	<b>TECHNICAL SPECIFICATION</b>		Nº: I-ET-3010.1M-1200-456-P4X-001						
	CLIENT: SRGE		SHEET: 1 of 13						
	JOB: REFERENCE BASIC DESIGN		1001056398 0010						
	AREA: BUZIOS								
DP&T-SRGE	TITLE: <b>PLATE HEAT EXCHANGER SPECIFICATION</b>		NP-1						
		ESUP							
MICROSOFT WORD / V. 2013 / I-ET-3010.1M-1200-456-P4X-001_0.DOC									
<b>INDEX OF REVISIONS</b>									
<b>REV.</b>	<b>DESCRIPTION AND/OR REVISED SHEETS</b>								
0	ORIGINAL ISSUE								
	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
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TECHNICAL SPECIFICATION

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PRELIMINARY

## 1. OBJECTIVES

**1.1** This Technical Specification covers the technical requirements and recommended practices for thermal, mechanical design, fabrication, testing and inspection of Gasketed Plate Heat Exchangers.

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

## 2. DEFINITIONS

Within the contents of this Technical Specification, the following definitions shall be observed:

Shall	Shall is an absolute requirement to be followed strictly in order to conform to the specification.
MANUFACTURER	Firm or organization responsible for the thermal and mechanical design, fabrication and test of the heat exchanger.
PURCHASER	The Company designated as such in the contract or the purchase order.
FPSO	An abbreviation of “Floating Production Storage and Offloading Vessel”.
Classification Society	Means such authority or organization appointed to ensure conformity by the MANUFACTURER with all requirements necessary to obtain certification or classification of the goods and/or services described herein.

## 3. CODES AND STANDARDS

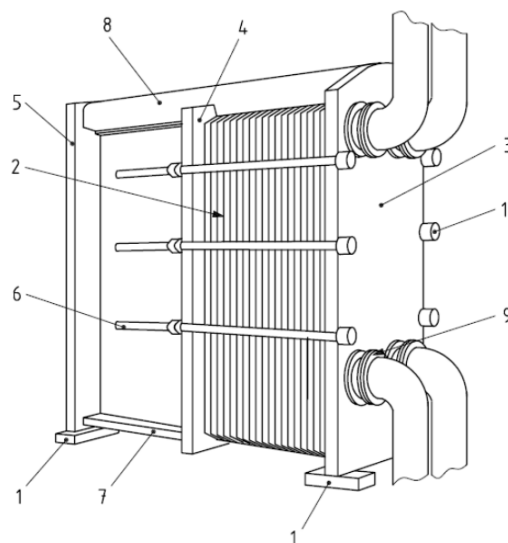
**3.1** Plate Heat Exchangers designed and fabricated in accordance with this Technical Specification, shall comply, where applicable, with the documents mentioned on item 3.2 below. Equipment shall also be in accordance with rules and regulation of the Classification Society applied for the unit. In case of conflict between Classification Society rules and regulations and this Technical Specification, the MANUFACTURER must submit this issue to PETROBRAS.

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

API 662 Part 1	Plate Heat Exchangers for General Refinery Services;
ASME BPVC	Sections II, V, VIII and IX;
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
ISO 34	Rubber, Vulcanized or Thermoplastic - Determination of Tear Strength
ISO 37	Rubber, Vulcanized or Thermoplastic - Determination of Tensile Stress-strain Properties
ISO 48	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 AMD
ISO 15156	Petroleum and natural gas industries - Materials for Use in H <sub>2</sub> S-containing Environments in Oil and Gas Production
IEC-61892-6	Mobile and Fixed Offshore Units – Electrical Installations - Installation
IEC-61892-7	Mobile and Fixed Offshore Units – Electrical Installations – Hazardous Area
IEC-60092-502	Electrical Installation in Ships – Tankers – Special Features

For the purposes of these documents, the API terms presented on figure 1 shall be applied:


**Key**

- |                  |                                   |
|------------------|-----------------------------------|
| 1 mounting feet  | 6 tie bolts                       |
| 2 plate pack     | 7 guide bar (bottom)              |
| 3 fixed cover    | 8 carrying bar (top)              |
| 4 movable cover  | 9 connections, studded or flanged |
| 5 support column | 10 tie nuts                       |

**Figure 1 – “Typical single-pass gasketed plate heat exchanger” extracted from API 662.**

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## 4. MANUFACTURER'S OBLIGATIONS

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

**4.2** In those cases, where PETROBRAS 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 approved by PETROBRAS.

**4.3** MANUFACTURER shall be responsible for the thermal and mechanical design. MANUFACTURER shall guarantee, that the equipment meets the performance specified at fouled conditions. PETROBRAS reserves the right to check the mechanical and fabrication design prepared by MANUFACTURER.

**4.4** MANUFACTURER's responsibility shall also include but not limited to:

- Resolving all engineering questions and/or problems relating to design and manufacture.
- Providing details of any design and manufacture sub-vendor as requested.

**4.5** MANUFACTURER shall design the equipment for the full range of process conditions as specified in the provided data sheets.

**4.6** It is MANUFACTURER's responsibility to submit to the Classification Society the documentation as described in the latest edition of their rules for equipment on offshore facilities. All elements of the heat exchanger package, including sub-orders, shall be of proven design and well within the MANUFACTURER's actual experience.

## 5. GENERAL REQUIREMENTS

**5.1** 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. The equipment shall be preferably designed for thermal exchange in countercurrent (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.

**5.2** Exchangers shall be suitable for operation in accordance with the area classification presented in I-DE-3010.1M-5400-94A-P4X-001 – AREA CLASSIFICATION - GENERAL.

### 5.3 Design Loads

In addition to the loads described in the ASME Code and loads due to vessel motion described in I-RL-3010.1M-1350-960-P4X-009 - MOTION ANALYSIS, the following design loads must be considered where relevant:

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

A wind basic velocity of 40 m/s, referenced to 10m above mean sea level, shall be considered for wind load calculations in accordance with ABNT NBR 6123 Standard.

**5.4 MANUFACTURER** shall design and fabricate the heat exchangers for a minimum lifetime of 25 years.

**5.5** English language shall be used for all design and engineering documents, for drawings and for communication with the PURCHASER.

## 6. EQUIPMENT SPECIFICATION

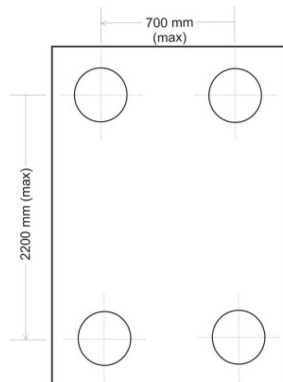
MANUFACTURER shall be responsible for supplying complete and fully operative heat exchangers in accordance with the requirements of this Technical Specification, attachments and standards referenced herein.

### 6.1 Design Requirements

6.1.1. The heat exchangers shall be designed, manufactured, and tested in accordance with the requirements stated herein, API 662 Part 1 and ASME VIII Div.1, where applicable. The deviations shall be previously approved by PETROBRAS.

6.1.2. The mechanical design of all pressure retaining parts like fixed and movable covers shall be as per ASME VIII Div 1.

6.1.3. Plate dimensions shall contribute to increase equipment rigidity, as well as facilitate maintenance. The maximum plate dimensions shall be 700mm in width and 2200mm in height, where dimensions are taken from nozzle centerlines, as in Figure 2.



**Figure 2 – Maximum Plate Dimensions**

6.1.4. The recommended maximum number of plates is 350 for services with process fluids (hydrocarbon) and 500 for cooling water/sea water applications. An intermediate reinforcing device must be used whenever the number of contiguous heat transfer plates exceed the limit of 300 plates.

6.1.5. 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. If the increase exceeds the limit mentioned in item 6.1.4, the intermediate device shall be provided previously installed.

6.1.6. To ensure plate pack stability and rigidity, for services with process fluids (hydrocarbon), the titanium plates shall have a minimum thickness of 0.8mm.

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

6.1.8. 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.

6.1.9. When personal protection insulation is required, it shall ensure a temperature below  $60^\circ\text{C}$  on the outside surface and shall be of non hygroscopic material.

6.1.10. 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.

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

6.1.12. A drip pan 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.

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

6.1.14. MANUFACTURER 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.

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

6.1.16. For cyclic services the fatigue design shall be in accordance with ASME VIII Division 2.

6.1.17. For services containing particles larger than 50% of the nominal plate gap, strainers shall be provided.

6.1.18. 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.

6.1.19. Heat exchangers shall be provided with two diametrically opposite earthing bosses. Equipment, accessories, piping and structures shall be grounded according to requirements of IEC 61892-6 and IEC 60092-502. Besides these standards, for installations in hazardous area, the grounding requirements of IEC 61892-7 shall be complied with.

## 6.2 Gasket Requirements

6.2.1. For the supply of gasket material to be used in hydrocarbon services, the MANUFACTURER shall present certificates of approval in all qualification tests as per Table 1 for that specific gasket model. Once the MANUFACTURER has a certain gasket model approved in the qualification tests, only the quality control tests comprising of the Density, Hardness and Tensile Strength tests must be performed on the gasket supplies.

Qualification Tests (NBR, HNBR and FKM)	
	Acceptance Criteria
Density (ISO 2781)	1.15 to 1.27 g/cm <sup>3</sup> (NBR and HNBR) and 1.75 to 1.90 g/cm <sup>3</sup> (FKM)
Hardness (ISO 48)	75 to 85 IRHD ; hardness determined using "N" method
Tensile strength (ISO 37)	> 17 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)	< 23% (in 24 h), < 50% (in 72 h) and <60% (in 336 h) at design temperature using method "A"
Tear strength (ISO 34-1)	> 30 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 % Minimum test duration 14 days with samplings at 2h, 24h, 7d and 14d; tested at operation temperature

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. The length of the gasket portion used for testing should be at least twice the specified height of the gasket.

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 PETROBRAS, 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, PETROBRAS may request samples of the elastomers.

**Table 1 – Required Qualification Tests for Gasket Materials**



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

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

6.2.4. There is a concern about corrosion of titanium alloys due to halogens released by gasket materials, MANUFACTURER must be aware of it and guarantee that it is not possible at design and operation temperatures.

6.2.5. The manufacturer shall select the gasket material to ensure 3 years of operation under pressure and operating temperature conditions.

6.2.6. Gaskets consisting of more than one piece joined together shall not be accepted.

6.2.7. In the data sheet of the exchanger, the information in Table 2, relative to the gaskets, should be included.

Material			
Manufacturer			
Type of elastomer	<input type="checkbox"/> NBR	<input type="checkbox"/> HNBR	<input type="checkbox"/> FKM
Elastomer code			
Properties			
Density	ISO 2781	g/cm3	
Hardness	ISO 48	IRHD	
Tensile Strength	ISO 37	MPa	
Dimensions of transversal section			
Transversal section	<input type="checkbox"/> Δ <input type="checkbox"/> □ <input type="checkbox"/> ○ <input type="checkbox"/> ◇ <input type="checkbox"/> ◡ <input type="checkbox"/> _		
Height	mm		
Width	mm		

**Table 2 – Gasket information to be included in the Data Sheet**

## 6.2 Welding

6.2.1. Welding on the plate type heat exchanger shall be performed in compliance with ASME BPVC Section IX. All welding methods defined therein, with exception of oxyacetylene gas, are accepted, as long as qualified by applicable welding procedure.

6.2.2. Only full penetration welds are permitted.

## 6.3 Piping connections

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

6.3.2. Nozzles or nozzle connections on fixed and movable covers shall be designed to accept the loads due to piping reaction shown in the table for severe service nozzle loading from API 662 – Part 1. It shall be noted that with the listed standard nozzle loads, no heave, surge or sway combinations are implied.

6.3.3. All flange connections (nominal size and flange facing) shall comply with ASME Code.

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

6.3.5. Carbon steel nozzles or studded openings in the fixed cover plate in contact with the process fluid must 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 PETROBRAS approval.

#### **6.4 Equipment supports**

6.4.1. The heat exchangers shall be provided with mounting feet or brackets capable of handling the dynamic forces as stated in the I-RL-3010.1M-1350-960-P4X-009 - MOTION ANALYSIS.

6.4.2. MANUFACTURER 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.


6.4.3. MANUFACTURER 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.

**6.5** MANUFACTURER shall inform the necessity of using any accessory equipment to guarantee the exchanger performance and satisfactory continuous operation.

**6.6** MANUFACTURER shall inform the number of plates for each operational case shown on Process Data Sheet.

#### **6.7 Material Selection**

MANUFACTURER shall refer to I-ET-3010.1M-1200-450-P4X-001 - MATERIAL SPECIFICATION FOR HEAT EXCHANGERS for the material selection of the plate heat exchangers. Other plate heat exchangers presented on the platform, not listed therein, shall have their design and material selection submitted to PETROBRAS approval, and shall conform to all other requirements of this specification.

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## 7. CORROSION PROTECTION AND PAINTING

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

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

**7.3** Tie bolts and nuts must 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 must be submitted and receive prior approval from PETROBRAS.

**7.4** 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. MANUFACTURER shall submit for PETROBRAS approval the protective coating for bolts and nuts.

**7.5** 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 MANUFACTURER.

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

## 8. NAMEPLATES AND SIGNS

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

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

- All Code and Classification requirements,
- Design code,
- Tag number,
- Manufacturer 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.

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

Note: Any plate-and-frame heat exchanger that has a lining (e.g. in the nozzles) such as lead, rubber, glass, epoxy, etc. shall have warnings printed on the outside of the unit saying "No welding permitted".

**8.3** All safety signs shall be in the Portuguese language.

## 9. CERTIFICATION REQUIREMENTS

For all heat exchangers, a Classification Society certificate shall be supplied. MANUFACTURER shall be responsible to obtaining all necessary certification of the equipment. MANUFACTURER 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 Inspection

10.1.1. MANUFACTURER shall submit an Inspection and Test Plan (ITP) based on the technical data sheet with witnessed inspections and tests identified.

10.1.2. MANUFACTURER shall ensure that all the witnessed inspection requirements by the Classification Society are fully accommodated and the due notice requirements are satisfied.

10.1.3. The notification period for such inspections shall be mutually agreed.

### 10.2 Testing

10.2.1. Testing shall be in accordance with API 662 and ASME VIII Div. 1 as a minimum. At least, the following tests will be carried out:

- Hydrostatic test as per codes.
- UV light box test on plates.
- Liquid penetrant examination on liner welds if applicable.
- Radiographic examination of main welds of all welded plate heat exchangers.
- Visual examination.
- Liquid penetrant or magnetic particle on lifting attachments.
- 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.

10.2.2. Minimum extent of non destructive examination shall be as follows:

- Radiographic examination on fully welded plate heat exchangers shall be 100% of all welds.
- Welded cassettes shall receive visual inspection and helium or halogen leak test.
- Radiographic examination of construction welds shall be 10% of all welds.

- Ultrasonic examination shall be applied instead of radiography wherever the plate thickness exceeds 50 mm.
- 100% welds must be subjected to a visual inspection, internal and externally.
- 100% lifting attachments.
- 100% of all pressure retaining parts.

### 10.3 Commissioning

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

## 11. PREPARATION FOR SHIPMENT

### 11.1. Marking

11.1.1. All items supplied to this specification shall be adequately marked for identification against a certificate or relevant test documentation. Marking shall be such that it will not damage or impair the component.

11.1.2. Items that cannot be identified shall be rejected. Rejected items may be re-certified by carrying out all relevant testing, with previous approval of the PURCHASER.

11.1.3. As a minimum, the following identification shall be provided:

- Project Number
- Manufacturer's name
- Purchase Order Number
- Minimum Breaking Load (MBL)
- Item Number
- Classification Society surveyor's stamp

### 11.2. Shipment Packing

11.2.1. The equipment shall be suitably prepared for the type of shipment specified. The preparation shall make the equipment suitable for 12 months of outdoor storage from time of shipment.

11.2.2. MANUFACTURER shall submit the packing design to the PURCHASER for approval. MANUFACTURER shall package the equipment in accordance with the packaging requirements of the country to which the equipment is being shipped. The package must be protected from corrosion.

11.2.3. MANUFACTURER shall provide the procedures for unpacking, handling, and installation, as well as repacking, and long-term storage requirements. MANUFACTURER shall specify any limitations applicable to the transport and installation phase.