PETROBRAS	TECHNICAL SPECIFICATION	N°. I-ET-3010.00-1200-540-P4X-001	
	CLIENT: SRGE		SHEET: 1 of 67
	JOB: -		-
	AREA: -		
SRGE	TITLE: REQUIREMENTS FOR PRESSURE VESSELS DESIGN AND FABRICATION		INTERNAL
			ESUP

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
H	REVISED WHERE INDICATED
J	ITEMS REVISED: 4.7.13, 9.1.2, B.2.5 AND D.1.3
K	GENERAL REVISION

	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H	REV. J	REV. K
DATE	JUL/20/20	FEB/24/21	APR/21/21	DEC/30/21	OCT/28/22	DEC/13/22	FEB/28/23	APR/17/23	JUN/07/24
DESIGN	ESUP	ESUP	EEA	EEA	EEA	EEA	EEA	EEA	EEA
EXECUTION	DANISCHMIDT	CJX4	CJX4	CJX4	CJX4	CJX4	CJX4	CJX4	CJW2
CHECK	PONTE	HR7W	QM66	HR7W	HR7W	CJW2	CJW2	CJW2	CSM0
APPROVAL	GONZALEZ	U32N	U32N	U32N	U32N	U32N	U32N	U32N	CJX4

SUMMARY

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 ASSURANCE 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 is modified, this specific section is identified with one of the following tags: ***Add*** (add to section or add new section), ***Replace*** (part of or entire section) or ***Delete***. 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 PRODUCT DEVELOPMENT), Exhibit IV (DIRECTIVES FOR PRODUCT FABRICATION), Exhibit V (DIRECTIVES FOR ACQUISITIONS), Exhibit VI (DIRECTIVES FOR PLANNING AND CONTROL), Exhibit VII (DIRECTIVES FOR QUALITY ASSURANCE SYSTEM) and Exhibit VIII (DIRECTIVES FOR COMMISSIONING PROCESS).The requirements herein listed are applicable to all players performing such related activities within the scope of this unit, including **SELLER**s, manufacturer, 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**.

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.

Add to list

5) other materials not indicated here but 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.

Add to section

Requirements under Annex M and Annex N are common for all pressure vessels.

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

If 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.

All equipment manufacturers shall be ASME certified according to the applicable design code (e.g., “U” for ASME BPVC Section VIII Division 1, “U2” for ASME BPVC Section VIII Division 2).

In addition to the manufacturer’s certification, the equipment shall be acquired with ASME stamp, if any of the following conditions apply:

- Equipment with design pressure above 200 bar.
- Equipment with minimum design temperature below -46°C.
- Equipment manufactured in duplex or superduplex stainless steel.
- Equipment with internal corrosion resistant clad / weld overlay.
- Equipment designed as per ASME BPVC Section VIII Division 2.

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

Add to list

ASME BPVC Section I, Rules for Construction of Power Boilers

ASME BPVC Section II, 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-538, Determination of Pressure Boundary Joint Assembly Bolt Loads

Add 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.

Add section

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.

Add section

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-3010.00-1200-540-P4X-003, Requirements for Stress Analysis by Finite Element Method (FEM)
- 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 Maritime 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

Add section

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

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.

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).

Replace section

3.1.5
standard flange
flanges dimensioned and manufactured 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).

Add section

3.1.10
Finite Element Method (FEM)
Numerical technique used to perform finite element analysis.

3.1.11
FMC/TFM
Full Matrix Capture / Total Focusing Method - advanced ultrasonic technique.

3.1.12
PAUT
Phased Array Ultrasonic Testing - advanced ultrasonic technique.

3.1.13
ToFD
Time-of-Flight Diffraction - advanced ultrasonic technique.

Add 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

Add 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.

Replace Section

4.1.3 ASME Code cases can only be used with prior BUYER approval.

Replace 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 custom designed flanges for nozzles.

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.

Replace Section

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.

Replace Section

4.1.9 All welds on the primary pressure boundary shall be butt-weld and full penetration type and shall be suitable to allow 100% volumetric inspection, even in those cases where the design Code does not require it. Corner joints are not acceptable.

The welded connections between flat heads and the adjacent cylinder shall be in accordance with ASME Section VIII, Div. 1 Figure UW-13.3 (a).

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.

Add section

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

4.1.14 When design by analysis is performed, FEM shall be in accordance with I-ET-3010.00-1200-540-P4X-003 - REQUIREMENTS FOR STRESS ANALYSIS BY FINITE ELEMENT METHOD (FEM).

4.2 CORROSION ALLOWANCE

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

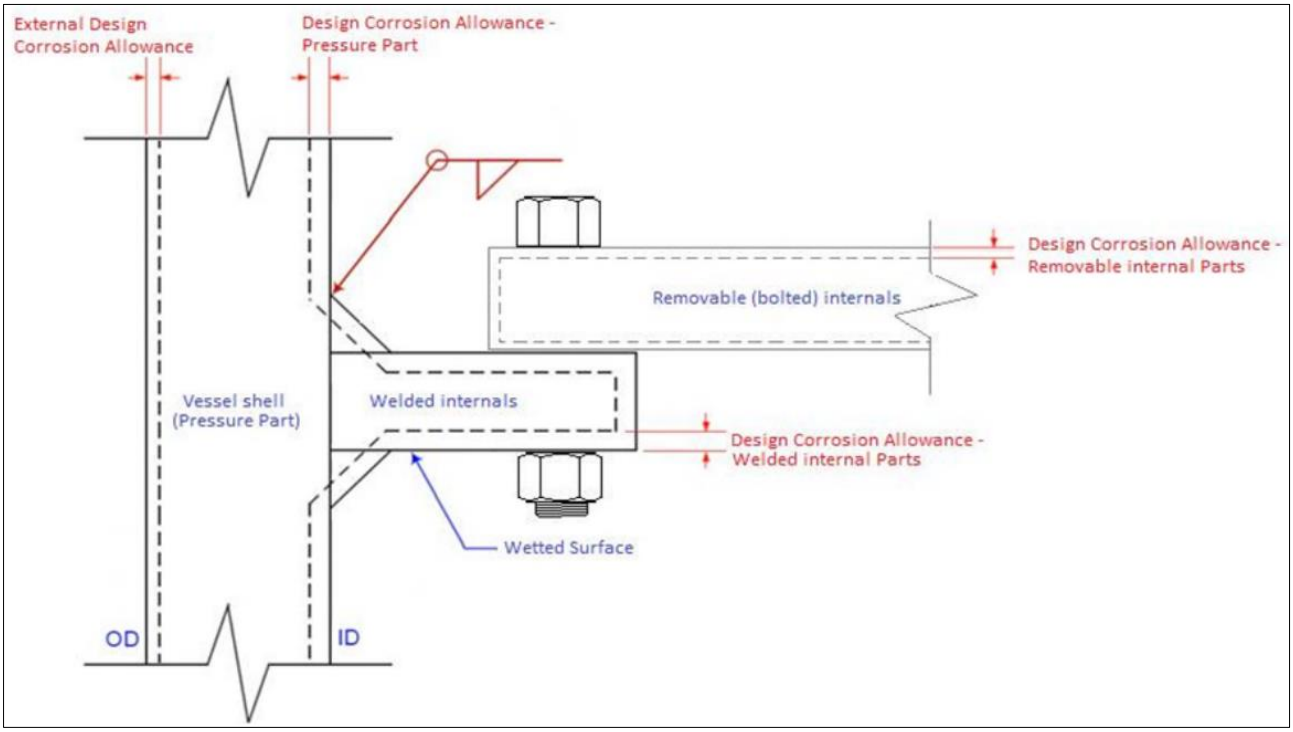

Figure 1 - Design corrosion allowance

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

Add 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

Replace 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.

Add section

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**].

Add section

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

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.

Add to section

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.

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.

Add to section

In this case Seller shall perform finite element analysis.

Replace section

4.6.4 Evaluation shall be performed in accordance with WRC 297, WRC 537 or finite element analysis. Any other standard or numerical methods may be used subject to approval by the purchaser. All geometrical limits specified in methods (such as WRC etc.) used for local load analysis shall be followed. Extrapolation beyond stated limits is not allowed. When the application of these nozzle loads would require an increase in the local cylinder or head thickness, acceptable loads shall be agreed mutually with the purchaser.

All Nozzles shall be designed to withstand the simultaneous application of forces and moments in the corroded condition, as defined in ANNEX N. In addition, pressure thrust shall be included for all nozzles.

Replace section

4.6.5 Nozzles to which external piping is not connected (e.g. manways, inspection openings, nozzles for instruments and vent) shall be evaluated only taking into account the pressure thrust load.

Add section

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

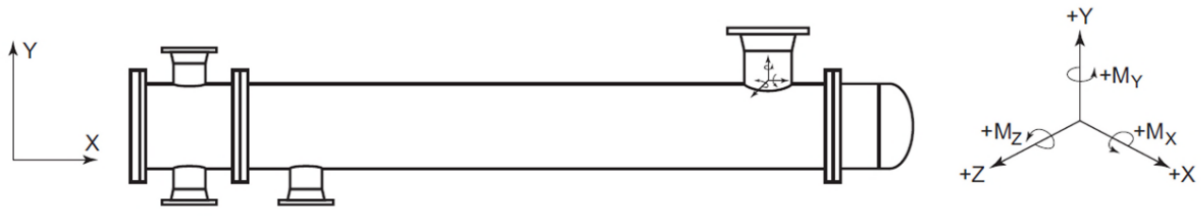

Figure 2 - Directions of moments and forces on nozzles

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.

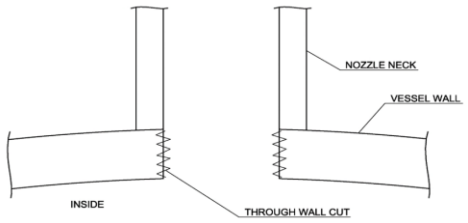

Figure 3 - Through-wall-cut

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.

Add section

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

Replace 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).

Replace 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, if all the following requirements are met:

a) Nozzles flanges pressure up to class 300;
b) Service with one of the 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.

Add to section

Additional manholes may be necessary in order to enable the internals removal, maintenance or inspection. This shall be established during detailing design by SELLER.

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.

Add to section

The use of two inspections openings, (located as far as possible from each other, in opposite sides of the vessel) 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).

4.7.9 Nozzle-to-vessel wall 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

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 with Inconel 625. The superposition of the coating over the weld overlay shall be as specified in I-ET-3010.00-1200-956-P4X-002 – GENERAL PAINTING.

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 S-619 J.12).

Add section

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

Add section

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.

Add section

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.

Add section

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 at least 2 manholes.

Add section

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.

Add section

4.7.23 Standard flanges shall be selected from ASME B16.5 and ASME B16.47 standards. API Spec 6A and ISO 27509 flanges might be used when there is no flange available from the above standards. Otherwise, custom designed flanges could be used.

Add section

4.7.24 Equipment nozzles used for instruments or standpipes connections shall not be positioned on the lowest bottom line of horizontal vessels (6 o´clock position) or bottom head of vertical vessels, because they are susceptible to clogging. Refer to General Criteria for Instrumentation Projects - I-ET-3010.00-1200-800-P4X-013 for instrumentation nozzle requirements.

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.

Add section

4.8.6 Custom designed flanges , as well as flanges in compliance with ISO 27509 or API 6A, when connecting to piping shall be supplied with companion flanges, bolts, nuts and gasket. Unless otherwise specified line blanks shall be supplied also. Materials for companion flange, line blanks, bolts, nuts and gasket shall be as per connecting piping spec.

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.

Add section

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

Add section

4.9.6 For custom designed flanges, **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.

Add section

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

Replace section

4.10.1 The skirt thickness shall not 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.

Replace 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.

Replace section

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

4.11 LEG SUPPORTS

Replace 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.

Add section

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.

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.

Add section

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

Add section

4.12.4 When the operating weight of vessel is greater than 200 kN (20 t) PTFE sliding plates shall be used in the sliding saddle support in accordance with Figure J.10a.

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).

Add 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.

Add section

4.16 ACCESS REQUIREMENT

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

a) safety or relief valve;
b) instruments requiring local reading;
c) accessories requiring frequent maintenance, operation or inspection.

Vessels that require frequent maintenance, operation or inspection activities (e.g. filters) shall be provided with permanent access for manways and cover flanges.

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

Manways and skirt's access openings shall be clearly accessible without any obstructions including the provision of any possible scaffolding spaces.

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

Add section

4.17 INTERNAL PIPING AND ACCESSORIES CONNECTED TO NOZZLES

4.17.1 Nozzles shall have an internal projection to allow butt weld (full penetration) configuration when internal piping or accessories are to be welded to these nozzles.

5 MATERIALS

5.1

Castings shall not be used.

Add 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.

Add to section

External parts, such as supports for ladders, platforms, piping, brackets and lifting lugs, shall not be welded directly to the vessel pressure boundary. A reinforcement pad of the same material as vessel shall be provided prior to welding.

Piping supports shall not be located on pressure vessels for lines susceptible to vibration, including multiphase flow.

Pads are not necessary for earthing lugs and clips for insulation.

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.

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

where

D_S is the skirt outside diameter

T_S is the skirt nominal thickness

Add 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

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.

Add to section

Additional requirements for PMI testing are presented in item 8.7.

Add 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 thermally 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) 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.

6.1.5 The distance between main seam welds (longitudinal and circumferential joints) and nozzles, reinforcement or other welded attachments shall be at least 50 mm (2 in), measured weld toe to weld toe (see Figure 4).

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).

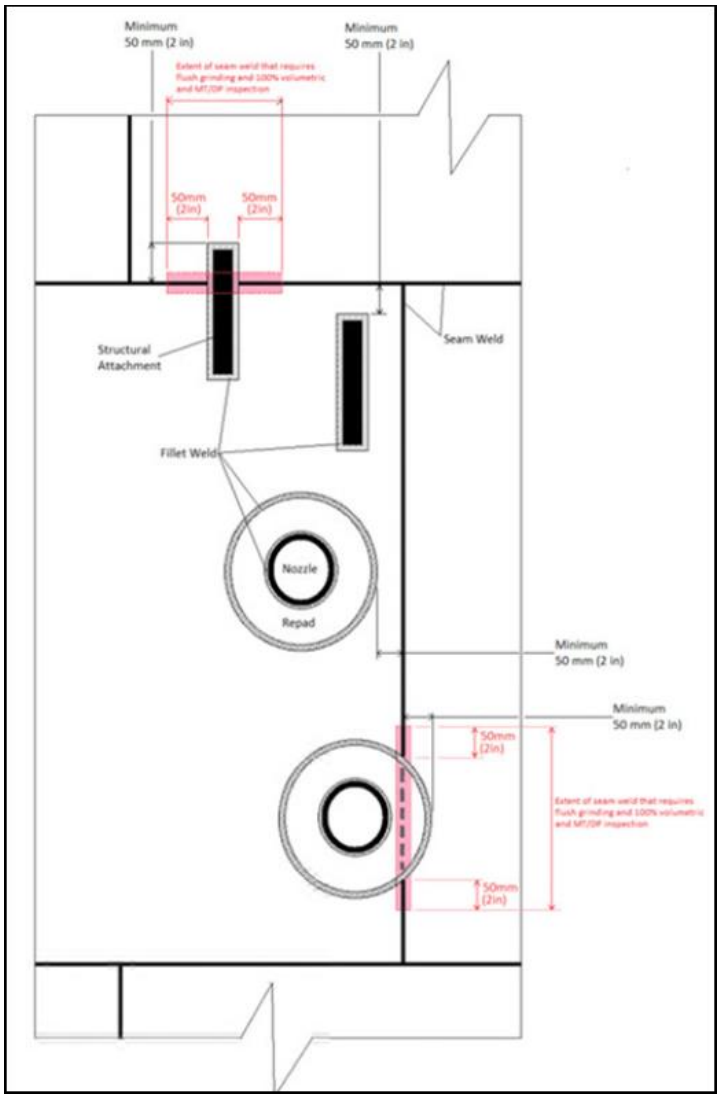

Figure 4 - Weld Seams Clearance and Overlapping

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.

Add section

6.1.13 Welds of the shell and heads shall not interfere with internal parts welded to the vessel.

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.

Add section

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.

Add section

6.1.15 Longitudinal welds of adjacent rings shall be at least 30º apart from each other.

Add section

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.

Add section

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.

Add section

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

Replace 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).

Add section

6.2.3 Welds between internal attachments and a pressure part shall be continuous (intermittent welds are not allowed), unless full penetration is required (see item A.11).

Add section

6.2.4 Reinforcement pads for internal accessories shall be provided with one 6 mm (1/4 in) diameter vent hole. This vent hole shall be sealed by welding immediately after welding the pad to the vessel wall, and before any PWHT, if required.

Add 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 liquid penetrant or magnetic particles.

7 HEAT TREATMENT

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

Add section

7.1

Post weld heat treatment shall be applied:

a) when required by design code (due to material and thickness) for all material, including cladded/overlaid pressure vessels;
b) even when not required by design code, for all carbon steel and low alloy steel pressure vessels for H_2S service and/or Amine service, except for cladded/overlaid pressure vessels.

Add section

7.2

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

Replace section

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.

Add section

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.

Add to section

When used in lieu of the radiographic examination, only automated or semi-automated ultrasonic examination shall be performed. Full record of the examination shall be provided with a 100 % coverage of the welding volume. Ultrasonic examination technique shall be PAUT and/or ToFD.

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.

Replace 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.

Add section

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.

Add section

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

Add section

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.

Add section

8.2.10 Welds in austenitic steels, austenic-ferritic steels, nickel-based alloys, dissimilar metal joints and other coarse grain materials cannot be tested by conventional UT. Only advanced ultrasonic techniques, e.g., phased array, FMC/TFM shall be used in these situations and the inspection procedure performance shall be demonstrated to BUYER.

8.3 MAGNETIC PARTICLE OR LIQUID PENETRANT EXAMINATION

Replace 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.

8.3.2 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.

Add 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.

Add section

8.4 VISUAL INSPECTION

8.4.1 A visual inspection shall be performed in all materials, sections and parts of the equipment, 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.

8.4.3 All welds shall be subjected to a visual inspection, internally and externally.

Add section

8.5 DIMENSIONAL INSPECTION

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

Add section

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.

Add section

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

Replace 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, UG-99(c) for div 1 or 8.2.1(e) for div 2, 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.

9.6

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.

Add to section

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.

Add section

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.

Add section

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.

Add section

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.

Add section

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.

Add section

9.12

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

a) The equipment shall be fully drained, dried and cleaned.
b) For 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

Replace 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.

Add 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 to 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.

11.5

Internal accessories that require coating shall be designed as to allow for the coating to be applied on all exposed surfaces.

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.

Replace Section

A.2

The requirements of ISO 15156/NACE MR0175 (all parts) shall be satisfied for base materials and welding procedures.

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.

Replace 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

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).

Replace 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.

Add section

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).

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.

Add to section

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

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).

Add section

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

Add section

B.1.7 When sour service is applicable the requirements of ISO 15156-2 are applicable to the base materials and welding procedures, and the requirements of ISO 15156-3 are applicable to the cladding material, overlay and cladding restoration welding procedures.

Add section

B.1.8 Cladded and weld overlaid plates shall be ultrasonically tested as per level C of ASTM 578 standard. Final thickness of the base material shall meet the minimum required according to the Calculation Report.

Add section

B.1.9 Formed heads or sections shall be ultrasonically tested after forming as per level C of ASTM 578 standard. The test shall include base material thickness measurement and disbonding evaluation.

Add section

B.1.10 When clad is required, it shall be applied entirely throughout the equipment, including nozzles, flanges, sealing faces, etc. Partial vessel cladding is not acceptable.

Add section

B.1.11 Considering the fabrication of pressure vessel with weld overlay vs. cladding selection, the shell and the heads shall have the same fabrication route. Therefore, if the shell is to be weld

overlaid, the heads shall be weld overlaid as well. If cladding is selected for the shell, the heads shall be obtained from cladded plates as well.

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.

Add section

B.2.5 CRA clad for flanges shall extend to all internally wet surfaces, including the sealing areas, as presented in the Figures B.1 and B.2 below.

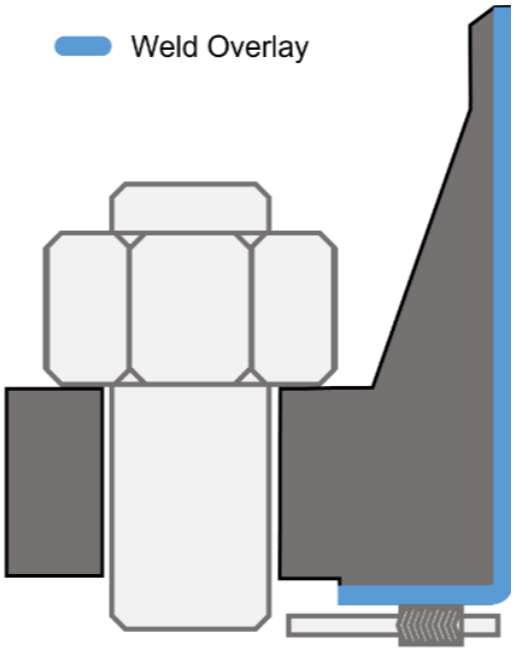

Figure B.1 - Equipment with internal weld overlay and RF flange

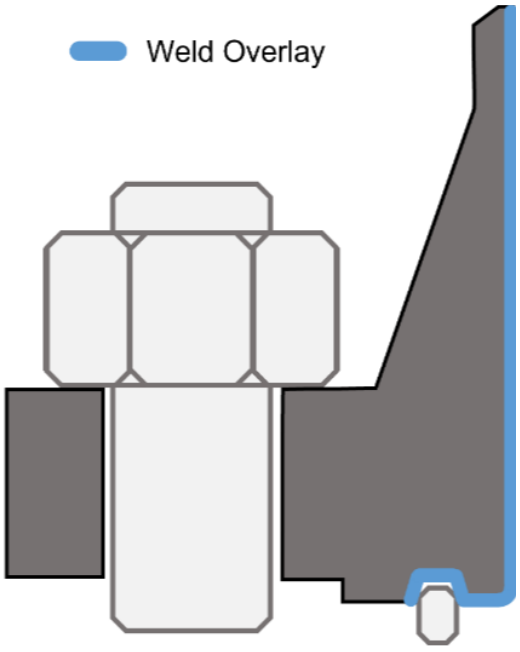

Figure B.2 – Equipment with internal weld overlay and RTJ flange.

B.3 Integral cladding

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.

Add to section

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.

Add to section

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.

Add section

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

B.4 Weld overlay

Replace 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 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

Add to section

Note: This section is also applicable for all materials listed in UCS Part of ASME VIII division 1.

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%.

Delete sections

C.3

C.4

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.

Replace section

C.6

Impact testing shall be performed for all components and welding procedures for design temperatures below -29ºC, even if it is not required by the design code.

Impact testing for welding procedures and production test plates 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

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

Add to section

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 any pressure vessel part.

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.

Replace section

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.

Replace section

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.

Test coupon for mechanical tests shall be welded to the part it represents, so that they share the same heat treatment. The effectiveness of the heat treatment shall also be demonstrated by performing an in situ optical metallography (portable equipment) on the equipment part. Acceptance criteria shall be as per ISO 17781.

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).

Add to section

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.

Add 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.

Add section

D.6.5 Pressure vessels made of material 22Cr and 25 Cr shall have 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°.

Add 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

Add 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.

Add Figure

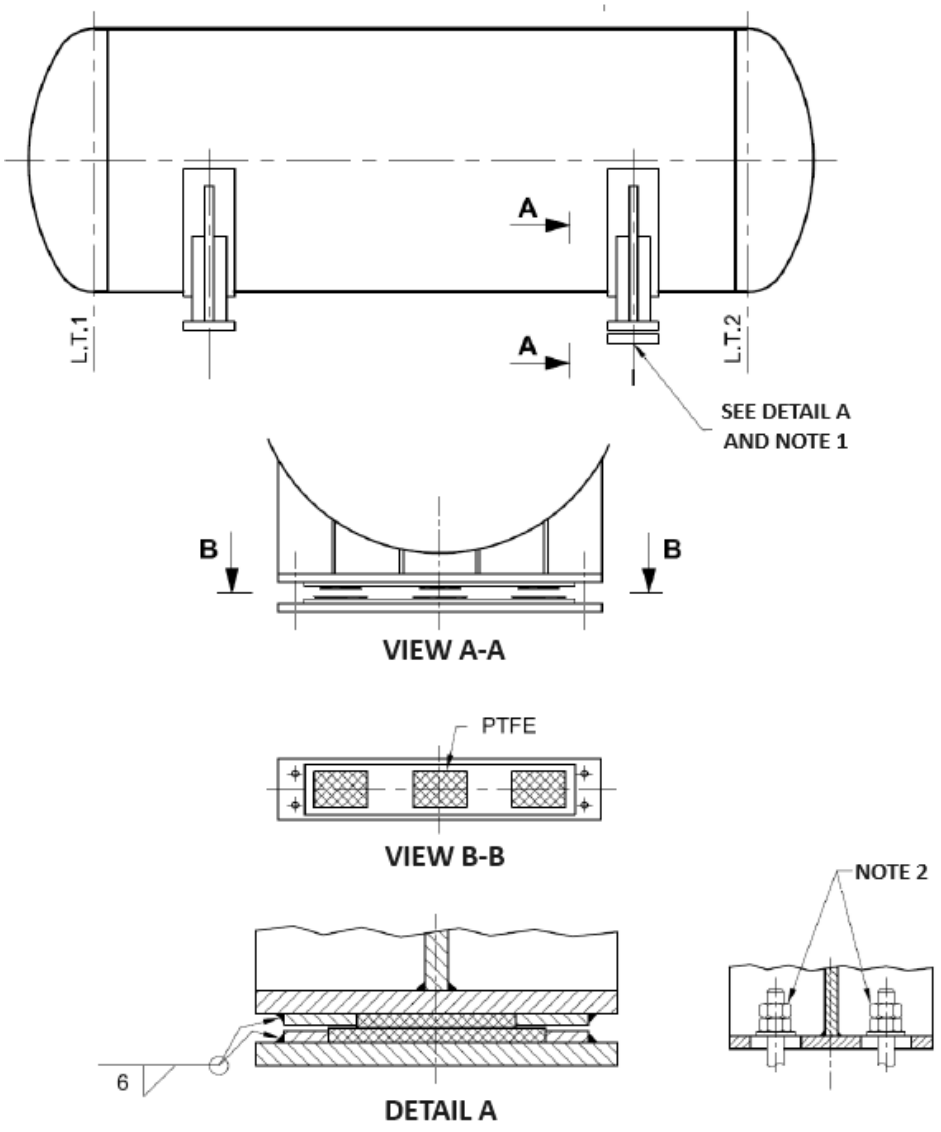

Figure J10a - Details of Saddle Sliding Plates

Note 1: see 4.12.4. PTFE pad shall be at least 2 mm thicker than the base plate.

Note 2: the lower nut shall be snug tight only, and the upper nut shall receive the recommended tightening torque

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

Delete Annex K

Note: The table from Annex N replaces Annex K.

Add 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.

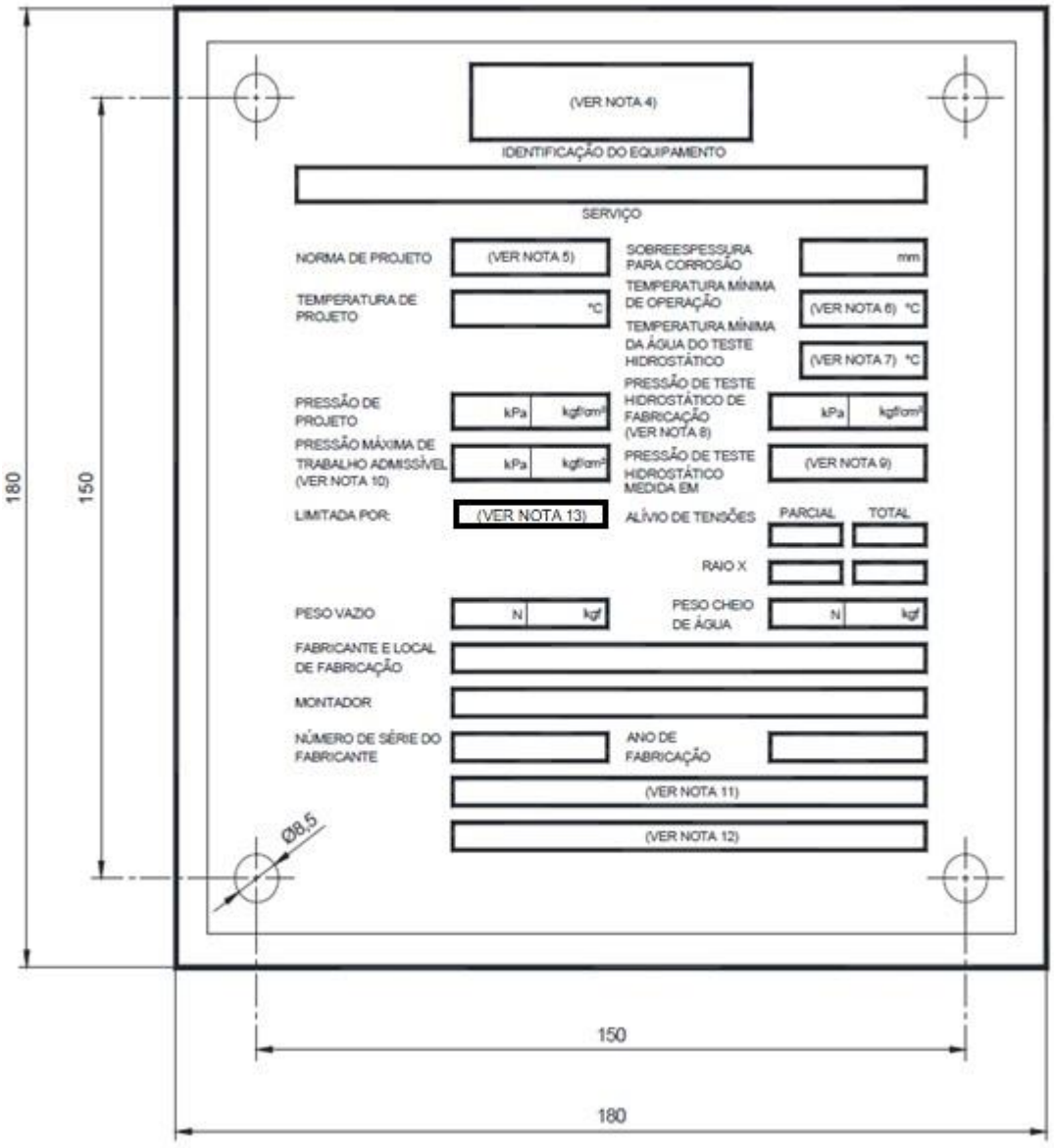

Figure L 1 - Nameplate (for translation of terms see Figure L.2)

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.

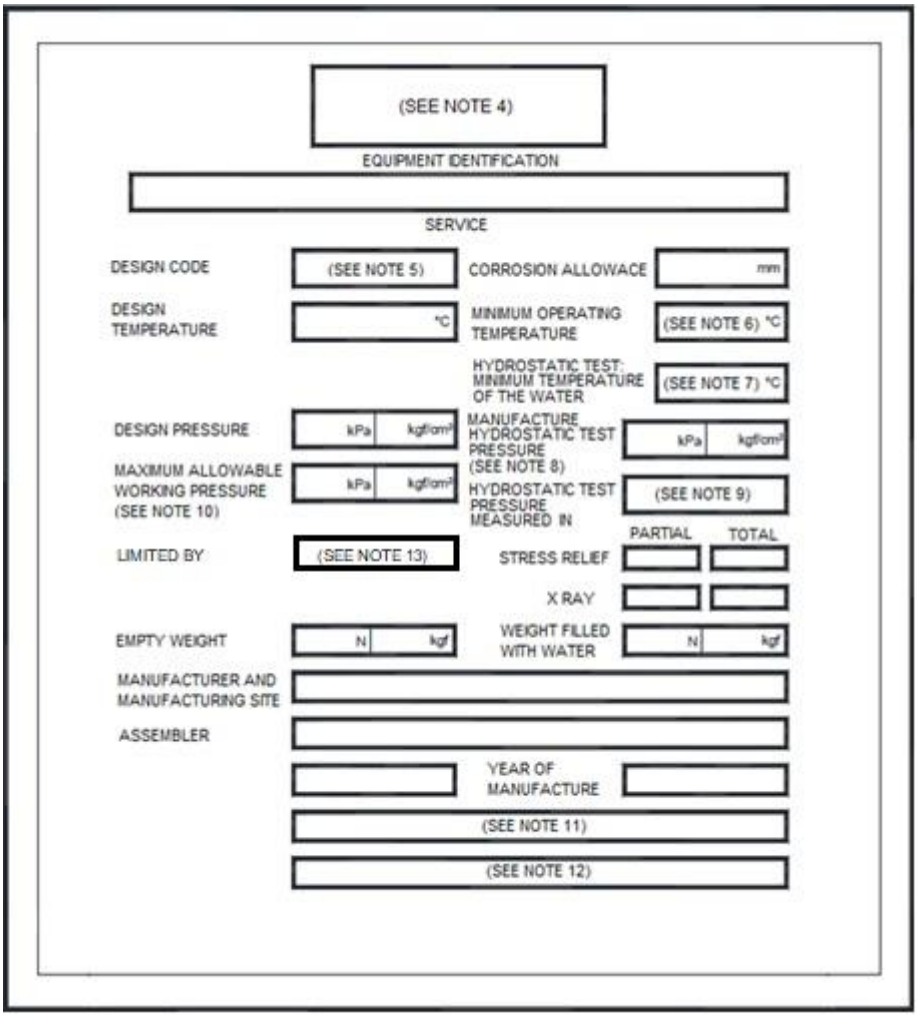

Figure L 2 - Translation of Terms Used in Figure L.1.

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 to item 9.1.2.

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: It shall be filled in with the component that limit the maximum allowable working pressure (corroded 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) according to I-ET-3010.00-1200-970-P4X-013 - COMPLIANCE WITH NR-13 AND SPIE REQUIREMENTS.

Add 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. calculation report (Native file of complete mechanical calculation shall be submitted with the report);
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.

Add section

ANNEX N – NOZZLE ALLOWABLE FORCES AND MOMENTS AT THE NOZZLE NECK TO SHELL/HEAD INTERFACE

NPS	Pressure Class	Mx (N.m)	My (N.m)	Mz (N.m)	Fx (N)	Fy (N)	Fz (N)	Mx (lbf.ft)	My (lbf.ft)	Mz (lbf.ft)	Fx (lbf)	Fy (lbf)	Fz (lbf)
2	**150**	540	860	680	3180	2540	3180	400	640	500	740	580	740
	300	680	1080	860	3980	3180	3980	500	800	640	900	720	900
	600	940	1500	1180	5560	4440	5560	700	1120	880	1260	1000	1260
	900	1800	2910	2280	10740	8580	10740	1320	2160	1680	2460	1950	2460
	1500	1800	2910	2280	10740	8580	10740	1320	2160	1680	2460	1950	2460
	2500	2010	3240	2550	11910	9510	11910	1470	2370	1890	2700	2160	2700
3	**150**	1160	1880	1480	4680	3740	4680	860	1380	1080	1060	840	1060
	300	1440	2340	1840	5860	4680	5860	1080	1720	1360	1340	1060	1340
	600	2020	3260	2560	8180	6540	8180	1500	2420	1900	1860	1480	1860
	900	3900	6300	4950	15810	12630	15810	2880	4650	3660	3570	2850	3570
	1500	3900	6300	4950	15810	12630	15810	2880	4650	3660	3570	2850	3570
	2500	4770	7680	6030	19290	15420	19290	3510	5670	4470	4350	3480	4350
4	**150**	1920	3080	2420	6040	4820	6040	1420	2280	1800	1360	1080	1360
	300	2380	3860	3040	7540	6020	7540	1760	2840	2240	1700	1360	1700
	600	3340	5400	4240	10540	8420	10540	2460	3980	3120	2380	1900	2380
	900	6450	10380	8160	20310	16230	20310	4740	7680	6030	4590	3660	4590
	1500	7140	11550	9090	22560	18030	22560	5280	8520	6690	5070	4050	5070
	2500	7860	12690	9990	24810	19830	24810	5790	9360	7380	5610	4470	5610
6	**150**	4140	6680	5240	8860	7080	8860	3060	4920	3880	2000	1600	2000
	300	7220	11680	9180	15480	12380	15480	5340	8620	6760	3500	2800	3500
	600	9280	15000	11800	19900	15920	19900	6860	11080	8700	4480	3580	4480
	900	17010	27510	21630	36510	29190	36510	12570	20280	15960	8220	6570	8220
	1500	20130	32520	25560	43140	34500	43140	14850	23970	18840	9720	7770	9720
	2500	21660	35010	27510	46440	37140	46440	15990	25830	20280	10470	8370	10470
8	**150**	7000	11300	8880	11540	9220	11540	5160	8340	6560	2600	2080	2600
	300	12240	19780	15540	20160	16120	20160	9020	14600	11460	4560	3640	4560
	600	17480	28260	22200	28780	23020	28780	12900	20840	16380	6480	5180	6480
	900	36690	59340	46620	60450	48360	60450	27060	43770	34380	13620	10890	13620
	1500	41940	67800	53280	69090	55260	69090	30930	50010	39300	15540	12420	15540
	2500	44580	72030	56610	73410	58710	73410	32880	53130	41760	16500	13200	16500
10	**150**	10860	17560	13800	14360	11480	14360	8020	12960	10180	3240	2580	3240
	300	19000	30720	24140	25140	20100	25140	14020	22660	17800	5660	4520	5660
	600	27160	43880	34480	35880	28700	35880	20020	32360	25440	8080	6460	8080
	900	57000	92160	72420	75360	60270	75360	42060	67980	53400	16950	13560	16950
	1500	65160	105330	82740	86100	68880	86100	48060	77670	61020	19350	15480	19350
	2500	69210	111900	87930	91470	73170	91470	51060	82530	64860	20610	16470	20610

NPS	Pressure Class	Mx (N.m)	My (N.m)	Mz (N.m)	Fx (N)	Fy (N)	Fz (N)	Mx (lbf.ft)	My (lbf.ft)	Mz (lbf.ft)	Fx (lbf)	Fy (lbf)	Fz (lbf)
12	150	15280	24700	19400	17040	13620	17040	11280	18220	14320	3840	3060	3840
	300	26740	43220	33960	29780	23820	29780	19720	31880	25040	6700	5360	6700
	600	30560	49380	38800	34060	27240	34060	22540	36420	28620	7660	6120	7660
	900	51570	83340	65490	57450	45960	57450	38040	61470	48300	12960	10350	12960
	1500	63000	101850	80040	70200	56160	70200	46470	75120	59040	15810	12630	15810
	2500	68730	111120	87300	76590	61260	76590	50700	81960	64380	17220	13770	17220
14	150	23020	37220	29240	23380	18700	23380	16980	27440	21560	5260	4200	5260
	300	32240	52100	40940	32700	26160	32700	23780	38420	30200	7360	5880	7360
	600	46040	74420	58480	46740	37380	46740	33960	54880	43120	10500	8400	10500
	900	89790	145140	114030	91110	72870	91110	66210	107040	84090	20490	16380	20490
	1500	124290	200940	157890	126120	100890	126120	91680	148200	116430	28350	22680	28350
	2500	151920	245580	192960	154140	123300	154140	112050	181110	142320	34650	27720	34650
16	150	24060	38880	30560	28480	22780	28480	17740	28680	22540	6400	5120	6400
	300	42100	68040	53460	49840	39860	49840	31040	50180	39440	11200	8960	11200
	600	60140	97200	76380	71180	56940	71180	44340	71680	56320	16000	12800	16000
	900	126270	204120	160380	149490	119580	149490	93120	150540	118290	33600	26880	33600
	1500	144300	233280	183300	170820	136650	170820	106440	172050	135180	38400	30720	38400
	2500	153330	247860	194760	181500	145200	181500	113070	182790	143640	40800	32640	40800
18	150	30440	49220	38680	32060	25640	32060	22460	36300	28520	7200	5760	7200
	300	53280	86120	67660	56060	44840	56060	39300	63520	49900	12600	10080	12600
	600	76100	123020	96660	80080	64060	80080	56120	90720	71280	18000	14400	18000
	900	148410	239910	188490	156150	124920	156150	109440	176910	139020	35100	28080	35100
	1500	182640	295260	231990	192210	153750	192210	134700	217740	171090	43200	34560	43200
	2500	194070	313710	246480	204210	163350	204210	143100	231360	181770	45900	36720	45900
20	150	37580	60760	47740	35600	28480	35600	27720	44800	35200	8000	6400	8000
	300	65780	106320	83540	62280	49820	62280	48500	78400	61600	14000	11200	14000
	600	84560	136700	107400	80080	64060	80080	62360	100800	79200	18000	14400	18000
	900	183210	296160	232710	173490	138780	173490	135120	218400	171600	39000	31200	39000
	1500	211380	341730	268500	200190	160140	200190	155880	252000	198000	45000	36000	45000
	2500	239580	387300	304290	226890	181500	226890	176670	285600	224400	51000	40800	51000
24	150	67640	109360	85920	53400	42720	53400	49900	80640	63360	12000	9600	12000
	300	94700	153100	120300	74760	59800	74760	69840	112900	88720	16800	13440	16800
	600	135280	218700	171840	106780	85420	106780	99780	161280	126720	24000	19200	24000
	900	263820	426480	335100	208200	166560	208200	194550	314520	247110	46800	37440	46800
	1500	365280	590490	463950	288270	230610	288270	269370	435480	342150	64800	51840	64800
	2500	446430	721710	567060	352320	281850	352320	329220	532230	418200	79200	63360	79200
26	150	37900	56860	48140	60400	48400	60400	27960	41940	35500	13580	10880	13580
	300	37900	56860	48140	74640	59780	74640	27960	41940	35500	16780	13440	16780
	600	79340	119020	100760	110140	88160	110140	58520	87780	74320	24760	19820	24760
	900	180930	271410	229770	223800	179220	223800	133440	200190	169470	50310	40290	50310

NPS	Pressure Class	Mx (N.m)	My (N.m)	Mz (N.m)	Fx (N)	Fy (N)	Fz (N)	Mx (lbf.ft)	My (lbf.ft)	Mz (lbf.ft)	Fx (lbf)	Fy (lbf)	Fz (lbf)
28	150	47640	71460	60500	67340	54000	67340	35140	52700	44620	15140	12140	15140
	300	47640	71460	60500	74460	59700	74460	35140	52700	44620	16740	13420	16740
	600	98820	148240	125500	113420	90920	113420	72880	109340	92560	25500	20440	25500
	900	223950	335940	284430	239280	191910	239280	165180	247770	209790	53790	43140	53790
30	150	60560	90840	76920	74380	59600	74380	44660	67000	56740	16720	13400	16720
	300	60560	90840	76920	74380	59600	74380	44660	67000	56740	16720	13400	16720
	600	124300	186460	157880	116820	93680	116820	91680	137520	116440	26260	21060	26260
	900	280560	420870	356310	254880	204450	254880	206940	310410	262800	57300	45960	57300
32	150	74660	112000	94820	79260	63600	79260	55060	82600	69940	17820	14300	17820
	300	74660	112000	94820	79260	63600	79260	55060	82600	69940	17820	14300	17820
	600	153160	229720	194540	124640	100000	124640	112960	169440	143480	28020	22480	28020
	900	345720	518550	439050	271830	218040	271830	255000	382470	323820	61110	49020	61110
36	150	106180	159280	134840	89240	71520	89240	78320	117480	99460	20060	16080	20060
	300	106180	159280	134840	89240	71520	89240	78320	117480	99460	20060	16080	20060
	600	217060	325620	275660	140200	112460	140200	160100	240160	203320	31520	25280	31520
	900	494430	741660	627930	305850	245400	305850	364680	547020	463140	68760	55170	68760
38	150	111040	166540	141040	94120	75540	94120	81900	122840	104020	21160	16980	21160
	300	111040	166540	141040	94120	75540	94120	81900	122840	104020	21160	16980	21160
	600	241220	361840	306340	147940	118680	147940	177920	266880	225940	33260	26680	33260
	900	622530	933810	790620	322800	259020	322800	459150	688740	583140	72570	58230	72570
40	150	127980	191980	162540	106220	85220	106220	94400	141600	119880	23880	19160	23880
	300	127980	191980	162540	106220	85220	106220	94400	141600	119880	23880	19160	23880
	600	282660	424000	359000	177040	141980	177040	208480	312720	264780	39800	31920	39800
	900	744300	1116420	945270	339900	272640	339900	548970	823440	697200	76410	61290	76410
42	150	148460	222700	188540	111480	89500	111480	109500	164260	139060	25060	20120	25060
	300	148460	222700	188540	111480	89500	111480	109500	164260	139060	25060	20120	25060
	600	331820	497740	421420	185840	149100	185840	244740	367120	310820	41780	33520	41780
	900	852000	1278000	1082010	356850	286230	356850	628410	942600	798060	80220	64350	80220
44	150	174460	261700	221560	116820	93680	116820	128680	193020	163420	26260	21060	26260
	300	174460	261700	221560	116820	93680	116820	128680	193020	163420	26260	21060	26260
	600	386320	579480	490620	194740	156220	194740	284940	427400	361860	43780	35120	43780
	900	929280	1393920	1180200	373770	299850	373770	685410	1028100	870480	84030	67410	84030
46	150	197780	296680	251180	122140	97940	122140	145880	218820	185260	27460	22020	27460
	300	197780	296680	251180	122140	97940	122140	145880	218820	185260	27460	22020	27460
	600	439340	659000	557980	203560	163340	203560	324040	486060	411540	45760	36720	45760
	900	1015680	1523520	1289910	390870	313590	390870	749130	1123680	951390	87870	70500	87870
48	150	228320	342480	289960	127400	102220	127400	168400	252600	213860	28640	22980	28640
	300	228320	342480	289960	127400	102220	127400	168400	252600	213860	28640	22980	28640
	600	504600	756900	640840	212360	170360	212360	372180	558260	472660	47740	38300	47740
	900	1105890	1658880	1404480	407820	327210	407820	815670	1223520	1035900	91680	73560	91680

NPS	Pressure Class	Mx (N.m)	My (N.m)	Mz (N.m)	Fx (N)	Fy (N)	Fz (N)	Mx (lbf.ft)	My (lbf.ft)	Mz (lbf.ft)	Fx (lbf)	Fy (lbf)	Fz (lbf)
50	150	263700	395580	334880	132740	106500	132740	194500	291760	247000	29840	23940	29840
	300	263700	395580	334880	132740	106500	132740	194500	291760	247000	29840	23940	29840
	600	567680	851500	720960	221260	177480	221260	418700	628040	531760	49740	39900	49740
52	150	296240	444360	376220	138080	110760	138080	218500	327740	277480	31040	24900	31040
	300	296240	444360	376220	138080	110760	138080	218500	327740	277480	31040	24900	31040
	600	635960	953960	807660	230060	184600	230060	469060	703600	595700	51720	41500	51720
54	150	336000	504020	426740	143420	115040	143420	247820	371740	314740	32240	25860	32240
	300	336000	504020	426740	143420	115040	143420	247820	371740	314740	32240	25860	32240
	600	719000	1078500	913140	238960	191720	238960	530300	795460	673500	53720	43100	53720
56	150	374100	561180	475100	148660	119300	148660	275920	413900	350420	33420	26820	33420
	300	374100	561180	475100	148660	119300	148660	275920	413900	350420	33420	26820	33420
	600	798660	1198000	1014280	247760	198840	247760	589060	883600	748100	55700	44700	55700
58	150	420380	630600	533860	154000	123580	154000	310060	465100	393760	34620	27780	34620
	300	420380	630600	533860	154000	123580	154000	310060	465100	393760	34620	27780	34620
	600	840980	1261500	1068080	256660	205860	256660	620280	930440	787780	57700	46280	57700
60	150	464500	696760	589920	159340	127840	159340	342600	513900	435100	35820	28740	35820
	300	464500	696760	589920	159340	127840	159340	342600	513900	435100	35820	28740	35820
	600	900000	1349980	1143000	265460	212980	265460	663800	995700	843040	59680	47880	59680

Note: Annex N is based on the values from API 660 table 2 and from IOGP 619 Annex K with a multiplier factor applied: multiplier factor 2(two) up to class 600 and 3(three) for class 900 to 2500.

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