



PTT Exploration and Production Public Company Limited




PTTEP Engineering General Specification
(Engineering and Development Group)

Standard

**Design, Materials and Fabrication of Flanges and Branch
Outlet Fittings for Carbon Steel Pipelines**
(Mild, Intermediate and Severe Sour Service)

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1.0 INTRODUCTION

PEGS (PTTEP Engineering General Specification) is the PTT Exploration and Production PCL internal publishes standard. The objective of PEGS is to promote the best practices collecting from all PTTEP execution projects and to standardize those best practice to the future projects.

Every 5 years or upon request by the internal user, PEGS will be reviewed by related subject experts to reach decisions/agreements, then the document will be updated and publish to PTTEP intranet website. This is to ensure that all lesson learns from users can be applied to the future projects as the benefit to PTTEP.

2.0 PURPOSE

This specification defines the COMPANY's general technical requirements for the design, materials, manufacture, testing and inspection of hot forged carbon steel flanges and the like (e.g. anchor flange/deadweight support, swivel flange/swivel ring, etc including flanges and Quick Opening Closure neck (or hub) of pipe traps.), of the welding neck type, to be used in onshore and offshore pipeline systems. It also applies to branch outlet fittings.

3.0 SCOPE

This specification applies to flanges with minimum specified yield strength ranging from 290 N/mm² (42,100 Psi) up to 485 N/mm² (70,300 Psi). (i.e. X42 to X70 grades of ISO 3183)

1. Within this specification the term "flanges" is indifferently used to designate all items stated in section 2.0 here-above
2. This specification shall be used in conjunction with a Project Particular Specification (PPS) detailing the additional tests and requirements or the possible modifications to the present specification, based on the particular design conditions of the pipeline Project
3. This specification, also, covers ring joint gaskets, as well as stud bolts and nuts used with the Flanges.

Note that split ring of swivel flanges (to hold the swivel flange in position) needs not to meet any special requirements in regard to H₂S service.

4. Flanges specified in this specification are to be used in Mild Sour Service, Intermediate Sour Service or Severe Sour Service as defined in specification [10008-STD-6-COR-032](#), PEGS-0842-COR-032.
5. Flanges shall comply with the requirements of MSS SP 44 for flanges and MSS SP 97 for branch outlet fittings, except where otherwise noted in this specification. Other application standards shall be ISO 15503-3 (Flanges LS) and Norsok L005 (compact flange connections). Pressure-temperature ratings shall be defined in table of Appendix 1.
6. Flanges shall be forgings meeting the material requirements of this specification and the requirements of ASTM A 694 and NACE MR-01-75 / ISO 15156-2 unless otherwise indicated in this specification.

7. NPS 38 and larger sizes of the 300 and higher classes of welding neck flanges shall have 42 ksi minimum yield strength in the ring section (plateau); unless otherwise specified in the PPS.
8. Special requirements are also stated in this specification for flanges to be used in platform topsides, risers, expansion loops, etc., where the properties of Base Steel are to be ascertained after a Post Weld Heat Treatment.
9. Flanges may be supplied welded onto a piece of pipe at least 500 mm in length, when so required in the PPS or by the Purchaser. This welded pipe piece is designated as “pup piece” in this specification.

4.0 RESPONSIBLE ACTION PARTIES

This specification is distributed under the responsibility of the relevant department and divisions in PTTEP engineering entity in accordance with the procedures, approved by the line management.

This specification is applicable for all PTTEP operated assets and new project at the time of the study phase or pre-project or project sanction phase apply.

5.0 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.

5.1 LANGUAGE

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

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.
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.

5.2 TERMINOLOGY

Terminology	Description
Approval	The authorization in writing given by the COMPANY to the Contractor to proceed the work without releasing in any way the 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 and affiliates.
Contractor	Per contract: Contractor – ‘The contractor who is a PARTY to this CONTRACT and where the context so requires including, SUBCONTRACTORS utilized by CONTRACTOR for the performance of the WORK’
Inspector	Means the COMPANY’s inspector(s) or the inspector(s) from an independent Inspection Agency duly appointed by the COMPANY or the SUPPLIER (as applicable) to act on its behalf for the purpose of the contract.
Manufacturer	The company or its sub-contractors selected by the COMPANY or the Contractor or the Supplier (as applicable) as the Manufacturer of the said material.
Mill	The plants, Mills, workshops, laboratories or other locations where the fabrication, inspection and testing of materials and products are to be performed complete or in part, shall be referred to herein as the “Mill”.
PPS	Designates Project Particular Specification detailing the additional tests and requirements or the possible modifications to the present specification, based on the particular design conditions or the local legislation of the project.
Purchaser	The COMPANY or the Contractor or the Supplier (as applicable) which have placed the Purchase Order to the Supplier/Vendor/Manufacturer.
Supplier	Means the company or its agent designated on the Purchaser Order or Contract as being the selected SUPPLIER of the said materials
Supplier/Vendor	The company designed on the Purchase Order form or Contract as being the selected supplier of the said materials.

5.3 COMMON ACRONYMS

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

DAC	Distance Amplitude Curve
GTAW	Gas Tungsten Arc Welding
HAZ	Heat Affected Zone
HIC	Hydrogen Induced Cracking
ITP	Inspection and Test Plan
LPI	Liquid Penetrant Inspection
MPI	Magnetic Particle Inspection
MPS	Manufacturing Procedure Specification
MSYS	Minimum Specified Yield Strength
NDT	Non-Destructive Testing
NPS	Nominal Pipe Size
PPS	Project Particular Specification
PWHT	Post Weld Heat Treatment
QA	Quality Assurance
QCP	Quality Control Plan
RLC	Reference Level Curve
SAW	Submerged Arc Welding
SMAW	Shielded Metal Arc Welding
SS	Stainless Steel
SSC	Sulphide Stress Cracking
WPQR	Welding Procedure Qualification Record
WPS	Welding Procedure Specifications
WT	Wall Thickness

6.0 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 Documents, 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 completed 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.

6.1 PTTEP INTERNAL REFERENCES

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

Document Number	Document Title
10008-STD-6-GEN-005 , PEGS-12060-ADM-006	Quality Requirements for Vendor
10008-STD-6-GEN-007 , PEGS-12060-MMA-001	Material Traceability
10008-STD-6-PLR-025 , PEGS-12059-PLR-012	Welding of carbon steel pipelines to API 1104 (mild, intermediate and severe sour service)
10008-STD-6-PLR-005 , PEGS-12059-PLR-017	Seamless pipes for carbon steel pipelines (mild, intermediate and severe sour service)
10008-STD-6-COR-010 , PEGS-12059-COR-010	Painting of offshore structures and topside facilities

6.2 INTERNATIONAL STANDARDS

International standards applicable to this document are indicated in the table below i.e. ISO, IEC or ITU.

Document Number	Document Title
API 5L/ISO 3183 Mod.	Petroleum and natural gas industries - Steel pipe for pipeline transportation systems
ISO 10893-4	Non-destructive testing of tubes – Part 4: Liquid Penetrant Inspection
ISO 10893-5	Non-destructive testing of steel tubes - Part 5: Magnetic particle inspection of seamless and welded ferromagnetic steel tubes for the detection of surface imperfections
ISO 148-1	Metallic materials - Charpy pendulum impact test Part 1: Test method
ISO 15156-2	Petroleum and natural gas industries – Materials for use in H2S containing environments in oil and gas production - Part 2: Cracking-resistant carbon and low-alloy steels, and the use of cast irons
ISO 15503-3	Flanges
ISO 6507-1	Metallic materials – Vickers hardness test – Part 1: Test method
ISO 6892	Metallic materials - Tensile testing
ISO 9712	Non-destructive testing - Qualification and certification of personnel
ISO/TS 29001	Petroleum, petrochemical and natural gas industries - Sector-specific quality management systems - Requirements for product and service supply organizations
NACE MR 01-75/ISO 15156-2	Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment

6.3 CODE AND OTHER STANDARDS

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

Document Number	Document Title
ASME B1.1	Unified Inch Screw Threads
ASME B16.20	Ring-Joint Gaskets and Grooves for Steel Pipe Flanges
ASME B16.47	Large Diameter Steel Flanges NPS 26 Through NPS 60 Metric/Inch Standard
ASME B16.5	Pipe Flanges and Flanged Fittings : NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B18	Fasteners
ASME B31.4	Pipeline Transportation Systems for Liquid Hydrocarbons and other Liquids
ASME B31.8	Gas Transmission and Distribution Piping Systems
ASME Section IX	Boiler and Pressure Vessel Code – Section IX: Welding and Brazing Qualifications
ASME Section V	Boiler and Pressure Vessel Code – Section V: Non-Destructive Examination
ASME Section VIII	Boiler and Pressure Vessel Code – Section VIII: Pressure Vessel
ASTM E384	Standard Test Method for Knoop and Vickers Hardness of Materials
ASTM A 193/A 193 M	Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
ASTM A 194/A 194 M	Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A 370	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM A 388/A 388 M	Standard Practice for Ultrasonic Examination of Steel Forgings
ASTM A 694/A 694M	Standard Specification for Carbon and Alloy Steel Forging for Pipe Flanges, Fittings, Valves and Parts for High- Pressure Transmission Service
ASTM A 956	Standard Test method for Leeb Hardness Testing of Steel Products
ASTM E709	Standard Guide For Magnetic Particle Examination
BS EN 10088-1	Stainless steels. List of stainless steels
DNV-OS-F101	Submarine Pipeline Systems
EN 10204	Types of inspection documents
EN 10228-3	Ultrasonic Testing of Forging
MSS SP-44	Steel Pipeline Flanges
MSS SP-55	Quality Standard for Steel Castings for Valves, Flanges, Fittings and Other Piping Components – Visual Method for Evaluation of Surface Irregularities
MSS SP-97	Integrally Reinforced Forged Branch Outlet Fittings - Socket Welding, Threaded, and Buttwelding Ends
NORSOK L-005	Compact Flanged Connections

7.0 DESIGN, MATERIALS AND FABRICATION OF FLANGES AND BRANCH OUTLET FITTINGS FOR CARBON STEEL PIPELINES

7.1 APPROVAL OF SUPPLIER'S PROCEDURES

The SUPPLIER shall submit the following documentation for review and approval one month prior to commencement of fabrication.

- a) Design calculations and fabrication drawings of flanges
- b) Design calculation of ring joint and bolting
- c) Aimed chemical composition of flange material
- d) Manufacturing Procedure Specification (MPS), describing all proposed forging operations, heat treatment, inspection and non-destructive testing in their correct sequence. This document will also mention the characteristics of equipment used to carry out above mentioned operations
- e) Sketch showing the rough forging piece before machining and, when applicable, the prolongation or the test blank with exact location and orientation of test specimens (refer to section 7.5.4.1)
- f) Material heat treatment(s) and recording procedures, including number and location of thermocouples
- g) Welding end preselections
- h) Dimensional inspection procedures
- i) Non-Destructive Testing (NDT) procedures
- j) H₂S corrosion test procedures
- k) Quality Control Plan (QCP) or Inspection and Test Plan (ITP)
- l) Welding Procedures Specifications (WPS) (where applicable)
- m) Welder qualifications (when applicable)
- n) Handling, storage and packing procedures
- o) Proposed measures for temporary corrosion prevention (non-coated flanges).

Once approved, these procedures shall not be altered without the approval of the COMPANY

7.2 QUALITY ASSURANCE / QUALITY CONTROL

1. The SUPPLIER shall operate a Quality Assurance (QA) system in accordance with ISO/ TS 29001 or equivalent approved by a COMPANY recognized authority. The Quality Assurance Manual shall be submitted prior to the start of work. It shall be made available to the Inspector.
2. Four weeks prior to the commencement of the flange manufacture, the SUPPLIER shall prepare and submit a Quality Control Plan (QCP), which describes the inspections to be performed during the supply of flanges. The Quality Control Plan or Inspection and Test Plan (ITP) shall set forth “witness”, “hold”, “review”, and “monitor” points.

7.3 PROJECT PARTICULAR SPECIFICATION (PPS)

The PPS shall clarify, where needed, the following:

1. The necessity or no necessity to have pup piece(s) (refer to section 3.9)
2. The minimum flange thickness above which the simulated PWHT is required, if this thickness is below or equal to 25 mm (refer to section 7.5.4.5)
3. The sour service severity and type of pipeline effluent to clarify the H₂S test conditions and hardness requirements in welds (if any) (refer to section 7.5.6 and 7.14.4.3)
4. The minimum yield strength in the ring section (plateau) for NPS 38 and larger sizes of the 300 and higher classes of welding neck flanges (not less than 290 MPa = 42,100 psi (refer to section 7.5.4.2)
5. The supply or not of 1”1/2 valve and plug for blind flanges (refer to section 7.9)
6. The number of originals and copies required for the documentation (refer to section 7.19.2)
7. The flanges characteristics, including impact test temperature (refer to section 7.5.4.3 and Appendix 1).

7.4 DESIGN

7.4.1 DESIGN DATA

Details of pipe diameter, wall thickness and material grades of the matching pipelines shall be stated in pipeline Data Sheets and in flange Data Sheet to be presented as per the form shown in Appendix 1 of the present specification, together with the relevant design conditions.

A standard rating as per ASME B16.5 or MSS SP-44 (where applicable) shall be allocated to all flanges.

7.4.2 FLANGE DESIGN

1. The SUPPLIER shall provide design calculations and fabrication drawings in accordance with MSS SP-44 (flanges) or MSS SP-97 (branch outlet fittings) and ASME, Section VIII, Division 1, Appendix 2, for approval. Specially, the flanges shall be checked/designed for the hydrostatic operating and extreme conditions. Equivalent pressure due to axial force and ending moment in the flange shall be defined, as well as the decrease of allowable stresses due to flange service temperature.

Finite Element Analysis (FEA) shall comply with ASME VIII, Division 2, Appendix 4 or COMPANY equivalent recognized standard

However, the design factor for hoop stress, longitudinal stress and combined stress shall comply with ASME B 31.4 or B 31.8, as applicable, and shall be, as a minimum, that of the matching pipeline (specially at flange hub).

The dimensions of flanges shall be, as a minimum, those specified in ASME B 16.5 for NPS ½" through 10", and MSS-SP-44 for NPS 12" through 60".

Design calculations shall also be provided for the flange itself (including hub), bolts (pretensioning included) and ring joint (seating) for the intended service conditions.

2. The required type of flange facing (i.e. raised face, ring type joint) shall be clarified in the PPS. Facing shall be RTJ for subsea flanges. Flange facings (including ring joint grooves) shall be in accordance with MSS SP-44 and ASME B16.5, as applicable.
3. All flanges shall be designed with material tensile properties at least equal to those of the matching pipes (refer to par. 7.5.4 of this specification). If lower yield strength is proposed in the ring section (plateau) for NPS 38 and above of the 300 class and above, this proposal shall be assessed by calculation note for COMPANY approval.
4. The nominal internal diameter (bore) shall be that of the matching pipeline/riser, with a tolerance of ± 1.0 mm.
5. The minimum wall thickness at weld neck (or hub) shall not be less than that of the matching pipeline. The flange hub shall be designed so that it can be easily fitted to the matching pipeline.

Where there is a difference in steel grade or material thickness between flange and the connecting pipe, the transition joint shall be designated according to ASME B 31.8, Appendix I, Figure 15, or equivalent recognized code. There shall be no internal taper

6. All calculation notes shall clearly show the input sectionmeters and calculation methodology. All in-house softwares shall have proofs of validation to the satisfaction of COMPANY.

7.5 FLANGE MATERIAL

7.5.1 APPLICABLE SPECIFICATION

Flange material shall comply with ASTM A 694 and the requirements stated in the following.

7.5.2 MANUFACTURING PROCESS

1. Steel shall be made by the Electric Furnace or Basic Oxygen Converter, and shall be fully killed and made to fine grain practice.
2. Inclusion control with respect to content, distribution and shape shall be carried out by desulphurising, degassing and calcium injection, in order to provide resistance of steel to sour environments.
3. The material shall be hot forged (within range 800-1050 °C) to bring it as close as possible to the final shape and size of flange. All parts shall undergo a minimum total reduction ratio of a least 4 to 1 during the forging process.
4. All flanges shall be quenched and tempered after hot forging and rough machining. Rough machining means that the product is machined near to its final dimensions with an extra thickness of less than 10mm against nominal finished thickness of product.

In water quenched operation, the time from removal of flange from the furnace until it is immersed in quenching water shall not exceed 90 seconds. The start and end temperature of quenching water shall be recorded and shall not exceed 40°C.

Where simulated PWHT is required, the tempering temperature shall be minimum 605°C to allow a PWHT of 580°C minimum at pipeline construction stage.

7.5.3 CHEMICAL COMPOSITION

Unless alternative compositions are proposed by the SUPPLIER and approved at the bid stage, the chemical analysis shall comply with the following for ladle and product.

Element	Weight % max.	
	Ladle	Product
Aluminum (total)	0.050	0.050
Calcium	0.006	0.006
Carbon	0.15	0.17
CE (IIW)	0.43	0.44
Chromium	0.30	0.30
Copper	0.30	0.30
Cr + Mo +Cu + Ni	1.00	1.00
Hydrogen	2 ppm	2 ppm
Manganese	1.30	1.40
Molybdenum	0.35	0.35
Nb+V+Ti	0.15	0.15
Nickel	1.00	1.00
Niobium	0.06	0.06
Nitrogen	0.012	0.012
Oxygen	0.003	0.003
Pcm	0.23	0.24
Phosphorus	0.020	0.020
Silicon	0.35	0.40
Sulphur	0.005	0.005
Titanium	0.04	0.04
Vanadium	0.06	0.06

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Cu + Ni}{15}$$

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

No alloying additions of elements other than those listed above shall be made without prior approval of the COMPANY.

The SUPPLIER shall perform analysis for all the elements listed above and any other intentionally added elements.

The SUPPLIER shall carry out a chemical analysis on each cast of steel used and, also, on one product per cast. For flange diameter above 12" NPS, chemical analysis shall be carried out on 2 products per cast.

If any part of the product analyses fails to meet the requirements stated above, the whole cast shall be rejected or each individual product shall be fully analyzed and all products failing to meet the requirements shall be rejected.

7.5.4 MECHANICAL PROPERTIES

7.5.4.1 SAMPLING AND FREQUENCY OF TESTING

- a) The SUPPLIER shall test specimens cut from a complete production forging from locations and with orientations shown in Appendix 2 and Appendix 3.
- b) For flange 24" and larger in size, testing on prolongations is permitted, subject to COMPANY approval on prolongation sizes and location of test specimens. Testing on separately forged test blanks may exceptionally be agreed, at COMPANY's option, provided that shape and size of test blanks (to be proposed by the SUPPLIER) are quite realistic against size of the products to test and approval has been obtained from the COMPANY at the bid stage.
- c) When specimens are cut from rough machined forging, the sketch showing location of specimens in regard to rough forging shall be submitted (see section 7.1 e)
- d) The sampling requirement shall be 3 tensile and 3 Charpy impact tests as per Appendix 2 per each steel cast, flange size and heat treatment batch. Grouping of flange sizes and materials may be agreed with the COMPANY.
- e) Hardness tests shall be carried out on every flanges after heat treatment and final machining.

7.5.4.2 TENSILE PROPERTIES

Round bar tensile tests shall be carried out in accordance with ISO 6892 or ASTM A 370. Each test shall consist of one specimen. The largest practical test specimen size shall be used. The required tests results are stated in the following table.

Mechanical properties	Flange material grade (ASTM A 694)							
	F 36	F 42	F 46	F 52	F 56	F 60	F 65	F 70
Minimum Yield Strength (0.2% proof stress) (MPa)	245	290	320	360	390	415	450	485
Minimum TS (MPa)	415	415	435	460	490	520	535	570
Minimum Elongation in 2 inches (%)	25	25	25	25	22	20	20	18
Max YS/TS	≤ 0.85	≤ 0.85	≤ 0.85	≤ 0.85	≤ 0.85	≤ 0.88	≤ 0.90	≤ 0.91
Max Vickers Hardness (5 or 10 kg)	200	250	250	250	250	250	250	250

For NPS 38" and larger sizes of the 300 and higher classes, welding neck flanges shall have 42.1 ksi (290 MPa) minimum yield strength in the ring section (plateau), unless otherwise specified in the PPS

7.5.4.3 IMPACT PROPERTIES

Charpy V-notch tests shall be carried out in accordance with ISO 148-1 or ASTM A 370 at locations shown in sketches of Appendix 2 and Appendix 3. Each impact test shall consist of three specimens with notch oriented as per the Figures of above Appendices. Full size specimens (10 mm x 10 mm) shall be used.

The minimum required impact energies shall be as stated in the table below, whatever the transported effluent. The impact test temperature shall be stated in the PPS and/or Data Sheet.

Grade (A 694)	Minimum Average Value (Joules)	Minimum Individual Value (Joules)	Minimum Shear area Avge (Single)
F 36	28	22	85% (75%)
F 42	40	30	85% (75%)
F 46	40	30	85% (75%)
F 52	40	30	85% (75%)
F 56	40	30	85% (75%)
F 60	40	30	85% (75%)
F 65	54	40	85% (75%)
F 70	54	40	85% (75%)

Note: Lateral expansion of broken specimens shall be recorded for information only

7.5.4.4 HARDNESS SURVEY

A VICKERS hardness survey shall be carried out on each produced flange after final heat treatment and final machining, in accordance with ISO 6507-1, or equivalent, using a 5 or 10 kg load. A minimum of eight equi-spaced readings shall be carried out on the inside edge (or outside edge when impracticable) close to the welding neck (i.e. on flange “hub”). A further minimum of eight readings shall also be made at random locations on the thicker part of each flange (i.e. on flange “ring”) and on the transition part of hub.

Hardness shall not exceed the maximum individual hardness shown in table of section 7.5.4.2 above, at any point. The Inspector reserves the right to ask for hardness checks at any other location on the flange, in case of inconsistency of results.

Hardness testing shall be performed using a portable equipment approved by the COMPANY

7.5.4.5 SIMULATED PWHT

When so required in the PPS (and in all cases when wall thickness at flange welding end exceeds 25 mm), tensile tests and impact tests as per section 7.5.4.2 and 7.5.4.3 above shall be repeated after a simulated Post Weld Heat Treatment (PWHT) has been made on the flange material at a soaking temperature of not less than 25°C of the tempering temperature and 580°C \pm 10°C for one hour per 25 mm thickness of flange hub at beveledge (refer to section 7.5.2 bullet 4). This S. PWHT temperature shall comply with Appendix C, G400 of DNV-OS-F101 and be submitted to COMPANY for approval. The test procedures and test results shall meet the requirements of this specification.

PWHT tests shall also be required on flanges when a PWHT is made by the MANUFACTURER on weld between flange and pup piece, if any.

All heat treatment records (chart and sketch) shall be approved, signed, dated and stamped by the Inspector.

7.5.4.6 FAILED TESTS

The Inspector will only permit a retest if there is reason to believe that failure was due to error during preselection or testing and that result was not representative of the test sample. Otherwise, the failed test shall be carried out on every flanges of the cast or lot, or alternatively, the entire cast or lot shall be re-heat treated and the full set of tests carried out on at least one flange.

7.5.5 MATERIAL RINGS FOR WELDING TESTS

When it is agreed that flanges can be supplied without welded pup pieces, then the flange Manufacturer shall supply three (3) test rings to the COMPANY for qualification of weld procedures to be made by others. The rings shall be of the same steel cast and size as the flange hub and also shall have been forged and heat treated in the same way as the related supplied flanges.

Test rings shall have a minimum length of 300 mm. Three rings shall be required for each steel source, flange size and material grade. Both ends of the rings shall be bevelled as for the related flanges of the order.

Identification marking of test rings shall be agreed with the COMPANY.

7.5.6 H₂S CORROSION TEST

Hydrogen Induced Cracking (HIC) tests and Sulfide Stress Cracking (SSC) tests shall be carried out in accordance with Appendices 5 and 4 respectively of spec. [10008-STD-6-PLR-005](#), PEGS-12059-PLR-017, using specimens cut in flange hub or an extension ring at flange hub. The number of specimens shall be one set of three specimens for HIC tests and two sets (one set sub-surface at flange internal and one set at flange mid-thickness) of three specimens for SSC tests. All specimens shall be cut longitudinally to flange axis and the three specimens of each set shall be at three equispaced locations around the flange hub circumference. All SSC tests shall be made at under the stress as specified in above stated company General Specification. When there are pup pieces welded to flanges, the circular welds shall be subject to SSC tests as per [10008-STD-6-PLR-025](#), PEGS-12059-PLR-012. Test duration shall be 96 hours for HIC tests and 30 days for SSC tests. Acceptance criteria shall be as stated in the said appendices.

H₂S corrosion tests shall be made once per steel source/steel grade/steel cast flange size and heat treatment batch, on a product selected in agreement with the COMPANY. Grouping of flanges may be agreed with COMPANY.

7.6 WELDING NECK ENDS

The flange welding neck bevel shall be as per MSS SP-44, except that root face shall be 1.6 mm ± 0.6 mm.

7.7 GASKETS AND BOLTING MATERIALS

7.7.1 GASKETS

Ring joint gaskets shall be made to ASME B 16.20 and MSS SP-44 and shall be manufactured from soft iron having a maximum hardness of 250 HV 5 or 10.

7.7.2 BOLTING (BOLTS AND NUTS)

Unless otherwise specified in the PPS, bolts and nuts shall be as follows for temperature range -46°C to +400°C

- Bolts as per ASTM A 193 Grade B7M, with cut threads and 22 HRC max. or 250 HV10
- Nuts as per ASTM A 194 Grade 2HM, with 22 HRC max. or 250 HV10

The hardness of bolting shall be verified on each lot (i.e. bolting of the same size and material, from each heat of steel and heat treatment batch). Bolts and nuts shall have rolled threads. Bolts and nuts shall be supplied with 3.1 certificates as per EN 10 204

Surface treatment is not recommended. After assembly, stud bolts and nuts shall be cleaned (washed and degreased), abrasive blasted and painted as per Specification [10008-STD-6-COR-010](#), PEGS-12059-COR-010 or PPS requirements.

The bolts shall allow for use hydraulic tightening system.

7.8 PUP PIECES

The welded pup pieces, if any, (refer to section 3.9 of this specification) shall be selected among the pipes procured for the pipeline Project, and complying with the requirements of relevant Project specifications.

7.9 BLIND FLANGES

When required in the PPS, blind flanges with a 1½ valve and plug, suitable for hydrotest, will be supplied with the flanges. Blind flanges will be forged items. These items are temporary items and bolts and gaskets used for the connections to the flange are also considered as temporary items (i.e. they will not be re-used for the final connection).

These temporary items have to be designed (flange rating) by the SUPPLIER for one-year design life on the construction site.

Blind flanges and gaskets shall comply with MSS SP-44 and ANSI B 16.20.

7.10 PARTICULAR REQUIREMENTS FOR CARBON STEEL FLANGES TO BE CONNECTED TO STAINLESS STEEL FLANGES

1. Carbon steel flanges to be connected to stainless steel flanges (e.g. valve flanges) shall have a welding overlay made of the said stainless steel (e.g. Inconel 625, SS 316L,...) on the complete surface of the flange to be in contact with the stainless steel flange, plus on a band 30 mm wide minimum at the inner surface of the flange (in continuation with the overlay of flange surface).
2. The welding overlay shall be made with 3 layers minimum of stainless steel (e.g. 24/12/3 – 18/12/3 – 18/12/3, refer to BS EN 10088-1), so that there shall be no dilution with carbon steel within the last 3 mm in thickness below flange surface machine finish. PWHT is required after overlay welding operation, unless this PWHT is performed, later on, when fabrication is completed (example: pig traps).
3. Chemical analysis of weld overlay shall be made by energy dispersive X-Rays spectography on the finished surface after machining of each flange to check the conformance of chemical composition.
4. The procedure for welding overlay shall be qualified by tests made according to ASME IX. The hardness test shall consist of a line of indentations located 1mm below the fusion line in HAZ (6 indentations separated by 4mm). In addition, the chemical analysis of weld overlay shall be made as stated above at a point located 1 mm minimum. below the anticipated machine finish surface to check the conformance of chemical composition.
5. Gaskets to be used shall be those specified for the stainless steel flange.
6. Bolting shall be that specified for the carbon steel flange (however, protection of bolting shall be ensured to avoid corrosion by contact with stainless steel).

7.11 INSPECTION AND NON-DESTRUCTIVE TESTING

7.11.1 GENERAL

The Inspector shall have access to the Mill at all times when work is in progress and shall be at liberty to inspect the manufactured items at any stage and to reject any part not complying with this specification.

Sufficient inspections shall be made at all stages of the work by the SUPPLIER and Manufacturer to ensure that the materials, manufactured items and testing comply in all respects with the requirements of this specification.

The COMPANY inspection shall not relieve the SUPPLIER from his responsibility, being understood that the SUPPLIER shall remain responsible for quality and inspections.

7.11.2 NON-DESTRUCTIVE TESTING (NDT)

7.11.2.1 GENERAL

The SUPPLIER shall submit detailed inspection and NDT procedures for review and approval. This shall also detail the full extent of the inspection.

The SUPPLIER shall establish, before commencing production, an identification system such that each flange can be fully identified against the Mill test certificates.

The NDT personnel used shall be fully certified level 2 minimum as per ISO 9712 and subject to approval of the Inspector. The Inspector reserves the right to request for retest or reject any of the NDT personnel at any time.

7.11.2.2 EXTENT OF INSPECTION

Flanges shall be subject to the following inspections:

- 100% visual inspection of internal and external surfaces
- 100% Magnetic Particle Inspection of internal and external surfaces
- 100% ultrasonic inspection for flange size above 4”.

Final NDT shall be carried out after final heat treatment, with the forging in the finish-machined condition.

7.11.2.3 VISUAL INSPECTION

Forgings shall comply with the workmanship, finish and appearance requirements of ASTM A 694 Std and ISO 15590-3.

7.11.2.4 MAGNETIC PARTICLE INSPECTION (MPI) AND LIQUID PENETRANT INSPECTION (LPI)

MPI shall be carried out over the entire surface area of the forgings as per SE 709, Article 25 of ASME V or ASTM E 709, using wet particles and the yoke method.

LPI as per ISO 10893-4 shall apply only on stainless steel overlays.

No linear indication shall be permitted.

7.11.2.5 ULTRASONIC INSPECTION

Ultrasonic testing shall be carried out in accordance with ASTM A 388/A 388 M or EN 10228-3. The entire volume of the forging shall be subject to UT (straight-beam and angle-beam examinations).

a) Straight Beam Examination

The reference block calibration method shall be used. The reference block of thickness representative of that of the tested forging shall comprise flat-bottom holes of 5 mm dia. distributed through the thickness at different depths to develop the Reference Level Curve (RCL) and adjust the sensitivity.

All indications that exceed the Distance Amplitude Curve (DAC) reference curve when examined with the gain setting used to produce the DAC reference curve shall be cause for rejection.

Any isolated laminar imperfection larger than 60mm² in product body and 25 mm² at welding ends shall not be acceptable.

b) Angle Beam Examination

Indications which are equal to or exceed those obtained from a 60 deg. V-notch 25 mm long and having a depth no greater than 5% of the actual thickness under examination in the forging or 6mm (whichever is smaller) shall be unacceptable

7.12 REPAIR OF DEFECTS

Minor surface defects on flanges shall be ground out leaving a smooth gradual profile provided that the wall thickness is not reduced below the nominal value given in MSS SP-44 or by proper calculations for non-standard flanges. Any ground areas (except for cosmetic grinding) shall be examined by Magnetic Particle Inspection. Forgings containing larger defects shall be rejected. Repair welding of forging shall not be permitted.

7.13 DIMENSIONAL REQUIREMENTS AND INSPECTION

1. Flanges shall be machined, as a minimum, according to the dimensions and tolerances of MSS SP-44 for sizes above NPS 10", and of ANSI B 16.5 for NPS 10" and smaller, or otherwise according to calculation results for non-standard flanges.
2. In all cases, the nominal internal diameter of the flange shall be the same as the nominal internal diameter of the matching pipeline, with a tolerance of ± 1.0 mm (refer to section 7.4.2.4 of this specification). This shall be checked in the presence of the Inspector using internal callipers, gauges or equivalent approved devices.
3. The finish of contact faces of flanges shall be checked on each flange in full compliance with MSS SP-44.
4. Profile and dimensions of weld neck ends are defined in section 7.6 of this specification. This requirement also applies to welded pup pieces, if any. Refer, also, to section 7.4.2, bullet 5.
5. The dimensional inspection shall be carried out after welding the pup piece (if any) to the flange.

7.14 WELDING OF PUP PIECE (IF ANY)

7.14.1 GENERAL

Welding of pup pieces to flanges shall be in accordance with the requirements of specification [10008-STD-6-PLR-025](#), PEGS-12059-PLR-012 and the additional requirements stated in the following.

7.14.2 WELDING PROCESS

The use of welding processes other than SMAW and SAW shall not be permitted without prior approval of the Inspector, except that GTAW is acceptable and recommended for root runs. Only low hydrogen coated electrodes shall be used when the SMAW arc process is employed.

7.14.3 WELDING PROCEDURE SPECIFICATION (WPS)

Before performance of qualification test welds (see section 7.14.4 hereafter), the SUPPLIER shall submit to COMPANY detailed Proposed Welding Procedure Specifications (pWPS) for the main weld and repair welds.

Each pWPS shall include:

- A detailed description of the welding procedures
- Bevel profile and dimensions
- The Manufacturer, brand name and designation of all welding consumables
- The extent and method of interpass cleaning
- For each run, the current type, polarity, arc current and voltage, direction of welding, welding speed and/or run out length (when applicable)
- Preheating and interpass temperature
- Details of welding consumable baking and handling procedures.

7.14.4 WELDING PROCEDURE QUALIFICATION TESTS

7.14.4.1 WELDING QUALIFICATION TESTS

After approval of the pWPS, the SUPPLIER shall demonstrate by qualification tests that the pWPS and the equipment intended for production meet the quality and property requirements of this specification. Final approval by the Inspector shall only be given on satisfactory completion of all testing specified in this specification.

The welding procedure qualification tests shall be carried out on a butt weld between a flange from the same lot as the rest of the flanges being supplied and a pup piece of matching nominal pipe size and wall thickness.

The welding consumables used for weld procedure qualification tests shall be from the same lots as those planned for use in production welding.

Tests conducted by the SUPPLIER in qualifying the welding procedures shall be witnessed by the Inspector.

7.14.4.2 EXAMINATION OF QUALIFICATION WELD

The completed test weld shall be examined visually in accordance with specification 10008-STD-6-PLR-025, PEGS-12059-PLR-012.

After visual examination and at least 24 hours after completion of welding, the test joint shall be 100% examined by X-radiography in accordance with above mentioned General Specification.

The Inspector may request to have an ultrasonic examination where there is any doubt on weld quality after X-radiography inspection.

Mechanical testing of the joint can only proceed after the weld is judged satisfactory.

7.14.4.3 DESTRUCTIVE TESTING

The number, type and position of test specimens shall be as stated in specification 10008-STD-6-PLR-025, PEGS-12059-PLR-012. Test procedures and results shall comply with the requirements of specification 10008-STD-6-PLR-025, PEGS-12059-PLR-012.

a) Macrosection/Hardness tests

The maximum HV5/HV10 hardness values shall not exceed the values stated in Table below:

Sour service	Weld root	Weld cap
Mild	300	300
Intermediate	275	300
Severe	250	275

b) Impact tests

The specimen size shall be the largest practicable. The minimum values of impact energy absorption for weld and base material are stated in specification 10008-STD-6-PLR-025, PEGS-12059-PLR-012 or related PPS and/or pipeline Data Sheets, together with the impact test temperature.

No fabrication shall commence until the procedure qualification test results have been approved by the Inspector.

7.14.4.4 SSC TESTS

They shall be made according to the requirements of 10008-STD-6-PLR-025, PEGS-12059-PLR-012 for the specified sour service (i.e. Intermediate or Severe Sour Service) and type of effluent.

7.14.4.5 STORAGE OF TEST SPECIMEN

The test specimen and the remaining part of tested pipes shall be stored by Manufacturer till the final release of goods. Those pieces may be used for any further investigation or counter tests as addressed in that present specification.

7.14.4.6 QUALIFICATION OF WELDERS

Welders shall be qualified as per 10008-STD-6-PLR-025, PEGS-12059-PLR-012. Welders who are previously qualified may be accepted at the discretion of the Inspector.

7.14.4.7 INSPECTION AND TESTING

7.14.4.7.1 NON-DESTRUCTIVE EXAMINATION

Inspection of production welds shall not commence until at least 24 hours have elapsed since weld completion.

All welds shall be 100% visually inspected for surface appearance and defects, and shall satisfy the acceptance criteria of 10008-STD-6-PLR-025, PEGS-12059-PLR-012.

All welds shall then be 100% examined by Magnetic Particle Inspection and Radiography in accordance with 10008-STD-6-PLR-025, PEGS-12059-PLR-012.

All NDT procedures shall have been previously submitted to and approved by the Inspector.

7.14.4.7.2 WELD ACCEPTANCE CRITERIA

The weld acceptance criteria for welding procedure qualification tests, welder qualification tests and production welds shall be as defined in 10008-STD-6-PLR-025, PEGS-12059-PLR-012.

7.15 MILL HYDROSTATIC TESTING

The SUPPLIER shall certify that the flanges (including pup pieces, if any) can withstand the hydrostatic test pressure which develops a hoop stress of 90% of SMYS of matching pipe (using the Barlow's formula and the specified nominal wall thickness of matching pipe for calculation).

7.16 PROTECTION

The bevelled ends and contact faces of flanges shall be protected by a peel-off varnish. Unless otherwise agreed, flanges (or their pup pieces) shall be fitted with bevel protectors of a type approved by the Purchaser.

7.17 MARKING OF FLANGES

Marking shall be such that complete traceability is demonstrated in all stages of manufacture.

Each flange shall be clearly identified and paint marked on the outside rim with the following data:

- COMPANY's name
- Project name
- Purchase Order no.
- Manufacturing name/Mill Name/Mark/Logo
- Steel grade (ASTM A 694)
- Item No./Requisition No.
- Heat number
- Pressure-temperature rating (MSS SP 44)
- Nominal flange diameter and WT
- Theoretical weight (in kg).

Marking shall be approved by the Inspector prior to flange production. The original marking of the pipes shall be transferred to each corresponding pup piece, if any. The flange size (O.D. x W.T.), steel grade, class rating and applicable standards (e.g. MSS SP-44), as a minimum, shall be die stamped on the periphery of each flange ring. The mark of the Inspector shall also be added.

7.18 HANDLING, STORAGE AND PACKING

The SUPPLIER shall ensure that all finished flanges are handled and stored in such a manner as to preserve the machined faces and general surface condition of the product. The SUPPLIER shall ensure that all flanges are adequately protected against corrosion on a temporary basis (until installation), on those areas where atmospheric corrosion may occur.

The flanges shall be stored clear of the ground and adequately protected from water and mud.

The SUPPLIER shall take suitable corrective action if damage is observed by the Inspector due to inadequate handling or storage conditions.

7.19 DOCUMENTATION

7.19.1 MILL CERTIFICATES

Mill certificates shall be 3.2 according to EN 10204 for the flanges. Mill certificates shall be issued by the flange Manufacturer, and signed, dated and stamped by the Inspector. Mill certificates shall make reference to MSS SP-44 or MSS SP-97, where applicable, together with the present PEGS and related PPS.

Mill certificates shall show the following:

- Manufacturer's name
- Product serial number/Requisition no.
- Flange diameter and rating
- Purchase Order number
- Heat number
- Test number
- Chemical analysis (ladle and product) including Carbon Equivalent and Pcm
- Mechanical test results
- Non-Destructive tests performed with results
- Heat treatment batch with number and Heat Treatment details
- Any additional tests and inspections carried out
- Definition of overlay (if any)

7.19.2 PRODUCTION REPORT

Upon completion of flange manufacture, the SUPPLIER shall produce a production report which shall include the following minimum information and documents:

- Manufacturing Procedure Specification (MPS) of flanges
- Report of flange manufacturing procedure qualification tests
- Production test report (mechanical tests, NDT reports, dimensional reports, etc.)
- Mill certificates of flanges
- Quality Control Plan (QCP)
- Heat treatment charts signed, dated and stamped by the Inspector, showing date of treatment and clear definition of the scales used
- Sketch showing test specimen removal and identification (see section 7.5.4.1)
- H₂S corrosion test reports

- WPS, WPQR and Welder Certificates
- Non-Destructive Testings made on production welds (if any)
- Hydrostatic testing certificate of compliance
- Compilation of concessions/deviations, if any, granted by the COMPANY.

The PPS shall state the number of originals and copies of the production reports which are to be supplied to the COMPANY.

The Inspector shall stamp (rubber stamp), sign and date the original documents. The copies shall be stamped (as a minimum) by the Inspector.

7.19.3 SCHEDULE

1. The flanges shall be dispatched only after a Release Certificate has been issued by the Inspector. Test rings may be released before the flanges, where so agreed
2. Mill Certificates shall be supplied at the time of dispatch of the flanges.
3. The final production report as above shall be transmitted to the COMPANY without delay after completion of flanges production. The latest date of submission of this report shall be three weeks maximum after dispatch of flanges.

7.19.4 DOCUMENTATION TO SUBMIT BY THE POTENTIAL SUPPLIER AT BID STAGE

1. Full technical features of raw materials: sourcing, aimed chemical composition (including Carbon Equivalent and Pcm), shape and dimensions, etc.
2. A simplified Manufacturing Procedure Specification (MPS) giving the main features of manufacturing process, forging process, forging ratio, sectionmeters that are monitored and/or recorded, sampling of test specimens, etc.
3. Final heat treatment details.
4. Nominated company for conducting flange design/calculations.
5. Nominated laboratory for conducting the H₂S embrittlement tests.
6. Past experiences of laboratory on HIC and SSC tests performed as per this specification (including the laboratory preliminary or typical procedures).
7. Track record of SUPPLIER in manufacturing flanges similar to the order
8. Details of bevel protections.
9. Details of flange packing.
10. Quality Assurance Certification (ISO TS 29001, etc.)
11. Deviations to present specification, if any.

7.20 TECHNICAL QUERIES/NON-CONFORMANCE REPORT

1. Any SUPPLIER's requests for clarifications or deviations to COMPANY specifications shall be submitted to PTTEP authorized technical specialist only through Technical Queries (TQ), the format of which shall have prior approval of the COMPANY.

A deviation to specification shall not be considered as accepted if it has not been submitted to and accepted by specialist here-above through a Technical Query.

2. Approval given by the PTTEP specialist to any SUPPLIER's work procedures, specifications, equipment, etc. shall not release, in any way, the SUPPLIER from his obligation to meet the COMPANY specifications.
3. Any work performance or test result which is found, at a later date, not in conformance with COMPANY specifications or agreed procedure shall be subject to a Non-Conformance Report (NCR) to be issued by the SUPPLIER for submission to COMPANY. NCR report shall indicate the submitted corrective action intended by the SUPPLIER.

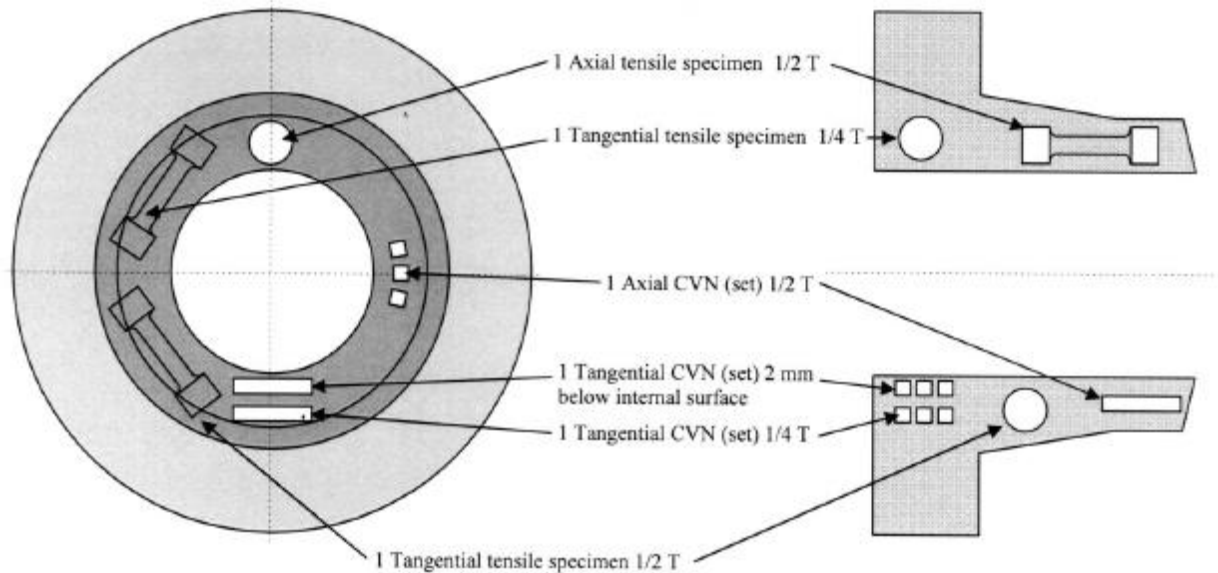
8.0 APPENDICES

Appendix 1. Flanges Characteristics

(Table to be filled-in and incorporated in PPS)

Flange nominal Dia.	.....	.....
• Pipeline service (Sour Service level 1, 2 or 3)		
• Type of effluent (Oil – Gas – Water)	.....	.....
• Flange steel grade (ASTM A 694)	.....	.....
• Pressure-temperature rating (B 16.5 / MSS SP-44)	.....	.....
• Flange Nominal Internal Dia. (Bore) (mm)	.....	.....
• Standard of design		
- Standard of dimension		
- Ring Mechanical characteristics		
- Flange facing (e.g. raised face)		
- Ring type joint		
• Matching pipe:	.....	.....
- Steel grade (API 5L/ISO 3183)	.....	.....
- Nominal internal dia. (Bore) (mm)	.....	.....
- Nominal wall thickness (mm)	.....	.....
- Mill hydrostatic pressure (Barg)	.....	.....
• Design/Safety factor	.....	.....
• The minimum yield strength in the ring section (plateau – See section 7.4 & 7.4.2)		
• Max. Design Temperature (°C)	.....	.....
• Min. Operating Temperature (°C)	.....	.....
• Min. Design Temperature (°C)	.....	.....
• Min. Steel Design Temperature (°C)	.....	.....
• Design Pressure (Barg)	.....	.....
• Corrosion Allowance (mm)	.....	.....
• Charpy V impact Test :	.....	.....
- Test Temperature (°C): .....	.....	.....
- Absorbed energy (J): .....	.....	.....
• Min. average: .....	.....	.....
• Min. single: .....	.....	.....

Appendix 2. Sampling of test specimens



For test pieces (components) having maximum section thickness, $T \leq 50\text{mm}$, and test specimens shall be taken at mid-thickness and the mid-length shall be at least 50mm from any second surface. For test pieces (components) having maximum section thickness $T > 50\text{mm}$, the test specimens shall be taken at least $\frac{1}{4} T$ from the nearest surface and at least T or 100mm, whichever is less, from any second surface.

The notch shall be perpendicular to the component's surface.

In case of specific request in the ring, axial tensile test at $\frac{1}{2} T$ is sampled.

Appendix 3. Sampling of test specimens (swivel rings)

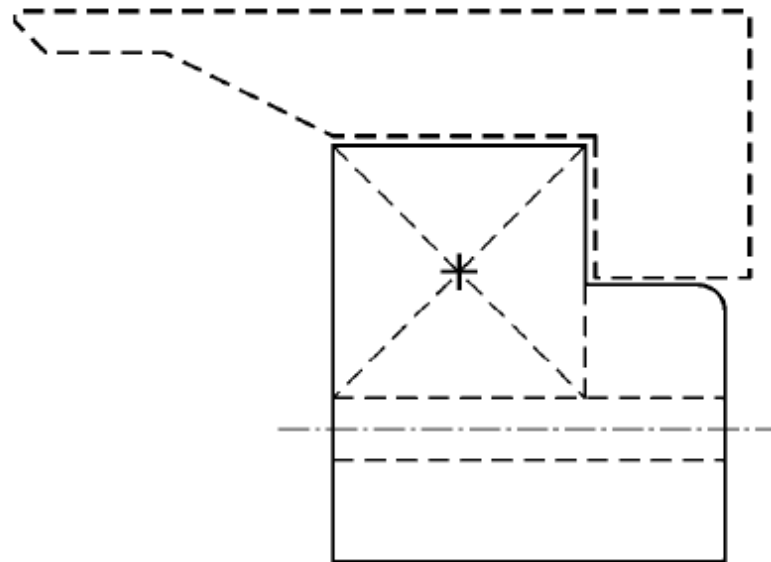


Figure 1 - Sampling position of mechanical test specimens

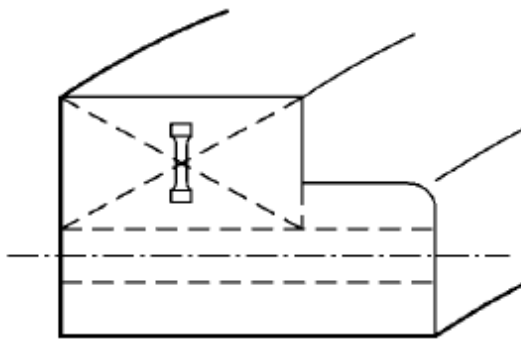


Figure 2 - Location and orientation of tensile specimens (1 specimen from the location)

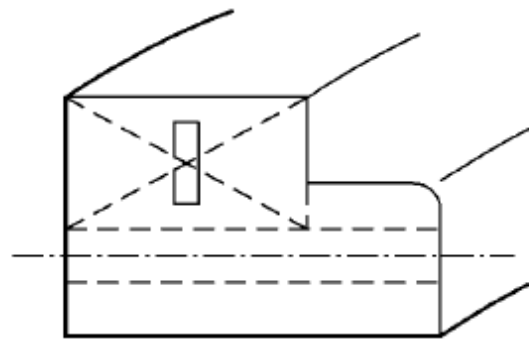


Figure 3 - Location and orientation of impact specimens (3 specimens from the location i.e. 9 samples in total)

Appendix 4. Inconel 625 or SS TP 316 L-Seal pockets weld overlay procedure

1. Scope

This appendix covers requirements for weld overlay of Inconel 625 or 316L stainless steel on carbon steel substrate material of valve parts for corrosion protection purpose. It applies to sealing areas of valves exclusively.

This appendix does not apply to weld overlays of large valve surfaces such as internal surface of bodies.

2. Weld overlay requirements

2.1. Service conditions

- a) Weld overlay shall provide corrosion protection on specified sealing areas of valves.
- b) Welded surfaces are in contact with the corrosive fluid.
- c) No surface defects are allowed on sealing surfaces.

2.2. Weld overlay description

- a) Weld overlay shall be in accordance with ASME, section IX (Corrosion protection – Weld Metal Overlay).
- b) Overlay thickness shall be sufficient in order to obtain a minimum of 3.5 mm thick protective layer in the final machined condition. 1.5 mm thick only is acceptable for the PAW (Plasma Arc Welding) process only.
- c) Areas to be welded and dimensional tolerances shall be shown on detailed drawings (overlay thickness included).
- d) Maximum allowable hardness at any location on welded surface after final machining operation shall be less than 22 HRC for 316 L and 35 HRC for Inconel 625 (NACE MR 01-75).
- e) Heat Affected Zone (HAZ) thickness shall be minimised.
- f) Overlay shall be performed in a minimum of 3 layers.
- g) Welded surfaces are sealing areas in which any defect shall not be accepted.

3. Fabrication

3.1. General requirements

Weld production and qualification test shall be performed in accordance with ASME IX. Only welders having satisfactorily passed a performance qualification test shall conduct the production of welded pieces.

3.2. Welding consumables

Welding consumables used for fabrication shall conform to the description shown in the relevant WPS. A test certificate shall be provided for each lot used.

3.3. Welders qualification

Welders without same or equivalent performance qualification shall satisfactorily pass the test using the procedure of section 4 here-after

3.4. Fabrication procedures

No fabrication shall start until the welding procedures are approved. These procedures shall cover at least the following:

- Storage, drying and handling of consumables
- Cleaning of base metal surfaces to be welded
- Welding method with operating mode and sectionmeter description.

The Welding Procedure Qualification Record (PQR) shall be documented and submitted together with the relevant WPS for approval by the COMPANY.

3.5. Defect removal and repair

a) Repairs may be local or total when non-conforming conditions are found. Defects in excess of acceptance standard shall be removed by reducing weld overlay thickness and shall be repaired by re-welding.

b) All excavations shall be inspected by LPI prior to the start of repair welding in order to confirm the complete removal of defects.

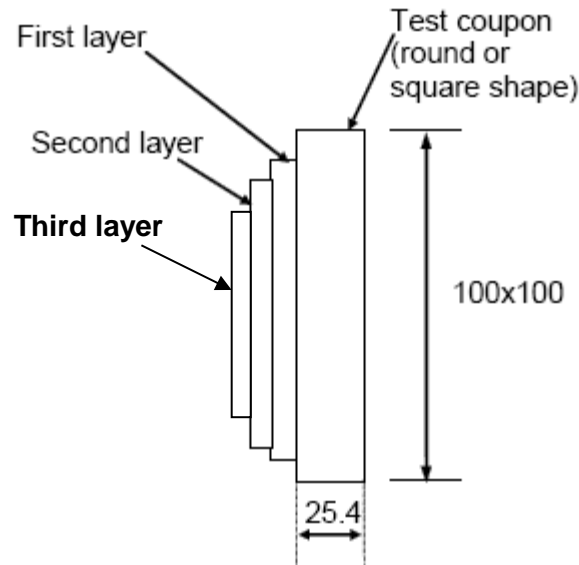
c) Repair by re-welding shall be performed in accordance with a written procedure. The following information must be given in these procedures:

- Method of removing defects
- Requirements related to the shape of the excavation
- Inspection of repair prior to re-welding
- Applicable welding procedure and qualification tests
- Inspection after welding.

4. Qualification tests and acceptance criteria

4.1. Qualification coupon

Qualification test coupon shall be of the same material and grade as the production material. Type and dimensions of the qualification test plate shall be as follows:



Qualification test plate dimensions

The following examination shall be performed after weld overlay on the coupon:

- a) Dimensional verification:** overlay thickness and conformity of dimensional tolerances (any change in dimensions after welding).
- b) Visual inspection:** method as per MSS SP 55. No defects are allowed.
- c) Liquid Penetrant Inspection:** overlay shall be examined according to ASME VIII, division 1, Appendix 8 or ISO 10893-4. No defects are allowed.
- d) Chemical analysis:** spectrographic analysis of the weld metal surface at the minimum overlay thickness as specified for finished components. Chemical analysis results shall be within the nominal composition of the required type of overlay (i.e., SS TP 316L or Inconel 625, as applicable).
- e) Hardness testing:** ten indentations shall be performed at three test line locations. Testing shall include Base Material, Heat Affected Zone (HAZ) and Weld Metal. Three indentations minimum are required within each layer. The hardness survey shall be made at a maximum 0.5 mm distance between the indentations from the Fusion Line, through HAZ and into the unaffected Base Material. Hardness testing shall be the Vickers hardness test, 5 or 10 kg load.
- f) Macrographic examination (x1.5):** the macro-section required by ASME IX shall be documented by original photographs attached to the test report.

g) Micrographic examination: the microstructure of the Heat Affected Zone (HAZ) shall be free of precipitations and intermetallic phases. The micro-examination of the etched specimens shall be performed at a magnification of x 400 and documented by photographs attached to the test report, which shall be submitted on request. The frequency of examination shall be as for mechanical testing.

4.2. Production weld overlay (100% extent of testing)

The following examination shall be performed after production weld overlay:

a) Dimensional verification: overlay thickness to meet final machined condition requirement (as per drawings), and conformity of welded pieces.

b) Visual inspection: method as per MSS SP 55. No inclusion, porosity, crack, slag, nor any visible defects are permitted.

c) Liquid Penetrant Inspection: on last layer, this final non-destructive examination shall be carried out after any post-weld head treatment and final machining. Inspection method and procedures shall comply with the code- ASME VIII, division 1, Appendix 8 or ISO 10893-4. No defects are allowed on sealing surfaces. Any linear indication or rounded indication greater than 4.5 mm are not allowed; four or more rounded indications in line sectioned by 1.6 mm or less (edge to edge) are not acceptable if their individual size is greater than 1.6 mm.

4.3. Documentation

The following shall be submitted for information:

- Welding Procedures (WPS) and Welding Procedure Qualification Records (PQR)
- For each piece, the required test and examination certificates
- Welding consumable certificates.



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