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	CLIENT:	SRGE						SHEET 1 of 27	
	PROJECT:	REFERENCE BASIC DESIGN						1001056398 0010	
	AREA:	BÚZIOS							
<b>DDP-SRGE</b>	TITLE: <b>SHELL &amp; TUBE HEAT EXCHANGER SPECIFICATION</b>		NP-1						
			ESUP						
MICROSOFT WORD / V.2010 / I-ET-3010.1M-1200-451-P4X-001_A									
<b>INDEX OF REVISIONS</b>									
<b>REV.</b>	<b>DESCRIPTION AND/OR REVISED SHEETS</b>								
0	ORIGINAL ISSUE.								
A	GENERAL REVISION ACCORDING TO THE REQUIREMENTS OF IOGP S-614								
	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
DATE	AGO/13/20	JUL/23/20							
DESIGN	ESUP	ESUP							
EXECUTION	IZAO	DANISCHMIDT							
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TITLE:


**SHELL & TUBE HEAT EXCHANGER SPECIFICATION**


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**WORKING GROUP RESPONSIBLE FOR REVISION A**

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## OBJECTIVE

This Specification establishes the technical requirements for the execution of the design of engineering, materials, fabrication, inspection, testing and certification of all Shell & Tube Heat Exchangers (including Double Pipe and Multi-Tube Hairpins) to be supplied to PETROBRAS FPSOs. This specification complements:

- API 660,
- IOGP S-614 and its amendments (IOGP S-614L and IOGP S-614Q)
- Technical Specification I-ET-3010.00-1200-540-P4X-001 - REQUIREMENTS FOR PRESSURE VESSELS DESIGN.

This specification is written as an overlay to IOGP S-614, version 1.0, December 2018, following the section structure of this standard, to assist in cross-referencing the requirements. The IOGP S-614 specification is based on API-660.

If a section or subsection of: API 660 or IOGP S-614 is not mentioned in this document, it means that no supplementary requirements and no modifications are considered in this respective section. Then, the respective section of IOGP S-614 or API 660 is mandatory. All modifications into API 660 or IOGP S-614 requirements are identified in this document with: **Add** (add to section or add new section), **Replace** (part of or entire section) or **Delete**.

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

The requirements herein listed are applicable to all players performing such related activities within the scope of this unit, including **CONTRACTORS**, 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 **CONTRACTOR**.


## SECTION I – COMPLEMENTARY REQUIREMENTS TO IOGP S-614 AND API 660


### 1 SCOPE


### 2 NORMATIVE REFERENCES

Add to List

API 660	- Shell and Tube Heat Exchangers for General Refinery Services
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<table><tr><td>IOGP S-614 (December 2018)</td><td>- Supplementary Specification to API Standard 660 Shell-and-Tube Heat Exchangers</td></tr><tr><td>IOGP S-614L (December 2018)</td><td>- Information requirements for Shell-and-Tube Heat Exchanger</td></tr><tr><td>IOGP S-614Q (December 2018)</td><td>- Quality requirements for Shell-and-Tube Heat Exchanger</td></tr><tr><td>IOGP S-619 (December 2018)</td><td>- Specification for Unfired, Fusion Welded Pressure Vessels</td></tr><tr><td>ASME BPVC Sec II</td><td>- Materials</td></tr><tr><td>ASME BPVC Sec VIII Div.1 and Div.2</td><td>- Boiler and Pressure Vessel Code. Rules for construction of pressure vessels</td></tr><tr><td>ASME B 16.47</td><td>- Large Diameter Steel Flanges NPS 26 Through NPS 60;</td></tr><tr><td>ABNT NBR 6123</td><td>- “Forças devidas ao Vento em Edificações” (Brazilian technical standard for wind load calculation)</td></tr></table> <p><u>Add to Section</u></p> <p><b>2.1 CLASSIFICATION SOCIETY</b></p> <p><b>CONTRACTOR</b> shall perform the work in accordance with the requirements of the Classification Society.</p> <p><b>CONTRACTOR</b> is responsible submit to the Classification Society the documentation in compliance with stated Rules.</p> <p><b>2.2 GOVERNMENT REGULATION</b></p> <table><tr><td>NR-13</td><td>- Caldeiras, Vasos de Pressão, Tubulações e Tanques Metálicos de Armazenamento</td></tr><tr><td>NR-37</td><td>- Saúde e Segurança em Plataformas de Petróleo</td></tr></table> <p>Brazilian Government regulations and Classification Society Rules are mandatory and shall prevail, if more stringent, over the requirements of this specification and other references herein. In case of conflict, <b>CONTRACTOR</b> shall submit an issue to <b>OWNER</b>’s clarification.</p> <p><b>2.3 REFERENCE DOCUMENTS</b></p> <table><tr><td>DR-ENGP-I-1.15</td><td>- COLOR CODING</td></tr></table>					IOGP S-614 (December 2018)	- Supplementary Specification to API Standard 660 Shell-and-Tube Heat Exchangers	IOGP S-614L (December 2018)	- Information requirements for Shell-and-Tube Heat Exchanger	IOGP S-614Q (December 2018)	- Quality requirements for Shell-and-Tube Heat Exchanger	IOGP S-619 (December 2018)	- Specification for Unfired, Fusion Welded Pressure Vessels	ASME BPVC Sec II	- Materials	ASME BPVC Sec VIII Div.1 and Div.2	- Boiler and Pressure Vessel Code. Rules for construction of pressure vessels	ASME B 16.47	- Large Diameter Steel Flanges NPS 26 Through NPS 60;	ABNT NBR 6123	- “Forças devidas ao Vento em Edificações” (Brazilian technical standard for wind load calculation)	NR-13	- Caldeiras, Vasos de Pressão, Tubulações e Tanques Metálicos de Armazenamento	NR-37	- Saúde e Segurança em Plataformas de Petróleo	DR-ENGP-I-1.15	- COLOR CODING
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<div><div>DR-ENGP-M-I-1.3</div><div>- SAFETY ENGINEERING</div></div> <div><div>I-ET-3010.00-1200-540-P4X-001</div><div>- REQUIREMENTS FOR PRESSURE VESSELS DESIGN</div></div> <div><div>I-ET-3010.00-1200-251-P4X-001</div><div>- BOLT MATERIALS</div></div> <div><div>I-ET-3010.00-1200-955-P4X-001</div><div>- WELDING</div></div> <div><div>I-ET-3010.1M-1000-970-P4X-002</div><div>- REQUIREMENTS FOR NDT</div></div> <div><div>I-ET-3010.00-0000-970-P4X-001</div><div>- REQUIREMENTS FOR PROCEDURES AND PERSONNEL QUALIFICATION AND CERTIFICATION</div></div> <div><div>I-ET-3010.00-1200-956-P4X-002</div><div>- GENERAL PAINTING</div></div> <div><div>I-ET-3010.00-1200-956-P4X-003</div><div>- THERMAL SPRAY COATING APPLICATION OF ALUMINUM</div></div> <div><div>I-ET-3010.00-1200-431-P4X-001</div><div>- THERMAL INSULATION FOR MARITIME INSTALLATIONS</div></div> <div><div>I-DE-3010.00-5140-700-P4X-003</div><div>- GROUNDING INSTALLATION TYPICAL DETAILS</div></div> <div><div>I-ET-3010.00-1200-940-P4X-002</div><div>- GENERAL TECHNICAL TERMS</div></div> <div><div>I-ET-3A36.00-1000-941-PPC-001_D</div><div>- METOCEAN DATA (Revision D)</div></div> <div><div>I-RL-3010.1M-1350-960-P4X-009</div><div>- MOTION ANALYSIS</div></div>				
<h3>3 TERMS AND DEFINITIONS</h3>				
<u>Add to Section</u>				
Terms and definitions are also established in the latest revision of I-ET-3010.00-1200-940-P4X-002 - GENERAL TECHNICAL TERMS.				
<h3>4 GENERAL</h3>				
<h4>4.1</h4>				
<u>Replace section with</u>				
The engineering, fabrication, materials specification, inspection and testing of Shell & Tube and Double Pipe (including Multi-Tube Hairpin) heat exchangers shall be in accordance with ASME VIII Division 1 or Division 2. Pressure retaining parts shall also meet all the requirements from I-ET-3010.00-1200-540-P4X-001 - REQUIREMENTS FOR PRESSURE VESSELS DESIGN.				

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**4.2**

Add to Section

All shell-and-tube heat exchangers shall be in accordance with one of the types indicated in the TEMA standard. For any heat exchanger that does not precisely correspond to any of the TEMA standardized types, thorough description and drawings, giving complete details, shall be presented and shall be approved by **OWNER**.

**4.3**

Add to Section

All Shell & Tube Heat Exchangers shall comply with the requirements of NR-13.

**4.12**

Replace section with

The use of expansion joint will in no case be accepted.

**4.14**

Add to Section


In those cases where **OWNER** provides data sheets, basic drawings showing the arrangement and general dimensions or other specific documents for the heat exchanger, the mechanical and thermal designs shall fully comply with those documents, which shall prevail over this Technical Specification. Any discrepancies or alternatives suggested will only be accepted after expressly approved by **OWNER**. **CONTRACTOR** shall submit Mechanical calculation report for **OWNER**’s approval.

For heat exchangers not designed by **OWNER**, **CONTRACTOR** shall be responsible for the thermal and mechanical design and shall guarantee that the equipment meets the performance specified: heat transfer and pressure drop at fouling conditions. **CONTRACTOR** shall submit a complete calculation report (thermal and mechanical) for **OWNER**’s approval.

**4.15**

Add to the end of section

For field (or future) hydrostatic test condition, motion induced loads (L14) shall be considered, in addition to the other related items of table 8, in Design load combination.

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Motion induced loads shall be in accordance with MOTION ANALYSIS report [document supplied by **OWNER**].

A wind basic velocity of 45 m/s shall be considered for wind load calculations in accordance with ABNT NBR 6123 Standard.

Add new section

**4.16**

In the mechanical design of stacked heat exchangers, with more than one shell directly connected to the other, the additional stresses due to the weights and stresses resulting from differential expansion between shells shall always be taken into account in the various components, especially supports and nozzles.

Add new section

**4.17**

**CONTRACTOR** shall design and fabricate the equipment for a minimum lifetime of 30 years.

Add new section

**4.18**

Heat exchangers identical or of the same type shall contain the largest possible number of exchangeable parts. In particular, the tube bundle and test ring shall be exchangeable with other equipment whenever this is economically practicable.

**5 PROPOSAL INFORMATION REQUIRED**

**5.2**

Delete item d (the use of expansion joints is not allowed).

**5.5**


Add to end of section

c) Spare parts list recommended for 2 (two) years operation.

**6 DRAWINGS AND OTHER REQUIRED DATA**

**6.3**



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Add to list

q) all documents required by NR-13;  
r) weld map records.

## 7 DESIGN

### 7.1 Design Temperature and Design Pressure

#### 7.1.1

Add to the end of section

When not previously informed by **OWNER**, for shell and tubes heat exchangers working with gas, bolt material selection shall be evaluated for the possibility of temperature reduction due to flange leakage. **CONTRACTOR** shall submit a study informing the minimum expected temperature and the bolt material selected for such case.

#### 7.1.3

Replace section with

No part of the heat exchanger shall be designed for differential pressure.

### 7.2 Cladding for Corrosion Allowance

#### 7.2.8

Replace section with

Minimum of two layers shall be applied for all weld overlay.

Add new section


#### 7.2.16

Plates shall be ultrasonically tested as per acceptance criteria agreed with the purchaser. The disbonding assessment shall meet at least level B of ASTM 578 standard. Final thickness shall meet the minimum required according to the Calculation Report.

Add new section

#### 7.2.17

Formed heads or sections shall be ultrasonically tested after forming. The test shall include metal base's thickness measurement and disbonding evaluation.

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Add new section

**7.2.18**

Additional requirements for weld overlay for corrosion allowance shall be in accordance with I-ET-3010.00-1200-955-P4X-001 – WELDING.

**7.3 Shell Supports**

**7.3.7**

Add to end of section

Grounding lugs shall be according to I-DE-3010.00-5140-700-P4X-003 – GROUNDING INSTALLATION TYPICAL DETAILS.

Add new section

**7.3.8**

Shell & tubes heat exchangers supports shall be also in accordance with I-ET-3010.00-1200-540-P4X-001 - REQUIREMENTS FOR PRESSURE VESSELS DESIGN.

**7.4 Stationary and Floating Heads**

**7.4.12**

Add to section

To increase rigidity of the assembly of floating head cover, split rings shall be coupled by means of ring segments (attachment plates) at least 25 mm thick and attached by at least 4 bolts, in accordance with **Figure 1**.

**7.5 Tube Bundle**

**7.5.1 Tubes**

**7.5.1.3**

Replace section with

Finned tubes shall not be accepted.

Add new section

**7.5.1.5**

The maximum recommended weight for the tube bundle is 10000 kg. Weights exceeding this value shall be approved by **OWNER**, in which case **CONTRACTOR** shall include any devices needed for the use of a bundle extractor.



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### 7.5.2 Tubesheets

#### 7.5.2.7

Replace last sentence

For other cases, tubesheet connection details indicated in ASME Section VIII, Div. 1, Figure UW-13.2 Type (i), (j) or (k) may be accepted. Use of alternative configurations shall be subject to OWNER's approval.

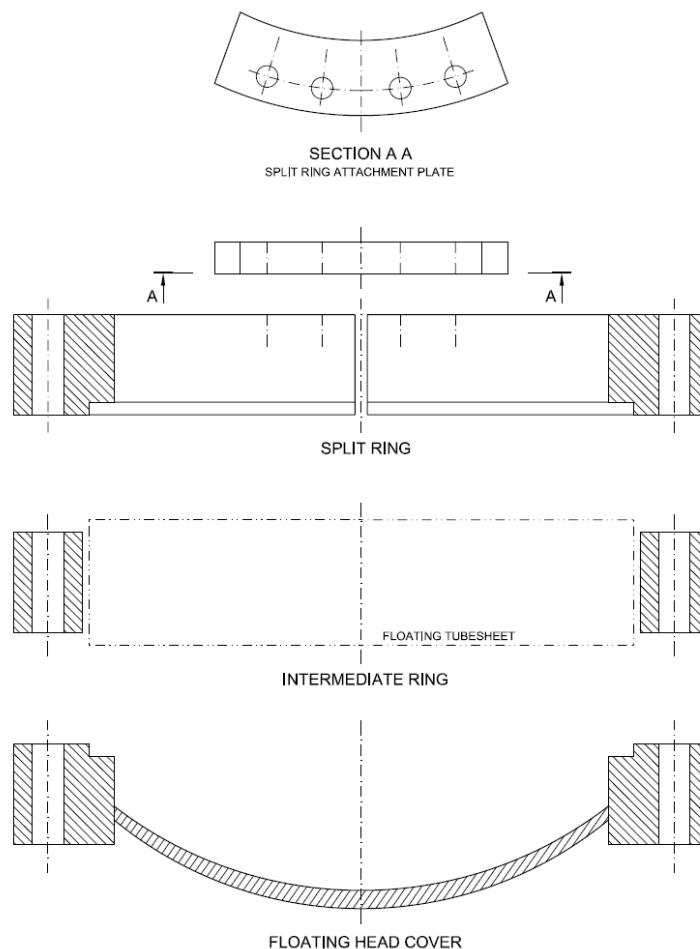



Figure 1-Floating Head Cover Assembly

### 7.5.6 Tube Bundle Skid Bars

#### 7.5.6.1

Replace first sentence with

For all removable tube bundle with mass of more than 3000 kg or for heat exchangers with anticorrosive clad, a continuous sliding surfaces and skid bars shall be provided to facilitate the bundle removal and to prevent damage of the clad. Skid bars shall be welded to the transverse baffles and support plates to form a continuous sliding surface. These bars and tracks shall be made of material resistant to corrosion caused by the shell fluid. See A.4.3 for additional guidance.

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**7.5.6.7**

Replace first section with

Skid bars dimensions shall be in accordance with Table 10. The skid bars shall be radially orientated and located between 15° to 20° from the vertical centerline. Skid design for bundles over 10000 kg shall be subject to approval by **OWNER**. See A.4.3 for additional guidance.

**7.5.7 Tube-to-Tubesheet Joint**

**7.5.7.3**

Replace section with

**CONTRACTOR** shall consider API 660 Annex A A.4.4 to define which tube-to-tubesheet joints shall be designed as strength-welded, seal-welded and or expanded.

**7.6 Nozzles and Other Connections**

**7.6.3**

Add to sentence

The use of half-coupling shall not be acceptable. No threaded connections shall be screwed directly into any pressure part of the heat exchanger.

**7.6.5**

Replace section with

Slip-on flanges (SO) may be used for inspection openings and manways since all the following requirements are met:

- Nozzles flanges pressure up to 300;
- Service with following fluids: compressed air, inert gases or water;
- Corrosion allowance up to 3 mm;
- Impact test is not required;
- PWHT is not required.


  

**7.6.9**

Add to the end of section

For nozzles not connected to pipes, such as manways, the evaluation shall be performed according to finite element method (FEM) or WRC Bulletin 368, provided its limitations for use are met.

For all nozzles the effect of pressure thrust shall be considered in stress analysis.

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**7.6.13**

Replace section with

The use of set-on nozzles is not allowed.

**7.7 Flanged External Girth Joints**

**7.7.2**

Add to section

Ring-type flanges made of bar of any rating shall be obtained from forged rings **OR ROLLED**, having not more than 2 fully radiographed butt welds. These flanges shall be heat treated as required in ASME Code Section VIII, Division 1, and the surfaces of the original plate shall be parallel to the axis of the finished flange. These flanges are only allowed if previously approved by **OWNER**.

**7.7.13**

Add to section

Forged steel flanges that have all their dimensions (including hole circle, number and diameter of bolts) exactly in accordance with ASME B16.5 or B16.47 standards are accepted for working pressures and temperatures up to the limits established above, without the need for special calculations. Flanges of any other dimensions or construction systems shall obligatorily be calculated in accordance with ASME Code, Section VIII, Div 1, and calculations shall be included in Mechanical Calculation Report to **OWNER**'s approval.

**7.8.7**

Replace first sentence and Equations (1) and (2)

For stationary tubesheets with gaskets on both the shell and tube sides of the tubesheet, in Step 6 of ASME PCC-1, the following additional checks, as calculated by Equation (1) shall consider the selected assembly bolt stress without include the effects of pressure acting from the opposing side of the tubesheet. In this case, the maximum design pressure,  $P_{\max}$ , shall be taken individually, considering the pressure in the shell ( $P_s$ ) or in the tubes ( $P_t$ ), and the pressure on the other side as equal to zero (0) in each case.

$$Sb_{\text{sel}} \geq \frac{(Sg_{\text{min-o}} \cdot A_g) + \left[ \frac{\pi}{4} \cdot P_{\max} \cdot G_{\text{ID}}^2 \right]}{\varphi_g \cdot A_b \cdot n_b}$$


(Eq. 1)

Where:

$A_b$  is the bolt root area, expressed in mm<sup>2</sup> (in<sup>2</sup>)

$A_g$  is the gasket area, expressed in mm<sup>2</sup> (in<sup>2</sup>)

$P_{\max}$  is the maximum design pressure, expressed in MPa (psi)

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G<sub>ID</sub> is the gasket inner diameter, expressed in mm<sup>2</sup> (in<sup>2</sup>)

**7.9 Expansion Joints**

Replace hole section with

The use of expansion joints in shell is not allowed in any case.

**7.10 Gasket**

Add new section

**7.10.16**

For girth flanges the gaskets shall be of the standard confined joint construction type, unless where otherwise specified.

**7.11 Handling Devices**

**7.11.4**

Add new sentence

It shall be also possible to remove the tube bundle of vertical heat exchangers from the top of the equipment.

**8 MATERIALS**

**8.1 General**

**8.1.1**

Replace section with

Casting shall not be used.

**8.1.2**


Add to section

External parts as lifting lugs, davits and others shall not be welded directly to the vessel. A reinforcement pad of the same material as vessel shall be provided prior to welding. Welds shall also be of the full penetration type.

**8.1.4**

Add to section

Shell and Tube Heat Exchangers material selection shall be according to MATERIAL SPECIFICATION FOR HEAT EXCHANGERS [document supplied by OWNER]. Only if the

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material selection is not specified by OWNER, CONTRACTOR shall define the complete pressure vessel's material considering the minimum design lifetime and requirements of ISO 21457.

Studs, bolts, tightening bolts and nuts shall be according I-ET-3010.00-1200-251-P4X-001 – BOLT MATERIALS.

**8.1.5**

Replace section with

Tubesheet shall be of forged construction whenever possible. The use of tubesheets made of plate material shall be previously approved by **OWNER**. If plate material is used, it shall be 100%ultrasonically inspected for laminations and other defects prior to attachment to the cylinder.

Add new section

**8.1.11**

For shell side fluids that are electrical conductors, the material of tubesheets, baffles, tie-rods, spacers and any other parts in direct or indirect contact with the tube bundle shall be compatible with the material of the tubes, so as to avoid the formation of a galvanic couple.

Add new section

**8.1.12**

All materials that are exposed to hydrocarbons containing hydrogen sulphide shall follow the requirements of ISO 15156 for sour service.

Add new section

**8.1.13**


Equipment subject to temperatures above 60°C or those that require heat conservation shall be thermally insulated according to I-ET-3010.00-1200-431-P4X-001 – THERMAL INSULATION FOR MARITIME INSTALLATIONS. To avoid corrosion underneath insulation, only non-hygroscopic insulation material shall be selected.

**8.2 Requirements for Carbon Steel in Sour or Wet Hydrogen Sulfide Service**

Add new section

**8.2.6**

All butt welds shall be subject to 100 % volumetric examination. Nozzle to vessel wall joints shall be 100 % ultrasonically tested.

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### 8.3 Gaskets

#### 8.3.6

Replace section with

Compressed sheet type gaskets shall not be used in hydrocarbon, steam, hydrogen, sour, CO<sub>2</sub> or wet hydrogen sulphide service.

### 8.4 Tubes

#### 8.4.1

Replace section with

Finned tubes shall not be accepted.

#### 8.4.2

Add to section before first sentence

Seamless tubing shall be specified for all cases.

Add new section

#### 8.4.3

When required by the tube specification and when a strength welding is specified for the tube-to-tubesheet connection, tubes shall be subjected to hydrostatic testing by the manufacturer as per ASME II/A SA-450 / SA-450M. In any case, however, the stress at the tube wall, determined by ASME II/A SA-450 / SA-450M, shall not exceed 80% of the yield strength of the tube material.

### 8.5 Requirements for Austenitic Stainless Steel, 22Cr Duplex and 25Cr Super Duplex

#### 8.5.1


Add to section

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

#### 8.5.10



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Add to List

d) the material is operating in sour service.

**8.6 Additional Requirements for 22Cr Duplex and 25Cr Duplex**

Add new section

**8.6.3**

Additional requirements are established in I-ET-3010.00-1200-955-P4X-001 – WELDING.

**9 FABRICATION**

**9.1.1**

Replace section with

The main cylinder (shell and channel) seams, connections and external attachments (except circumferential stiffening and insulation support rings) shall be laid out so that connections or reinforcement pads do not intersect seams and the distance between weld toes shall be 3 times the thickness of the thinnest plate and at least 50 mm (2 in.).

**9.1.4**

Replace section with

Longitudinal weld seams on horizontal exchangers shall be located above the horizontal centerline. When this is not possible, longitudinal seams shall not be located under saddle bearing plates.

**9.1.5**

Add to section before first paragraph

Welds of the shell and heads shall be arranged in such a manner as not to interfere with: vessel supports, welded internal, nozzles, manholes, nozzles and manholes reinforcements.


In any case the longitudinal welds of adjacent rings shall be at least 45° apart from each other.

**9.5 Welding**

**9.5.1**

Add to section

Shell and tubes welds shall be according to the requirements described in I-ET-3010.00-1200-955-P4X-001 – WELDING.

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Qualification and certification for procedures and personnel shall be in accordance with I-ET-3010.00-0000-970-P4X-001 – REQUIREMENTS FOR PROCEDURES AND PERSONNEL QUALIFICATION AND CERTIFICATION.

## 9.5.15

### Replace section with

Dissimilar metal welds are prohibited for pressure-retaining joints.

## 9.6 Heat Treatment

### 9.6.2

### Replace section with

Based on the “U” tube material, the **CONTRACTOR** shall assess the need for residual stress relief heat treatment or for restoring the mechanical and/or micro-structural properties after the tube bending operation. When austenitic stainless steel U-tubes are cold-worked, and the external fibres are deformed more than 15%, a heat treatment for stress relief as described in ASME II/A SA-213 Supplementary Requirement S1 shall be done, but at a temperature range of 1040 to 1120°C.

### 9.6.14

### Delete section


(The use of expansion joints is not allowed in any case.)

## 9.8 Gasket Contact Surfaces Other Than Nozzle Flange Facing

### 9.8.1

### Replace Table 4

Type	Surface Roughness $R_a^*$
Solid flat metal gaskets	1,6 (63) maximum
Spiral-wound gasket	3,2 to 6,3 (125 to 250)
Grooved or corrugated metal gaskets with soft gasket-seal facing	
Non-metallic soft sheet gasket, $\leq 1,5$ mm ( $1/16$ in) thickness	3,2 to 6,3 (125 to 250)
Non-metallic soft sheet gasket, $> 1,5$ mm ( $1/16$ in) thickness	3,2 to 12,7 (125 to 500)
* $R_a$ is the roughness average - Dimensions in micrometres (micro-inches)	

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### 9.10 Tube-to-Tubesheet Joints

#### 9.10.1

Add to section

Tube-to-tubesheet connection by expansion shall not be used in the following cases:

- Service rating equal to or higher than 600;
- Service with lethal fluid, on only one of the sides (shell side or tube side), with an operating pressure higher than the operating pressure of the other fluid;
- Service with inadmissible leakage (e.g.: H<sub>2</sub> and H<sub>2</sub>S), on only one of the sides (shell side or tube side), with an operating pressure higher than the operating pressure of the other fluid (service).

#### 9.10.3

Replace section with

As a general rule, tubes shall be expanded into the tubesheet holes. Tube ends shall extend 3 mm beyond the surface of the tubesheet (except in the case of vertical heat exchangers where the tube end shall be flush with the surface of the top tubesheet). There shall be at least 2 expansion slots, on the base metal in each hole of the tubesheet, approximately 3 mm wide and 0.4 mm deep.

#### 9.10.4

Add to section

In the case of a clad tubesheet, it shall have1 more expansion slot made in the clad. The minimum distance between the edge of the slot and the outer face of the clad shall be 3 mm.

Add new section


#### 9.10.9

In the cases of tube-to-tubesheet connection by total full-strength welding as per ASME Code Section VIII, Division 1, item UW-20.2 (a)., the tube shall be slightly expanded into the hole (thickness reduction of approximately 5 %).

If the tube-to-clad connection is obtained by a full-strength weld, the minimum thickness of the clad shall be 3 mm.

## 10 INSPECTION AND TESTING

### 10.1

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Add to section

Inspection and testing shall also be in accordance with I-ET-3010.00-1000-970-P4X-002 – REQUIREMENTS FOR NDT.

Qualification and certification for procedures and personnel shall be in accordance with I-ET-3010.00-0000-970-P4X-001 – REQUIREMENTS FOR PROCEDURES AND PERSONNEL QUALIFICATION AND CERTIFICATION.

**10.1.1**

Replace section with

f) The use of set-on nozzles is not allowed.

**10.1.2**

Replace section with

The use of set-on nozzles is not allowed.

**10.1.20**

Add to section

Optical emission spectroscopy shall be used in cases where the PMI technique is not able to identify the alloy steel material.

**10.1.21**

Add to section

Unless otherwise specified, pressure components shall undergo the PMI examination when they are received, except for carbon steel material. Inspection in 100 % of lot. Non-complying parts shall be identified and disposed.


Fixing elements (studs/bolts and nuts) and equipment internals shall undergo the PMI examination, by sampling in 20 % of its lot at the receiving, except for carbon steel materials. Sampling acceptance criteria: 100 %. In case of non-compliance, the sampling shall be extended to 100 %. Non-complying parts shall be identified and disposed.

**10.1.24**

Add to section

The test shall include metal base's thickness measurement and disbonding evaluation.

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**10.2 Pressure Testing**

**10.2.2**

Add to section

When strength-welded joint is specified, tube-to-tubesheet joint integrity shall be verify by a helium leak test using ASME code Section V as a basis.

**10.2.14**

Replace section with

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

Add new section

**10.2.16**

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

Add new section

**10.2.17**

Hydrostatic test shall be performed only after presentation of all inspection and testing records provided in approved ITP.

Add new section

**10.2.18**

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


Add new section

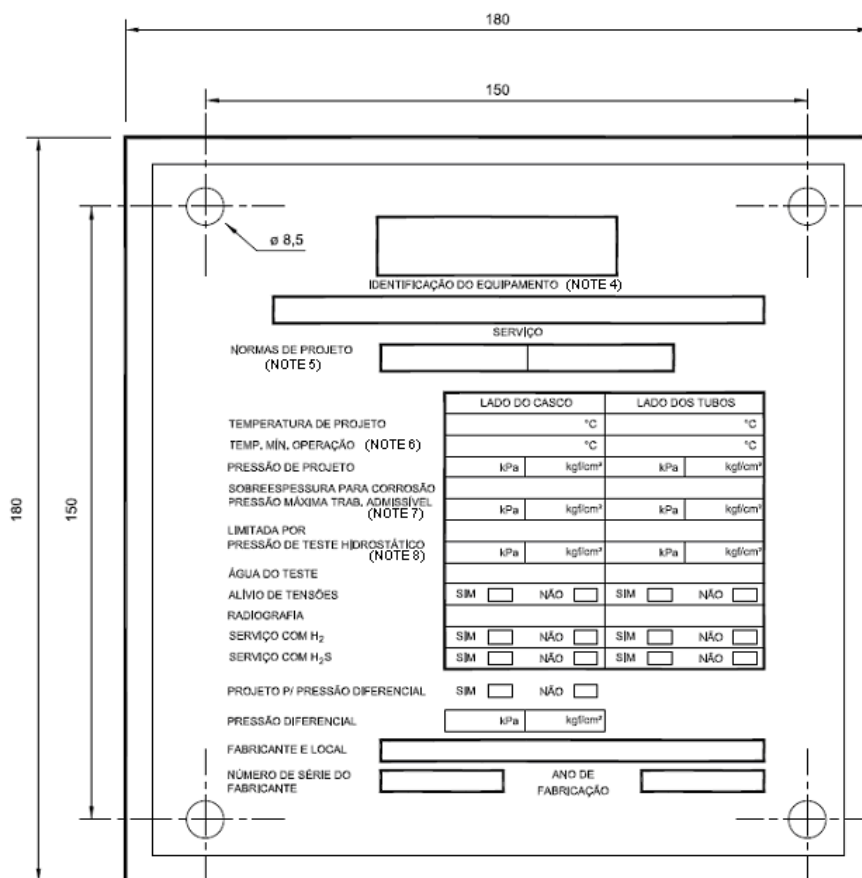
**10.2.19**

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 new section

**10.2.20**

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<p>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:</p> <ul style="list-style-type: none"> <li>• 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.</li> <li>• Pressure gages shall be calibrated before the beginning of the test. Calibration certificate shall not be older than 3 months at test data. Calibration shall be done using a standard deadweight gauge or a calibrated master pressure gauge or a column of mercury.</li> <li>• The maximum scale value shall always be within 1.5 and 4 times the test pressure and be preferably twice the test pressure.</li> <li>• The smallest scale division shall not exceed 5% of the maximum scale indication.</li> <li>• Valves shall be provided between the pressure gages and equipment to allow substitution, if necessary.</li> </ul> <p><b>10.3 Nameplates and Stampings</b></p> <p><b>10.3.1</b></p> <p><u>Add to section</u></p> <p>The nameplate shall be in Portuguese language and shall be 3 mm thick, fastened by corrosion resistant bolts.</p> <p><b>10.3.2</b></p> <p><u>Add to section</u></p> <p>The nameplate shall be located in a visible and accessible location.</p> <p><u>Add new section</u></p> <p><b>10.3.4</b></p> <p>For orientation and minimum data required on nameplate see <b>Figure 2</b>.</p>				




**Figure 2 – Shell and Tube Heat Exchanger nameplate model.**

**Notes:**

- 1) All heat exchangers shall have a nameplate containing at least the information indicated in the drawing. The technical data shall be filled out in the units indicated in the drawing (SI and metric).
- 2) The model given in the drawing has the purpose to orientate the **CONTRACTOR** about the disposition of the minimal obligatory information on the nameplate. Additional information may be included if necessary or to **CONTRACTOR'S** criterion.
- 3) Dimensions in mm.
- 4) Tag number, as mentioned in data sheet, P&ID and equipment list.
- 5) The year of edition of the design code shall be indicated.
- 6) When applicable.
- 7) The maximum allowable working pressure (MAWP) shall be determined for the corroded and hot condition.
- 8) The hydrostatic test pressure shall be determined as by ASME Code Section VIII.

## 11 PREPARATION FOR SHIPMENT

### 11.1.7

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Replace section with

The paint system shall be according to I-ET-3010.00-1200-956-P4X-002 – GENERAL PAINTING.

Non-metallic anticorrosive coating may only be placed inside the shell in exceptional circumstances, when expressly authorized by **OWNER**.

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

Color code adopted shall be in accordance with DR-ENGP-I-1.15 – COLOR CODING.

## 12 SUPPLEMENTAL REQUIREMENTS

### 12.1

Add to section

For the purpose of this specification, critical services shall be identified as those listed below, but not limit to:

- Fluids with an H<sub>2</sub>S concentration greater than 3% by weight;
- H<sub>2</sub> partial pressure fluids greater than 441 kPa (4.5 kgf / cm<sup>2</sup>);
- Flammable fluids at an operating temperature equal to or higher than the auto-ignition temperature;
- Process gas, fuel gas;
- Toxic product “category M” of ASME B31.3;
- High level of vibration with hydrocarbons and / or toxic or flammable chemicals;
- Hydrocarbons and / or toxic or flammable chemicals, at a working temperature above auto-ignition;
- Hydrocarbons and / or toxic or flammable chemicals that can promote stress corrosion and contain;
- Hydrocarbons and chemicals that reach temperatures below 0° C in operation or even in case of sudden depressurization to atmospheric pressure.

### 12.2.1

Replace third sentence with


The use of set-on nozzles is not allowed.


Add new section

### 12.3.12

Non-destructive examination shall be performed in accordance with the requirements stated in I-ET-3010.00-1000-970-P4X-002 – REQUIREMENTS FOR NDT.



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<p><u>Add new section</u></p> <h3>13 CERTIFICATION</h3> <p>For all heat exchangers, a Classification Society certificate shall be supplied. <b>CONTRACTOR</b> shall submit to the classification society the documentation as described in the latest edition of their rules for equipment on offshore facilities and shall be responsible for obtaining all necessary certification of the equipment through the respective independent certifying authority.</p> <p><b>CONTRACTOR</b> shall supply all certificates related to the materials, inspections, tests and qualification activities detailed in the approved Quality Plan.</p>			

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## ANNEX D (NEW) - THERMAL AND HYDRAULIC DESIGN GUIDELINES

### D.5.1.1

Replace item “e” with

e) Exchangers with two passes on the shell side (TEMA Type “F”) are not allowed when:

- Shell side pressure drop is greater than 49 kPa (0,5 kgf/cm<sup>2</sup>);
- Shell side temperature range is greater than 190 °C.

When the F type shell is allowed to be used, **CONTRACTOR** shall provide and submit to **OWNER** for approval, the following analysis:

- an analysis of the thermal and physical leakage across the longitudinal baffle;
- an analysis of the possibility of severe thermal stresses and distortion of shell.

### D.5.2.2

Add to section

Fixed tubesheet shall not be specified for heat exchangers subjected to thermal stresses due to differential temperature between the tubes and the shell during normal operation, start-up, shutdown or other conditions. For oil processing system, heat exchangers shall be provided with removable bundle.

### D.5.2.3

Replace section with

The use of expansion joints is not allowed.

### D.5.2.5

Add to section

The use of U-tube bundle is subject to **OWNER**’s approval, including for heat exchangers from package units such as turbo-compressors.

### D.5.3.3

Add to section before first paragraph

For dirty fluid flowing through shell, the tube pattern shall be square or rotated square to allow mechanical cleaning of the shell side.



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## SECTION IV – IOGP S-614Q QUALITY REQUIREMENTS FOR SHELL-AND-TUBE HEAT EXCHANGERS