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INDEX OF REVISIONS

REV.	DESCRIPTION AND/OR REVISED SHEETS
0	ORIGINAL ISSUE
A	ITEMS: 2;4.1; 4.2; 4.3; 4.4.5; 4.5.1; 4.5.2; 5.1; 5.9; 8.1.14; 8.1.15 and 15 ADDED; ITEMS1; 2.3; 4.9; 5.3.2.2; 5.6; 6.1.4; 6.1.7; Table 8.3; 13.1.2 and 17 REVIEWED; ITEM 5.7 EXCLUDED.
B	GENERAL REVISION ACCORDING TO THE REQUIREMENTS OF IOGP S-619. THIS TECHNICAL SPECIFICATION ALSO INCLUDES THE REQUIREMENTS FROM I-ET-3010.00-1200-540-PX4-002 (REQUIREMENTS FOR PRESSURE VESSELS FABRICATION).
C	ITEM 5.14 ADDED.
D	REVISED WHERE INDICATED
E	ITEMS REVISED/ADDED: 2.3; 5.4.2; 5.4.3; 5.6.2.; 5.7.2; 5.9.5; 5.14 and A.10
F	GENERAL REVISION UPDATED WITH IOGP S-619 (APRIL 2022) REQUIREMENTS
G	REVISED WHERE INDICATED

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
DATE	AGO/13/18	APR/01/19	JUL/20/20	FEB/24/21	APR/21/21	DEC/30/21	OCT/28/22	DEC/13/22	
DESIGN	ESUP	ESUP	ESUP	ESUP	EEA	EEA	EEA	EEA	
EXECUTION	PONTE	PONTE	DANISCHMIDT	CJX4	CJX4	CJX4	CJX4	CJX4	
CHECK	ESTEVES	DANISCHMIDT	PONTE	HR7W	QM66	HR7W	HR7W	CJW2	
APPROVAL	JUVENTINO	JUVENTINO	GONZALEZ	U32N	U32N	U32N	U32N	U32N	

SUMMARY

OBJECTIVE 4

SECTION I – COMPLEMENTARY REQUIREMENTS TO IOGP S-619 4

1 SCOPE 4

2 NORMATIVE REFERENCES 5

3 TERMS, DEFINITIONS, ACRONYMS, ABBREVIATIONS AND SYMBOLS 8

4 DESIGN 11

5 MATERIALS 22

6 FABRICATION 24

7 HEAT TREATMENT 28

8 NON-DESTRUCTIVE EXAMINATION 29

9 PRESSURE TESTING 33

10 PREPARATION FOR SHIPMENT 35

11 COATING AND PAINTING 36

ANNEX A – ADDITIONAL REQUIREMENTS FOR SOUR SERVICE VESSELS 37

ANNEX B – ADDITIONAL REQUIREMENTS FOR INTEGRALLY CLAD AND WELD OVERLAY VESSELS 40

ANNEX C – ADDITIONAL REQUIREMENTS FOR CARBON STEEL VESSELS 43

ANNEX D - ADDITIONAL REQUIREMENTS FOR AUSTENITIC STAINLESS STEEL, 22CR AND 25CR DUPLEX VESSELS 44

ANNEX E - VESSEL TOLERANCES 46

ANNEX F - REQUIREMENTS FOR MAXIMUM ALLOWABLE CORROSION ALLOWANCE (MACA) 47

ANNEX G – ADDITIONAL REQUIREMENTS FOR VESSELS IN CYCLIC SERVICE 50

ANNEX H – ADDITIONAL REQUIREMENTS FOR CARBON STEEL VESSELS IN CAUSTIC AND LEAN AMINE SERVICE VESSELS 53

ANNEX I – ADDITIONAL REQUIREMENTS FOR VESSELS IN HYDROGEN CHARGING SERVICE 54

ANNEX J – STANDARD DRAWINGS 56

ANNEX K – ALLOWABLE NOZZLE LOADS FOR NOZZLE SIZES DN 650 (NPS 24) TO DN 1500 (NPS 60) 57

ANNEX L – REQUIREMENTS FOR NAMEPLATES 58

ANNEX M – SELLER'S DATA 61

BIBLIOGRAPHY 64

SECTION II - IOGP S-619 SPECIFICATION FOR UNFIRED, FUSION WELDED PRESSURE VESSELS 65

SECTION III – IOGP S-619D PROCUREMENT DATA SHEET FOR UNFIRED, FUSION WELDED PRESSURE VESSELS 65

SECTION IV – IOGP S-619L INFORMATION REQUIREMENTS FOR UNFIRED, FUSION WELDED PRESSURE VESSELS 65

OBJECTIVE

This Specification establishes the technical requirements for the execution of the mechanical design of pressure vessels to be supplied to **PETROBRAS**' FPSOs. This specification complements IOGP S-619 and its amendments[1].

[1]Quality requirements of IOGP S-619Q shall be replaced by Exhibit VII (Directives for Quality Management System), I-ET-3010.00-1200-972-P4X-001 - MANUFACTURING SURVEY INSPECTION, and I-ET-3010.00-1200-978-P4X-001 – TRACEABILITY.

In case of conflicting requirements **PETROBRAS**' specification shall prevail.

This technical specification is written as an overlay to IOGP S-619 (version 2.0, April 2022), matching the same numbers of section and subsections, which are reproduced in the following items. If a section (or subsection) of IOGP S-619 needs a modification, this specific section is identified with: ***Added*** (added to section or added new section), ***Replaced*** (part of or entire section) or ***Deleted***. Otherwise, if no supplementary or modification is required, the section (or subsection) of IOGP S-619 specification is mandatory.

In addition to the requirements of this technical specification, **SELLER** shall follow all the requirements of the Exhibit I (Scope of Supply) as well as Exhibit III (Directives for Engineering Execution), Exhibit IV (Directives for Construction and Assembly), Exhibit V (Directives for Procurement), Exhibit VI (Directives for Planning and Control), Exhibit VII (Directives for Quality Management System) and Exhibit VIII (Directives for Commissioning Process).

SECTION I – COMPLEMENTARY REQUIREMENTS TO IOGP S-619

1 SCOPE

This specification defines the minimum requirements for the design, materials, fabrication, inspection, testing and preparation for shipment of unfired, fusion welded pressure vessels.

Vessels fabricated in accordance with this specification are intended for use in the typical services associated with oil and gas production facilities, mid-stream or pipeline facilities, gas plants, LNG facilities, oil refineries or petrochemical facilities.

The requirements in this specification are selected based upon the following boundary conditions.

a) The vessel is manufactured from one of the following materials:
   1) carbon steel;
   2) austenitic stainless steel;
   3) 22 Cr Duplex, 25 Cr Super Duplex; or
   4) carbon steel base integrally clad or weld overlaid with austenitic stainless steel, alloy 276, alloy 625 and alloy 825.

Added to List

5) other materials not indicated here and referenced in Datasheets.

b) The design temperature is less than or equal to 425 °C (800 °F).
c) The design pressure is less than or equal to 20 MPag (3000 psig).
d) The nominal thickness of the vessel shell or heads is less than or equal to 100 mm (4 in).
e) The vessel is designed, fabricated, inspected and tested in accordance with a recognized industry standard (e.g. ASME BPVC, Section VIII, Division 1, ASME BPVC, Section VIII, Division 2, EN 13445 and PD 5500).

The use of this specification for fabrication of vessels with one or more parameters that are outside the boundary conditions defined above may be an acceptable practice. However, as is provided by the base requirements in this specification, it is the purchaser responsibility to:

— determine which requirements, if any, need to be modified;

— specify additional requirements as necessary to ensure an equivalent level of safety and reliability.

Requirements under Section 2 to Section 10, Annex E, Annex F and Annex J are common for all pressure vessels.

For a typical facility covered by the scope of this specification, it is expected that approximately 60 % to 80 % of the vessels required for an average project can be purchased using this specification. This is one of the key premises against which requirements were tested when deciding whether a requirement is or is not to be included in this specification. In addition, this specification is focused on the identification of fabrication requirements where the vessel vendor is the primary audience, rather than the creation of a design guideline intended for the purchaser.

Added to Section

Pressure vessels design shall be according ASME BPVC Section VIII Divisions 1 and 2. Other internationally recognized standards or code can be used only with the prior **BUYER** approval.

When the vessel is a component part of steam generation equipment, it shall be designed according to ASME BPVC Section I.

All pressure vessels shall comply with the requirements of NR-13 and I-ET-3010.00-1200-970-P4X-013 - COMPLIANCE WITH NR-13 AND SPIE REQUIREMENTS unless therein exempted.

The requirements herein listed are applicable to all players performing such related activities within the scope of this unit, including manufacturer, packager, main contractor, subcontractors, suppliers, sub suppliers, integrators, constructors, and all technical personnel involved. Within the scope of this document, they are all referred to as being a **SELLER**.

2 NORMATIVE REFERENCES

The following publications are referred to in this document, the procurement data sheet (IOGP S-619D) or the IRS (IOGP S-619L) in such a way that some or all of their content constitutes requirements of this specification. For dated references, only the edition cited

applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

- API Recommended Practice 578, Guidelines for a Material Verification Program (MVP) for New and Existing Assets
- API Standard 579-1/ASME FFS-1, Fitness-For-Service
- API Standard 660, Shell-and-Tube Heat Exchangers
- ASME B16.5, Pipe Flanges and Flanged Fittings NPS ½ Through NPS 24 Metric/Inch Standard
- ASME B16.9, Factory-Made Wrought Buttwelding Fittings
- ASME B16.47, Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch Standard
- ASME BPVC, Section VIII, Division 1, Rules for construction of Pressure Vessels
- ASME BPVC, Section VIII, Division 2, Rules for Construction of Pressure Vessels - Alternative Rules
- ASME PCC-1, Guidelines for Pressure Boundary Bolted Flange Joint Assembly
- ASTM A262, Standard Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels
- ASTM A263, Standard Specification for Stainless Chromium Steel-Clad Plate
- ASTM A264, Standard Specification for Stainless Chromium-Nickel Steel-Clad Plate
- ASTM A265, Standard Specification for Nickel and Nickel-Base Alloy-Clad Steel Plate
- ASTM A388, Standard Practice for Ultrasonic Examination of Steel Forgings
- ASTM A578, Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications
- AWS A4.2M, Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Austenitic-Ferritic Stainless Steel Weld Metal
- EN 10160, Ultrasonic testing of steel flat product of thickness equal or greater than 6 mm (reflection method)
- EN 13445, Unfired pressure vessels
- IOGP S-705, Supplementary Specification to API Recommended Practice 582 for Welding of Pressure Containing Equipment and Piping
- ISO 8249, Welding — Determination of Ferrite Number (FN) in austenitic and duplex ferritic-austenitic Cr-Ni stainless steel weld metals
- ISO 8501-1, Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of uncoated steel substrates after overall removal of previous coatings
- ISO 9712, Non-destructive testing — Qualification and certification of NDT personnel
- ISO 15156-1/NACE MR0175 (all parts), Petroleum and natural gas industries — Materials for use in H2S-containing environments in oil and gas production
- ISO 17782, Petroleum, petrochemical and natural gas industries — Scheme for conformity assessment of manufacturers of special materials
- ISO 17945/NACE MR01030, Petroleum, petrochemical and natural gas industries — Metallic materials resistant to sulfide stress cracking in corrosive petroleum refining environments

- NACE TM 0284, Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking
- NORSOK M-601, Welding and inspection of piping
- NORSOK M-650, Qualification of manufacturers of special materials
- PD 5500, Specification for unfired pressure vessels
- TEMA, Standards of the Tubular Exchanger Manufacturers Association

Added to List

- ASME BPVC Section I, Rules for Constructions of Power Boilers
- ASME BPVC Section II Part D, Materials - Part D: Properties
- ABNT NBR 6123, Forças devidas ao Vento em Edificações
- API Spec 6A, Specification for Wellhead and Tree Equipment
- IOGP S-619, Specification for Unfired, Fusion Welded Pressure Vessels
- IOGP S-619D, Datasheet for Unfired Fusion Welded Pressure Vessels
- IOGP S-619L, Information requirements for Unfired Fusion Welded Pressure Vessels
- IOGP S-619Q, Quality requirements for Unfired Fusion Welded Pressure Vessels
- ISO 21457, Materials selection and corrosion control for oil and gas production systems
- ISO 27509, Compact flanged connections with IX seal ring
- WRC-368, Stresses in Intersecting Cylinders Subjected to Pressure
- WRC-538, Determination of Pressure Boundary Joint Assembly Bolt Loads

Added to Section

2.1 CLASSIFICATION SOCIETY

SELLER shall perform the work in accordance with the requirements of Classification Society.

SELLER is responsible for submitting to the Classification Society all documentation in compliance with stated Rules.

2.2 GOVERNMENT REGULATION

- NR-13, *Norma Regulamentadora N° 13 (NR-13) - "CALDEIRAS, VASOS DE PRESSÃO, TUBULAÇÕES E TANQUES METÁLICOS DE ARMAZENAMENTO"* (Boilers, Pressure Vessels, Piping, Metal Storage Tanks)
- NR-37, *Norma Regulamentadora N° 37 (NR-37) – "SEGURANÇA E SAÚDE EM PLATAFORMAS DE PETRÓLEO"* (Safety and Health in Oil Platforms)

*Note: Government codes, regulations, ordinances, or rules applicable to the equipment in Brazil shall prevail over the requirements of this specification, including reference codes and standards, only if more stringent.

2.3 REFERENCE DOCUMENTS

- DR-ENGP-I-1.15, COLOR CODING

- I-ET-3010.00-1200-251-P4X-001, REQUIREMENTS FOR BOLTING MATERIALS
- I-ET-3010.00-1200-955-P4X-001, WELDING
- I-ET-3010.00-1200-970-P4X-013, COMPLIANCE WITH NR-13 AND SPIE REQUIREMENTS
- I-ET-3010.00-1200-970-P4X-004, NON-DESTRUCTIVE TESTING REQUIREMENTS FOR METALLIC AND NON-METALLIC MATERIALS
- I-ET-3010.00-1200-956-P4X-002, GENERAL PAINTING
- I-ET-3010.00-1200-956-P4X-003, THERMAL SPRAY COATING APPLICATION OF ALUMINUM
- I-ET-3010.00-1200-431-P4X-001, THERMAL INSULATION FOR MARITME INSTALLATIONS
- I-ET-3010.00-1200-970-P4X-003, REQUIREMENTS FOR PERSONNEL QUALIFICATION AND CERTIFICATION
- I-ET-3010.00-1200-972-P4X-001, MANUFACTURING SURVEY INSPECTION
- I-ET-3010.00-1200-978-P4X-005, REQUIREMENTS FOR MATERIALS TRACEABILITY
- I-ET-3010.00-1200-940-P4X-002, GENERAL TECHNICAL TERMS
- I-ET-3000.00-5400-98G-P4X-001, EXPLOSION STUDY

Other documents to be supplied by **BUYER:**

- METOCEAN DATA
- MOTION ANALYSIS
- PROCESS DATASHEET
- GENERAL ARRANGEMENT
- GENERAL AREA CLASSIFICATION
- MATERIAL SPECIFICATION FOR PRESSURE VESSELS
- ERGONOMIC REQUIREMENTS

2.4 CONFLICTING REQUIREMENTS

In case of conflicting requirements between this technical specification and the referred applicable standards, the most stringent requirement shall prevail. In case of conflicting information between this Specification and other specific **BUYER**'s document, a formal technical query shall be issued to **BUYER**, seeking clarification.

3 TERMS, DEFINITIONS, ACRONYMS, ABBREVIATIONS AND SYMBOLS

3.1 TERMS AND DEFINITIONS

Replaced Section

3.1.1 custom designed flange

flange (e.g. girth flange, flanged head, nozzle flange, companion flange) designed in accordance with the rules of the specified design code.

Only flanges not available in ASME B16.5, ASME B16.47, API Spec 6A and ISO 27509 shall be calculated according to ASME BPVC Section VIII.

3.1.2 effective diameter

outside diameter of the insulated vessel plus the additional diameter for any externally attached piping, ladders and platforms

3.1.3 fitting

fitting dimensioned and manufactured in conformance with ASME B16.9 or equivalent standard

3.1.4 hydrogen charging service

service in which the diffusion of atomic hydrogen can occur in the steel

Note 1 to entry: Hydrogen charging services include wet hydrogen sulphide, sour service, hydrofluoric acid service or hydrogen service where the operating temperature is greater than 205 °C (400 °F).

Replaced Section

3.1.5 standard flange

Flanges dimensioned and manufacturer in conformance with ASME B16.5, ASME B16.47, API Spec 6A, ISO 27509 or equivalent standard.

3.1.6 design corrosion allowance

minimum corrosion allowance as specified on the vessel data sheet

3.1.7 maximum allowable working pressure (MAWP)

maximum internal gauge pressure permissible at the top of the completed vessel in its normal operating position at the designated coincident design temperature using the entire new (non-corroded) thickness minus the full corrosion allowance

3.1.8 maximum allowable external pressure (MAEP)

pressure acting on the completed vessel in its normal operating position, excluding the effect of the static head, at the designated coincident design temperature using the entire new (non-corroded) thickness minus the full corrosion allowance

3.1.9 maximum allowable pressure (MAP)

calculated allowable pressure using the entire new (non-corroded) thickness at ambient temperature (sometimes referred to as MAP new and cold)

Added to Section

Terms and definitions are also established in I-ET-3010.00-1200-940-P4X-002 – GENERAL TECHNICAL TERMS.

3.2 ABBREVIATED TERMS AND SYMBOLS

3.2.1 Abbreviated terms

ACCP - ASNT Central Certification Program

BHN - Brinell hardness number

CE - carbon equivalent

CLR - crack length ratio

CSR - crack sensitivity ratio

CTR - crack thickness ratio

DN - nominal diameter

FN - ferrite number

HIC - hydrogen-induced cracking

LNG - liquefied natural gas

MACA - maximum allowable corrosion allowance

MAEP - maximum allowable external pressure

MAP - maximum allowable pressure

MAWP - maximum allowable working pressure

MT - magnetic particle testing

NPS - nominal pipe size

NPT - national pipe thread

PSA - pressure swing absorber

PT - liquid penetrant testing

PWHT - post weld heat treatment

WFMT - wet fluorescent magnetic particle

WRC - Welding Research Council

Added to List

FPSO - Floating Production Storage and Offloading

IOGP - International Association of Oil & Gas Producers

LPG - Liquefied Petroleum Gas

P&ID - Piping & Instrumentation Diagram

SSC - Sulphide Stress Corrosion

TSA - Thermal Spray Aluminium

3.2.2 Symbols

d - average outside diameter of the vessel

D - outside diameter of nozzle

h - distance from the base of the support to the top tangent line of the vessel

4 DESIGN

4.1 GENERAL

4.1.1 The vessel shall be designed, fabricated, inspected and tested in accordance with the specified design code.

4.1.2 The minimum thickness t of the vessel wall shall not be less than the thickness calculated in accordance with Equation (1).

$$t = \frac{d_i}{1000} + ca + x \qquad (1)$$

where

t - is the minimum thickness of the vessel wall in mm (in);

ca - is the corrosion allowance in mm (in);

x - is 2,5 mm (0,1 in);

d_i - is the inside diameter of shell or head in mm (in).

NOTE For formed heads, the minimum thickness t is after forming.

4.1.3 The use of ASME code cases shall not be permitted.

Replaced Section

4.1.4 The MAWP, MAP or MACA of the vessel shall not be limited by fittings, nozzle reinforcement, nozzle neck thickness, flange bolting or nozzle custom designed flanges.

NOTE Flanges specified using an industry standard (e.g. ASME B16.5) and custom designed body flanges are permitted to limit the MAWP, MAP or MACA.

4.1.5 During the hydrotest, the general primary membrane stress in any pressure part shall not exceed 90% of the material minimum specified yield strength, unless otherwise specified by the design code.

4.1.6 Pressure components shall be designed for the most severe combination of pressure and coincident temperature.

4.1.7 The effects of one or more loads not acting shall be considered.

4.1.8 Elements common to two or more pressure chambers (e.g. jacketed vessels, internal heads, tubesheets) shall be designed to accommodate the most severe combination of pressures that may include the effects of coincident vacuum in an adjacent chamber.

Replaced Section

4.1.9 Butt welds on the primary pressure boundary shall be full penetration type.

All welded joints of the shell and heads shall be suitable to allow 100 % radiographic inspection, even in those cases where the design Code does not require it.

4.1.10 Design by analysis methodology shall not be used to justify a thinner thickness for a pressure component where design by rule thickness requirements are specified (e.g. ASME BPVC, Section VIII, Division 1 and ASME BPVC, Section VIII, Division 2, Part 4).

4.1.11 Each vessel support shall have an earthing lug.

4.1.12 Attachments intended to be removed prior to commissioning shall be identified on the vessel drawing.

Added Section

4.1.13 Unless otherwise specified, **SELLER** shall design and fabricate the complete equipment for a minimum service life of 30 years.

4.2 CORROSION ALLOWANCE

4.2.1 The corrosion allowance for internal parts shall be applied as detailed in Figure 1.

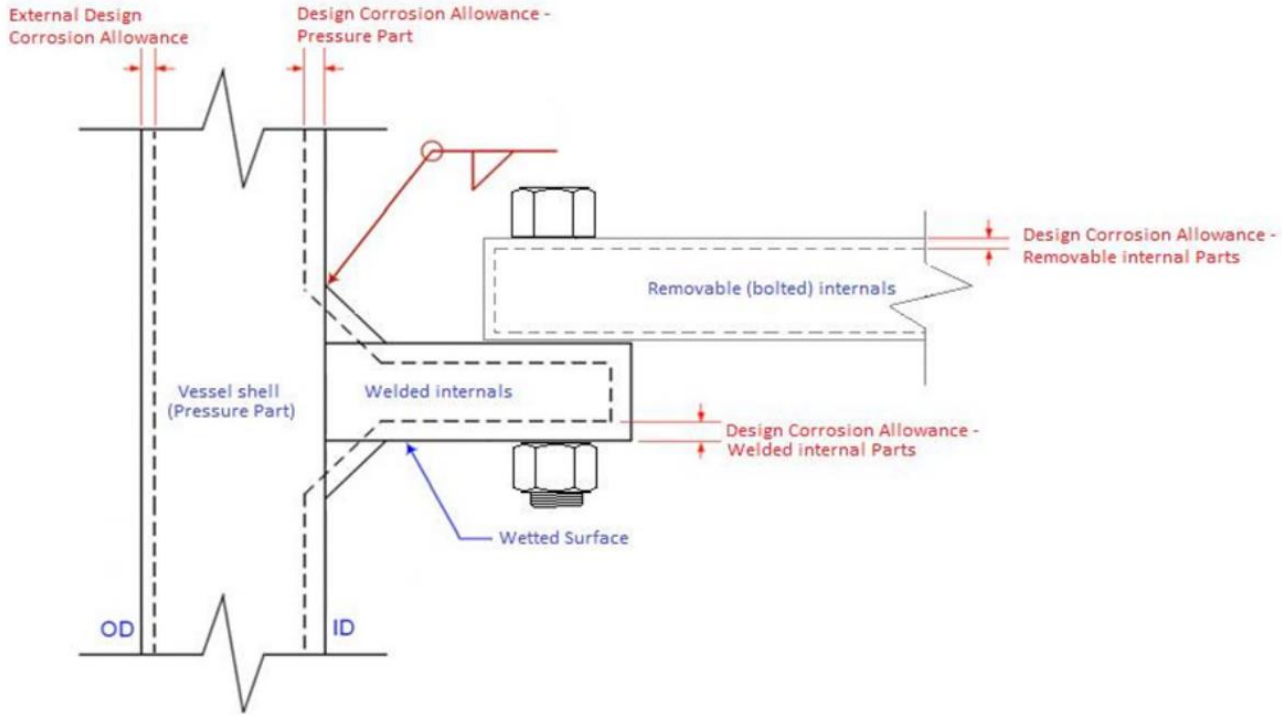

Figure 1 - Design corrosion allowance

4.2.2 Corrosion allowance shall not be considered on the gasket seating surface of flanges.

Added Section

4.2.3 Unless otherwise specified on the datasheet, the following minimum values shall be adopted for corrosion allowance, for parts made of carbon-steel or low alloy steels:

a. Towers, vessels and heat exchangers for hydrocarbon service: 3 mm;

b. Sumps for the above vessels: 6 mm;

c. Vessels and filters containing fresh water: 3 mm

d. General pressure vessels for either vapour or air: 1.5 mm;

e. LPG storage vessels: 1.5 mm.

For carbon-steel or low alloy steel parts, a minimum corrosion allowance of 1.5 mm shall be adopted, even if the estimated corrosion is lesser than this value.

Corrosion allowances shall be based on the service life, as specified in this Technical Specification. As a general rule, when the expected corrosion rate exceeds 0.24 mm/year, or when the corrosion allowance exceeds 6 mm, other materials with a higher corrosion resistance should be used.

4.3 WIND, SEISMIC AND SNOW LOADS

Replaced Section

4.3.1 Wind, seismic and snow loads shall be calculated in accordance with the applicable code and any additional requirements specified in the data sheet.

NOTE Wind loads shall be calculated according to ABNT NBR 6123 with wind basic velocity of 45 m/s. Another standard may be used with previous **BUYER**´s approval.

4.3.2 Vibration analysis for wind induced vortex-excited resonance shall be performed on:

a) vertical vessels with $5 \leq h/d \leq 15$ and natural frequency of vessel less than 2 Hz;
b) vertical vessels with $h/d > 15$, irrespective of natural frequency.

4.3.3 Deflection at the top of vertical vessels shall not exceed $h/200$.

4.3.4 The effective diameter of the vessel shall be used when determining the projected area in the wind load calculations.

Added sections

4.3.5 The equipment shall be suitable for the environment and range of ambient conditions, defined in METOCEAN DATA specification [document supplied by **BUYER**].

4.3.6 The necessary design data and information on motion requirements of the floating unit are given in MOTION ANALYSIS report [document supplied by **BUYER**].

4.4 DESIGN LOADS AND LOAD COMBINATIONS

4.4.1 Design loads and load combinations shall be in accordance with Table 1 and Table 2.

Table 1 - Design load combinations

Design load combination	Description
L2 + L10 + L12 + L14	Erected or (as installed) condition with full wind load and full snow load
L3 + L10 + L12 + L13 + L14 + L16	Operating condition (corroded), no pressure, with full wind load and full snow load

L3 + L11 + L12 + L13 + L14 + L16	Operating condition (corroded), no pressure, with full seismic load and full snow load
L3 + L6 + L10 + L12 + L13 + L14 + L16	Operating condition (corroded and uncorroded) with full pressure, full wind load and full snow load
L3 + L6 + L11 + L12 + L13 + L14 + L16	Operating condition (corroded and un-corroded) with full pressure, full seismic load and full snow load
L4 + L8 + (0.25) L10 + L12	Shop (or initial) hydrostatic test condition (uncorroded)
L4 + L9 + (0.25) L10 + L12 + L14	Field (or future) hydrostatic test condition (corroded)
L5 + L12 + L17	Transport condition
L3 + L7 + L12 + L13 + L14 + L15	Blast load condition

Table 2 - Design load combination definitions

Design load	Description
L1 – Fabricated weight	Total weight of the vessel as fabricated in the shop
L2 – Empty weight	Total weight of the vessel sitting on the foundation, fully dressed, waiting for operating liquid
L3 – Operating weight	Empty weight plus any operating fluid weight
L4 – Hydrotest weight [a]	Weight of the vessel under hydrostatic test condition including the weight of the test fluid
L5 – Shipping weight	Fabricated weight of the vessel plus any weight added for shipping purposes (e.g. shipping saddle)
L6	Internal (including static head) or external design pressure and internal or external design temperature
L7	Normal operating pressure and temperature
L8	Shop (or initial) hydro test pressure and temperature
L9	Field (or future) hydro test pressure and temperature
L10	Wind load (not wind speed)
L11	Seismic load
L12	Snow load
L13	Static reactions from the load of attached equipment, such as motors, machinery, other vessels and piping
L14 – Motion induced load	Hull/floating unit movement effect, towing out motion whenever applicable

L15	Blast load
L16 – Thermal load	Steady state or transient effect of fluid flow (e.g. icing, chilling, thermal shock)
L17	Transportation load (transportation acceleration forces)
[a] The removable internals that are not included in field hydrotest weight shall be identified in the vessel data sheet.	

Added Sections

4.4.2 For field (or future) hydrostatic test condition, motion induced loads (L14) shall be considered, in addition to the other related items of Table 1, in Design load combination.

4.4.3 Blast load shall be evaluated in accordance with blast overpressure values of Annex II of I-ET-3000.00-5400-98G-P4X-001 – EXPLOSION STUDY.

4.5 LIFTING LOADS

4.5.1 For vessels lifted in conditions expected to be stable, lifting attachments shall be designed using a factor of 1.5 on the weight of the vessel during lifting.

4.5.2 For vessels lifted in conditions expected to be dynamic (e.g. lifting from a barge subject to wave action), lifting attachments shall be designed using a factor of 2.0 on the weight of the vessel during lifting.

4.5.3 Skirt supported vertical vessels with a total height h greater than or equal to 20 m (65 ft) or an empty weight greater than or equal to 20 000 kg (44 000 lb) shall be provided with tailing devices.

4.5.4 Vertical vessels including the lifting attachments shall be designed for erection from a horizontal to a vertical position.

4.5.5 The design shall be evaluated at 5° increments when lifting the vessel from a horizontal to a vertical position.

4.6 LOCAL LOADS

4.6.1 Localized stress resulting from concentrated loads on nozzles or structural attachments shall be evaluated using a recognized industry standard or method (e.g. WRC bulletin, finite element analysis).

4.6.2 Geometrical limits specified in the selected method (e.g. WRC) used for local load analysis shall be followed.

4.6.3 Extrapolation beyond the stated geometrical limits in the method selected for local load analysis shall not be permitted.

4.6.4 Nozzles shall be designed for the external loads specified in API Standard 660, Annex K or the loads determined by a pipe stress analysis (when available).

NOTE: Where the default nozzle loads lead to an increase in local shell and head thickness, a reduction in the default loads based on the piping layout and/or nozzle flexibility can be considered.

Replaced Section

4.6.5 Nozzles where external piping is not connected (e.g. manways, inspection openings, nozzles for thermowells and other similar instruments, packing withdrawal, ventilation) and where the total weight supported by the nozzle is less than four blind flanges shall be evaluated by WRC 368 or finite element analysis.

Added Section

4.6.6 Nozzles connected to piping shall be evaluated as indicated in 4.6.1 adding the load regarding pressure thrust.

4.6.7 Maximum allowable nozzle loads for class 10 000 shall be agreed with the **BUYER**, they shall not be lesser than class 2 500.

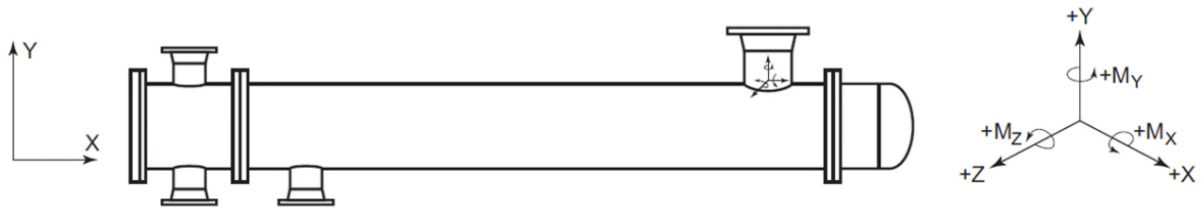

Figure 2 - Directions of moments and forces on nozzles

4.7 NOZZLES, MANWAYS AND REINFORCEMENTS

4.7.1 Set-on nozzles

4.7.1.1 Set-on nozzle connections may be used if one of the following applies:

a) The nozzle is attached to the header box of an air-cooled heat exchanger.
b) All of the following apply:
   1) the vessel shell or head thickness is greater than 50 mm (2 in);
   2) the nozzle thickness is less than half of the shell thickness; and
   3) when set-in nozzles are not required based on service (e.g. sour service or hydrogen charging service).

4.7.1.2 Prior to fit-up of set-on type nozzles, the surface of the through wall cut (see Figure 3) shall be examined using the liquid penetrant or magnetic particle method with zero defects allowed on this surface.

4.7.1.3 Prior to the fit-up of set-on type nozzles, the entire area of the plate adjacent to the nozzle opening shall be examined using the ultrasonic method to a distance of 100 mm (4 in) around the opening, with indications graded to Acceptance Level C in accordance with ASTM A578.

4.7.1.4 For set-on nozzles attached to plate with a thickness greater than 19 mm (3 /4 in), 100 % UT examination shall be performed on the attachment weld from the back side of the plate (when accessible) subjected to through-thickness shrinkage stresses.

Added section

4.7.1.5 Set-on nozzle weld shall be full penetration type.

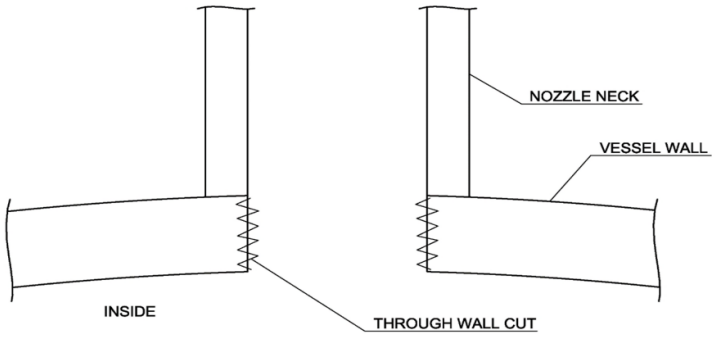

Figure 3 - Through-wall-cut

Replaced section

4.7.2 Unless otherwise indicated in P&IDs or Datasheets issued by **BUYER,** The minimum nozzle size shall be DN 40 (NPS 1½).

Replaced section

4.7.3 All nozzle connections shall be either weld neck or long weld neck flange. The use of stub-end shall not be permitted for pressure vessels. Slip-on flanges (SO) may be used for inspection openings and manways, since all the following requirements are met:

a) Nozzles flanges pressure up to 300;
b) Service with following fluids: compressed air, inert gases or water;
c) Corrosion allowances up to 3 mm;
d) Impact test is not required;
e) PWHT is not required.

Hub and clamp type connectors are not allowed.

4.7.4 Flanged nozzles DN 40 (NPS 1½) and DN 50 (NPS 2) shall be long weld neck flanges or fabricated from seamless pipe with a minimum nominal wall thickness of schedule 160 or schedule 80S as applicable.

4.7.5 No threaded connection shall be screwed directly into any pressure part of the vessel.

4.7.6 For vessels with removable internals, access shall be provided for maintenance or replacement.

Replaced section

4.7.7 For vessels with an internal diameter less than 1 000 mm (40 in), the use of bolted heads or body flanges for access shall be acceptable.

The use of two inspections holes, instead of a manhole or bolted head, is also acceptable for pressure vessels without internals and with internal diameter less than 1000 mm. For vessels with internal diameter greater than 1000mm, at least one manway is mandatory.

4.7.8 Inspection openings shall not be less than DN 100 (NPS 4).

Replace section with

4.7.9 Nozzle-to-vessel wall (including manholes) and reinforcement pad to nozzle neck weld joint shall be full penetration welds.

4.7.10 Internal reinforcing pads shall not be used for nozzles.

4.7.11 The minimum manway inside diameter shall be 546 mm (21.5 in).

4.7.12 Set-in nozzles

4.7.12.1 Set-in nozzles shall be ground to match the contour of the vessel inside diameter.

4.7.12.2 Inside edges of nozzles wall shall be rounded off to a radius of at least 3 mm (1 /8 in).

Replace section with

4.7.13 Unless otherwise specified, flanges face finishing, gasket, studs and nuts of each flange on nozzles shall be according to the piping specification to which they are connected. Manways, inspection opening and any other nozzles not connected to piping shall follow the same flange face finishing, gasket, studs, and nuts from the piping specification connected at the applicable section of the vessel.

NOTE: When pressure vessel material is defined with organic coating internally, flanges sealing areas shall be weld overlaid.

4.7.14 Reinforcing pads for nozzles shall be limited to two pieces.

4.7.15 The thickness of the reinforcing element for non-integrally reinforced nozzles shall not exceed the smaller of 50 mm (2 in) or of the nominal thickness of the vessel wall minus the total corrosion allowance at the location of the opening unless limited further by the code of construction.

4.7.16 Removable internals shall pass through vessel manways.

4.7.17 For vessels in cryogenic service, manway covers shall be hinged (see Annex J, Drawing S619 J.12).

Added Sections

4.7.18 All vessels shall have nozzles for vent, drain and pressure inlet connections. They shall be used for hydrostatic test, cleaning or maintenance. These connections shall have easy access.

4.7.19 Manholes on the horizontal plane opening downward shall be avoided; in those cases, in which they are inevitable, a safe device shall be provided to remove and handle its blind flange. Vessels with the manhole on the vertical plane shall be provided with stairs on the inside, except when internals preclude access to the manhole or make those stairs unnecessary.

4.7.20 For vertical vessels with a single manhole, it shall be located in the cylindrical shell at the lowest possible position, unless otherwise defined in respective datasheet. When the vertical vessel has 2 manholes, the second manhole shall be located above the upper tray or at the highest possible position. For vertical vessels with 3 or more manholes, additional manholes shall be equally spaced wherever possible along the length of the vessel and preferably located next to inlet nozzles and internal piping systems.

4.7.21 For horizontal vessels, the manhole shall be preferably located on one of the heads; the second manhole, if any, shall be located on the top part of the shell, near the opposite end. Horizontal vessels more than 10 m long shall have 2 manholes.

4.7.22 Manways and cover flanges shall be provided with davits for its blind flange removal. Hinges might be use for manways pressure class 150 NPS up to 24.

4.8 CUSTOM DESIGNED FLANGES

4.8.1 Minimum bolt spacing shall be in accordance with TEMA.

4.8.2 If hydraulic bolt tensioning is required, spacing shall be provided between bolts.

4.8.3 The flange design shall account for the design pressure and other applicable loads (e.g. externally applied bending moment, axial thrust loadings).

4.8.4 If not specified in the design code, the gasket seating surface finish and flatness tolerance for custom designed flanges shall be in accordance with ASME PCC-1.

4.8.5 The flatness of gasket contact surfaces for custom designed flanges shall be measured after heat treatment and final machining.

Added Sections

4.8.6 Custom flanges designed according to ASME BPVC Section VIII, just as flanges in compliance with ISO 27509 or API 6A shall be supplied with companion flanges.

4.9 FLANGE BOLTING

4.9.1 Bolts shall be studs, threaded full length, with heavy hex nuts.

4.9.2 Stud bolts shall be installed flush with the nut at one end of the stud.

4.9.3 When bolt tensioning is used, studs shall have the additional threaded length equivalent to one stud diameter, extending from the nut at one end.

4.9.4 When the stud bolt length is increased as required for bolt tensioning, the exposed length of the stud bolts shall be protected with a second heavy hex nut.

Added sections

4.9.5 Studs, bolts, tightening bolts, nuts and fasteners coatings shall be according to I-ET-3010.00-1200-251-P4X-001 – REQUIREMENTS FOR BOLTING MATERIALS.

4.9.6 For custom flanges designed according to ASME BPVC sec. VIII, the **SELLER** shall submit to **BUYER** approval the complete tightening calculation sheet containing at least the following information: lubricant, bolt/stud torque, gasket type and flange calculation report. In these cases, **SELLER** shall design the flange to be able to withstand a bolt tightening load at least equal to a 50% of the bolt yield stress. For this analysis WRC 538 may be applied.

4.9.7 For pressure vessels operating with gas, **SELLER** shall evaluate bolt material considering the possibility of temperature reduction due to flange leakage. When not previously informed, **SELLER** shall submit a study informing the minimum expected temperature and the bolt material selected for such case.

4.10 SKIRT SUPPORT

4.10.1 The skirt thickness shall be less than or equal to 6 mm (¼ in) inclusive of any skirt corrosion allowance or the nominal thickness of the vessel component to which it is attached.

Replaced Section

4.10.2 Skirts shall be provided with an access opening (see Figure J.4).

4.10.3 Piping shall not be routed through skirt access openings.

4.10.4 Flanged connection shall not be installed inside the skirt.

4.10.5 Skirt openings shall be provided with rings or collars sized for the structural stability.

Replaced Section

4.10.6 Skirt vents and drains shall be provided in accordance with Figure J.4.

4.11 LEG SUPPORTS

Replaced section

4.11.1 The use of leg supports, or lugs supports on vertical vessels shall be permitted if the following conditions are met:

a) vessel internal diameter no greater than 1 500 mm (60 in);
b) design temperature no greater than 230 °C (450 °F);
c) vessel height (h) to internal diameter ratio no greater than 5;
d) vessel not in cyclic service.

4.11.2 If a vessel is supported with legs, base plates drilled with anchor bolt holes shall be welded to each leg support.

4.12 SADDLES

4.12.1 Horizontal vessels shall be supported on two saddles, one fixed and one sliding.

4.12.2 Vessels shall be evaluated for stresses imposed by all applicable loading on the saddles.

Added Sections

4.12.3 Saddles (as per Figure J.10) shall be placed symmetrically in relation to the midpoint of length between tangent lines.

4.12.4 When the operating weight of vessel is greater than 200 kN (20 t) PTFE, or other low friction material, sliding plates shall be used in the mobile saddle in accordance with Figure J.16.

4.13

Vessels designed for internal pressure only shall be stamped for the calculated MAEPs at the internal pressure design temperature.

4.14 NAME PLATE BRACKETS

4.14.1 The nameplate bracket shall be a "C" shape.

4.14.2 The nameplate bracket shall be welded externally to the vessel shell or vessel support along the two edges.

4.14.3 Welds between the nameplate bracket and to vessel wall shall be full fillets on one side.

4.14.4 The nameplate bracket material thickness shall be greater or equal to 5 mm (¼ in).

Added section

4.15 SUPPORT´S DESIGN

Supports shall be designed in accordance with Part 4.15 of ASME BPVC Section VIII Division 2. For pressure vessels designed according to ASME BPVC Section VIII Division 1, PD 5500 may be used, except that allowable stresses shall in any case be according to ASME BPVC Section VIII Division 1.

4.16 ACCESS REQUIREMENT

For all vessels, permanent access (ladders and platforms) to the following points shall be provided:

a) manways whose centerline is more than 3 000 mm from the ground;
b) safety or relief valve;
c) level instrument;
d) instrument or equipment requiring local reading or operation or frequent inspection.

The orientation of the manways shall meet the arrangement requirements of platforms and ladders.

The access of manways and skirt's access openings shall be clearly accessible without any obstructions.

The design of ladders and platforms shall be in accordance with ERGONOMIC REQUIREMENTS specification [document supplied by **BUYER**].

5 MATERIALS

5.1

Castings shall not be used.

Added to Section

Pressure vessels material selection shall be according to MATERIAL SPECIFICATION FOR PRESSURE VESSELS [document supplied by **BUYER**]. Only if the material selection is not specified by **BUYER**, **SELLER** shall define the complete pressure vessel's material considering the minimum design lifetime, the requirements of ISO 21457 and the statements of this specification.

Parts of the pressure vessel in contact with the process fluid (e.g.: shells, heads, tubesheet, welded internals, nozzle necks, flanges, blind flanges) and reinforcements for openings shall have the same material selected to the shell.

5.2 PERMANENT ATTACHMENTS

5.2.1 Permanent attachments including vessel supports welded directly to pressure parts shall be of the same nominal chemistry as the pressure part.

Added to Section

A reinforcement pad of the same material as pressure vessel shall be provided prior to welding supports for ladders, platforms, piping, and others.

5.2.2 Permanent attachments shall be suitable for the minimum design metal temperature of the vessel.

5.2.3 The structural shape of stiffening rings or insulation support rings shall not hold water.

5.3

The skirt support material shall be the same nominal chemistry as the vessel wall base material for a minimum distance below the vessel-to-skirt connection line in accordance with Equation (2) or 300 mm (12 in), whichever is larger.

$$\textit{Minimum length of skirt support} = 1{,}8 \times \sqrt{D_s + T_s} \qquad (2)$$

where

D_s is the skirt outside diameter

T_s is the skirt nominal thickness

Added Note:

Leg support material shall be appropriate for the MDMT of the vessel. A reinforcement pad of the same material as vessel shall be provided prior to welding.

5.4

Achieving the specified minimum design metal temperature without impact testing by using a reduced stress ratio method shall not be permitted.

5.5

Use of non-impact tested materials as allowed by ASME BPVC, Section VIII, Division 1, UG-20 (f) shall not be permitted.

5.6

The proposed repair of defects in the as-received base metal of pressure components shall be approved.

5.7

Replaced Section

5.7.1 Positive material identification of alloy steel pressure containing parts, weldments, cladding and weld overlay shall be performed in accordance with API Recommended Practice 578 or NORSOK M-601.

5.7.2 Additional requirements for PMI testing are presented in item 8.7.

Added Section

5.8

Pressure vessels subjected to temperature of 60ºC and above shall receive a personal protection system, by means of stainless steel 316 wire mesh / perforated plates. Alternatively, a thermal insulation may be applied. Pressure vessels in which heat conservation is necessary shall be thermal insulated. The thermal insulation shall be according to latest revision of I-ET-3010.00-1200-431-P4X-001 - THERMAL INSULATION FOR MARITIME INSTALLATIONS.

6 FABRICATION

6.1 GENERAL

6.1.1 Continuously welded external attachments (e.g. wrapper plate for saddles, wear plates, reinforcement plates) shall be provided with one 6 mm (1 /4 in) diameter vent hole in each segment at the lowest practical point of the pad or attachment.

6.1.2 The vent hole in the nozzle reinforcement pad shall be tapped DN 8 (¼ NPT).

6.1.3 Non-circular attachment pads shall have a corner radius of at least five times the pad thickness or 50 mm (2 in), whichever is smaller.

6.1.4 Production test plates shall be welded and heat treated in accordance with the procedures used for production welds in the shell and head.

Replaced section

6.1.5 The distance between main seam welds (longitudinal and circumferential joints) and nozzles, reinforcement or other welded attachments shall be in any case 3 times the thickness of the thinnest plate and at least 50 mm (2 in), measured weld toe to weld toe (see Figure 4). Whenever possible, welds of the shell and heads shall be arranged in such a manner as not to interfere with vessel supports and nozzles, manholes, lifting lugs and their respective reinforcements.

6.1.6 Where attachments cover main seam welds, the length of the main seam weld covered by the attachment and projecting at least 50 mm (2 in) beyond each side of the attachment shall be ground flush (see Figure 4).

6.1.7 Where attachments cover main seam welds, the length of the main seam weld covered by the attachment and projecting at least 50 mm (2 in) beyond each side of the attachment shall be inspected with 100 % volumetric examination and magnetic particle or liquid penetrant examination (see Figure 4).

6.1.8 The thickness of all formed pressure parts shall be measured and recorded after forming.

6.1.9 Permanent marking

6.1.9.1 Permanent marking on the pressure boundary shall be applied with low-stress stamps on the outside of the vessel wall.

6.1.9.2 Permanent marking shall be applied before PWHT.

6.1.10 Local thin areas, as defined in accordance with the design code, that fall below the nominal thickness of the vessel wall (including consideration of the specified tolerance) shall be repaired or replaced.

6.1.11 Fitness for service calculation shall not be used as justification for accepting identified defects without repair.

6.1.12 Longitudinal weld seams of horizontal vessels shall be located on or above the horizontal plane through the centreline of the vessel

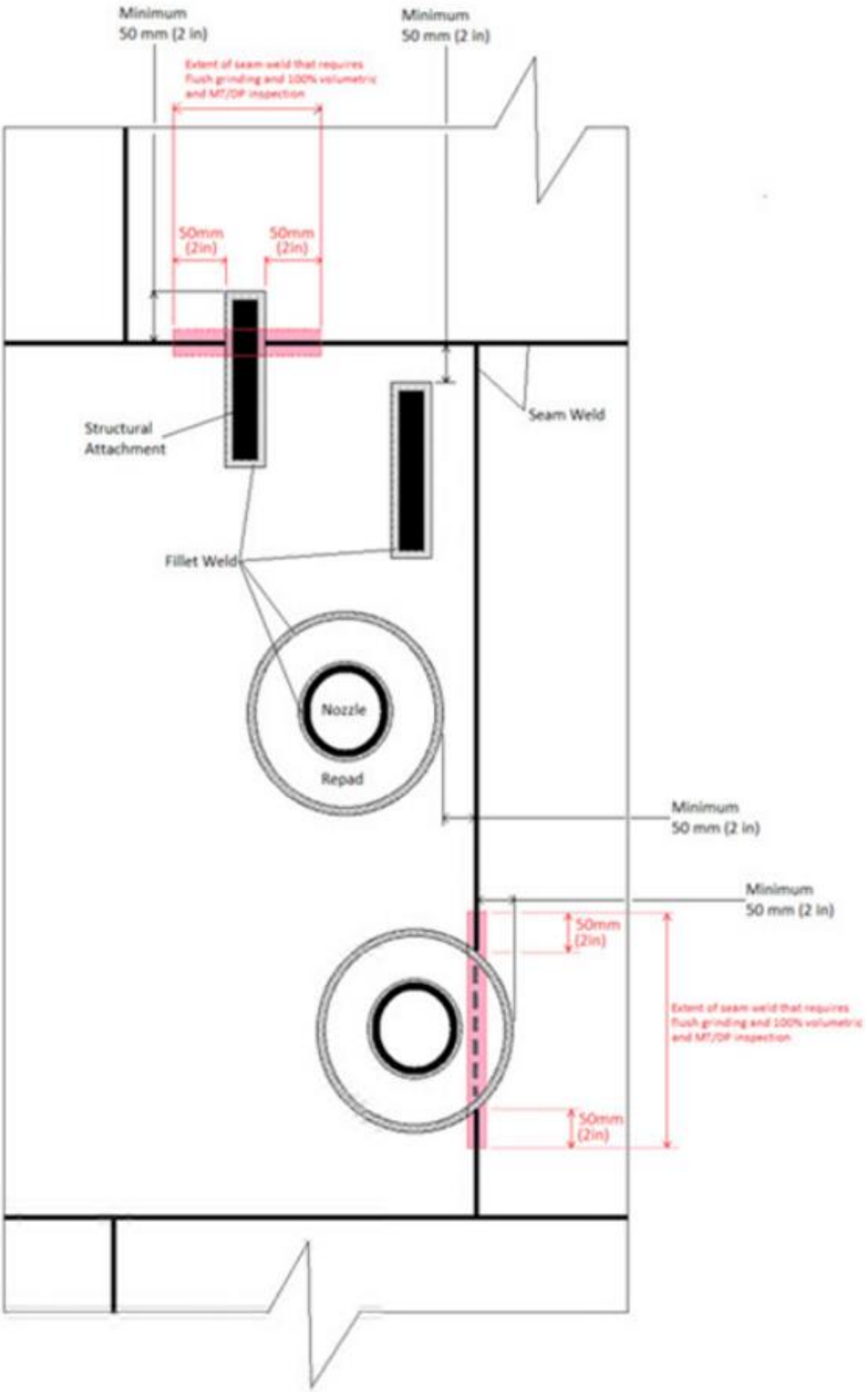

Figure 4 - Weld Seams Clearance and Overlapping

Added sections

6.1.13 Welds of the shell and heads shall not interfere with internal parts welded to the vessel. For horizontal vessels, longitudinal welds of the shell on the bottom generatrix of the vessel, where they interfere with the saddle, shall not be allowed.

For vertical vessels, the weld of the skirt to the vessel shell shall be located so as not to interfere with the weld of the shell to the bottom head and to allow inspection of the weld. For horizontal vessels, saddles shall also be located in such a manner as not to interfere with the circumferential welds of the vessel and allow the inspection of these welds.

6.1.14 For vessels less than 2000 mm in diameter, only a single longitudinal weld per shell section is allowed. For diameters equal to or greater than 2000 mm, commercial length plates shall be used and smaller plates shall only be allowed for adjustment purposes.

6.1.15 Longitudinal welds of adjacent rings shall be at least 45º apart from each other.

6.1.16 The same corrosion allowance specified for the vessel shall be added to the minimum dimension of the throat of the fillet welds.

6.1.17 For all vessels to be post weld heat treated, all welds shall be of the full penetration type, excepting for the weld of slip-on flanges and nozzles pads, where gas escape and pressure relief holes shall be provided.

6.1.18

6.1.18.1 Bevels shall be dimensionally and visually checked for cleanliness and absence of the following defects:

a) lamellar tearing;
b) pores;
c) cutting irregularities;
d) dents/notches;
e) cracks;
f) discontinuities crosswise to the surface;
g) discontinuities parallel to the surface, over 25 mm in length.

Note: Paragraphs e), f) and g) shall be verified by non-destructive tests, when there is suspicion of those defects' existence.

6.1.18.2 The visual test shall be completed by the liquid penetrant or magnetic particle test, in the following cases:

a) bevels of alloyed steels/materials (low alloy steels, stainless steels, nickel steels, nickel alloys, cooper alloys and so on);
b) bevels of carbon steels with thickness 38 mm and greater;
c) bevels of carbon steels with impact testing requirement;
d) bevels recovered by welding.

Note: The same defects mentioned in item 6.1.18.1 are deemed to be unacceptable.

6.2 WELDING

Replaced Section

6.2.1 Pressure part welding requirements shall be in accordance with IOGP S-705, and with the additional requirements of I-ET-3010.00-1200-955-P4X-001 – WELDING.

Personnel qualification and certification shall be in accordance with I-ET-3010.00-1200-970-P4X-003 – REQUIREMENTS FOR PERSONNEL QUALIFICATION AND CERTIFICATION.

6.2.2 Welds between a saddle, skirt, stiffening ring or similar external attachment and a pressure part shall be continuous (intermittent welds are not allowed).

Added Section

6.3 REPAIRS

Repairs of warped parts due to welding, among other factors, shall be done according to a repair procedure previously approved by BUYER and preferably done in the cold condition. After unwarping of warped parts, the higher strain regions in these parts shall be examined with penetrant liquid or magnetic particles.

7 HEAT TREATMENT

7.1

When additional simulated PWHT cycles are required for weld procedure qualification, mechanical tests shall be performed after the first and final PWHT cycles.

Added sections

7.2

Post weld heat treatment is required for:

a) all material, when required by design code (due to material and thickness) including cladded/overlaid vessels;
b) regardless the thickness, all carbon steel and low alloy steel vessels for H_2S service and/or Amine service, except for cladded/overlaid pressure vessels.

7.3

SELLER shall submit to **BUYER**´s approval a specific Heat Treatment procedure containing at least the following information:

a) type of heat treatment performed;
b) identification of applicable performance standard;
c) parameters required for performance, such as:

- beginning and ending control temperatures;

- minimum and maximum heating rate;
- minimum and maximum treatment temperatures;
- minimum and maximum treatment times;
- minimum and maximum cooling rate;
- maximum difference of temperature between thermocouples;

d) details of support and deformation control devices of equipment;
e) indication of performance method, such as:

- treatment in furnace;
- localized treatment;

f) indication of heating medium used;
g) furnace drawing (when applicable), indicating equipment the location inside it, burner nozzles or electrical resistances, and the overlap region when the equipment item is not fully inside the furnace;
h) when localized heat treatment is performed: welded joint drawing, indicating the location and distribution of electrical resistances, width of soak band (SB), width of heated band (HB), width of gradient control band (GCB) including SB, HB and insulation, distribution of thermocouples, and insulation attachment details;
i) type, quantity and identification (number and color in chart) of thermocouples employed;
j) attachment method of thermocouples to equipment;
k) equipment sketch and/or test coupon indicating the location and relative distance between thermocouples.

8 NON-DESTRUCTIVE EXAMINATION

8.1 GENERAL

Replaced Sections

8.1.1 Non-destructive examination shall be performed in accordance with the requirements stated in I-ET-3010.00-1200-970-P4X-004 – NON-DESTRUCTIVE TESTING REQUIREMENTS FOR METALLIC AND NON-METALLIC MATERIALS. All required non-destructive examination for final acceptance of the vessel shall be performed at least 48 hours after the completion of all welding and weld repairs, if required, and prior to pressure testing.

8.1.2 The person responsible for the non-destructive examination shall be qualified to ISO 9712 level III, ACCP level III or equivalent.

8.1.3 Non-destructive examination operators shall be qualified in accordance with ISO 9712 level II or ACCP level II or equivalent.

Added sections

8.1.4 Qualification and certification for procedures and personnel shall be in accordance with I-ET-3010.00-1200-970-P4X-003 – REQUIREMENTS FOR PERSONNEL QUALIFICATION AND CERTIFICATION.

8.2 RADIOGRAPHIC AND ULTRASONIC EXAMINATION

8.2.1 Where allowed by the design code, ultrasonic examination shall be acceptable in lieu of radiographic examination.

8.2.2 Where 100 % volumetric examination is specified, the complete length of butt welds, nozzle-to-vessel wall joints, nozzle neck weld seams, nozzle to flange joints and skirt to vessel wall welds shall be examined.

8.2.3 The welds of heads constructed from two or more pieces shall be subjected to 100 % volumetric examination after forming.

Replaced section

8.2.4 When spot radiography is specified, the purchaser or the purchaser's representative shall designate the locations at which the spot radiographs shall be taken. All weld crossing points that shall be included in the extent of examination.

8.2.5 All plates with a nominal thickness greater than or equal to 50 mm (2 in), excluding any thickness of cladding or weld overlay, shall be inspected in accordance with the requirements of ASTM A578, including supplementary requirement S1 or EN 10160, as specified in the data sheet.

8.2.6 All forgings with a nominal thickness greater than or equal to 50 mm (2 in), excluding any cladding or weld overlay, shall be in accordance with the requirements of ASTM A388.

Added Sections

8.2.7 For pressure vessels designed in accordance with ASME BPVC Sec. VIII Div 1, all longitudinal and circumferential welds of the shell and heads shall be, as a minimum, examined by spot radiography.

Butt welds shall be subjected to 100% volumetric examination for pressure vessels designed according to ASME BPVC Sec. VIII Div.2.

8.2.8 Welds used for closing guide-holes at the center of formed heads shall be subjected 100% volumetric examination.

8.2.9 Welds of any parts, regardless of the material, thickness or service, shall be fully (100%) radiographed before any severe deformation (thickness to local radius ratio greater than 5%), by any process, such as spinning, pressing and rolling.

8.3 MAGNETIC PARTICLE OR LIQUID PENETRANT EXAMINATION

Replaced section

8.3.1 The minimum extent of MT or PT examination shall be as follows:

8.3.1.1 In a 100% of the weld length magnetic particle or liquid penetrant test shall be performed before the hydrostatic test in the following regions:

a) internally and externally welded joints, covering a 200 mm wide area centered at the joint;
b) weld repairs
c) regions of weld removed from auxiliary assembly device and temporary weld;
d) welds for attachment of accessories.

For equipment subject to heat treatment, the requirements above shall be met before and after the heat treatment.

8.3.1.2 Liquid penetrant test or magnetic particle test shall be performed on all vessel lifting devices (example: lifting lugs)

8.3.2 Cold formed heads shall have the inside and outside surfaces of the knuckle region examined by magnetic particle or liquid penetrant examination after completion of forming and material heat treatment.

8.3.3 MT or PT examination shall be performed for all lifting attachment welds.

Added to section

8.3.4 After forming, the welds and the most deformed areas shall be examined by magnetic particles or liquid penetrant, before any manufacturing operation is subsequently carried out.

Added section

8.4 VISUAL INSPECTION

8.4.1 A visual inspection shall be performed in all materials, sections and equipment used, which shall be free of:

a) defects which cause a sudden transition on the surface of the part;
b) defects which reduce the thickness of the part to a value lower than the thickness defined in fabrication drawing;
c) any degree of corrosion for stainless steels and nonferrous metals.
d) corrosion above grade C of standard ISO 8501-1 for the following materials:

- Carbon Steels;
- Molybdenum Alloy Steels;
- Chromium Molybdenum Alloy Steels.

8.4.2 Flange faces shall be visually checked, for verification of the condition and type of grooves, being unacceptable corrosion or dents/notches at the sealing surface.

8.5 DIMENSIONAL INSPECTION

It shall be performed in accordance with code ASME BPVC Section VIII and tolerances of Annex E.

8.6 HARDNESS TEST

8.6.1 Hardness test shall be performed in accordance with the requirements stated in I-ET-3010.00-1200-970-P4X-004 – NON-DESTRUCTIVE TESTING REQUIREMENTS FOR METALLIC AND NON-METALLIC MATERIALS.

8.6.2 For pressure vessels subjected to heat treatment, hardness reading shall be taken after heat treatment, being:

a) a hardness reading performed for each 6 m of weld;
b) at least two readings shall be taken per longitudinal bead and per circumferential bead. The hardness measurement in circumferential joint shall be made in all crossings with longitudinal welds;
c) at least one hardness reading shall be taken in the flange connection with neck and one in the nozzle connection with vessel;
d) at least one reading shall be taken for each WPS used;
e) one reading in region of removal of temporary welds.

Note: Each reading shall contain three points in weld metal (cast zone), three points in each HAZ, and one point in base metal of each side of bead.

8.7 POSITIVE MATERIAL IDENTIFICATION (PMI)

8.7.1 PMI shall be applied to all materials except carbon steel.

8.7.2 PMI shall be performed in accordance with the requirements stated in I-ET-3010.00-1200-970-P4X-004 – NON-DESTRUCTIVE TESTING REQUIREMENTS FOR METALLIC AND NON-METALLIC MATERIALS.

8.7.3 PMI shall be performed in a 100% of the pressure containing parts of the vessel including the welds.

8.7.4 PMI shall be performed in 20% of the internals and fasteners (studs/bolts and nuts). In case of non-compliance, the sampling shall be extended to 100 %. Non-complying parts shall be identified and disposed.

8.7.5 Optical emission spectrometry shall be used in cases where x-ray fluorescence spectrometry method is not able to identify the alloy steel material (e.g., low carbon content austenitic stainless steels).

9 PRESSURE TESTING

Replaced Section

9.1

9.1.1 Vessels shall be hydrostatically tested using potable water or water filtered through a 10 micrometre (1 250 openings per inch mesh).

9.1.2 Shop hydrostatic test shall be performed according to ASME BPVC Section VIII, based on a calculated pressure, considering nominal thickness with corrosion allowance.

9.2

The more stringent water quality requirements of Annex B, Annex C or Annex D shall apply when applicable.

9.3

The hold time at hydrotest pressure shall not be less than 1 h.

9.4

Vertical vessels hydrotested in a horizontal position shall be supported to prevent overstress during testing.

9.5

Each reinforcing pad segment shall be tested at a pressure of 100 kPag (15 psig) with dry air or nitrogen and a bubble forming solution.

Replaced Section

9.6

9.6.1 Gaskets and bolting used during pressure testing shall be identical in geometry, dimensions, bolt strength and gasket m and y factors to those required for service.

NOTE If the bolted joint is not disassembled after completion of hydrostatic pressure testing, these gaskets can be service gaskets.

9.6.2 The design torque shall be applied in the tightening sequence, according to ASME PCC-1, using a calibrated torque wrench. The record of applied torque shall be presented to inspector during the test.

9.7

Surface preparation and painting shall not be applied to the vessel prior to hydrostatic testing.

Added Sections

9.8

Vents shall be provided at the high points of the vessel to purge air from the tested component while it is being filled.

9.9

The test shall only be performed after 48 hours have elapsed from the last welding or after PWHT in pressure parts and equipment supporting parts.

9.10

At least two pressure gages shall be used, and a third one shall be used when the test takes more than 6 hours, observing the following requirements:

a) At least one of the pressure gages shall be located in an area allowing easy access, visible to the inspector during the entire testing and pressurization time and one of the pressure gages shall be located at the top of the equipment.
b) Pressure gages shall be calibrated before the beginning of the test. Calibration certificate shall not be older than 3 months at test date. Calibration shall be done using a standard deadweight gauge or a calibrated master pressure gauge or a column of mercury.
c) The maximum scale value shall always be within 1.5 and 4 times the test pressure and be preferably twice the test pressure.
d) The smallest scale division shall not exceed 5% of the maximum scale indication.
e) Valves shall be provided between the pressure gages and equipment to allow substitution, if necessary.

9.11

The hydrostatic test procedure shall consider the scheme presented below:

a) Elevate the pressure until 50% of hydrostatic test pressure (PT) and proceed the equipment inspection.
b) Increase gradually, with a rise ratio of 20% of PT per minute or lower, to reach the hydrostatic test pressure. Remain in this pressure during, at least, 60 minutes.
c) Reduce the pressure down to 77% of PT, and perform a new inspection.
d) Decrease gradually to the atmospheric pressure, and open the upper nozzles to avoid the emptying vacuum.

9.12

After the hydrostatic test, the following items shall be completed:

a) The equipment shall be fully drained, dried and cleaned.
b) All nozzles left open, flange faces shall be protected against corrosion and mechanical damage.
c) Visual inspection shall be performed (internal visual inspection may be performed with the aid of a borescope).

d) A dimensional examination of the perimeter of cylindrical shells and distances between equipment tangent lines shall be performed to check if there is permanent deformation after hydrostatic test.

10 PREPARATION FOR SHIPMENT

10.1 GENERAL

Replaced Section

10.1.1 Vent holes shall be filled with grease and plugged after testing.

10.1.2 The material used to plug vent holes shall not be capable of sustaining pressure between the reinforcing plate and the vessel wall.

10.1.3 The vessel shall be shipped with service gaskets and bolting in place for body flanges, custom designed flanges and permanently blinded connections.

10.1.4 A barrier material shall be provided between shipping saddles and the vessel to prevent damages to the surface of the vessel or contamination of the vessel material.

10.2 PROTECTION

10.2.1 Liquids used for cleaning or testing shall be drained from the vessel and any residues dried prior to shipment.

10.2.2 The vessel shall be free of any foreign matter prior to shipment.

10.2.3 Removable internal and external parts assembled with the vessel prior to shipment shall be tied or braced with temporary supports.

10.2.4 Temporary supports shall be painted with a fluorescent colour paint.

10.2.5 Exposed machined and threaded surfaces on the vessel and parts to be shipped loose shall be protected with rust preventive.

10.2.6 Flanges shall be blanked with oil-resistant rubber gaskets or self-adhesive flange protectors and steel or water-resistant plywood blanks with a minimum of four bolts.

10.2.7 Vessel purging

10.2.7.1 When an inert gas purge is specified, the pressure shall be maintained at a minimum of 35 kPag (5 psig) indicated by a pressure gauge during transportation and storage.

10.2.7.2 Gauges shall be protected from damage during transportation.

10.2.7.3 When the vessel is purged with dry air and desiccant bags are placed in the vessel, the quantity and location of the desiccant bags shall be recorded.

10.3 IDENTIFICATION

10.3.1 The exterior of the vessel shall be marked with the vessel tag number, shipping weight and purchase order number with a minimum of 75 mm (3 in) high letters of contrasting colour against the background.

NOTE Other markings may have 25 mm (1 in) high letters.

10.3.2 The centre of gravity shall be marked on each side of the exterior of the vessel.

10.3.3 Vessels that have received PWHT shall be labelled or painted with the text "POST WELD HEAT TREATED – DO NOT BURN OR WELD".

10.3.4 Equipment protected by an inert gas fill shall display the warning "DANGER - NON-LIFE SUPPORTING ATMOSPHERE" in the immediate vicinity of any manway and other point of access to the interior of the vessel.

Added Section

11 COATING AND PAINTING

11.1

External painting shall be according to I-ET-3010.00-1200-956-P4X-002 - GENERAL PAINTING.

11.2

Pressure vessels color shall be according the latest revision of DR-ENGP-I-1.15 – COLOR CODING.

11.3

If TSA is required, it shall be in accordance with I-ET-3010.00-1200-956-P4X-003 - THERMAL SPRAY COATING APPLICATION OF ALUMINUM.

11.4

If internal coating is required, it shall be in accordance with I-ET-3010.00-1200-956-P4X-002 - GENERAL PAINTING.

ANNEX A – ADDITIONAL REQUIREMENTS FOR SOUR SERVICE VESSELS

A.1

The requirements specified by this annex are minimum requirements. If more stringent requirements such as butt-welded type nozzles, forged ring type skirt to head joints and full penetration groove welds for welded attachments are required based on severity of the service, these shall be agreed between the purchaser and the vendor.

Replaced Section

A.2

The requirements of ISO 15156/NACE MR0175 (all parts) shall be satisfied. For cladded vessels the requirements shall be applied to both base material and clad material.

A.3

Nozzles shall be set-in type, integrally reinforced and fitted flush with the shell or head.

A.4

Butt welds shall be subjected to 100 % volumetric examination.

A.5

Nozzle-to-vessel wall joints shall be 100 % ultrasonically tested.

A.6

Welds directly to the internal surfaces of the pressure part shall be subjected to 100 % surface inspection by WFMT or liquid penetrant examination.

Replaced Section

A.7

As a rule, HIC testing is only applicable for rolled plates in the condition established below or if determined at project specific document. HIC testing is not applicable for seamless pipes, castings, and forgings. HIC testing is not applicable for wrought accessories, unless they are fabricated from products that originate from rolled plates. HIC testing need not be applied for parts that will be fully protected by a weld overlay or clad.

Where Table A.1 indicates the need for HIC testing, one plate per lot shall be HIC tested in accordance with NACE TM0284, using test solution A.

Where Table A.1 indicates the use of a clean steel, the following requirements applies for the steel plates:

- Be vacuum degassed.

- Be fully killed, made to fine grain practice.
- Either normalized, TMCP or Q&T.
- Maximum sulfur (S) content of 0.001 wt%.
- Maximum phosphorus (P) content of 0.010 wt%.
- Inclusion shape control shall be applied.

pH	Partial pressure of H_2S in the gas phase (MPa/psia)		
	< 0.0003 MPa / 0.05 psia	> 0.0003 MPa / 0.05 psia	
	Aqueous phase total sulfide (ppmw)		
	<50	50-2000	>2000
<4	N/A	Clean steel required	Clean steel and HIC test required
4 to 7,6	N/A	N/A	Clean steel required
>7,6	N/A	Clean steel required if HCN-present	Clean steel and HIC testing required

Table A.1 – HIC Testing Requirements

1.1. A.8

The acceptance criteria for HIC testing for sour service shall be in accordance with the following:

a) CLR lesser than or equal to 15 % per specimen;
b) CTR lesser than or equal to 5 % per specimen;
c) CSR lesser than or equal to 2 % per specimen;
d) 5 mm (0,2 in) maximum individual crack length;
e) ultrasonically tested as per ASTM A578 S1, S2.1 or EN 10160 quality classes S2 (plate) E3 (edge).

Replaced Section

A.9

PWHT shall be performed for vessels according to 7.2

A.10

Unless they are vented in accordance with 6.1.1, external attachments shall be welded to the pressure boundary with full penetration welds.

A.11

Internal attachments shall be welded to the pressure boundary with full penetration welds.

Added Sections

A.12

Hardness testing shall also be performed on production welds. These tests shall be performed in the deposited weld metal and on the Heat Affected Zone (HAZ).

A.13

Construction details that result in crevice in contact with the fluid is not allowed.

Confined space between welds is not allowed.

ANNEX B – ADDITIONAL REQUIREMENTS FOR INTEGRALLY CLAD AND WELD OVERLAY VESSELS

This annex covers the requirements for integrally clad and weld overlaid carbon steel with austenitic stainless steel, alloy 276, alloy 625 or alloy 825.

B.1 GENERAL

B.1.1 The method of cladding shall be integral cladding by hot rolling, explosion bonding or weld overlay.

B.1.2 The base metal nominal thickness shall not be less than 10 mm (⅜ in).

B.1.3 The minimum thickness of cladding or overlay welding shall be 3 mm (⅛ in) after machining.

B.1.4 Design calculations shall be based on the base material thickness after clad restoration, excluding the machining allowance for clad restoration (see Annex J, Drawing S619 J.6).

B.1.5 The chloride content of the hydrostatic test water shall not exceed 50 mg/kg (50 parts per million by mass).

Added Section

B.1.6 Cladding for flanges shall extend to all internally wet surfaces, including the sealing areas and the flange raised face.

B.2 NOZZLES

B.2.1 The minimum nozzle size for nozzles in cladded sections shall be DN 50 (NPS 2).

B.2.2 Nozzles shall be clad, either integrally or by weld overlay.

NOTE Nozzles DN 100 (NPS 4) and smaller and girth flanges may be of solid alloy subject to the purchaser's approval.

B.2.3 When nozzles are rolled from integrally clad plate, the longitudinal and circumferential welds in the nozzle section shall be subjected to 100 % volumetric examination.

B.2.4 Radius or profiling at nozzle connections shall not reduce the clad thickness below the specified minimum value.

Added Section

B.2.5 CRA clad for flanges shall extend to all internally wet surfaces, including the sealing areas at the flange raised face.

B.3 INTEGRAL CLADDING

Replaced Section

B.3.1 Integrally clad plates shall comply with the requirements of ASTM A263, ASTM A264 or ASTM A265 including supplementary requirement S12 with a bond quality level of Class 1.

When post weld heat treatment is required, clad plate shall include corrosion testing according to ASTM A262 practice E for austenitic stainless steel. Test coupons shall be heat treated prior to testing with at least twice the fabrication heat treatment soak time as specified for the equipment.

B.3.2 Formed heads or sections shall be ultrasonically tested after forming in accordance with the requirements specified under B.3.1.

NOTE: The final thickness of the clad shall be verified after forming. Final thickness shall meet the minimum required according to the drawing.

B.3.3 Shear strength tests shall be performed on all integrally clad steel plates in accordance with the provisions of the applicable material specification.

B.3.4 Internal attachments

B.3.4.1 When the induced weld stress due to thermal and mechanical loads on the attachment exceeds 25 % of the allowable shear stress or 50 % of the allowable tensile stress for the weld, welding of internal attachments to integrally clad plates shall not be permitted.

B.3.4.2 Internal welded attachments that do not meet the requirements in B.3.4.1 shall be welded directly to the base metal after stripping back the cladding locally.

B.3.4.3 When an integrally clad plate has regions that are locally stripped back, the stripped back areas shall be restored by weld overlay.

Added Section

B.3.5 For vessels with clad, any blistering detected in the visual inspection shall not be permitted.

B.4 WELD OVERLAY

Added item

A minimum of two layers shall be applied for all weld overlay.

Replaced Section

B.4.1 Internal attachments in weld overlaid sections shall be welded to the overlay. The material selected for internals shall have the same nominal chemistry of the overlay, in order to avoid dissimilar welding.

B.4.2 For transition areas at nozzles and flanges, a fabrication procedure shall be provided.

B.4.3 The fabrication procedure shall include as a minimum all of the following.

a) detailed arrangement drawing showing:
    1) functionality of the nozzle or flange;
    2) constructive detail of nozzle;
    3) preparation of the nozzle or flange;
    4) tapering;
    5) line up and measurement prior to overlay welding.
b) Details of overlay welding including:
    1) reference to the applicable welding procedure;
    2) number of layers.
c) Method of preparation after overlay welding.
d) Examination after overlay welding including:
    1) thickness;
    2) liquid penetrant;
    3) ferrite testing.

B.4.4 Where there is change in geometry for highly stressed areas (e.g. nozzle or manway welds in shells or heads, internal beam support weld build-ups), the weld overlay shall be provided with a smooth contour finish and a minimum radius of 6 mm (¼ in).

B.4.5 Weld overlay, clad restoration welds and internal attachment welds shall be subjected to 100 % liquid penetrant examination.

B.4.6 Weld overlaid surfaces shall be examined with the liquid penetrant method after final machining.

B.4.7 The test acceptance criteria for liquid penetrant inspection of weld overlay shall be zero cracks or crack-like indications and zero open defects of any size.

B.4.8 Any linear indication in the weld overlay as identified by the liquid penetrant test shall be repaired.

B.4.9 When partial removal of the final weld overlay or clad layer is performed by grinding, machining or another method, a copper sulphate test shall be performed on all surfaces that were subjected to metal removal during the grinding or machining process.

ANNEX C – ADDITIONAL REQUIREMENTS FOR CARBON STEEL VESSELS

C.1

The maximum allowable CE shall be in accordance with Table C.1.

Table C 1 - Maximum allowable CE

Nominal plate thickness	Maximum allowable CE
≤ 50 mm (2 in)	0.43
> 50 mm (2 in) ≤ 100 mm (4 in)	0.45
> 100 mm (4 in)	0.48

C.2

The maximum carbon content of carbon steel material shall not exceed 0.23 %.

C.3

Deleted Section

C.4

Deleted Section

C.5

The minimum Charpy impact values, at the minimum design metal temperature or impact testing temperature specified in design code (whichever is lower), shall be 27 J (20 ft-lb) average of three specimens and 20 J (15 ft-lb) minimum for a single specimen, unless the design code contains more stringent requirements.

Replaced Section

C.6

Impact testing shall include testing of specimens from the base metal, weld metal and heat affected zone. When impact testing is required for the weld joint, the interpass temperature shall not exceed 250 ºC.

C.7

The chloride content of the hydrostatic test water shall not exceed 250 mg/kg (250 parts per million by mass).

ANNEX D - ADDITIONAL REQUIREMENTS FOR AUSTENITIC STAINLESS STEEL, 22CR AND 25CR DUPLEX VESSELS

D.1 GENERAL

Replaced Sections

D.1.1 Materials shall be supplied in a solution annealed condition.

In case of austenitic stainless-steel selection for services in saline atmosphere or with salt water, AISI 304 (UNS S30400) or 304L (UNS S30403) shall not be acceptable for pressurized parts or parts subject to mechanical stress.

When the sensitization of austenitic stainless steels is deleterious to their corrosion resistance, materials that are not susceptible to sensitization shall be used (L and ELC grades or stabilized types). Attention is drawn to the fact that sensitization may occur as a result of welding, heat treatments or operating temperature of the vessel.

D.1.2 Cold formed heads and tori-conical transition sections shall be solution annealed after forming and before welding to the shell. The same mechanical tests in the mill certificate shall be carried out after solution annealing.

D.1.3 Hot formed heads shall be solution annealed followed by rapid cooling. The same mechanical tests in the mill certificate shall be carried out after solution annealing.

D.1.4 Arc-air or oxy-gas methods of cutting and bevelling shall not be permitted.

D.2 CONTAMINATION CONTROL

D.2.1 Procedures shall be in place to ensure no cross-contamination between ferritic, austenitic or duplex materials.

D.2.2 Exterior surfaces shall be protected from chloride exposure during fabrication, shipping and storage.

D.2.3 Materials for marking, painting or inspection shall not contain halides and heavy metals.

D.2.4 Aluminium and zinc containing paints shall not be used for material identification.

D.2.5 The chloride content of the hydrostatic test water shall not exceed 50 mg/kg (50 parts per million by mass).

D.3 FERRITE MEASUREMENT

D.3.1 The FN shall be measured during procedure qualification and production welding prior to any post weld heat treatment using a ferrite scope calibrated in accordance with ISO 8249 or AWS A4.2.

D.3.2 Ferrite number measurements of production welds shall include all longitudinal and circumferential pressure retaining welds.

D.3.3 A minimum of three separate measurements per weld shall be performed.

D.4 WELDING

The minimum preheat temperature shall be 10 °C (50 °F).

Added Section

D.4.1 When post weld heat treatment is required, weld procedure qualifications shall include corrosion testing according to ASTM A262 practice E for austenitic stainless steel.

D.5 PICKLING AND PASSIVATION

D.5.1 The internal surfaces of vessels with a wall thickness of less than 10 mm (⅜ in) shall be pickled and passivated after completion of all welding activities.

D.5.2 Surfaces contaminated with iron during fabrication shall be pickled and passivated.

D.5.3 Internal and external surfaces of welds shall be pickled and passivated.

D.6 SPECIAL REQUIREMENTS FOR 22CR DUPLEX AND 25CR DUPLEX

D.6.1 Pressure retaining components shall be supplied by manufacturers qualified in accordance with the requirements of ISO 17782 or NORSOK M-650.

D.6.2 The maximum number of repairs of the same defective area shall not exceed the values listed in Table D.1.

Table D 1 - Repair Limits

Material	Repairs allowed
22Cr Duplex	2
25Cr Duplex	1

D.6.3 22Cr duplex and 25Cr duplex shall not be post weld heat treated.

Added Section

D.6.4 External coating shall be applied to austenitic stainless, 22Cr and 25Cr duplex in accordance with I-ET-3010.00-1200-956-P4X-002 - GENERAL PAINTING.

D.6.5 Pressure vessels made of material 22Cr and 25 Cr shall be 100% volumetric examination.

ANNEX E - VESSEL TOLERANCES

E.1

Tolerances shall be in accordance with the design code, and Figure E.1 or Figure E.2.

E.2

Where tolerances for horizontal vessels are not shown, vertical vessel tolerances shall be applied.

E.3

Tangent lines, principal axis centre lines and orientation shall be punch marked externally.

E.4

Out of roundness tolerance for skirts shall be in accordance with the design code for shell under external pressure.

E.5

Flatness tolerances for vessel support base plates (e.g. skirts, legs, lugs and saddles) shall be ±6 mm (¼ in).

E.6

For nozzles supplied with an agitator mounting, the maximum out of plane tolerance shall be ±0.25°.

Added Note

Note: Vessel tolerances are shown in Figures E.1 and E.2, and these figures are not attached to this specification, to get the full access to the content see IOGP S-619 April 2022, pages 36 and 37. In any case, **SELLER** can seek **BUYER** for clarification.

ANNEX F - REQUIREMENTS FOR MAXIMUM ALLOWABLE CORROSION ALLOWANCE (MACA)

The MACA for pressure components is the difference between the nominal thickness and the calculated required (retirement) thickness in accordance with the design code. The MACA is the sum of the design minimum corrosion allowance (internal, external or both) plus the thickness added (“round up thickness”) to obtain a commercially available nominal thickness.

The MACA methodology is used to optimize the design for the CA. The CA is not required to be displayed on the nameplate by the ASME code or by this specification.

Calculation of the MAWP is not required for vessels build to ASME BPVC, Section VIII, Division 1; the design pressure may be substituted for the MAWP. However, this specification allows for the MAWP to be calculated as an option after the MACA has been determined. This calculated MAWP may be slightly higher than the design pressure.

F.1

The MACA shall be determined individually for each of the cylindrical, straight conical or flat major components first.

F.2

The MACA shall be calculated regardless of whether the CA is internal or external. NOTE Where the as-built head and minor component (typically a nozzle) configuration allows, it is preferable for the minor component to inherit the MACA of its parent major component.

F.3

The reinforcement requirements of openings shall be calculated after the MACA for the parent component has been determined.

F.4

Thickness added to the component for additional reinforcement or for meeting the supplemental minimum thickness requirements of other standards is not required to be counted towards the MACA.

EXAMPLE 1 (SI) A shell course may be designed with a required thickness of 5.7 mm plus a design CA of 3.0 mm at 8.7 mm. This is rounded up to 10 mm as the next commonly available thickness. If the fabricator chooses or is required by TEMA to use 12 700 mm plate, the MACA is calculated based on 10 mm, thus MACA is 4.3 mm. Accounting for the slight increase in ID with a larger CA as well as roundoff error, it is likely that the actual MACA will drop to 4.2 mm. The excess 3 mm can be allocated to opening reinforcement, external nozzle loads, etc. or at the fabricator’s option added to the MACA.

EXAMPLE 2 (US Customary) A shell course may be designed with a required thickness of 0.225 in plus a design CA of 0.125 in at 0.350 in. This is rounded to 0.375 in as the next commonly available thickness. If the fabricator chooses or is required by TEMA to use 0.500

in plate, the MACA is calculated based on 0.375 in, thus MACA is 0.15 in. Accounting for the slight increase in ID with a larger CA as well as roundoff error, it is likely that the actual MACA will drop to 0.14 in. The excess 0.250 in can be allocated to opening reinforcement, external nozzle loads, etc. or at the fabricator's option added to the MACA.

F.5

The MACA of the pressure component need not exceed twice the design CA for that component.

F.6

When attached to a formed head or formed transition component, the CA of minor components may be designed using 150 % of the vessel design corrosion allowance instead of a calculated MACA.

F.7

The MACA for each major component shall be calculated to the nearest 0.2 mm (0.01 in).

F.8

For vessels with more than one shell course, the MACA shall be calculated separately for each course.

F.9

When attached to cylindrical shell components, straight conical transitions or flat heads, the CA of minor components (e.g. nozzle neck, nozzle flange) shall inherit the MACA of the cylindrical shell or flat head component that it is attached to.

F.10

The thickness of formed heads and formed knuckles for conical transition components shall be measured after forming.

F.11

The as-built MACA shall be calculated based on the as-received thickness.

F.12

Calculations shall clearly state the minimum required thickness for all major components of the vessel.

F.13

The minimum required thickness for all major components shall be included in a table on the general arrangement drawing.

F.14

The MACA of each major component shall be listed on the manufacturer’s data report.

F.15

The manufacturer's draft data report shall be submitted to the purchaser for review and approval.

ANNEX G – ADDITIONAL REQUIREMENTS FOR VESSELS IN CYCLIC SERVICE

There is a range of operating conditions that may be considered fatigue service based upon the cyclic loading screening requirements in the selected code of construction. However, some vessels may be designed for a relatively small number of operating cycles (e.g. the range of 100 to 1 000 cycles) and may therefore be operating in a lower severity cyclic service application. In other cases, a vessel may be designed for a large number of cycles (e.g. 100 000 or more cycles) and/or experience extreme stress cycles associated pressure and thermal stress, and are as such in a more severe cyclic service application. Examples of this category include PSA vessels, molecular sieve dryer vessels, or coke drums.

Appropriate mechanical details for vessels in these two broad categories may be quite different. For vessels that are designed for a small number of operating cycles, the mechanical details specified in Section 4 to Section 10 may prove to be sufficient provided the local stress at critical locations is accurately accounted for in the fatigue design calculations.

For vessels designed for a larger number of operating cycles, experience has shown that the mechanical details similar to those included in Section 4 to Section 10 of this specification may not be sufficient to ensure reliable, predictable operation. This is due to the following difficulties:

a) accurately predicting the local stress at a discontinuity;
b) assuring a defect free vessel for some detail types during initial fabrication;
c) inspecting certain detail types for fatigue cracks after the vessel has experienced a number of operating cycles.

The mechanical design requirements in Annex G have been selected assuming that a vessel is designed for a cyclic operating condition that is more likely to result in unreliable, unpredictable fatigue life if the Annex G requirements are not followed. The mechanical design of vessels intended for less severe cyclic service applications is outside the scope of this annex. However, the mechanical design of the vessels shall be evaluated for cyclic service in accordance with the code of construction and either found to be exempt or analysed in order to demonstrate compliance to the code. Vessels intended to be stamped as compliant with ASME BPVC, Section VIII, Division 1 can either be demonstrated to be exempt from fatigue analysis basis and the ASME cyclic loading screening criteria or to pass a fatigue analysis in accordance with ASME BPVC, Section VIII, Division 2, Part 5.

G.1

If the selected design code is ASME BPVC, Section VIII, Division 1, the screening and evaluation method for fatigue analysis shall be in accordance with ASME BPVC, Section VIII, Division 2.

G.2

If other than ASME BPVC, Section VIII, Division 1, the selected design code does not include a screening and evaluation method for fatigue analysis, ASME BPVC, Section VIII, Division 2, EN 13445, PD 5500 or API Standard 579-1/ASME FFS-1 shall be used.

G.3

Fatigue analysis shall include attachments welded to the pressure envelope and the following locations:

a) head-to-shell;

b) support-to-vessel;

c) nozzle-to-vessel wall, considering external piping loads.

G.4

Integrally reinforced nozzles shall be used.

G.5

Internal and external attachments welds shall be full penetration type excluding welds attaching saddle wear pads to a vessel wall.

G.6

The cap of all butt welds shall be ground smooth with the parent material.

G.7

Fillet welds caps on a full penetration weld shall be ground to form a smooth transition with the parent metal.

G.8

Butt welds shall be subjected to 100 % volumetric examination and surface examination by MT or PT.

G.9

Nozzle-to-vessel wall welds shall be subjected to 100 % volumetric examination and surface examination by MT or PT.

G.10

Welds between attachments and the pressure envelope shall be subjected to 100 % surface examination by WFMT or PT.

G.11

Conical transitions shall be made with a knuckle at both ends.

G.12

Lifting attachments on a pressure part shall be designed for removal prior to commissioning.

G.13

The weld toe to weld toe distance between a nozzle and an adjacent structural discontinuity shall be a minimum of 1.8 x $(D \times t_{min})^{0.5}$ or 50 mm (2 in), whichever is greater.

G.14

Permanent attachments or openings in the knuckle region of a formed head shall be prohibited.

G.15

If not specified in the code of construction, the requirements of ASME BPVC, Section VIII, Division 2 for "Peaking of Welds in Shells and Heads for Internal Pressure" shall be satisfied.

NOTE See ASME BPVC, Section VIII, Division 2, 6.1.6.3.

G.16

The back of the root pass, if applicable, shall be examined by MT or PT after preparation for welding.

ANNEX H – ADDITIONAL REQUIREMENTS FOR CARBON STEEL VESSELS IN CAUSTIC AND LEAN AMINE SERVICE VESSELS

H.1

All welds in contact with the process fluid shall be inspected with the WFMT method after PWHT (if performed).

H.2

If crack-like indications are identified via the WFMT inspection (regardless of the code of construction acceptance criteria) and the indications are not removed, a dimensional map shall be provided with sizing and information allowing location of indication during the inspections.

ANNEX I – ADDITIONAL REQUIREMENTS FOR VESSELS IN HYDROGEN CHARGING SERVICE

I.1

Nozzle-to-vessel wall connections shall be set-in type.

I.2

Integrally reinforced nozzles shall be used.

I.3

Butt welds shall be subjected to 100 % volumetric examination.

I.4

Butt welds shall be subjected to MT or PT examination of all weld surfaces exposed to the process fluid, including a 25 mm (1 in) wide band on either side of the weld.

I.5

Nozzle-to-vessel wall welds shall be subjected to 100 % volumetric examination.

I.6

Nozzle-to-vessel wall welds shall be subjected to MT or PT examination of all weld surfaces exposed to the process fluid, including a 25 mm (1 in) wide band on either side of the weld.

I.7

Welds between attachments and the pressure envelope shall be subjected to 100 % surface examination by WFMT or PT method.

I.8

External attachments shall be welded to the pressure boundary with full penetration welds unless they are vented in accordance with 6.1.1.

I.9

Internal attachments shall be welded to the pressure boundary with full penetration welds.

I.10

Wetted surfaces of pressure boundary and attachment welds shall be hardness tested.

I.11

The hardness of attachment welds shall not exceed 200 BHN.

I.12

PWHT shall be performed for all vessels in hydrogen charging service.

ANNEX J – STANDARD DRAWINGS

Added Note

Note: The chapter ANNEX J, which includes Figures J.1 to J.15 is not attached to this specification, to get the full access to the content see IOGP S-619 April 2022, pages 46 to 74. In any case, **SELLER** can seek **BUYER** for clarification.

Added Figure

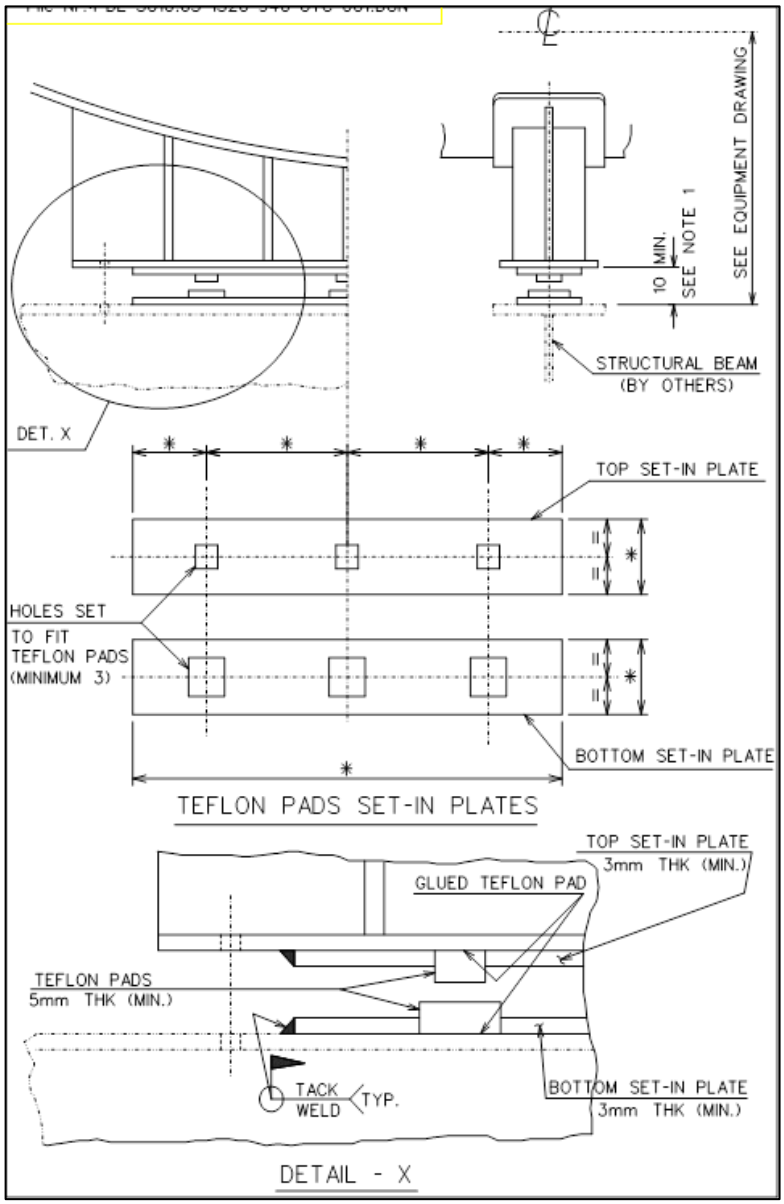

Figure J 16 - Details of Saddle Sliding Plates

ANNEX K – ALLOWABLE NOZZLE LOADS FOR NOZZLE SIZES DN 650 (NPS 24) TO DN 1500 (NPS 60)

Added Note

Note: The chapter ANNEX K, which includes Table K.1 is not attached to this specification, to get the full access to the content see IOGP S-619 April 2022, pages 75 to 81. In any case, **SELLER** can seek **BUYER** for clarification.

Added Section

ANNEX L – REQUIREMENTS FOR NAMEPLATES

L.1

Pressure vessels shall have an identification nameplate containing at least the information and dimensions shown in Figure L.1.

L.2

Nameplate shall be made of AISI 316 stainless steel plate with a minimum thickness of 1.5 mm.

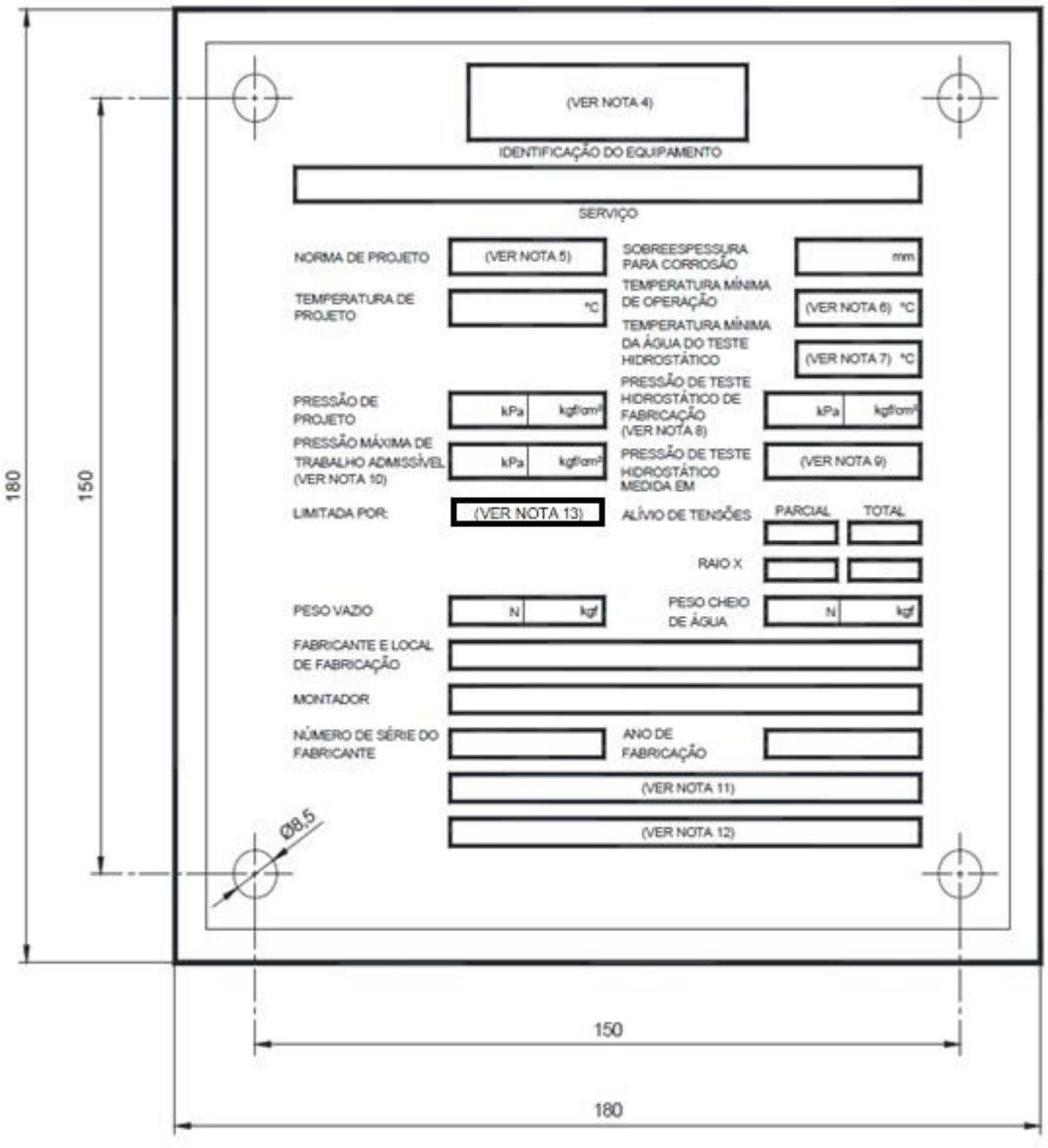

Figure L 1 - Nameplate (for translation of terms see Figure L.2)

L.3

The plate shall be situated on the cover of the lower inspection cover of the vessel, or in another visible and easily accessible location. The localization of the identification plate shall be defined in the vessel manufacturing drawing.

L.4

The characters shall be engraved or stamped and shall have a minimum dimension of de 3 mm.

L.5

For fixation there shall be used Ø 5/16" x 5/8" screws made of stainless steel or tin, with a six sided nut and a washer in a Ø 8.5 mm holes as shown in the drawing. In vessels with thermal insulation or with any other external cladding, the identification plate shall be fixed to a support welded to the body of the vessel, in a manner that it stands out well from the external surface of the insulation or cladding.

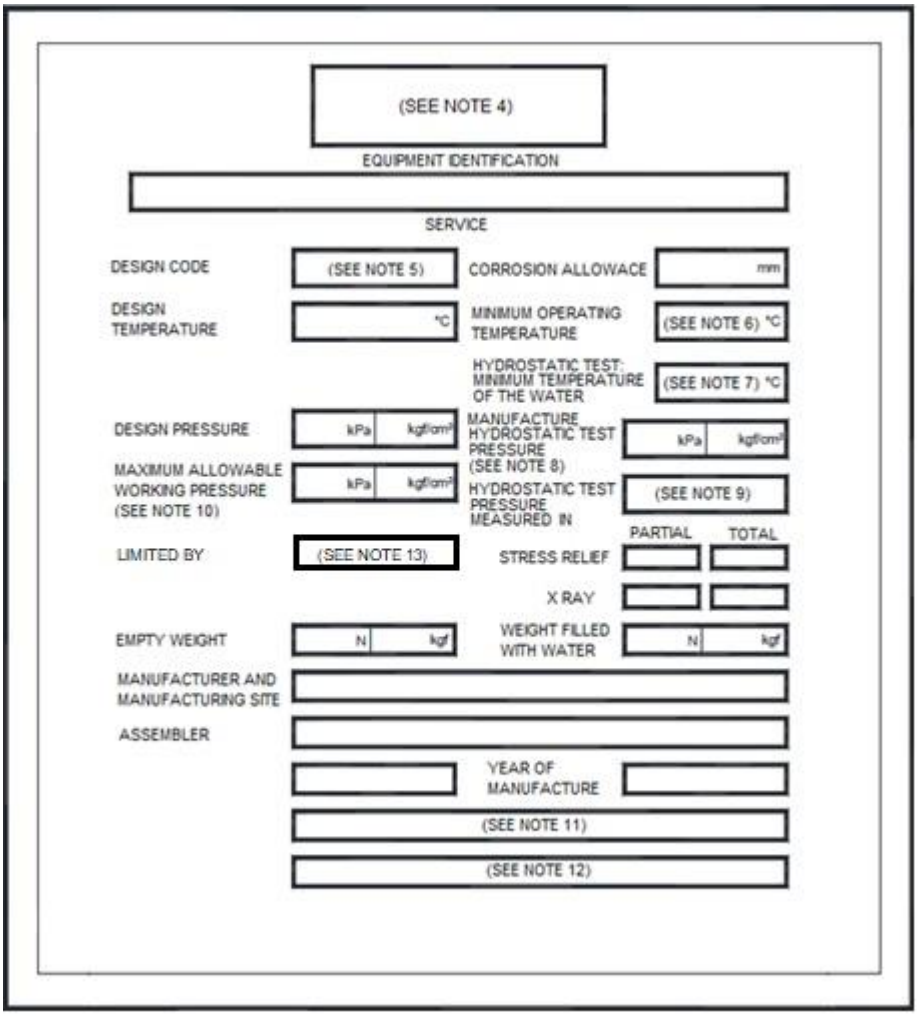

Figure L 2 - Translation of Terms Used in Figure L.1.

L.6

Notes of Figure L.2:

NOTE 1: Dimension in mm.

NOTE 2: The units shall be completed in the international system and in the technical system.

NOTE 3: The language to be used for engraving all nameplate information shall be Portuguese. For translation of the terms see Figure L.2.

NOTE 4: Equipment Identification (Tag Number). It shall be engraved as mentioned on Process Data Sheet, P&ID and Equipment List.

NOTE 5: The year of the edition of the design code/standard adopted shall be shown.

NOTE 6: When applicable

NOTE 7: The minimum temperature of water for hydrostatic testing of the equipment shall be determined according to ASME BPVC SECTION VIII.

NOTE 8: The hydrostatic pressure test for a new vessel shall be determined according item 10.1.

NOTE 9: Show the equipment position and equipment point where the hydrostatic pressure test is measured (e.g. vertical position/ at the top).

NOTE 10: The Maximum Allowable Working Pressure (MAWP) shall be determined using the nominal vessel thicknesses, without the corrosion allowance, and the allowable stress value in the working temperature.

NOTE 11: In this space shall be written “SERVIÇO COM HIDROGÊNIO” (service with hydrogen) or “SERVIÇO COM H_2S “(service with H_2S) when applicable.

NOTE 12: In this space shall be inscribed the requirements for the hydrostatic test water.

NOTE 13: In this space shall be inscribed which component limits the maximum allowable working pressure (without the corrosion allowance at working temperature).

L.7

In addition to the nameplate, the pressure vessel category, according to NR-13, shall be shown at a visible location along with its TAG (identification code). The letters and numbers of equipment TAG and category shall be arranged in the horizontal direction, with “Helvetic”, “PETROBRAS Sans” or “Swiss 721 BT” fonts. The size shall be in accordance with pressure vessels external diameter, as stated in Table L.1.

Table L 1 - Recommendation for height “H” of letters and numbers

External Pressure Vessel diameter (mm)	Height “H” (mm)
D ≤ 300	25
300 < D ≤ 1000	70
1000 < D ≤ 2500	125
2500 < D ≤ 5000	220
D > 5000	300

Added Section

ANNEX M – SELLER'S DATA

M.1 PROPOSAL INFORMATION REQUIRED

SELLER's proposal shall, as a minimum, include the following documents:

a. completed datasheet;

b. delivery schedule;

c. list of sub-vendors and sub-contractors;

d. concession requests.

M.2 DRAWINGS AND OTHER INFORMATION REQUIRED

SELLER shall submit the following documentation to the purchaser:

a. non-conformance records;

b. concession requests;

c. completed datasheet;

d. quality plan;

e. inspection and test plan;

f. general arrangement drawing;

g. detail drawings;

h. design calculations;

i. welding book;

j. non-destructive examination procedures, if applicable;

k. forming procedure, if applicable;

l. positive material identification procedure, if applicable;

m. pickling and passivation procedure, if applicable;

n. heat treatment procedure, if applicable;

o. pressure test procedure;

p. lifting plan;

q. load testing certification of external lifting devices, if applicable;

r. surface preparation and coating procedure;

s. post welding heat treatment temperature chart;

t. non-destructive examination map;

u. material test certificates;

v. handling, shipping, storage and preservation procedure;

w. installation, operation and maintenance instructions;

x. spare part list;

y. manufacturing record book (MRB).

z. weld-repair map

aa. All documents required by NR-13.

Documents mentioned above as well as the following ones shall be submitted to the inspector for examination before the beginning of the corresponding activity:

a. Fabrication drawings approved for execution;

b. Material quality certificates;

c. Certificates of consumable material quality;

d. WPQR´s;

e. Welders/Weld operators qualification records;

f. Report indicating procedures and inspectors and/or qualified non-destructive testing operators and qualified welding inspectors;

g. Report of welding record.

M.3 MANUFACTURING RECORD BOOK (MRB)

SELLER shall furnish a complete set of technical fabrication data books for each equipment containing at least the following documents:

a. Certified mechanical design and fabrication drawings and documents;

b. Technical specifications;

c. Data sheets;

d. Material quality certificates of pressure parts, internals and equipment supporting parts;

e. Quality certificates of welding consumables, including drying control;

f. Traceability map of materials and welding consumables;

g. Report with NDE´s results;

h. Drawing with radiography spot positions;

i. Map of repaired defects;

j. PMI report;

k. Production test reports;

l. Report of dimensional inspection, including dimensions measured;

m. PWHT report, including temperature chart;

n. Pressure test report;

o. Pneumatic test report;

p. Hardness test report;

q. Hydrostatic test report, including pressure chart;

r. Report of ferrite content examination;

s. Report of internal coating/clad inspection;

t. Report of external coating inspection;

u. Report of insulation inspection;

v. Report of nonconformities, if any;

w. Hibernation procedure;

x. Assembly procedure.

y. Data files (soft copies) of recordable NDT´s (automated UT and digitalized radiographic films);

z. All documents required by NR-13.

M.4 FILES

SELLER shall keep the information required below in an organized file, making it available for **BUYER**´s examination (or its authorized representative) at any time within a period of 5 years from the equipment shipping date:

a. Mill certificates for shell components: the certificate shall contain a specification to which the material conforms, the heat number, the treatment undergone by the material and the results of the chemical analysis and mechanical tests.

b. Certificates of compliance for materials obtained from sub-suppliers and for which mill certificates are unavailable: when it is not possible to prove the material specification, the manufacturer shall carry out tests and analyses and issue certificates of compliance.

c. For piping accessories and flanges manufactured in accordance with an approved standard, certificates are not required, provided they are marked as required by code ASME BPVC Section VIII. Certificates are required when markings are removed.

d. Registers of qualified welding procedures, registers of qualification of welders and weld operators.

e. Radiographic films and UT digital records, when is required.

f. Non-destructive test certificates.

g. Charts and/or certificates of hydrostatic and pneumatic tests and other tests.

h. Temperature recording charts and other heat treatment registers.

BIBLIOGRAPHY

[1] ASME 2016 Pressure Vessels and Piping Conference, PVP2016-63074, The Case for MACA: The Optimization of Corrosion Allowance

[2] ASME 2016 Pressure Vessels and Piping Conference, PVP2016-63075, Guidelines for MACA: The Optimization of Corrosion Allowance

SECTION II - IOGP S-619 SPECIFICATION FOR UNFIRED, FUSION WELDED PRESSURE VESSELS

S-619.pdf

SECTION III – IOGP S-619D PROCUREMENT DATA SHEET FOR UNFIRED, FUSION WELDED PRESSURE VESSELS

S-619D.xlsx

SECTION IV – IOGP S-619L INFORMATION REQUIREMENTS FOR UNFIRED, FUSION WELDED PRESSURE VESSELS

S-619L.xlsx