

PETRONAS TECHNICAL STANDARDS

MANUAL

SHOP AND FIELD FABRICATION OF PIPING

PTS 31.38.01.31

OCTOBER 2011



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This revision of PTS 31.38.01.31 - Shop and Field Fabrication of Piping (October 2011) has been updated to incorporate 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 31.38.01.31 (December 2010) will be removed from PTS binder / e-repository from herein onwards.

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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.

When Contractors or Manufacturers/Suppliers use PTS they shall be solely responsible for the quality of work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, it is expected of them to follow those design and engineering practices which will achieve the same level of integrity as reflected in the PTS. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the owner.

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1. INTRODUCTION

1.1 SCOPE

This PTS specifies requirements and gives recommendations for shop and field fabrication and testing of piping, which shall also comply with ASME B31.3.

This PTS is a revision of an earlier PTS of the same number dated *December 2010*. A summary of the changes from the previous edition is listed in (1.6).

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS, the distribution of this PTS is confined to companies forming part of the PETRONAS or managed by a Group company and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them.

This PTS is intended for use in oil refineries, chemical plants, gas plants and, where applicable, in exploration and production facilities 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, environment, 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 that carries out all or part of the design, 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/Vendor** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

NOTE: In the context of this PTS, the term Vendor is used to mean both the material supplier and the piping system fabricator. The term Contractor is used in the sense of a managing contractor.

The **Principal** is the party that initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may 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

hydrogen service	refers to all process conditions with a hydrogen partial pressure greater than 7 bar (abs).
sour service	means "sour" service and "moderate/high severity wet H ₂ S" service, both of which are defined in PTS 31.38.01.11.
very toxic	substances as defined in PTS 01.00.01.30.

1.4 ABBREVIATIONS

GTAW	Gas Tungsten Arc Welding
HAZ	Heat Affected Zone
HFIB	High Frequency Induction Bending
ITCS	Impact Tested Carbon Steel
PWHT	Post Weld Heat Treatment
Q+T	Quenched and Tempered

1.5 CROSS-REFERENCES

Where cross-references to other parts of this PTS are made, the referenced section number is shown in brackets. Other documents referenced by this PTS are listed in (6).

1.6 CHANGES FROM THE PREVIOUS EDITION

The previous edition of this PTS was dated *December 2010*. Other than editorial changes, the following are the major changes to the previous edition.

Old Section	New Section	Change
2.1	3.1	Section number has been changed to maintain the sequence of piping fabrication activities.
2.2	3.2	Section number has been changed to maintain the sequence of piping fabrication activities.
2.3	3.3	Section number has been changed to maintain the sequence of piping fabrication activities.
2.4	3.4	Updated existing requirements for certification. Section number has been changed to maintain the sequence of piping fabrication activities.
2.5	3.5	Updated existing colour coding of piping bulk materials. Section number has been changed to maintain the sequence of piping fabrication activities.
2.6	3.6	Section number has been changed to maintain the sequence of piping fabrication activities.
2.7	3.7	Updated existing PMI requirements. Section number has been changed to maintain the sequence of piping fabrication activities.
2.8	3.8	Section number has been changed to maintain the sequence of piping fabrication activities.
3.1	2.1	Updated existing general requirements of piping fabrication, assembly and erection. Section number has been changed to maintain the sequence of piping fabrication activities.

3.2.1	2.2.1	Incorporated detailed requirements on cutting tools (grinding wheels) Section number has been changed to maintain the sequence of piping fabrication activities.
3.2.1	2.2.2	Updated existing piping assembly requirements. Incorporated requirements for flange bolt holes alignment, pipe spool length requirement. Section number has been changed to maintain the sequence of piping fabrication activities.
3.3	2.3	Section number has been changed to maintain the sequence of piping fabrication activities.
3.3.1	2.3.1	Updated existing bending requirements. Incorporated requirements to calculate the required wall thickness of welded pipe after bending. Section number has been changed to maintain the sequence of piping fabrication activities.
3.4	2.4	Section number has been changed to maintain the sequence of piping fabrication activities.
3.4.1	2.4.1	Updated existing welding requirements. Also updated welding root pass requirements. Section number has been changed to maintain the sequence of piping fabrication activities.
3.4.2	2.4.2	Incorporated PQR acceptability requirements for welding of duplex stainless steel. Section number has been changed to maintain the sequence of piping fabrication activities.
3.4.3	2.4.3	Incorporated welding consumables requirements for GMAW and GTAW. Section number has been changed to maintain the sequence of piping fabrication activities.
3.4.3.2	-	Incorporated new section on condition and storage of welding consumables.
3.4.3.3	-	Incorporated new section on heating and baking requirements of welding consumables.
3.4.4	-	Incorporated new section on qualification of welding procedures.
3.4.5	-	Incorporated new section on qualification of welder and welding operators.
3.4.6	-	Incorporated new section on production welding requirements.
3.4.7	-	Incorporated new section on weld surface finishing

		requirements.
3.4.7	-	Incorporated new section on welding repair requirements.
3.5	-	Incorporated new section on pipe spools marking requirements.
3.6	5.	Updated existing preservation requirements. Also changed painting applications PTS. Include PTS reference for preservation of piping systems and components. Section number has been changed to maintain the sequence of piping fabrication activities.
3.7	-	Incorporated new section on pipe erection requirements.
3.8	2.5	Updated existing requirements for final corrections. Section number has been changed to maintain the sequence of piping fabrication activities.
3.9	2.6	Section number has been changed to maintain the sequence of piping fabrication activities.
3.10	-	Incorporated new section on cleaning requirements.
3.11	-	Incorporated new section on assembly of flanged joints requirements.
4.1	4.1	Updated existing inspection general requirements.
4.2	-	Incorporated new section on inspection personnel requirements.
4.3.1	4.3.1	Updated existing NDE general requirements.
4.3.2	4.3.2	Changed section title to visual examination of welded joints. Include ASME BPV Code requirements for visual examination.
4.3.3	4.3.3	Include ASME BPV Code requirements for radiography (RT).
4.3.4	4.3.4	Include ASME BPV Code requirements for ultrasonic examination (UT).
4.3.5	4.3.5	Include ASME BPV Code requirements for liquid penetrant (PT) and magnetic particle examination (MT).
4.3.6	4.3.6	Updated existing FN measurement requirements.
4.4.1	4.4.1	Include hardness requirements for (super) duplex stainless steel.
4.4.2	4.4.2	Cosmetic changes
4.5	4.2	Updated existing requirements for pressure testing. Section number has been changed to maintain the

		sequence of piping fabrication activities.
5.	-	Incorporated new section on documentation.
6.	-	Include PTS 30.48.00.31-P and PTS 70.10.70.11.

2. MATERIAL SPECIFICATION, CERTIFICATION, COLOUR CODING AND TRACEABILITY

2.1 INTRODUCTION

This Section provides the minimum supplementary requirements for material certification, colour coding and material traceability during fabrication and construction.

2.2 RESPONSIBILITY

The Contractor shall be responsible for ensuring that the requirements stated in this PTS are followed.

2.3 MATERIAL SPECIFICATION

All steel pipes, flanges and fittings, etc. that shall be welded shall comply with the requirements of PTS 31.38.01.11.

2.4 GENERAL REQUIREMENTS FOR CERTIFICATION

The certification is used for the purpose of confirming the specified mechanical, chemical and physical properties of materials. Minimum certification requirements for materials and final products are given in the MESC buying descriptions and specifications. In addition to the requirements of MESC, the following also apply:

1. Material certificates shall comply with ISO 10474 or EN 10204.

2. *The following types of certificates are distinguished:*

- *Type A (Equivalent to DIN 50049.2.2)*

Certificates on material based on testing carried out by the manufacturing or processing works. It shall confirm that on the basis of test results from in-production testing the material supplied corresponds to what was agreed in the order.

- *Type B (Equivalent to DIN 50049.3.1B)*

Certificates in which the manufacturers inspectors confirm, on the basis of tests carried out on the delivery itself or on test specimens in accordance with the applicable specifications and related to the delivery, that the product supplied corresponds with what was agreed in the order. The necessary testing must have been carried out by a testing centre which is independent of the production section in the manufacturing works and which has the necessary facilities. When the independence of the testing centre is not warranted, the Principal approval of the testing centre shall be obtained.

- *Type C (Equivalent to DIN 50049.3.1C)*

Certificates as described under Type B. however the mechanical and physical tests are witnessed by an independent third party inspector approved by the Principal. These certificates shall be signed and stamped by this inspector for acceptance or alternatively this inspector issues a separate certificate which refers to the mill certificates.

3. The language used in material certificates shall be English. Certificates in other languages are acceptable provided that these are accompanied by an endorsed, stamped and dated English translation of the original certificate.
4. Certificates for final products (such as welded fittings) shall include certification of the base material and a copy of the welding procedure qualification applied. If the Manufacturer of a semi-finished product and the Supplier of the base material are not the same, the certificate shall consist of two documents covering both stages of the manufacturing process.
5. *All material certificates shall state the following:*
 - *Name of manufacturer and factory symbol*
 - *Purchaser order number and date of revision*
 - *Certificate number and date of issue*
 - *Material specification in full*
 - *Dimensions*
 - *Quantity and/or weight*
 - *Heat number, charge number or batch number*
 - *Actual chemical, mechanical and physical properties*
 - *When applicable, NDT methods applied and results thereof*
 - *When applicable, heat treatment procedure, furnace charge number of heat treatment records*
 - *Supplementary or additional requirements*
- *In addition, DIN 50049.3.1C type shall state:*
 - *That identification of the material has been verified by the independent third party inspector*
 - *That all tests were witnessed by the independent third party inspector*
 - *Independent third party inspector's identification symbol*
 - *Certificate number and date of issue*
6. *Certificates issued by material stockists or agents are not acceptable.*

2.5 COLOUR CODING OF PIPING BULK MATERIALS

2.5.1 General

Colour coding of piping bulk materials shall be applied on any project that includes alloy or special carbon steel systems. Colour coding is one of the QA system tools intended to maintain material traceability. Colour coding is intended to supplement, not replace, the normal identification requirements of the specification (for example, ASME, ASTM, MSS, etc.) to which the pipe and piping components were purchased.

The material supplier shall be responsible for the application of colour coding. The coding shall be checked by the supplier's QC department before being released for shipment to site. The project organization's procedure for colour coding shall clearly address the critical stage where pre-fabricated pipe spools are sent for blasting and painting. Colour coding is not necessary once the pipe spool is painted. For the spool to be released for painting, all components shall have been welded on and relevant NDE, including PMI shall be complete. The spool is then tracked by the spool tagging number and isometric

2.5.2 Colour standard

BS 381C colour standard shall be used.

Paint shall be resistant to salt water atmosphere and tropical climate, and be durable and of a distinctive identifying colour. It shall not cause corrosion of the material to which it is applied, neither during storage and construction, nor during operation of the equipment.

Paints and markers shall not contain harmful metals or metal salts such as zinc, aluminum, lead or chlorides, sulphur, or other halogens that may be harmful to the alloy. Material Safety Data Sheet (MSDS) documentation and paint data sheets shall be available for review by the designated inspector.

2.5.3 Method of identification

The following colour codes for Bulk Piping Materials shall be applied.

MATERIAL	COLOUR	BS 381C
Plain Carbon Steel (pipe, flanges, fittings and valves)	None	
Plain Carbon Steel Plate	None	
Fine Grain Carbon Steel for Low Temperature Service (all items, including valves)	Yellow	363
Fine Grain Carbon Steel for Low Temperature Services (Valves specified as ASTM A 353-LCC only)	Green	262
Stainless Steel Type 304 (all items, excluding valves)	None	
Stainless Steel Type 304L (all items)	Red	537
Stainless Steel Type 316 (all items, excluding valves)	Brown	320
Stainless Steel Type 316 (valves)	None	
Stainless Steel Type 316L (all items, including valves)	Blue	166
Ductile Iron (valves)	Light Orange	557
Bronze (valves)	None	
ASTM A 193 Grade B7 (Stud bolts)	White	
ASTM A 193 Grade B8 (Stud bolts)	None	
ASTM A 320 Grade L7 (Stud bolts)	None	

2.5.4 Pipe

Each length of pipe shall be painted over the entire length with a 12 mm to a 40 mm wide stripe, depending on pipe size.

2.5.5 Fittings

Each socket weld fitting, swage or pipe nipple shall be dabbed with a spot of paint 12 mm to 25 mm in diameter.

The entire length of each butt weld fitting shall be painted on the outside surface with a 12 mm to 40 mm wide stripe, depending on size.

2.5.6 Flanges, spectacle blinds etc.

The outer peripheral edge of each flange shall be painted over the entire circumference. For flanges thicker than 25 mm, the width of the band may be limited to 25 mm.

2.5.7 Plate

A stripe shall be painted across from corner to corner.

2.5.8 Valves

Each welded or flangeless (wafer type) valve shall be dapped with a spot of paint 12 mm to 25 mm in diameter.

Each flanged valve shall have the outer peripheral edge of each flange painted over the entire circumference. For flanges thicker than 25 mm, the width of the band may be limited to 25 mm.

2.5.9 Bolting

Each stud bolt shall be dapped with a spot of paint on each end.

2.5.10 Special notes

Paint shall not be applied, in any circumstances, to the following:

- inside surfaces of pipe, flanges or fittings;
- threads;
- weld bevels;
- symbols or markings which would obliterate identification;
- gasket seating surface.

Colour codes shall be applied when carbon steel and LT carbon steel are handled concurrently.

2.6 MATERIAL TRACEABILITY

Material certification, colour coding, intake inspection, storage and material handout shall be strictly controlled to exclude rogue materials from equipment and plant.

The Vendor shall organise its manufacturing process so that material traceability is ensured, in which case positive alloy material identification after material assembly is not required.

To ensure material traceability the following shall be documented in fully implemented and auditable fabrication and/or construction procedures:

Step 1	Material procurement The purchase order shall specify that the Vendor shall ship the material certificates together with properly marked materials.
Step 2	Material certification and identification Upon material receipt the Contractor shall verify that materials are properly marked and match the certificates.
Step 3	Strict separate material storage based on material grade Following verification, the materials shall be stored by material grade.
Step 4	Controlled material issue Bulk materials required for construction/fabrication purposes shall be supplied from their storage area by means of a materials issue voucher which clearly identifies the required material grade and for which construction/fabrication item it is required.
Step 5	Strict separation of material grades At the construction/fabrication site materials grades shall be kept strictly separate and identifiable until such time as the fabricated item is complete and the likelihood of rogue materials being substituted is minimised.

Positive Material Identification (2.7) of the finished products shall be performed if any of Steps 1 through Steps 5 is not followed completely.

2.7 POSITIVE MATERIAL IDENTIFICATION (PMI)

If (2.6) is not completely adhered to, *as well as where the hydrostatic leak test is replaced by a pneumatic leak test as defined in ASME B31.3*, PMI tests shall be performed on completed equipment or assembled parts of equipment at such time as to ensure that no material and construction/fabrication changes are made.

An approved third party contracted by the Vendor shall carry out PMI. An action plan for PMI testing shall be submitted by the Vendor for the approval of the Principal.

Any portable X-ray emission analyser, such as Texas Nuclear analyser Model 9266 or equivalent with computerised read-out, is acceptable.

The Contractor shall ensure that auditable measures of quality assurance are in place to verify that welds are made with the consumables specified on the WPS, in particular for the root pass of austenitic stainless steel welds. Also, these measures shall ensure that the degree of oxidation which occurs at the weldments in stainless steel, whether applied as solid material or as cladding, is acceptable in accordance with the criteria given in of PTS 30.10.60.31, Appendix 1.

2.8 PROCEDURE FOR CONCESSION REQUEST / MATERIAL SUBSTITUTION

If the Vendor intends to deviate from the originally specified requirements, it shall provide in its written proposal to the Contractor a detailed list of the items so proposed with a copy of a full description, along with all the particulars of intended deviations and the underlying reasons. All deviations shall be subject to the approval of the Principal.

PTS 30.10.02.11 may be used in considering material substitutions.

3. PIPE FABRICATION, ASSEMBLY AND ERECTION

3.1 GENERAL

Piping fabrication, assembly and erection shall conform to the requirements of the applicable Codes, or ANSI B31.3, and also to the requirements included in this specification.

Piping will normally be fabricated on the basis of a "Bill of Materials for Piping", which includes isometric drawings, material lists and (where necessary) additional information. For the content of the Bill of Materials, see PTS 31.38.01.13.

All measures shall be taken to ensure correct positioning and swing of the components to be welded.

Work shall not be performed when the weather and/or lack of sufficient protection does not permit satisfactory workmanship or when conditions prevent adequate inspection.

If any fabrication is to be carried out in the vicinity of equipment already installed then, before such fabrication work commences, adequate protection shall be provided to prevent any damage from weld spatter, flame cutting droplets etc.

Care shall be taken to avoid overloading, damage or undue deformation in any of the pipe components at all stages of the work.

The full pipe joint shall not be used, if laminations or split ends were discovered in any pipe.

The piping fabricator shall be responsible for the accuracy of detailed spool drawings and pipe spool fabrication. Pipe spool drawings shall identify all connected equipment and also connected piping system.

3.2 PREPARATION

3.2.1 Cutting and bevelling

Cutting and bevelling of pipes may be done by mechanical means: flame cutting, plasma cutting or water cutting. The following shall apply:

1. For carbon steel, flame (or arc) cuts shall be reasonably smooth and all oxides shall be removed from the surface by grinding to bright metal.
2. For low-alloy steel, after flame cutting a minimum of 2 mm of material shall be removed from the cut surface by grinding.
3. For stainless steel, flame cutting shall not be used but plasma or water cutting may be used. The surface shall be ground to bright metal after plasma cutting.

Weld bevels for butt welds of pipes and fittings shall be in accordance with ASME B16.25.

Shop-bevelling of field welds is not required if a make-up length (extra length for field cutting to size) is provided. In these cases, bevels shall be prepared after cutting the relevant pipe spool to the required length. Cutting oil shall be removed.

Grinding wheels for stainless steel shall be resin bonded alumina or silicon carbide. Rubber bonded wheels shall not be used. Wheels shall be dedicated to a single material grade and the fabricator shall ensure wheels used on one material grade are not subsequently used on another grade. Wire brushes for stainless steel shall be stainless steel. Wire brushes shall be dedicated for use on a single material grade, and fabricator shall ensure brushes used on one material grade are not subsequently used on any other material grade.

NOTE: *Especially contamination of the surface by use of carbon steel tools, tools previously applied on carbon steel equipment or presence of carbon steel particles can reduce the corrosion resistance of CRAs.*

Galvanized materials shall be cut using 'cold' cutting methods.