

PETRONAS TECHNICAL STANDARDS

TECHNICAL SPECIFICATION

WELDING OF PIPELINES AND RELATED FACILITIES (AMENDMENTS/SUPPLEMENTS TO API STD. 1104)

PTS 61.40.20.30

OCTOBER 2011



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This revision of PTS 61.40.20.30 - WELDING OF PIPELINES AND RELATED FACILITIES (AMENDMENTS/SUPPLEMENTS TO API STD. 1104) (October 2011) has been updated to incorporate PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards.

The previous version of this PTS 61.40.20.30 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/Divisions 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, the Principal will expect 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 Principal or its technical advisor.

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PART I INTRODUCTION

1.1 SCOPE

This PTS gives minimum requirements for the welding of pipelines and related facilities.

This PTS is based on API Std 1104, twentieth edition (November 2005) plus Errata/Addendum (July 2007) and Errata 2 (December 2008). Part II of this PTS gives amendments and supplements to the API Std 1104 in the form of replacements or additions to specific clauses and paragraphs. Clauses and paragraphs of API Std 1104 which are not amended by this PTS shall remain applicable as written. Tables or Figures supplementary to those of API Std 1104, have been referred to using a capital letter, e.g. Table A, Figure B.

1.2 DISTRIBUTION, APPLICABILITY AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS, the distribution of this PTS is confined to companies forming part of PETRONAS or managed by a Group Company, and to Contractors nominated by them.

This PTS is intended for use on pipeline projects for oil refineries, gas handling installations, chemical plants, supply/marketing installations and oil and gas production facilities.

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, 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 objective 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, maintenance or inspection 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

Where the term **Company** has been used throughout API Std. 1104, this shall be understood to mean the **Principal** as defined in paragraph 1.3 above.

A **Pipeline** is a system of pipes and other components used for the transportation of fluids between (but excluding) plants. A pipeline extends from pig trap to pig trap (including the pig traps), or, if no pig trap is fitted, to the first isolation valve within the plant.

1.4 ABBREVIATIONS

AWS	American Welding Society
AC	Alternating Current
AI	Accumulated Imperfections
AWS	American Welding Society
BT	Burn Through
C	Crack
CP	Cluster Porosity
CTOD	Crack Tip Opening Displacement
DAC	Distance Amplitude Correction
DC	Direct Current
DWE	Double Wall Exposure
DWV	Double Wall Viewing
ESI	Elongated Slag Inclusion
EU	Undercutting adjacent to the cover pass
FCAW	Flux Cored Arc Welding
GMAW	Gas Metal Arc Welding
GTAW	Gas Tungsten Arc Welding
HAZ	Heat Affected Zone
HB	Hollow-bead Porosity
HV 10	Vickers Hardness (10 kg load)
IC	Internal Concavity
ICP	Inadequate Cross Penetration
IF	Incomplete Fusion
IFD	Incomplete Fusion Due to Cold Lap
IIW	International Institute of Welding
IP	Inadequate Penetration Without High-Low
IPD	Inadequate Penetration Due to High-Low
IQI	Image Quality Indicator
ISI	Isolated Slag Inclusion
IU	Undercutting adjacent to the root pass
JKP	Jabatan Pembangunan Kemahiran (Department of Skills Development)
LB	Linear Buried (Indication)
LPTA	Lembaga Perlesenan Tenaga Atom (Atomic Energy Licensing Board)
LS	Linear Surface (Indication)
MSS	Manufacturers Standardization Society
MT	Magnetic Particle Testing
PT	Liquid Particle Testing
NDT	Non Destructive Testing
PWHT	Post-weld Heat Treatment
SMAW	Shielded Metal Arc Welding
SWE	Single Wall Exposure
SWV	Single Wall Viewing
T	Transverse (Indication)
TCG	Time Corrected Gain
VC	Volumetric Cluster
VI	Volumetric Individual
VR	Volumetric Root
WPQT	Welding Procedure Qualification Test(ing)
WPS	Welding Procedure Specification

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 (Part III).

1.6 UNITS

For simplicity, the common industry practice of indicating nominal pipe diameters in inches has been followed. For other dimensions, SI units have been used.

PART II AMENDMENTS/SUPPLEMENTS TO API STD. 1104

SECTION 1 GENERAL

1.1 SCOPE

Replace as follows:

This standard covers the arc welding of butt, fillet and socket welds in carbon and low alloy steel for oil, gas and utility pipelines and related facilities. The welding may be carried out by a shielded metal arc welding, submerged arc welding, gas tungsten arc welding, gas metal arc welding or flux cored arc welding process or combination of these processes using a manual, semi-automatic or automatic welding technique or combination of these techniques. The welds may be produced by position or roll welding or by a combination of position and roll welding. Roll welding is only acceptable when using a fully automatic welding process.

Oxyacetylene welding (otherwise known as gas welding) and flash butt welding processes shall not be used.

The use of gas metal arc, gas tungsten arc and flux cored arc welding (except the self-shielding type) processes shall be restricted to construction areas protected against wind and draught.

This standard also covers the procedures for radiographic, magnetic particle, liquid penetrant and ultrasonic testing, as well as the acceptance standards to be applied to production welds undergone destructive testing or non-destructive testing e.g. radiographic, magnetic particle, liquid penetrant, ultrasonic, and visual testing methods .

4. SPECIFICATIONS

4.1 Equipment

4.2 Materials

4.2.1 Pipe and fittings

Replace as follows:

This standard applies to the welding of pipe and fittings that conform to the following specifications:

- a. Line pipe in accordance with API 5L 44th edition / ISO 3183:2007, as amended by PTS 31.40.20.38.
- b. Applicable specifications for fittings (e.g. ASTM, MSS, ISO) and applicable PETRONAS specifications providing amendments/supplements to these.
- c. Induction bends in accordance with ISO 15590-1 (2001), as amended by PTS 31.40.20.33.

4.2.2 Filler metal

Replace as follows:

4.2.2.1 Filler metal and fluxes

Consumables shall conform to one of the following specifications:

- AWS A5.1
- AWS A5.2
- AWS A5.5

- AWS A5.17
- AWS A5.18
- AWS A5.20
- AWS A5.28
- AWS A5.29

All welding consumables shall be selected to produce welds with yield strength exceeding that specified for the parent material. Where steels with different specified properties are joined the weld metal yield strength shall match or exceed that of the higher strength grade.

**Amended per
Circular 41/04**

For sour service applications the deposited weld metal shall comply with the requirements of ISO 15156 or NACE MR0103, as applicable.

NOTES:

1. ISO 15156 shall apply to oil and gas production facilities and natural gas sweetening plants. NACE MR0175 is equivalent to ISO 15156.

2. NACE MR0103 shall apply to other applications (e.g. oil refineries, LNG plants and chemical plants).

If low-hydrogen electrodes are selected the diffusible hydrogen content shall not exceed 10 ml/100 g in the resulting deposited weld metal.

Amend as follows:

4.2.2.2 Storage, Handling and Issuance Control of Filler Metals and Fluxes

Add the following:

Electrodes shall be supplied in fully sealed packages and stored in a dry storage room with a maximum relative humidity of 50 percent. All manual types of electrodes shall be properly identifiable up to the time of usage, each electrode being distinguishable by proper coding. If the coding is destroyed by baking, handling, or other causes, the electrodes shall not be used.

Low hydrogen electrodes shall not be stored in heated cabinets containing electrodes of other types, such as rutile or organic type electrodes. Details on the control of welding consumables during production welding are addressed in 7.13.

Wire spools for automatic and semi-automatic processes shall be stored in cabinets with supplier wrapping not removed and remain clearly identifiable up to the time of usage. Unidentifiable wire shall not be used.

Flux shall be handled and stored in accordance with the flux manufacturer's recommendations.

Each batch of flux and wire shall be labelled with the information from the supply container. Unidentifiable, damaged, wet, rusty or otherwise contaminated or deteriorated consumables shall not be used.

4.2.3 Shielding gases

4.2.3.1 Types

Add the following:

Unless otherwise indicated by the Principal the maximum variation of specified gas additions, e.g. 5 percent carbon dioxide, shall be ± 10 percent of the value stated. The moisture content shall correspond to a dew point not exceeding -30°C .

4.2.3.2 Storage and handling

Add the following:

All shielding gas containers shall be secured vertically with clear identification labels which include the gas type.

SECTION 5 QUALIFICATION OF WELDING PROCEDURES FOR WELDS CONTAINING FILLER METAL ADDITIVES

5.1 PROCEDURE QUALIFICATION

Replace as follows:

Prior to carrying out qualification testing, a preliminary WPS shall be submitted to the Principal for review.

Welding procedures shall be tested to demonstrate that acceptable welds can be made by the procedure. The quality of the welds shall be determined by both non-destructive and destructive testing, as specified in (5.6). The welding procedure qualification testing (WPQT) shall be witnessed by the Principal. Only qualified and approved welding procedures shall be used for production welding.

Unless otherwise stated in the contract documents, for each contract all existing welding procedures shall be re-qualified by the contractor, and submitted for approval by the Principal.

Repair welding procedures shall be prepared and approved in the same manner as production welding procedures.

5.3.2.2 Pipe and fitting materials

Replace as follows:

The contract materials to which the procedure applies shall be identified on the WPS. Grouping of materials of different pipe manufacturers, supply condition, diameter, wall thickness or steel specification/grade shall not be done unless agreed by the Principal.

Where contract materials have been supplied in the same dimensions by more than one manufacturer, a qualification test may be performed using two pipes from different manufacturers. This may be used to qualify the procedure for use on the pipes from each manufacturer provided the specified range and number of tests in the heat affected zone are taken from both sides of the weld.

5.3.2.3 Diameters and wall thicknesses

Replace as follows:

Procedures shall be qualified for each combination of diameter and nominal wall thickness of contract materials.

5.3.2.4 Joint design

Add the following:

The specification shall indicate the allowable tolerances on each of the joint design details. Permanent backing bars shall not be used.

5.3.2.5 Filler metal and number of beads

Replace as follows:

Details of the filler metal sizes, classification and manufacturer/brand identity shall be given together with a sketch showing the location, minimum number, deposition sequence and characteristics (stringer or weave) of each weld bead.

5.3.2.6 Electrical characteristics

Add the following:

Additionally, the aim voltage and amperage for each bead shall be stated. The ranges of voltage and amperage shall not vary from the aim values by more than ± 10 percent.

5.3.2.10 Time between passes

Add the following:

For pipeline butt welds this time shall be 5 minutes or less.

5.3.2.12 Cleaning and/or grinding

Replace as follows:

The WPS shall state the methods to be used for inter-run cleaning, final weld surface preparation and treatment to backside of the weld, if any. The type of tools (power, manual, or both) shall be specified.

5.3.2.13 Pre- and post-heat treatment

Add the following:

Similar measures shall be taken to specify and monitor weld interpass temperatures.

5.3.2.15 Shielding flux

Replace as follows:

The type of shielding flux, the name of the flux manufacturer and the flux identity and/or brand name shall be designated.

5.3.2.16 Speed of travel

Add the following:

Alternatively, for shielded metal arc welding (SMAW) the range of electrode run-out length for each pass in each electrode size shall be clearly specified. Speed of travel or electrode run-out length shall be within a range of $\pm 10\%$ of the nominal value for the specified electrode type and size as stipulated by the manufacturer.

Add the following paragraphs 5.3.2.17 to 5.3.2.20:

5.3.2.17 Heat input range

The allowable range of heat input rates to be applied by the welding processes for each weld bead shall be clearly specified. The units to be used shall be kilo joules per millimetre (kJ/mm) based on the following formula:

$$\text{Heat input (kJ/mm)} = \frac{\text{Volts} * \text{Amps}}{1000 * \text{Welding Speed (mm/sec)}}$$

5.3.2.18 Number of welders

For pipeline girth welds the WPS shall designate:

- the number of root pass welders.
- the number of hot pass welders.

See (7.1).

5.3.2.19 Partially complete joint

The minimum number of passes before the joint is allowed to cool to ambient temperature.

5.3.2.20 Removal of line-up clamp

The stage at which line up clamp is removed. (See 7.3).

5.4 Essential Variables

5.4.2 Changes Requiring Requalification

5.4.2.2 Base Material

Replace as follows:

For pipeline welding, a change of pipe manufacturer, manufacturing process or steel specification/grade shall constitute an essential variable, unless agreed otherwise by the Principal. In addition, requalification shall be required if the carbon content or carbon equivalent exceed the value qualified by more than 0.03.

For non-pipeline welding, a change in the pipe manufacturing process, an increase in the base material specified minimum yield stress of more than 50 N/mm² or an increase in the carbon content or carbon equivalent of 0.03% or greater, shall constitute an essential variable.

5.4.2.3 Joint design

Replace as follows:

A major change in joint design (for example, from V groove to U groove) or any change outside the specified joint design tolerances constitutes an essential variable. Changes within the specified tolerances of the joint design (angle of bevel, root face thickness and root gap) are not essential variables.

5.4.2.5 Wall thickness

Change title and replace as follows:

5.4.2.5 Pipe diameter and wall thickness

A change in outside diameter outside the range 0.75 D to 1.5 D and/or any change in thickness outside the range 0.75 t to 1.5 t constitute essential variables.

5.4.2.6 Filler metal

Replace as follows:

The following changes in filler metal constitute essential variables:

- a. A change from one filler metal group to another (see Table 1).
- b. A change from one consumable manufacturer and/or trade name, or AWS classification to another.
- c. A change in the minimum specified yield strength of the filler metal.
- d. A change in the diameter of electrode or filler metal.

5.4.2.10 Shielding gas and flow rate

Replace as follows:

A change from one shielding gas to another or from one mixture to another constitutes an essential variable. A flow rate of the shielding gas outside the range specified and qualified also constitutes an essential variable.

5.4.2.11 Shielding flux

Replace footnote a) of Table 1 as follows:

- a. Any combination of flux and electrode in Group 4 may be used to qualify a procedure. The combination shall be identified by its complete AWS classification number, such as F71-EL12 or F62-EM12K. Any change in either wire or flux manufacturer and/or AWS classification number shall constitute an essential variable.

Add the following:

A change in the flux size grading shall also constitute an essential variable.

5.4.2.12 Speed of travel

Replace as follows:

A change in the range of speed of travel or electrode run-out length, shall constitute an essential variable.

Add the following paragraphs 5.4.2.15 to 5.4.2.21:

5.4.2.15 Interpass temperature

A change in interpass temperature range shall constitute an essential variable.

5.4.2.16 Electrical characteristics

A change in current type or electrode polarity (AC, DC positive, DC negative) shall constitute an essential variable.

5.4.2.17 Welding current or heat input

Any change outside the specified ranges of currents or heat inputs shall constitute an essential variable.

5.4.2.18 Wire feed speed

In semi-automatic and automatic welding processes any change of more than ± 10 percent in the wire feed speed shall constitute an essential variable.

5.4.2.19 Number and sequence of weld beads

A change in the minimum number of the weld beads deposited or the sequence of deposition shall constitute an essential variable.

5.4.2.20 Number of welders

A change in the number of root pass or hot pass welders shall constitute an essential variable.

5.4.2.21 Removal of line-up clamp

Removal of the line-up clamp at a stage earlier than the approval procedure shall constitute an essential variable.

5.5 WELDING OF TEST JOINTS - BUTT WELDS

Replace as follows:

The test weld shall be made under conditions which simulate production welding to a degree satisfactory to the Principal. For pipeline welding procedure qualification, two pipe nipples shall be welded together using production line up and clamping equipment. A further two pipe nipples shall also be welded if necessary to obtain the required number of specimens for testing. Making the test welds shall be witnessed by the Principal.

5.6 TESTING OF WELDED JOINTS - BUTT WELDS

5.6.1 Preparation

Delete and replace by the following 5.6.1.1 and 5.6.1.2:

5.6.1.1 Non-destructive testing of test welds

On completion of welding, all procedure qualification test pieces shall be left cold for at least 48 hours and shall then be subjected to NDT in accordance with Sections 8 and 9 of this PTS. This shall be carried out prior to sectioning for mechanical testing. Post-weld heat treatment, if required, shall be performed after 48 hours has elapsed, but before NDT is performed.

The NDT shall consist of:

- Visual examination, with the aid of optical instruments where necessary, to determine the dimensions of indications (refer to (9.7)).
- Magnetic particle testing as specified in (9.4).
- Radiographic testing in accordance with (9.3), supplemented, if specified by the Principal, by ultrasonic testing in accordance with (9.6). This supplementary ultrasonic testing shall always be carried out for test welds made in whole or in part by the GMAW, GTAW, SMAW or FCAW processes.

Acceptance criteria for the NDT shall be as stated in Section 9 of this PTS. If a test weld is found to be unsatisfactory following NDT it shall be rejected and not be submitted for destructive/ mechanical testing.

5.6.1.2 Destructive testing of test welds

Following satisfactory acceptance by NDT, all procedure qualification test welds shall be sectioned at the locations shown in Figure 3 of API 1104 and Figure A of this PTS.

The minimum number of test specimens and the tests to which they shall be subjected are given in Table 2 and in (5.6.6) and (5.6.7). The specimens shall be prepared as shown in Figures 4, 5, 6 or 7. Unless specified otherwise, tests shall be performed at ambient temperature. For pipe less than or equal to 1 5/16 inches (33.4 mm) in diameter, one full-section specimen may be substituted for the four reduced-section nick-break and root-bend specimens. The full-section specimen shall be tested in accordance with (5.6.2.2) and shall meet the requirements of (5.6.2.3).

Add the following paragraphs 5.6.6 and 5.6.7.

5.6.6 Macroscopic examination and hardness tests

5.6.6.1 Preparation

Specimens shall be prepared for macroscopic examination by grinding to a 600 grit paper finish. The prepared surfaces shall be etched using a suitable etchant (e.g. 3 percent Nital or ammonium persulphate) to reveal the grain structure.

The sections of the weld taken for macroscopic examinations shall be used for hardness testing.

5.6.6.2 Method

Hardness testing shall be performed in accordance with ISO 6507-1 or ASTM E 92, using a test force of 98.07 N (10 kg load).

For pipe butt welds, hardness traverses shall be carried out as indicated in Figure B.

The macro-specimens shall be examined at minimum x10 magnification.