Chlorine;
- Compressed air at a pressure in excess of 3 000 kPa (ga);
- Ethylene;
- Ethylene oxide;
- Fat/lean DEA/MEA;
- HP steam (pressure in excess of 5 000 kPa (ga));
- Hydrogen (partial pressure in excess of 700 kPa (ga));
- Hydrogen sulphide;*
- Hydrofluoric acid;
- Oxygen;
- Propene;
- Propene oxide;
- Sulphuric acid;
- *"Very toxic - acute" substances (as defined in PTS 01.00.01.30-Gen.).**

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

Conditions:

- Vacuum conditions;
- Dissolved hydrogen in the pipe wall (e.g. due to service history);
- Pyrophoric scale deposits.

NOTE: The above list is not exhaustive, but gives an indication only.

3.3 PROCESS CONDITIONS

3.3.1 General

Attention shall be paid to controlling the pipe wall temperature, fluid pressure and fluid velocity within the pipe during welding in order to avoid:

- a) Blow-out of pressurized pipe due to the weakening effect of heat introduced during welding.
- b) Deterioration of the micro-structure of the pipe material due to:
 - excessive heat input resulting in excessive metal temperature;
 - too rapid cooling of pipe during or after welding.

3.3.2 Maximum temperature of the pipe wall

An estimate of the maximum temperature of the inside of the pipe wall attained during welding may be derived from (Appendix 2 or Appendix 3), using the actual wall thickness of the pipe (see definition of t_a in 3.3.3) and the expected heat input as derived below.

NOTE: Appendices 2 and 3 cover the more usual pipe wall temperatures of 25 °C and 150 °C, being the temperatures without and with preheat, respectively. For initial pipe wall temperatures above 150 °C, specialist advice should be obtained.

For a specific hot-tap, the permitted ranges of voltage, current and welding speed shall be defined in the WPS (see PTS 30.10.60.30-Gen.). For manual shielded metal arc butt and fillet welds, the total heat input shall be calculated from:

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

where:

HI = heat input (Joules per mm)

K = net factor = 0.85 for butt welds, and
= 0.57 (= 2/3 x 0.85) for fillet welds.

V = voltage (volts)

A = current (amperes)

S = travel speed (mm/s)

Note: Values of V, A and S shall be the actual values used in the welding procedure qualification. Alternatively, they may be taken as the mid-range values from the welding procedure specification.

Substitution of the calculated value of HI in the relevant graph in (Appendix 2 or Appendix 3) will give an estimate of weld penetration and maximum inner pipe wall temperature. 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.

Note: Regardless of the above recommendation, the simulation test **shall be performed** for pipelines (see DEP 30.10.60.30-Gen.).

Such a 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. Materials, wall thickness, welding process, weld configuration, weld preparation and essential welding parameters shall be identical to the proposed hot-tap operation.

Note: 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.

Afterwards, the simulation weld shall be sectioned at its most critical locations with respect to pipe blow-out and rapid cooling. Weld penetration and maximum hardness value shall be measured on a macro of the actual weld. Depth of penetration shall be checked against that predicted in (Appendix 2 or Appendix 3) to assess whether there is an adequate safety margin. 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 ASTM E92.

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

3.3.3 Pressure of process fluid

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) nor shall it exceed the maximum working pressure of the hot-tap equipment if this is lower.

During hot-tap welding the pressure of fluid inside the run-pipe shall not exceed the maximum allowable pressure, as detailed below.

Hot-tapping shall not be performed on equipment at sub-atmospheric pressures.

There are two ways to calculate the maximum allowable pressure during welding. The first is by temperature derating which allows for reduction in strength of the pipe wall at welding temperature, and is applicable to both on-plot and off-plot pipes. The second method is based on fracture toughness and is intended to prevent unstable crack propagation in pipelines. For off-plot pipeline applications, maximum pressures shall be calculated by both methods and the lower value taken as the maximum allowable pressure during the welding operation.

Method 1 - Temperature derating

The temperature derating calculation applies to both on-plot and off-plot pipe, the relevant formula being:

$$P = \frac{2S \cdot t \cdot F \cdot E \cdot T}{D}$$

where:

- P = Maximum allowable operating pressure during welding operation, in MPa;
- S = Specified minimum yield stress in N/mm² (for off-plot pipeline), or
Basic allowable stress, in N/mm² (for on-plot piping);
- D = Nominal outside diameter of run pipe, in mm;
- t = Reduced wall thickness (where $t = t_a - u$), in mm;
- u = Reduction in wall thickness during welding, representing the weld pool penetration, in mm. This may be derived from Appendix 2 or Appendix 3, or conservatively assumed to be 3 mm;
- t_a = Minimum actual wall thickness in mm. This value shall be determined in advance by ultrasonic measurement;
- F = A safety factor for off-plot pipeline (recommended maximum value 0.8) equivalent to the design factor. (For on-plot piping designed to ASME B31.3 this factor is already included in the basic allowable stress);
- E = Longitudinal joint factor, $E = 1$, for seamless, HFW and SAW linepipe manufactured in accordance with ISO 3183 or API 5L;
- T = Temperature derating factor, derived from Table 1 below.