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	JOB:	-	
	AREA:	-	
SRGE	TITLE: REQUIREMENTS FOR PLATE HEAT EXCHANGER DESIGN AND FABRICATION		INTERNAL
			ESUP

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EXECUTION	U3CI	U3CI	UPVY	CJX4					
CHECK	U5IC	U5IC	U3CI	U3CI					
APPROVAL	U32N	U32N	U32N	U32N					

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TECHNICAL SPECIFICATION

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INTERNAL
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REQUIREMENTS FOR PLATE HEAT EXCHANGER DESIGN AND FABRICATION

INTERNAL


ESUP

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1 OBJECTIVE

1.1 This Technical Specification covers the minimum requirements for thermal, mechanical design, fabrication, testing, inspection, and certification of Gasketed Plate Heat Exchangers. It complements API STD 667.

1.2 For this document, the designation “plate heat exchangers” covers Gasketed Plate-and-Frame Heat Exchangers in general such as heaters, coolers, reboilers and any other application.

1.3 The requirements herein listed are applicable to all players performing such related activities within the scope of this unit, including CONTRACTORS, main contractor, subcontractors, manufacturer, packager, 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.

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

2 NORMATIVE REFERENCES AND DESIGN SPECIFICATIONS

2.1 CLASSIFICATION SOCIETY


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

2.1.2 CONTRACTOR is responsible submit to the Classification Society the documentation in compliance with stated Rules.

2.2 CODES AND STANDARDS

Unless noted, the latest edition and addenda of each document listed below shall be used.

API STD 667	Plate-and-Frame Heat Exchangers
ASME BPVC Sec II	Materials
ASME BPVC Sec V	Non-Destructive Examination
ASME BPVC Sec VIII Div 1 and Div 2	Rules for construction of Pressure vessels
ASME BPVC Sec IX	Welding, Brazing and Fusing Qualifications
ASME B16.5	Pipe Flanges and Flanged Fittings (NPS ½ Through NPS 24);
ABNT NBR 6123	“Forças devidas ao Vento em Edificações” (wind load calculation) Brazilian Standard
ASTM B850	Standard Guide for Post-Coating Treatments of Steel for Reducing the Risk of Hydrogen Embrittlement
ASTM D471	Standard Test Method for Rubber Property-Effect of Liquids

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ISO 34	Rubber, Vulcanized or Thermoplastic - Determination of Tear Strength
ISO 37	Rubber, Vulcanized or Thermoplastic - Determination of Tensile Stress-strain Properties
ISO 48-2	Rubber, Vulcanized or Thermoplastic - Determination of Hardness (hardness between 10 IRHD and 100 IRHD)
ISO 815-1	Rubber, Vulcanized or Thermoplastic - Determination of Compression Set Part 1: At ambient or elevated temperatures
ISO 1817	Rubber, Vulcanized or Thermoplastic - Determination of the Effect of Liquids
ISO 2781	Rubber, Vulcanized or Thermoplastic - Determination of Density
ISO 15156 (all parts)	Petroleum and natural gas industries - Materials for Use in H ₂ S-containing Environments in Oil and Gas Production
ISO 21457	Petroleum and natural gas industries – Materials selection and corrosion control for oil and gas production systems


2.3 GOVERNMENT REGULATION

NR-13	“Caldeiras, Vasos de Pressão, Tubulações e Tanques Metálicos de Armazenamento” (Boilers, Pressure Vessels, Piping and Metal Storage Tanks)
NR-37	“Segurança e Saúde em Plataformas de Petróleo” (Safety and Health in Oil Platforms)

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.

2.4 REFERENCE DOCUMENTS

DR-ENGP-I-1.15	COLOR CODING
I-ET-3010.00-1200-540-P4X-001	REQUIREMENTS FOR PRESSURE VESSELS DESIGN AND FABRICATION
I-DE-3010.00-5140-700-P4X-003	GROUNDING INSTALLATION TYPICAL DETAILS
I-ET-3010.00-1200-251-P4X-001	REQUIREMENTS FOR BOLTING MATERIALS
I-ET-3010.00-1200-956-P4X-002	GENERAL PAINTING
I-ET-3010.00-1200-431-P4X-001	THERMAL INSULATION FOR MARITIME INSTALLATIONS
I-ET-3010.00-1200-955-P4X-001	WELDING
I-ET-3010.00-1200-940-P4X-002	GENERAL TECHNICAL TERMS
I-ET-3010.00-1200-970-P4X-003	REQUIREMENTS FOR PERSONNEL QUALIFICATION AND CERTIFICATION
I-ET-3000.00-1200-940-P4X-001	TAGGING PROCEDURE FOR PRODUCTION UNITS DESIGN
I-ET-3010.00-1200-970-P4X-004	NON-DESTRUCTIVE TESTING REQUIREMENTS FOR METALLIC AND NON-METALLIC MATERIALS

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I-ET-3010.00-1200-970-P4X-013 COMPLIANCE WITH NR-13 AND SPIE REQUIREMENTS

Specific Documents to be supplied by **OWNER**:

- PIPING SPECIFICATION FOR TOPSIDE
- PIPING SPECIFICATION FOR HULL
- METOCEAN DATA
- MOTION ANALYSIS
- MATERIAL SPECIFICATION FOR HEAT EXCHANGERS

3 DEFINITIONS AND ABBREVIATIONS

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

4 GENERAL REQUIREMENTS

4.1 Compliance with the requirements of this Technical Specification or other specifications shall in no case reduce or eliminate CONTRACTOR's responsibility, who will always bear full responsibility for the design and fabrication of the heat exchangers.

4.2 The use of gasketed plate heat exchangers is not acceptable for heating or cooling gas.

4.3 CONTRACTOR shall always 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 review, approval, and record.


4.4 In cases where OWNER does not issue data sheets, basic drawings or other specific documents for the heat exchanger, CONTRACTOR shall specify a percentage fouling margin, F, according to API 667 item 7.4.

4.5 In cases where OWNER provides data sheets, basic drawings showing the arrangement or other specific documents for the heat exchanger, the mechanical and thermal design shall fully comply with those documents, which shall prevail over this Technical Specification. Any discrepancies or alternatives suggested will only be accepted after expressly OWNER's approval.

4.6 CONTRACTOR shall design the equipment for the full range of process conditions as specified in the provided data sheets or other issued inquire/purchase documents. CONTRACTOR shall specify a maximum design temperature and a minimum design metal temperature.

4.7 The mechanical design of the equipment shall ensure that instantaneous and non-continuous flows up to 11% higher than the design flow of the equipment are supported, for both sides, in the event of failure of the control valve.

4.8 The maximum design temperature to be used for dimensioning and material selection shall be limited to 150 °C.

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4.9 The maximum design temperature of plate heat exchangers shall consider the temperature of the hottest fluid. The minimum design temperature shall be higher than the minimum design metal temperature.

4.10 The maximum design pressure of gasketed plate heat exchangers shall be limited to a pressure of 20 bar(g) for the entire temperature range. Both sides of the equipment shall meet the defined maximum design pressure.

4.11 No part of the heat exchanger shall be designed for differential pressure. In addition, the MANUFACTURER shall provide the safe operating boundary for the selected heat exchanger.

4.12 The minimum design pressure shall be specified 20% higher than the maximum operating pressure, including any fluctuations. Any deviation shall be approved by OWNER.

4.13 The plate type heat exchangers shall be of the single pass design, unless otherwise specified. All process connections shall be located in the fixed plate (U-type configuration) so that the plate pack can be serviced without disconnecting the piping. For auxiliary package exchangers (e.g., Lubricant Oil Cooler), when single pass design is not feasible, multi-pass design can be accepted, provided that Vendor follows API 667 item A.3.5. Moreover, every multi-pass design shall be previously presented and approved by Petrobras.

4.14 The equipment shall be designed for thermal exchange in countercurrent flow (hot fluid versus cold fluid). The hot fluid inlet and the cold fluid outlet shall be placed at the equipment upper part. The hot fluid outlet and the cold fluid inlet shall be placed at the equipment lower part.

4.15 CONTRACTOR shall inform and include on the scope any accessory equipment necessary to guarantee the exchanger performance, safety, and satisfactory continuous operation.

4.16 CONTRACTOR shall inform the number of plates for each operational case shown on Process Data Sheet or any other issued inquire/purchase documents.

5 DESIGN REQUIREMENTS

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

5.2 The necessary design data and information on motion requirements are given in MOTION ANALYSIS [document supplied by OWNER].

5.3 In addition to the Code described loads and loads due to vessel motion described in MOTION ANALYSIS [document supplied by OWNER], the following design loads shall be considered where relevant:

- Equipment transportation and erection loads
- Nozzle loads as described in this specification.
- Thermal loads.
- Wind load
- Weight load

5.4 Wind loads shall be calculated as per I-ET-3010.00-1200-540-P4X-001 -REQUIREMENTS FOR PRESSURE VESSELS DESIGN AND FABRICATION.

5.5 CONTRACTOR shall design and fabricate the heat exchangers for a minimum lifetime of 30 years.

5.6 EQUIPMENT SPECIFICATION

5.6.1 The heat exchangers shall be designed, manufactured, and tested in accordance with the requirements stated herein and API 667. The mechanical design of all pressure retaining parts like fixed and movable covers shall be as per ASME BPVC Section VIII Division 1.

5.6.2 Plate dimensions shall contribute to increase equipment rigidity, as well as facilitate maintenance. The maximum plate dimensions shall be 770mm in width and 2500mm in height, where dimensions are taken from nozzle centerlines, as in Figure 1.

5.6.3 An intermediate reinforcing plate, structurally connected to fixed and movable covers through additional demountable structural bars, shall be used whenever the number of contiguous heat transfer plates exceed the limit of 400 plates. The minimum thickness of intermediate reinforcing plate shall be 1/3 (one third) of the fixed cover. Intermediate reinforcing plate material and port holes lining shall be the same of fixed cover. The intermediate reinforcing plate shall be supplied with a movable support with rollers connected to the carrying bar with a construction like the one used in the movable cover.

5.6.4 Plate type heat exchanger shall be designed (frame, tightening bolts and supports) for a future installation of 20% additional plates, unless specified otherwise on the data sheets.

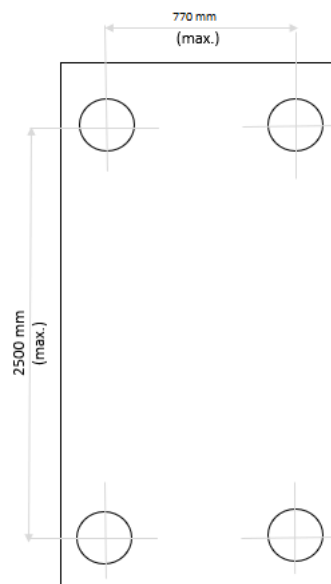



Figure 1 - Maximum Plate Dimensions

5.6.5 To ensure plate pack stability and rigidity, for services with process fluids (hydrocarbon), the titanium plates shall have a minimum thickness of 0.8mm. For other services with a plate number above 200 or plates in titanium, the minimum thickness shall be 0.7mm. For auxiliary package exchangers (e.g., Lubricant Oil Cooler) the minimum thickness shall be 0.6mm.

5.6.6 The maximum flow velocity (m/s) at fluid entrance and exit shall not exceed $150/\sqrt{\rho}$ where ρ is the mean specific mass of the fluid in kg/m^3 .

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5.6.7 CONTRACTOR shall assure that the pressure drop at the connections and port holes will not result in unbalanced flow distribution between PHE plate channels, for each of the fluids. To achieve a well-balanced flow distribution, the developed pressure drop at the heat exchange surface of the plates shall be at least 75% of the total pressure drop for each fluid, unless otherwise approved by OWNER. CONTRACTOR shall present, for both fluids, the pressure drop distribution among the connections, port holes and heat exchange surfaces in the thermal hydraulic calculation report.

5.6.8 Leakage vents shall be provided in the gaskets so that, should a seal failure take place, it will become immediately evident by visual inspection of the external surface of the heat exchanger. The leakage vents are to be located such that no cross-contamination of liquids can occur due to internal seal failure.

5.6.9 When personnel protection insulation is required, it shall ensure a temperature below 60° C on the outside surface, according to I-ET-3010.00-1200-431-P4X-001 – THERMAL INSULATION FOR MARITIME INSTALLATIONS.

5.6.10 Transfer plates shall be fully supported from the top carrying bar and only guided by the bottom bar with (reinforced) slots integral with the plate. The guides on the carrying bar and bottom guide bar for the plates shall be AISI 316.

5.6.11 Gasketed Plate type heat exchangers shall be provided with shroud protection shields around the plates. Shroud protection shield shall be fabricated of stainless-steel type 316. CONTRACTOR shall take care that the shroud shield will not obstruct installation of the foundation bolts.

5.6.12 A drip tray with drain connections shall be supplied in the structure of the exchanger and shall extend throughout all the exchanger, at least 25mm (1") beyond the shroud cover.

5.6.13 Torque fastening procedures (torque sequence, controlled or manual, bolt numbering and torque value) shall be informed on the equipment's manual.

5.6.14 CONTRACTOR shall show the plate space for withdrawal maintenance requirements on the general arrangement and side clearance for plate removal. It shall also be informed the equipment weight and gravity center.

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

5.6.16 For cyclic services the fatigue design shall be in accordance with API 667 and ASME VIII Division 2.

5.6.17 For services containing particulates, API 667 item A.3.2.5 shall be applied.

5.6.18 For sea water service, plate heat exchangers shall be provided with 4 (four) port holes at movable cover. The diameter of these "cleaning" port connections shall be the same as process connections. In addition, one port filter for sea water inlet shall be foreseen. The port filter's material shall be compatible with sea water.

5.6.19 Heat exchangers shall be provided with lifting lugs for single point lifting. The lifting lugs shall be designed with a safety factor of 2.0.

5.6.20 CONTRACTOR shall provide grounding installation for equipment and structures according to GROUNDING INSTALLATION TYPICAL DETAILS - I-DE-3010.00-5140-700-P4X-003.

5.7 GASKET REQUIREMENTS

5.7.1 CONTRACTOR shall present certificates of approval in all qualification tests as per Table 1 for that specific gasket model and material.

Table 1 - Required Qualification Tests for Gasket Materials

Qualification Tests (NBR, HNBR and FKM)	
	Acceptance Criteria
Hardness (ISO 48)	75 to 85 IRHD; hardness determined using "N" method
Tensile strength (ISO 37)	> 15 MPa (only dumb-bell type 1 test pieces shall be used)
Elongation at break (ISO 37)	> 170 % (only dumb-bell type 1 test pieces shall be used)
Compression set test (ISO 815-1)	< 50% (in 72 h) and <60% (in 336 h) at 120 °C (NBR) and 150 °C for the others, Cold Standing 24 hrs. at Room Temp. Before Opening. Tests conducted on a molded gasket with 50 mm length.
Tear strength (ISO 34-1)	> 20 kN/m ; tested at ambient temperature (test piece geometry shall be according to method "A" – "Trousers Test Piece")
Effect of immersion in liquids (ISO 1817)	Hardness +10/-20 units; Volume +18/0 % after 72 hours immersed on IRM 903 Oil at 100 °C. Tests conducted on ISO test piece or molded gasket (50 mm length).

- NOTES: 1) For the compression set and liquid immersion tests, the test pieces shall be sections of gaskets with geometry corresponding to that used in the exchanger.
 2) For the compression set test, the applied compression shall always be 25%, even if the sample hardness is greater than 80 IRHD.
 3) For the immersion tests, if the liquid is not supplied by OWNER, the reference oil IRM 903 of ASTM D471 shall be used. The test pieces shall have 100% of their superficial area in contact with the liquid.
 4) To verify the results, OWNER may request samples of the elastomers.

5.7.2 The use of NBR gaskets shall be limited in cases where the operating temperature is at most 80°C and, for HNBR gaskets, at most 120°C.

5.7.3 Only peroxide cured gaskets shall be accepted. No other type of curing system is accepted.

5.7.4 There is a concern about corrosion of titanium alloys due to halogens released by gasket materials (especially FKM gaskets), CONTRACTOR shall be aware of it and guarantee that it is not possible at design and operation temperatures.

5.7.5 The CONTRACTOR shall select the gasket material to ensure 3 years of continuous operation under operating pressure and temperature conditions.

5.7.6 CONTRACTOR shall include the information of Table 2, relative to the gaskets in the heat exchanger's data sheet.

Table 2 - Gasket information to be included in the Data Sheet

Material			
CONTRACTOR			
Type of elastomer	<input type="checkbox"/> NBR	<input type="checkbox"/> HNBR	<input type="checkbox"/> FKM
Elastomer code			
Properties			
Density	ISO 2781	g/cm ³	
Hardness	ISO 48	IRHD	
Tensile Strength	ISO 37	MPa	
Dimensions of transversal section			
Transversal section	<input type="checkbox"/> Δ <input type="checkbox"/> \square <input type="checkbox"/> \circ <input type="checkbox"/> \diamond <input type="checkbox"/> ∇ <input type="checkbox"/> $_$		
Height	mm		
Width	mm		

5.7.7 The entire length of the gaskets shall be attached to the plate surfaces with glue. Clip-on gaskets fixing is acceptable if the gaskets are also attached to the plate surface with glue in its entire length.

5.8 MATERIAL SELECTION AND CERTIFICATION

5.8.1 CONTRACTOR shall refer to MATERIAL SPECIFICATION FOR HEAT EXCHANGERS [document supplied by **OWNER**] for the material selection of the plate heat exchangers.

5.8.2 Other plate heat exchangers presented on the platform, not listed in item MATERIAL SPECIFICATION FOR HEAT EXCHANGERS [document supplied by **OWNER**], shall have their material selection according to ISO 21457 and it shall be submitted to OWNER's approval.

5.8.3 Heat transfer's plates made of carbon steel shall not be accepted.


5.8.4 All materials exposed to hydrocarbons containing H₂S shall comply with ISO 15156.

5.8.5 For the salt water / cooling water system, it shall be select titanium plate.

5.8.6 The use of asbestos or materials containing asbestos is prohibited.

5.8.7 CONTRACTOR shall be responsible for obtaining all necessary certification of the equipment.

5.8.8 CONTRACTOR through the independent certifying authority shall supply all certificates related to the materials, inspections, tests, and qualification activities detailed in the approved Quality Plan.

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5.9 PIPING CONNECTIONS

5.9.1 If the piping connections are of the studded design, stud bolts and nuts shall be included in the scope of supply.

5.9.2 Nozzles or nozzle connections on fixed and movable covers shall be designed to accept the loads due to piping reaction shown in the Table 1 of API 667, considering a factor of 2.5 (2.5 x API 667 Table 1). For auxiliary systems, allowable loads shall be in accordance with Table 1 of API 667.

5.9.3 In order to not exceed the pressure versus temperature curves of ASME B16.5, and for stiffness issues, flanges shall be specified in class 300.

5.9.4 If the flanges on nozzles are different from the specification of the piping connected to the heat exchanger, according to PIPING SPECIFICATIONS FOR TOPSIDE or PIPING SPECIFICATIONS FOR HULL [documents supplied by OWNER], as applicable, a counter flange shall be included in CONTRACTOR's scope of supply.

5.9.5 All nozzle connections shall be located on the fixed cover for single pass arrangements.

5.9.6 Carbon steel nozzles or studded openings in the fixed cover plate in contact with the process fluid shall be clad with the same material as the plate pack, especially when plate pack material is a titanium alloy. There is a concern about hydrogen embrittlement of titanium alloys due to galvanic corrosion. A corrosion allowance of 3 mm or suitable internal coatings may be used as alternatives only after written OWNER's approval.

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

5.10 EQUIPMENT SUPPORTS

5.10.1 The heat exchangers shall be provided with mounting feet or brackets capable of handling the dynamic forces as stated in MOTION ANALYSIS [document supplied by OWNER].

5.10.2 CONTRACTOR shall pay attention to the design of the Heat Exchanger supports so that the foundation bolts can be installed from the top and installation is not obstructed by the shroud shields.


5.10.3 CONTRACTOR shall give the foundation details of the movable plate support for installation of the initial plate pack size and for installation with extended plate pack.

5.11 WELDING

5.11.1 Welding on the plate type heat exchanger shall be performed in compliance with ASME BPVC Section IX and I-ET-3010.00-1200-955-P4X-001 – WELDING.

5.11.2 Only full penetration welds are permitted for nozzles and flanges.

5.11.3 CONTRACTOR shall furnish copies of applicable welding procedure specifications and weld map for review or record.

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5.12 QUALIFICATION AND CERTIFICATION

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.

6 CORROSION PROTECTION AND PAINTING

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

6.2 Color code adopted shall comply with DR-ENGP-I-1.15 – COLOR CODING.

6.3 Tie bolts and nuts shall be the cathodic side when connected to other materials, due to galvanic corrosion possibility. This can be accomplished by using integral material or suitable coatings, in this case this solution shall be submitted and receive prior approval from OWNER.

6.4 Studs, bolts, tightening bolts and nuts shall be coated with the protective coating indicated in the specification of the piping connected to the equipment. Under all nuts, washers shall be applied to prevent coating damage. CONTRACTOR shall submit for OWNER's approval the protective coating for bolts and nuts.

6.5 In case of electrolytic coating process or coating process with risk of hydrogen embrittlement, a baking treatment to remove hydrogen prior to service is required, according to ASTM B850. The effectiveness of this treatment shall be guaranteed by CONTRACTOR.

6.6 The tightening bolts shall be greased and covered with plastic sleeves.


7 NAMEPLATES

7.1 CONTRACTOR shall attach a 3 mm thick, SS 316 nameplate on each equipment, in an accessible location, fastened with corrosion resistant pins.

7.2 The nameplate information shall include, as a minimum, the following in the Portuguese language:

- All Code and Classification requirements,
- Design code,
- Tag number,
- MANUFACTURER/ PACKAGER and year built,
- Equipment's serial number and type,
- Design temperature and pressure,
- Maximum allowable working pressure,
- Minimum design metal temperature,
- Operating temperature and pressure,
- Thermal duty, volume, etc.
- Hydrostatic test pressure,
- Empty, operational test weight,
- Service.

7.3 All technical data shall be shown in metric units, except for pressure which shall be indicated in 'bar'.

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7.4 All safety signs shall be in the Portuguese language.

8 TAG NUMBERING

8.1 Tagging of all instruments, electrical, mechanical, and piping items, including valves, shall be in accordance with latest revision of I-ET-3000.00-1200-940-P4X-001 – TAGGING PROCEDURE FOR PRODUCTION UNITS DESIGN.

8.2 Tag numbers for remaining ancillary equipment shall be given after purchase order placement.

9 CERTIFICATION REQUIREMENTS

For all heat exchangers, a Classification Society certificate shall be supplied. CONTRACTOR shall be responsible to obtaining all necessary certification of the equipment. CONTRACTOR through the independent certifying authority shall supply all certificates related to the materials, inspections, tests, and qualification activities detailed in the approved Quality Plan.

10 INSPECTION, TESTING AND COMMISSIONING

10.1 Inspections and tests shall be according to API 667, ASME Code (all applicable parts), and I-ET-3010.00-1200-970-P4X-004 – NON-DESTRUCTIVE TESTING REQUIREMENTS FOR METALLIC AND NON-METALLIC MATERIALS.

10.2 As a minimum, at least, the following tests will be carried out:

- Hydrostatic test as per codes.
- UV light box test or fluorescent penetrant test on heat transfer plates.
- Liquid penetrant examination on liner welds if applicable.
- Visual examination.

10.3 Liquid penetrant or magnetic particle on lifting attachments.

- Volumetric examination (radiographic or ultrasonic examination) shall be performed in full penetration welds.
- Positive materials identification (PMI), required as indicated below:

- Note: The PMI shall be carried out with equipment capable to identify the specified type of material in accordance with established procedure. The equipment shall not make burn marks to the pipe material. The PMI shall be done prior the welding to identify the materials which will be welded.

10.4 Extent of non-destructive examination shall be as follows:

- 100% heat transfer plates shall be visually examined.
- 10% heat transfer plates shall be submitted to UV light box test or fluorescent penetrant test.
- 10% heat transfer plates shall be submitted to PMI.
- 5% heat transfer plates shall be submitted to dimensional inspection (width between midlines of the gasket installation grooves, height between hooks, distance between nozzles and depth of gasket housing) at 6 different points, as shown in Figure 2.
- 100% welds shall be subjected to a visual inspection, internal and externally.
- 100% of full penetration welds shall be subjected to volumetric examination.
- 100% lifting attachments.
- 100% of all pressure retaining parts.

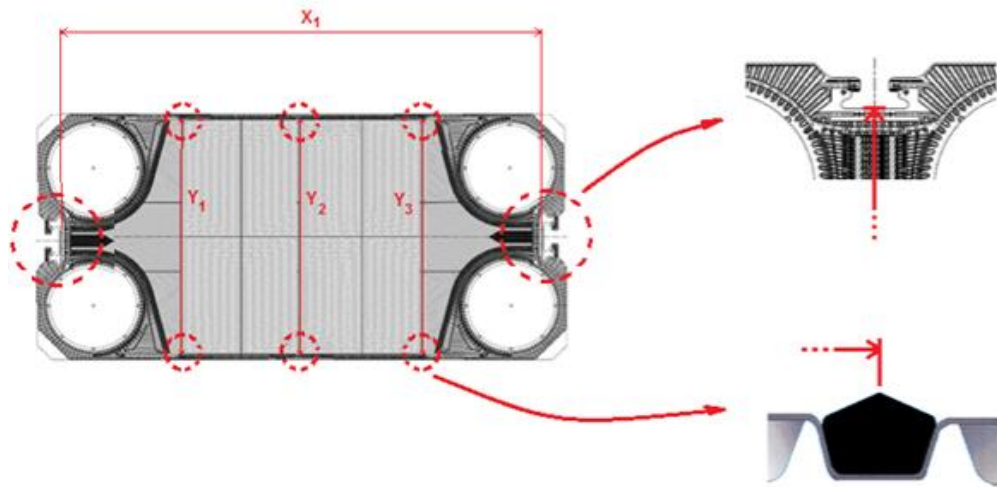


Figure 2 - Visual Inspection points.

10.5 An Initial Service Safety Inspection shall be performed on heat exchangers once the Unit itself has been erected to its final location.

10.6 CONTRACTOR will be required to provide any necessary support for installation and commissioning of the equipment at the construction yard or offshore.