PTT Exploration and Production Public Company Limited

PTTEP Engineering General Specification

PEGS

Piping and Equipment Subjecte to Severe Sour Service: Metallurgical and Welding Requirements

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1.0 PURPOSE

The purpose of this PTTEP Engineering General Specification, PEGS-0710-PIP-019 “Piping and Equipment Subject to Severe Sour Service. Metallurgical and Welding Requirements” is to specify general and fundamental requirements for the basis of design, materials and fabrication of the process systems, assuring technical integrity and fitness of purpose with optimum life cycle cost.

2.0 SCOPE

This specification covers the specific requirements applicable to equipment such as pressure vessels or heat exchangers, and to piping materials (including piping in instrumentation), which are intended to be used in Severe Sour Service conditions as defined in specification PEGS-0842-COR-032.

This specification makes major reference to the NACE MR0175 / ISO 15156. It states additional requirements with respect to Hydrogen Induced Cracking (HIC) and to Sulphide Stress Cracking (SSC) where the NACE MR0175 / ISO 15156 document is found insufficient.Valve materials shall comply with both this specification (for cast or forged materials, including weldments if applicable), and the COMPANY specification PEGS-0710-MMA-002 (TBA)”.

Transmission pipelines are outside the scope of this specification.

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3.0 DEFINITIONS

A number of different terms are commonly used to describe the work stages, processes, and approvals which take place during the early stages of a development. This can often be a source of confusion so the following section is intended to show the PTTEP preferred terminology as used in this document.

3.1 LANGUAGE

In this document, the words should and shall have the following meanings:

Should	Indicates a preferred course of action. Should is a non-mandatory word and is not forbidden, but use in the body of the text should be the exception. Where none mandatory terms are used, each paragraph within these clauses shall also have an associated commentary paragraph that provides the rationale for why the stated choices and modifications are appropriate and circumstance under which the stated choices and modifications might be different.
Shall	Indicates a course of action with a mandatory status. The term “shall” shall be used if a requirement is considered to be necessary to claim compliance with a PEGS document.

3.2 TERMINOLOGY

Terminology	Description
Approval	The authorization in writing given by COMPANY to Contractor on a procedure or to proceed with the performance of a specific part of the work without releasing in any way Contractor from any of his obligations to conform with the technical specifications, requisitions, etc. The words “Approve”, “Approved” and “Approval” shall be construed accordingly.
COMPANY	PTT Exploration and Production Public Company Limited
Contractor	Per contract: Contractor – ‘The contractor who is a PARTY to this CONTRACT and where the context so requires, any and all subcontractors utilised by Contractor for the performance of the WORK’.

3.3 COMMON ACRONYMS

Set out below in alphabetical order are common acronyms as found within this specification:

BM	Base Metal
CE	Carbon Equivalent
ERW	Electric Resistance Welding
H2S	Hydrogen Sulphide
HAZ	Heat Affected Zone
HIC	Hydrogen Induced Cracking
HRC	Rockwell C Hardness
HV	Vickers Hardness
IIW	International Institute of Welding
Psi	Pound per square inch
PWHT	Post Weld Heat Treatment
SSC	Sulphide Stress Cracking
TBA	To Be Approved
WM	Weld Metal

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4.0 REFERENCES

The reference documents listed below, including Industry Codes and Standards and COMPANY specifications, form an integral part of this Engineering General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published on the effective date of a contract.

The overall order of precedence of the applicable documents shall be:

1. Applicable Laws, Rules and Regulations of the country in which the system/equipment will be operated (if any);
2. Purchase Order/ Service Order/ Contract Documents (Only applicable for direct purchase by COMPANY);
3. Project Particular Specification (PPS), and relevant data sheet(s) if any;
4. COMPANY General Specification;
5. Codes and Standards in reference.

Any conflict between any of the Contract Documents, or between this specification and any other Contract Document, shall be reported to COMPANY for decision. In such a case, and unless otherwise agreed or decided by COMPANY, it is understood that the more stringent requirement shall apply.

Exceptions to, or deviations from this specification are not permitted unless previously accepted in writing by COMPANY. For this purpose, requests for substitutions or changes of any kind shall be complete with all pertinent information required for COMPANY assessment. COMPANY's approval, nevertheless, will not, in any way, relieve the responsibility of the Contractor to meet the requirements of the industry Codes and Standards referred to and amended herein, in the event of conflict.

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4.1 PTTEP INTERNAL REFERENCES

Internal documents applicable to this document are indicated in the table below.

Document Number	Document Title
PEGS-0710-MMA-002 (TBA)	Valves materials requirements for use in sour service
PEGS-0791-FAB-001 (TBA)	Welding of pressure containing piping and equipment
PEGS-0842-COR-032	Materials for Sour Service

4.2 INTERNATIONAL STANDARDS

International standards applicable to this document are indicated in the table below.

Document Number	Document Title
EN 10204	Steel and Steel Products - Inspection Documents
NACE MR0175 / ISO 15156 (all parts)	Materials for use in H_2S-containing environments in oil and gas production - All parts

4.3 INDUSTRY CODES AND STANDARDS

Industry codes, standards and regional legislation applicable to this document are indicated in the table below.

Document Number	Document Title
API 5L	Specification for Line Pipe
API RP 945 (all parts)	Avoiding Environmental Cracking in Amine Units - All parts
ASTM A 106	Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A 193	Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature or High Pressure Service and Other Special Purpose Applications
ASTM A 194	Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-pressure or High-Temperature Service, or Both
ASTM A 307	Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 Psi Tensile Strength
ASTM A 320	Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service
ASTM A 333	Standard Specification for Seamless and Welded Steel Pipe for Low-Temperature Service and Other Applications with Required Notch Toughness
ASTM A 578	Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications
ASTM E 45	Standard Test Methods for Determining the Inclusion Content of Steel
ASTM E 92	Standard Test Methods for Vickers Harness
ASTM E 384	Standard Test Method for Knoop and Vickers Hardness of Materials

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Document Number	Document Title
ISO 3183	Petroleum and natural gas industries – Steel pipe for pipeline transportation systems

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5.0 REQUIREMENTS FOR PIPING AND EQUIPMENT SUBJECTED TO SEVERE SOUR SERVICE - METALLURGICAL AND WELDING REQUIREMENTS

5.1 GENERAL

5.1.1 USE OF STAINLESS STEEL

Stainless steel can be used for some parts of equipment. If so, the following requirements and restrictions shall be applied :

- 13% Cr Stainless steel shall be heat-treated and have a hardness complying with NACE MR0175 / ISO 15156
- Austenitic or austenitic-ferritic stainless steel shall be in the solution annealed condition
- If welding and/or post-weld heat-treatment is required on austenitic stainless steel, this steel shall be low carbon or titanium-stabilised steels
- If welding repairs are required to the bodies of cast equipment in type 304 or 316 stainless steel, the procedure shall be subject to COMPANY approval
- Parts of austenitic stainless steel cold-formed by rolling, bending or stamping shall be quench-annealed a second time if the permanent deformation exceeds 15%
- In all cases, limits of use of stainless steel and the suitability of alternative material for specific applications shall be sought from COMPANY
- Any equipment or process pipework made of austenitic or austenitic-ferritic stainless steel or nickel base alloys shall comply with NACE MR0175 / ISO 15156 requirements with respect to hardness level and heat treatment (if any) unless otherwise approved by COMPANY.

5.1.2 METALLIC OVERLAY

Explosively clad, roll bonded or fusion-bonded corrosion resistant overlay such as austenitic or austenitic-ferritic stainless steel or nickel alloy are considered to be effective barriers to the sulphide environment when they are within their safe limit of use. Where such overlays are employed, the backing material do not need to conform to this specification.

5.2 PRESSURE VESSELS AND HEAT EXCHANGERS

5.2.1 CARBON STEEL PLATES (INCLUDING PLATES FOR HEADS)

The following requirements shall apply to pressure vessels and heat exchangers fabricated of unalloyed carbon steel.

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5.2.1.1 MANUFACTURING PROCESS

Plates shall be produced by a low sulphur and low phosphorus refining process such as in an electric furnace or in a basic oxygen furnace, with double deslagging. The steel shall be vacuum degassed while molten. When steel is cast by the continuous casting method, preference is given for Electromagnetic Stirring (EMS) and squeeze rolling to prevent centrelines segregation.

Plates shall be supplied in the normalised condition. Controlled rolled or quenched and tempered plates are not acceptable except by special arrangement (acceptance shall be based on HIC and simulated PWHT test results).

Plate materials shall receive an appropriate inclusion shape control treatment by addition of Calcium. Specific treatment by rare earth metals is not permitted.

Repair of defects by welding is not permitted.

5.2.1.2 PARTICULAR INSPECTION OF FINISHED PRODUCTS

In addition to what is already required in the plate material specification, the following examination shall be performed:

5.2.1.2.1 MICRO-EXAMINATION

The plates shall be checked for microstructure over the full thickness, with a minimum at the center, quarter width, and at each edge, for confirmation of effectiveness of shape control of the inclusions. The sample shall be typical of normal production material.

Plates rolled from continuous cast material shall be checked at one end of each plate. Plates rolled from ingots shall be checked at both ends of each plate. The examination method shall conform to the ASTM E 45 Standard (microscopical method, method D, with [A + B + C + D] ≤ 20).

5.2.1.2.2 ULTRASONIC EXAMINATION

Ultrasonic tests shall be performed according to ASTM A 578 level B .

5.2.1.3 CHEMICAL COMPOSITION

The chemical analysis (ladle) of plate materials shall be within the following limits (all values in percent, by weight):

- C < 0.20
- Si < 0.35
- Mn < 1.0
- Cr < 0.25
- Mo < 0.05
- Ni < 0.15
- Cu < 0.40

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- Nb ≤ 0.005[1]
- V ≤ 0.005
- P < 0.015
- S < 0.008
- Ca < 0.025 with $2 \leq \frac{Ca}{S} \leq 4$ and $\frac{Ca}{1.25\ x\ S + 0.625\ x\ O} > 1.5$ [2]
- B < 0.0005
- Al (Total) < 0.045
- Ti < 0.02
- O < 0.002
- N < 0.010
- Ni + Cu < 0.15
- Nb + V + Ti + Cu + Mo + Cr < 0.50
- C_E (IIW) ≤ 0.420 or C_E (Pcm) < 0.190[3]

[1] If C_E(IIW) ≤ 0.360, Vanadium and Niobium contents may be increased up to the following values : Nb < 0.05 & V < 0.08, with V + Nb < 0.08

[2] Calcium treatment is not necessary if S ≤ 0.002

[3] C_E(IIW) ≤ 0.430 is acceptable for plates in thicknesses 2 inches and above

If C ≤ 0.12, C_E(Pcm) shall apply and if C > 0.12, C_E(IIW) is only applicable.

C_E(Pcm) and C_E (IIW) are defined as follows :

$$C_E(Pcm) = C + \frac{Si}{30} + \frac{Mn+Cu+Cr}{20} + \frac{Ni}{60} + \frac{Mo}{15} + \frac{V}{10} + 5B$$

$$C_E(IIW) = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Ni+Cu}{15}$$

5.2.1.4 HARDNESS EXAMINATION

In addition to material specification requirement, hardness test using Vickers method (5kg or 10kg load) shall be conducted on each plate. For this test, specimen shall be cut as a cross-section through the thickness of plate. Total twelve (12) readings shall be taken, 4 readings at mid thickness, 4 readings at 2mm below external surface and 4 readings at 2mm from internal surface of specimen. The distance between each measurement shall be approximately 5 mm. No hardness readings shall exceed 248 HV.

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5.2.1.5 PLATE MATERIAL CERTIFICATE

Material certificates shall be in accordance with EN 10204 3.1 or 3.2 type (as specified) and shall give the following minimum information:

- Full chemical analysis
- Mechanical properties (as required in the material specification)
- Mechanical properties in simulated PWHT condition (as applicable)
- Steel making process, desulphurisation technique, method of monitoring inclusion shape control
    - Casting method and size of ingots/slabs
    - Rolling procedures
    - Heat treatment cycle
- Results of ultrasonic inspection
- Results of micro-examination.
- Result of hardness test

5.2.2 FITTINGS AND FLANGES

All carbon steel fittings and flanges for pressure vessels shall be supplied in accordance with section 5.3.2 of this specification.

5.2.3 PIPES

All carbon steel pipes for pressure vessels shall be supplied in accordance with section 5.3.1 of this specification.

5.2.4 INTERNAL BOLTING

All internal bolting subject to sour environments shall be selected to be resistant to SSC (see section 5.3.4 of this specification).

5.2.5 OTHER CONSTRUCTION MATERIAL

Pressure vessels in sour service constructed from materials other than carbon, carbon manganese and low-alloy steel e.g. austenitic or austenitic-ferritic stainless steel or internally clad vessels or other high alloy corrosion resistant alloy shall be subject to COMPANY for approval. In any case, as a minimum, it shall comply with applicable requirements of NACE MR 0175 / ISO 15156.

5.2.6 MATERIAL PROCURED FROM STOCKIST

Refer section 5.3.9

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5.3 PIPING MATERIALS

5.3.1 PIPES

5.3.1.1 SEAMLESS PIPES

Seamless carbon steel pipes shall be supplied to the requirements of API 5L / ISO 3183 (grades B to X 60 inclusive), or ASTM A 106 grade B, or ASTM A 333 grade 6, with the following additional requirements

Chemical composition (maximum values in weight, percent, based on ladle analysis)

- C < 0.20
- Mn ≤ 1.30
- Si < 0.35
- P < 0.020
- S ≤ 0.010

with:

- Mn ≤ (1.6 - 60 S)
- Cu < 0.40
- Mo < 0.05
- Nb ≤ 0.005
- V ≤ 0.005[1]
- C_E (IIW) ≤ 0.42

CE(IIW) = C + $\frac{Mn}{6}$ + $\frac{Cr+Mo+V}{5}$ + $\frac{Ni+Cu}{15}$[1] If CE(IIW) ≤ 0.360, Vanadium and Niobium contents may be increased up to the following values: Nb < 0.05 & V < 0.08, with V + Nb < 0.08

Repair by welding of out of manufacturing tolerance defects is not permitted.

Hardness test

Hardness test shall be conducted in accordance with section 5.2.1.4 of this specification except that it shall be conducted for each heat and heat treatment batch.

5.3.1.2 WELDED PIPES

Welded carbon steel pipes shall be supplied to the requirements of API 5L / ISO 3183 grades B to X 60 inclusive, or ASTM A 333 grade 6, with the following additional requirements :

Welded pipes shall be made from plates complying with Section 5.2.1 of this specification (i.e. plates for pressure vessels).

Welded pipes shall be Longitudinal Seam Submerged Arc Welded (LSAW) with at least two passes, one inside and one outside, and with a filler materials with a nickel content of not more than 1.00%.

Spiral welding and Electric Resistance Welding (ERW) fabrication processes are not allowed.

Repair of base metal by welding is not permitted

Longitudinal welds must comply with section 5.4 (Qualification tests) and section 5.5 (Fabrication) of this specification with the following specific requirements :

5.3.1.2.1 CHEMICAL ANALYSIS

$$C_E \text{ (IIW)} \leq 0.42 \text{ with } C_{E(IIW)} = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Ni+Cu}{15}$$

5.3.1.2.2 WELDING ENERGY

Welding heat input shall be equal to or greater than 12 kJ/cm for longitudinal seams.

5.3.1.2.3 POST WELD HEAT TREATMENT

No post weld heat treatment is required on longitudinal welds, except if otherwise called for in the product specification, in the design / fabrication code or in other contractual documents.

5.3.1.2.4 HARDNESS TEST

Hardness test for weld joint shall be conducted in accordance with section 5.4.1.3 with pipe cross section cut at both ends of the pipe. Frequency of hardness test shall be same as that of macrographic test for API 5L pipes

5.3.2 FITTINGS / FORGINGS

5.3.2.1 PROCESS OF MANUFACTURE

Cold work or machining from bars is not permitted.Hot work operations must be followed by an appropriate heat treatment with the following decreasing order to preference:

- Quenching and tempering
- Normalisation and tempering
- Normalisation

Repair of base metal by welding is not allowed.

5.3.2.2 CHEMICAL ANALYSIS

The chemical analysis (ladle) shall be within the following limits (all values in percent, by weight):

- C < 0.20
- Mn < 1.30
- P < 0.020
- S < 0.015

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- Nb ≤ 0.005
- V ≤ 0.005[1]
- C_E (IIW) ≤ 0.420 with $C_E(IIW) = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Ni+Cu}{15}$

(However, the limitation on carbon equivalent values does not apply if items are not welded and are not supposed to be welded in the future fabrication).

[1] If C(IIW) ≤ 0.360, Vanadium and Niobium contents may be increased up to the following values: Nb < 0.05 & V < 0.08, with V + Nb < 0.08

5.3.2.3 HARDNESS TEST

Hardness test shall be conducted in accordance with section 5.2.1.4 of this specification except that it shall be conducted for each heat and heat treatment batch and hardness values shall comply with requirements of NACE MR0175/ISO15156.

5.3.3 CASTINGS

Cast iron is not acceptable.

All castings shall be suitably heat treated after any welding operation has been performed, and this requirement also applies to the weld repair of defects, irrespective of size. The chemical analysis of castings must comply with the following :

- Mn < 1.35
- P < 0.020
- S < 0.020
- C_E (IIW) ≤ 0.420 with $C_E(IIW) = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Ni+Cu}{15}$

(However, the limitation on carbon equivalent values does not apply if items are not welded and are not supposed to be welded in the future fabrication).

5.3.4 BOLTING

5.3.4.1 GENERAL

Bolting shall comply with NACE MR0175 / ISO 15156 requirements when in contact with any concentration of wet H_2S.

5.3.4.2 MATERIALS

Ferritic steel bolts and nuts shall conform to NACE MR0175 / ISO 15156. As an example, the following materials are acceptable:

Threaded rods:

- ASTM A 307 grade B, carbon steel with grain refinement or normalising after manufacture if cold-formed and maximum acceptable hardness is 22 HRC

- ASTM A 193 grade B7M and ASTM A 320 grade L7M Cr Mo steel with maximum hardness 22 HRC.

Nuts:

- ASTM A 194 grade 2HM, carbon steel with maximum hardness of 22 HRC
- ASTM A 320 grade L7M with maximum hardness of 22 HRC.

Where austenitic stainless steel bolts and nuts are required, these items shall be free from cold work ; they shall be solution treated after thread forming, etc. as outlined below:

- Bolts shall be Class 1A of ASTM A 193 e.g. B8MA (type 316) solution treated after all cold work including thread forming
- Nuts shall be of the "A" suffix variety of ASTM A 194 e.g. Grade 8MA (type 316) solution treated after all hot or cold working.

Resulphurized steel is not permitted.

5.3.5 BELLOWS

5.3.5.1 GENERAL

Bellows shall comply with the NACE MR0175 / ISO 15156 requirement when in contact with any concentration of wet Hydrogen Sulphide (see PEGS-0842-COR-032).

5.3.5.2 MATERIALS

Austenitic stainless steel shall not be used for bellows, beyond 50% of their minimum specified yield strength otherwise material selection may be made according to the process conditions from the following:

- Alloy 825 (UNS N 08825)
- Alloy 625 (UNS N 06625)
- Alloy 400 (UNS N 04400)

Alternate materials shall be subjected to COMPANY approval.

The production procedure shall comply with the requirements of the NACE MR0175 / ISO 15156.

5.3.6 SPRINGS AND SPRING LOCK WASHERS

5.3.6.1 MATERIALS

Springs shall be made of a material resistant to environmental corrosion cracking in the presence of H2S and shall comply with this Specification.

The materials may be selected from among alloy 600 (UNS N 06600), alloy 625 (UNS N 06625), alloy X718 (UNS N 07718), alloy 825 (UNS N 08825), alloy 400 (UNS N 04400), alloy 17-4 PH (UNS S 17400), low alloy Cr-Mo steel (steel 41XX and its modifications).

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5.3.7 METALLIC COATING AND SURFACE TREATMENT

5.3.7.1 METALLIC OVERLAY

Explosively clad, roll bonded or fusion-bonded corrosion resistant overlay are considered to be effective barriers to the sulphide environment as long as they do not suffer from fabrication defects susceptible to alter overlay tightness and to allow a path to the backing material for the H2S containing fluid.

5.3.7.2 METALLIC COATING

Electroless deposited nickel/phosphorus or electroless deposited nickel/phosphorus alloy for the first plating, followed by electro-deposited chromium plating are acceptable. The procedures shall be subjected to COMPANY approval.

Cadmium plating and galvanisation are prohibited, because these metals corrode rapidly in contact with H_2S.

5.3.7.3 OTHER SURFACE TREATMENTS

Chromizing, chromating, nitriding or liquid or gas phase carbonitriding are unacceptable as these materials provide poor resistance to sulphide stress cracking in the presence of H_2S.

5.3.8 MATERIAL CERTIFICATES AND MATERIAL TRACEABILITY

All material shall be manufactured new.

All materials shall be supplied with manufacturing mill certificates that clearly identify that the material has been manufactured, examined, heat treated and tested to prove the material meets the requirements of material specification, NACE MR0175 / ISO 15156 and this specification.

All material certificates shall be in accordance with EN 10204 3.1(as a minimum) or EN 10204 3.2 as specified, alternative proposals shall be subject to COMPANY approval.

COMPANY reserves the right to perform any counter-analysis, particularly on chemical analysis of finished products, to ascertain the correctness of the material certificates submitted with the supply.

All piping bulk materials must be fully traceable and correctly identified, particularly to the heat and test numbers of the matching certificates.

5.3.9 MATERIAL PROCURED FROM STOCKIST

In case of short quantity where Contractor is unable to procure material from manufacturer, material may be procured from stockist with prior approval from COMPANY. In any case, material shall comply with all requirements of this specification.

All material procured from stockist shall be subjected to chemical and mechanical tests to the extent as decided by COMPANY. Contractor shall consider extra material for such testing while ordering the material.

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5.4 QUALIFICATION TESTS

5.4.1 WELDING PROCEDURES QUALIFICATION TESTS

5.4.1.1 GENERAL

Each particular welding procedure shall be specially qualified for the job; no previous test reports shall be recognised as a qualification of the work to be performed.

Welding Procedure Qualification Tests (WPQT) shall be carried out according to the ASME Section IX / design code and in particular, it shall comply with COMPANY General Specification PEGS-0791-FAB-001 (TBA).

Welding procedure qualification shall be conducted under witness of Independent Third Party Inspection Agency and all tests shall be witnessed by this inspection agency.

Prior to commencement of welding procedure qualification, Contractor shall submit WPQT Plan which shall consist of preliminary WPS, tests to be conducted and specific application of each WPS.

Laboratory tests shall be performed in an official laboratory approved by COMPANY. Sufficient advance notice shall be provided to COMPANY to witness all or part of the tests at their discretion.

5.4.1.2 MATERIALS FOR THE TESTS

The materials for the tests shall be selected among those of the greatest values of carbon equivalents and maximum thicknesses that are intended to be used on fabrication.

5.4.1.3 PARTICULAR REQUIREMENTS FOR HARDNESS TESTS

In addition to standard mechanical tests, each qualification test shall include a cross-section hardness survey with VICKERS hardness testing under a 5 kg load. Hardness test method shall be as per ASTM E384 standard. The location of indentations shall be in accordance with Appendix-1

The results shall not exceed 250 HV5. However, isolated values up to 260 HV5 will be acceptable if any three adjacent readings in the HAZ do not exceed 250 HV5.

5.4.1.4 MICROSTRUCTURE EXAMINATION

An optical examination of the microstructure shall be performed at a magnification of x200. Untempered martensite shall not be acceptable, even in small amount.

5.4.1.5 CORROSION TESTS

HIC and SSC corrosion tests are not in the scope of this specification. However, such tests may be specified at the time of the purchase order, or could also be required by COMPANY during the qualification tests or during the fabrication, to clarify a particular technical situation.

In such instances, the procedures would be based on the recommendations of PEGS-0842-COR-032, unless otherwise agreed or specified.

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5.5 FABRICATION

No fabrication shall start until COMPANY has approved the chemical analysis of the materials and the results of the Welding Procedure Qualification Tests (WPQT).

5.5.1 GENERAL

In addition to the general and detailed requirements below, the manufacturer of Contractor shall comply with the following:

- Design and/or fabrication rules described in the regulations in force and the construction code adopted
- The maximum service or hydrostatic test stresses (including re-testing) limited to 80% of the minimum specified yield stress, for equipment corresponding to Severe Sour Service conditions
- Limitation to the strict minimum of the number of taps and nozzles on pressure vessels.

The welding of temporary parts shall be limited to the minimum. No arc striking shall be accepted outside the bevel. Welds of temporary parts and accidental arc striking shall be ground. The ground zone shall be subject to Magnetic Particle Inspection (MPI) or Dye Penetrant Inspection (DPI).

5.5.2 WELDING

The welding parameters shall be set up to the following minimum values:

- Welding heat input : 10 kJ/cm
- Preheating, according to the following table (minimum values):

	Thickness of material		
Welding Heat Input	**Below 15 mm**	**From 15 to 25 mm**	**Above 25 mm**
10 kJ/cm	not required	100°C	150°C
13 kJ/cm	not required	75°C	100°C
16 kJ/cm	not required	50°C	75°C
19 kJ/cm and above	not required		50°C

Preheating temperatures shall be obtained by permanent heating systems for temperatures required at 150°C and above.

5.5.3 FILLER MATERIALS

5.5.3.1 HOMOGENEOUS JOINT

Filler materials shall be selected in accordance with the characteristics of the base metal.

The use of filler materials designed to obtain a deposit with very low diffusible hydrogen (less than 5 cm3/100 g of deposited Weld Metal) is mandatory for all welds in contact with effluent containing H_2S.

The filler materials used shall have a maximum nickel content of 1.00%.

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5.5.3.2 HETEROGENEOUS COMPOSITE JOINTS

For welded joints of a carbon steel with a stainless steel, precautions shall be observed in selecting the filler materials and in executing the welds, according to whether the joint is heat-treated or not after welding.

5.5.3.2.1 NON HEAT TREATED JOINTS

The filler material shall be of type 24Cr12Ni or 20Cr10Ni3Mo according to the dilution and grade of the stainless steel.

5.5.3.2.2 HEAT TREATED JOINTS

The fabrication procedure may be as follows :

- Buttering of the bevels on carbon steel with filler materials 75Ni10Cr type AWS A 5-11 class E NiCrFe3, or preferably with nickel filler materials type AWS A 5-1, Class E Ni1, to obtain an added thickness of at least 8 mm after re-machining of the bevel
- Execute the heat treatment selected for the carbon steel
- Re-machine the bevels
- Weld the stainless steel part with the filler materials of type 20Cr10Ni3MoNb, if buttering has been carried out with materials of type AWS E NiCrFe3, or with materials of type AWS E NiCrFe3, if the buttering has been carried out with materials of type AWS A 5-11, Class E Ni1.

5.5.4 POST WELD HEAT TREATMENT (PWHT)

PWHT shall conducted as per below requirement. More stringent requirement shall be applicable in case of conflict between this specification and design code.

- All equipment/pressure vessels in carbon steel and low alloy steel shall be subjected to Post Weld Heat Treatment(PWHT) irrespective of their thickness
- Piping weld joints (butt welds / branch weld) in low alloy steel material shall be subjected to PWHT irrespective of the thickness
- Piping weld joints in carbon steel material shall be subjected to PWHT for all butt welds / branch connection weld joints exceeding 12mm thickness through the weld (excluding weld reinforcement).
- For carbon steel / low alloy steel piping, requirement of PWHT for fillet weld on socket weld connections and attachment of external non pressure part on pressure parts shall be governed by applicable design code except that minimum thickness requiring PWHT shall be 12mm.

PWHT shall be conducted at 610°C ± 10°C with minimum soaking period of one(1) hour.

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5.5.4.1 APPROVAL OF HEAT-TREATMENT PROCEDURE

For piping and equipment which are to be post-weld heat treated, PWHT procedure which contains following information, as a minimum, shall be submitted to COMPANY for approval.

- Details of the method of heating, e.g. furnace, electric resistance, induction, etc.
- Information on heating and cooling rates with,maximum thermal gradients
- Details of the location of thermocouples, type of thermocouples and method of their attachment
- Special requirements for heat-treatment, e.g. if it is proposed to post-weld heat treat a heat-exchanger tube bundle incorporating tube end welding

Copies of relevant heat treatment charts and reports shall be submitted to COMPANY for approval after completion of heat treatment.

5.5.5 SOUR SERVICE WITH ALKALIS / AMINES

For sour service in association with alkalis, amines or other alkaline process fluids, which are related to downstream applications, API RP 945 and COMPANY requirements shall be the systematic post weld heat treatment of welds with the exception of low pressure storage tanks.

5.6 IDENTIFICATION, STAMPING, MARKING

5.6.1 H_2S MARKING

The identification “PIP 019” of each piece supplied in accordance with this specification, shall be carried out by cold stamping surrounded by yellow paint. The use of low stress stamps is mandatory.

5.6.2 HARD STAMPS

Conventional sharp "V" stamping is acceptable only on the outer circumferences of flanges. Rounded "V" stamps may be used elsewhere, providing the identities are placed on the external surfaces of low stress areas.

5.7 PRODUCTION HARDNESS TEST

Requirement of production hardness test shall be as follows

5.7.1 HARDNESS CHECKING FOR COMPONENTS

In case of any doubt or discrepancy, COMPANY reserves right to ask Contractor / manufacturer to conduct hardness test on piping components.

In case of items supplied from stock, hardness test shall be conducted on random basis (extent can be varying from 1% to 10% at the discretion of COMPANY)

Hardness shall be conducted using portable Vickers hardness tester (Equotip or Krautkramer MIC-10 or equivalent as approved by COMPANY). No hardness value shall exceed 248 HV.

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5.7.2 HARDNESS CHECKING ON WELDS

General

- Transverse weld hardness shall be conducted using portable Vickers hardness tester (Equotip or Krautkramer MIC-10 or equivalent as approved by COMPANY)
- Hardness test shall cover Base Metal, Weld Metal and Heat affected zone (3 indentations at each of BM, WM and HAZ).
- Hardness test shall be made on properly ground surface
- Wherever possible, hardness test shall be conducted on inside surface (surface in contact with process fluid)
- Hardness test reading at any of the locations shall not exceed 250 HV

Pressure Vessel

- Hardness test shall be conducted for each longitudinal and circumferential weld seam
- Hardness test shall be conducted for each nozzle flange to neck weld and for each category D welds

Piping Welds

- For carbon steel welds, hardness test shall be conducted on 10% piping weld joints per each WPS. COMPANY reserves the right to ask contractor to conduct hardness test on 100% weld joints in case hardness test conducted on any of the joints do not conform to the requirement.
- For low alloy steel welds, hardness test shall be conducted for 100% weld joints
- COMPANY reserves the right to ask contractor to conduct hardness test on 100% weld joints in case hardness test do not con

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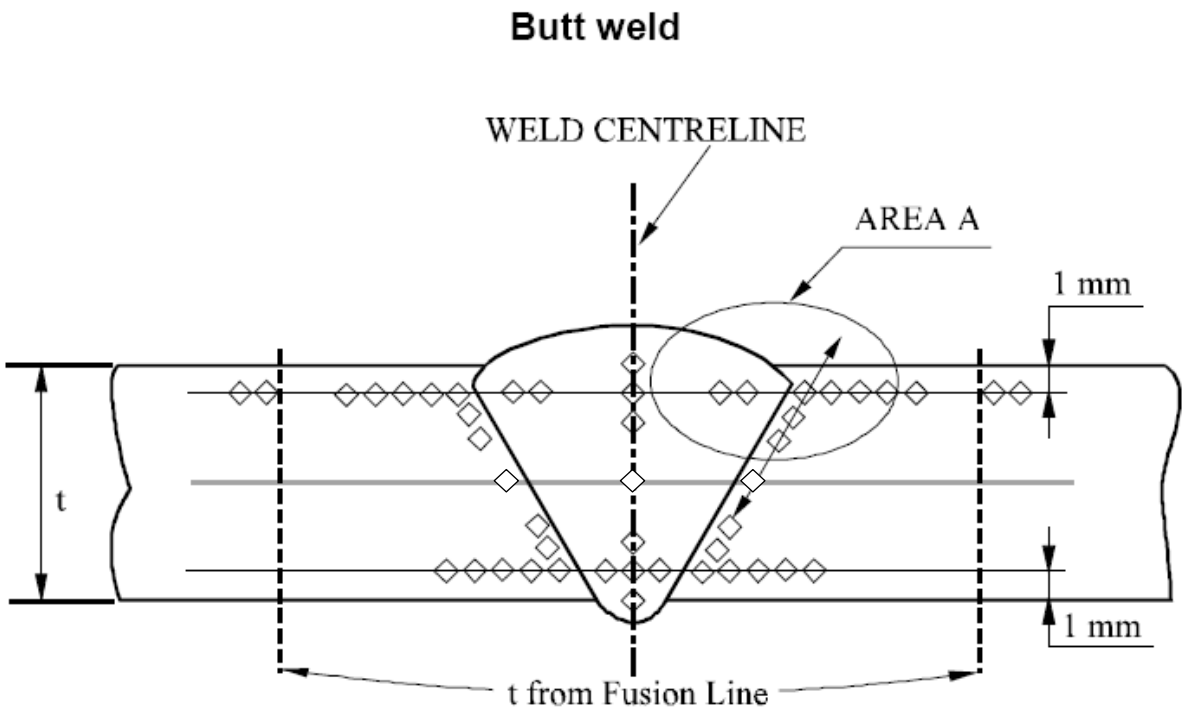
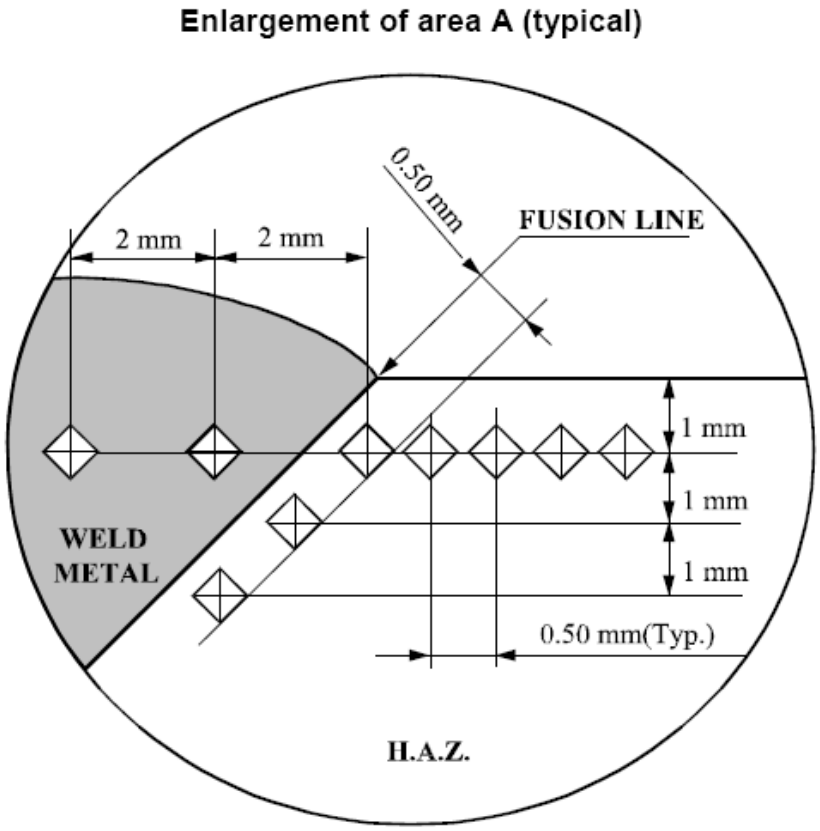
6.0 APPENDICES

Appendix 1. Vickers Hardness Survey





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