PETROBRAS	**TECHNICAL SPECIFICATION**	**Nº:** I-ET-3010.1M-1200-451-P4X-001	
	CLIENT: SRGE		**SHEET:** 1 of 17
	JOB: REFERENCE BASIC DESIGN		1001056398 0010
	AREA: BUZIOS		
DP&T-SRGE	**TITLE:** **SHELL & TUBE HEAT EXCHANGER SPECIFICATION**		NP-1
			ESUP

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SUMMARY

1 OBJECTIVES

1.1 This Technical Specification contains the minimum requirements for the design, engineering, materials, fabrication, inspection, testing and certification of all Shell & Tube Heat Exchangers (including Double Pipe and Multi-Tube Hairpins) for the FPSO's topsides. It complements the Technical Specification I-ET-3010.1M-1200-540-P4X-001 - REQUIREMENTS FOR PRESSURE VESSELS DESIGN.

1.2 For the purpose of this document, the designations "shell-and-tube heat exchangers" cover heat exchangers in general such as heaters, coolers, reboilers and any other heat exchanging equipment.

2 DEFINITIONS

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

May	indicates a course of action that is permissible within the limits of this specification (a permission).
Shall	an absolute requirement to be followed strictly in order to conform to this specification.
MANUFACTURER	Firm or organization responsible for the thermal and mechanical design, fabrication and test of the heat exchanger.
PACKAGER	Firm or organization responsible for the design, erection and test of the package where the heat exchanger under consideration is located.
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/PACKAGER with all requirements necessary to obtain certification or classification of the goods and/or services described herein.

3 MANUFACTURER/PACKAGER´S OBLIGATIONS

3.1 Compliance with the requirements or recommendations of this Specification or other standards shall in no case reduce or eliminate the responsibility of the MANUFACTURER/PACKAGER, who will bear full responsibility at all times for the design and fabrication of the heat exchanger.

3.2 In those cases where PURCHASER 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 PURCHASER.

3.3 For heat exchangers not designed by PURCHASER, MANUFACTURER/ PACKAGER shall be responsible for the thermal and mechanical design. MANUFACTURER/PACKAGER shall guarantee that the equipment meets the performance specified: heat transfer and pressure drop at fouling conditions. PURCHASER reserves the right to check the thermal, mechanical and fabrication design prepared by MANUFACTURER/PACKAGER.

3.4 MANUFACTURER/PACKAGER's responsibility shall also include but not limited to:

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

3.5 The MANUFACTURER/PACKAGER shall design the equipment for the full range of process conditions as specified in the data sheets.

3.6 It is the MANUFACTURER/PACKAGER'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.

4 CODES AND STANDARDS

4.1 Shell & Tube Heat Exchangers designed and fabricated in accordance with this Technical Specification shall comply with the documents mentioned on item 4.2 below. Equipment shall also be in accordance with rules and regulations of the Classification Society applied for the unit. In case of conflict between Classification Society requirements and this Technical Specification, the MANUFACTURER/PACKAGER must submit this issue to PURCHASER.

4.2 Unless noted, the edition and addenda of each document listed below shall be used as current on the date of this specification.

TEMA	Standards of the Tubular Exchanger Manufacturers Association
API 660	Shell-and-Tube Heat Exchangers;
ASME Boiler and Pressure Vessel Code	Section VIII Div. 1, II and V;
ASME B16.5	Pipe Flanges and Flanged Fittings (NPS ½ Through NPS 24);
ASME B 16.47	Large Diameter Steel Flanges Nps 26 Through Nps 60;

FBTS	Brazilian Welding Technology Foundation
ISO 15156	Petroleum And Natural Gas Industries - Materials For Use In H2S-Containing Environments In Oil And Gas Production.
ABNT NBR 6123	“Forças devidas ao Vento em Edificações” (Brazilian technical standard for wind load calculation)
NR-13	Ministério do Trabalho e Emprego (Brazilian Labor Ministry) – Norma Regulamentadora N° 13 (NR-13) - "CALDEIRAS, VASOS DE PRESSÃO, TUBULAÇÕES E TANQUES METÁLICOS DE ARMAZENAMENTO"
IEC 61892-6	Mobile and Fixed Offshore Units – Electrical Installations - Installation
IEC 61892-7	Mobile and Fixed Offshore Units – Electrical Installations – Hazardous Areas
IEC 60092-502	Electrical Installations in Ships – Tankers – Special Features

5 GENERAL REQUIREMENTS

5.1 Shell & Tube and Double Pipe (including Multi-Tube Hairpin) heat exchangers handling process fluids shall comply with TEMA R and API 660 and TEMA C for lube oil coolers. The engineering, fabrication, materials, inspection and testing shall be in accordance with ASME VIII Division 1 and TEMA. See also I-ET-3010.00-1200-540-P4X-001 - REQUIREMENTS FOR PRESSURE VESSELS DESIGN.

5.2 MANUFACTURER/PACKAGER shall check all tube bundles for flow-induced and acoustic vibration and shall include the necessary features to minimize their damaging results.

5.3 Bundle type U shall be accepted only for services with clean fluids flowing through tubes and only with PURCHASER approval, including heat exchangers from package units such as turbo-compressors.

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

5.5 Finned tubes shall be accepted only with PURCHASER approval.

5.6 For heat exchangers not designed by PURCHASER and when not previously specified in the data sheets, the following points shall be approved by PURCHASER:

- The selected heat exchanger type in accordance with TEMA standard;
- The side chosen for each fluid (shell or tube side);
- Tube pattern;
- Tube diameter and thickness;

- The solution of vibration problems observed.

5.7 Types of Heat Exchangers:

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 PURCHASER.

Fixed tubesheet heat exchanger is the preferred type when operating conditions allow this design. Limiting factors are shell side fouling conditions and thermal stresses due to differential temperature between the tubes and the shell during normal operation, start-up, shutdown or other conditions. Expansion joints shall be avoided and may only be used if expressly authorized by PURCHASER.

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/cm2);
- Shell side temperature range is greater than 190 °C.

When the F type shell is allowed to be used, the MANUFACTURER/PACKAGER shall provide and submit to PURCHASER 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 and tubesheet due to the resulting thermal gradient, which could result in leakage of fluids.

5.8 Exchangers shall be suitable for operation in accordance with the area classification defined in the equipment data sheet.

5.9 The MANUFACTURER/PACKAGER shall design and fabricate the equipment for a minimum lifetime of 25 years.

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

6 DESIGN REQUIREMENTS

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

6.2 In the mechanical design of 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.

6.3 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.

6.4 No part of the heat exchanger shall be designed for differential pressure, except when specifically accepted by PURCHASER.

6.5 In addition to ASME Code described loads 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.
- Thermal loads.
- Wind loads.
- Weight loads.

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

Effects of vessel motion (cyclic): the calculations shall take into account the liquid motions (lateral and longitudinal loads) within the vessels for saddle design (Plus & minus effects).
For vertical vessels, even though the liquid motion effects are small, the hydrostatic head will be cyclic because of the heave accelerations. This shall be taken into consideration.
Normally $H = \rho gh$, this becomes $H = \rho h (g + or – f)$, where f is the heave acceleration.

6.6 The determination of Minimum Metal Design Temperature (MDMT), as defined in ASME VIII, Div.1, must consider the possibility of a large temperature reduction due to sudden depressurization of equipment.

6.7 Girth Flanges

Girth flanges refer to flanges of the channel, shell, shell cover and floating head cover that do not belong to nozzles.

Forged steel welding neck flanges may be used for any pressure rating and diameter.

Forged steel slip-on flanges may be used for pressure ratings 150# and 300# and any diameter, but limited to 400 °C. This type shall not be used when the corrosion allowance is greater than 3 mm

Hot-rolled, forged steel, seamless ring-type flanges or those made of plate or bar shall be selected according to the design pressure in accordance with the following:

- For a design pressure up to and including 2,000 kPa (290 psi), regardless of the fabrication, ring-type flanges shall comply with one of the figures 2-4 (7), (8), (8a), (9), (9a), (10), (10a) or (11) of ASME Code, Section VIII, Division 1, provided the corrosion allowance is less than 3 mm.
- For a design pressure over 2,000 kPa (290 psi), regardless of the fabrication, ring-type flanges shall comply with one of figures 2-4 (7) or (11) of ASME Code, Section VIII, Division 1, and welds connecting flanges to the shell shall obligatorily be 100% inspected by ultrasonic testing.

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 available at all times to PURCHASER for examination, whenever so requested.

Bolt spacing must be within the recommended minimum and maximum spacing of TEMA and the use of the correction factor presented therein shall not be permitted. The minimum diameter of flange bolts shall be 3/4" as per TEMA standard. See also I-ET-3010.00-1200-540-P4X-001 - REQUIREMENTS FOR PRESSURE VESSELS DESIGN.

The flange of the floating head cover shall be preferably in accordance with Figure 1-6 (d) of ASME Code Section VIII, Div. 1, Appendix 1. A more accurate calculation method may be used for the flange of the floating assembly, in accordance with ASME Section VIII, Division 1, Paragraph 1-6 (h), provided the rigidity of the flange is maintained.

6.8 Floating Head Cover

The floating head cover shall have one of the configurations shown in the figure of the TEMA RCB 5.141 standard, types A, B, and D. Type A is preferable.

Since joints shall be of the “confined” type, there shall obligatorily be a projection (indicated as optional in the figure of the TEMA RCB 5.141 standard) and its length shall be 5 mm.

To increase rigidity of the assembly, 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 ANNEX 2.

Bolts of the floating head cover shall be easily accessible with the shell cover removed.

6.9 Types of Facing and Joints

The type of joints for girth flanges shall be selected according to ANNEX 1. Gaskets shall be asbestos-free with characteristics as per TEMA Standard and ASME Code.

Flat solid metal joints are only allowed in exceptional cases and when accepted by PURCHASER. Welded flat joints shall not be accepted.

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

In the design of the pair of flanges used to contain the tubesheet both joints are compressed by the same stud. In this case, identical joints suitable for both conditions shall be used.

6.10 Expansion joints shall only be used when specified or expressly authorized by PURCHASER. Its adoption is forbidden in the following cases:

- Lethal service;

- Equipment operating with hydrocarbons in the gas phase on the shell or tubes side at a pressure higher than other side fluid pressure;
- External expansion joint on shell side with hydrocarbons in the liquid phase inside it at a temperature higher than the flash point.

6.11 Nozzles shall be in accordance with I-ET-3010.00-1200-540-P4X-001 - REQUIREMENTS FOR PRESSURE VESSELS DESIGN and TEMA standard.

6.12 Tubesheets

The minimum distance between the edge of the tube holes and the edge of all gasket grooves shall be as required by API 660 standard.

For additional tubesheet construction requirements see 7.4.

6.13 Tube Bundle

The minimum outside diameter of the tubes and minimum tube wall thickness shall be in accordance with recommendations of API 660.

Impingement plates shall be circular type and shall extend at least 25 mm beyond the projection of the nozzle bore or have a diameter 10% larger than the nozzle internal diameter, whichever is greatest.

The maximum recommended weight for the tube bundle is 98.1 kN (10 000 kgf). Weights exceeding this value shall be approved by PURCHASER, in which case MANUFACTURER/PACKAGER shall include any devices needed for the use of a bundle extractor.

Whenever the weight of the tube bundle is greater than 29.5 kN (3,000 kgf) or there is an anticorrosive clad in the shell, slide bars shall be placed in the tube bundle and tracks in the shell to facilitate the removal of the tube bundle and to prevent damage of the coating. These bars and tracks shall be made of material resistant to corrosion caused by the shell fluid.

The thickness of tube bundle baffles shall not be less than twice the corrosion allowance adopted for the shell. Wherever necessary, transverse baffles shall be slotted to allow complete drainage of the shell.

The tube bundle of vertical heat exchangers shall be removable from the top.

6.14 Others Details

Jack screws shall be placed at all connections with girth flanges. Lifting lugs shall be placed on the channel, channel cover, shell cover and floating head. Lugs shall be long enough to avoid interference with insulation. Tubesheets shall have threaded holes, to allow insertion of eyebolts for the removal of the bundle. These holes shall be located on the periphery outside the coating, if existent.

All external bolts shall have a surplus threaded length at least equal to the thickness of the nut to allow a tensioning device to be coupled.

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

Each heat exchanger shall be provided with two earthing bosses, one on each support, in a diagonally opposed location. 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.

Equipment with type A or B front-end head shall be fitted with a special test flange (companion flange) to permit pressurization of the shell, for testing, with the tubesheet in place and the head removed. Alternatively, the outside diameter of the tubesheet may be the same as that of the shell flanges. When a floating head heat exchanger (Type S or T rear head) is specified, a test ring shall be designed and fabricated by the MANUFACTURER/PACKAGER. Test flange and ring assemblies shall become the property of PURCHASER and shall be shipped with the remainder of the equipment.

7 FABRICATION

7.1 Fabrication, welding, heat treatment, tests on materials and inspections of exchangers shall comply with appropriate Codes, this specification and with specification I-ET-3010.00-1200-540-P4X-002 - REQUIREMENTS FOR PRESSURE VESSELS FABRICATION.

7.2 All heat exchangers shall be fitted with a nameplate in the Portuguese language. The nameplate shall be of stainless steel, 3 mm thick and shall be fastened by corrosion resistant bolts and located in a visible and accessible location. For orientation and minimum data required on nameplate see ANNEX 3. The vessel category according to NR-13 must be fitted in an additional nameplate next to the main nameplate. Any other safety signs required shall be in Portuguese.

7.3 Girth Flanges

Welding neck flange obtained by machining a forged ring is only allowed in exceptional cases and when accepted by PURCHASER. In this case, a tensile test in the 3 directions shall be performed.

Ring-type flanges made of bar or plate of any rating shall be obtained from rolled or forged rings, 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 PURCHASER.

7.4 Tubesheets

Tubesheets shall preferably be of forged construction whenever possible, or made of plate if previously approved by PURCHASER. If the tubesheet is made of welded plates, the weld shall be fully radiographed and ultrasonically inspected.

Tubesheets for brass or aluminium brass tubes shall be made of cast or forged copper aluminium, the grade of which shall be approved by PURCHASER.

Tubesheets welded to the shell (or to the channel) shall comply with only one of the following figures in ASME Code Section VIII, Div. 1: UW-13.2 (i), UW-13.2 (j), UW-13.2 (k) and UW-13.3 (all types). Tubesheets in accordance with any of the types shown in Fig. UW-13.3 shall in all cases be of forged construction, regardless of the diameter and material used.

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 must 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. In the case of a cladded tubesheet, it shall have 1 more expansion slot made in the clad which shall be at least 9 mm thick so as to fully contain the additional slot. The minimum distance between the edge of the slot and the outer face of the clad shall be 3 mm.

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_2 and H_2S), 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).

In the cases mentioned above, the tube-to-tubesheet connection shall be by total full strength welding as per ASME Code Section VIII, Division 1, item UW-20.2 (a). In these cases, another type of tube-to-tubesheet connection shall only be permitted when explicitly authorized by PURCHASER. Whenever full strength welding is used, 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.

Tube holes shall be grooved, deburred, and cleaned of all debris and cutting fluids. The ID of the hole shall be free of all burrs, sharp edges, scratches, gouges, or indentations.

7.5 Tube Bundle

All tubes including U-tubes shall be formed from a single length and shall have no circumferential welds.

Based on the “U” tube material, the manufacturer 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 fibers are deformed more than 15%, a heat treatment for stress relief as described in ASME II/A SA-213 Supplementary Requirement S1 must be done, but at a temperature range of 1040 to 1120°C.

7.6 Shell and Channel

Shell welds shall be ground on the inside to facilitate the removal of the tube bundle. When there is a difference in thickness between shell plates or between the shell and the cover, the plates shall be aligned by the inside surface.

8 MATERIALS

8.1 Seamless tubing shall be specified for all cases.

8.2 When required by the tube specification, 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.

8.3 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.

8.4 Anticorrosive Coating

Tubesheets shall only be provided with anticorrosive coating (including clad-plate construction) on the tube side, i.e., on the side where the tube ends are expanded or welded. Anticorrosive coating on the tubesheet, on the shell side, is only allowed when expressly authorized by PURCHASER.

For tubesheets with anticorrosive metal coatings, only the clad plate construction (in accordance with specifications ASTM A 263, A 264 or A 265) is allowed without prior approval by PURCHASER. Any other type of coating shall be subject to express approval by PURCHASER in each case.

For tubesheets and channels with anticorrosive metallic coatings, the anticorrosive coating shall extend all the way around the insertion slots of pass partitions and the entire seating area of the gasket. For heat exchangers with a coated channel, the channel cover shall also be coated.

Cladding by weld overlay in the shell shall only be accepted with smooth surface finish by machining, so as to allow easy removal and assembly of the tube bundle.

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

8.5 Corrosion allowances shall not be less than the minimum values required by the TEMA standard. Corrosion allowance shall be added to the female faces (male and female flanges) and to grooves (tongue and groove flanges). No corrosion allowance shall be added to heat exchanger tubes made of any material.

8.6 Material of heat exchangers designed to operate with amine and amine compounds shall comply with requirements of I-ET-3010.00-1200-955-P4X-001 - WELDING.

8.7 Welding consumables shall be in conformity with I-ET-3010.00-1200-955-P4X-001 - WELDING. Consumables shall be qualified according to the certification system of FBTS (Fundação Brasileira de Tecnologia de Soldagem).

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

8.9 Painting

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

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

8.10 When insulation is required, it shall ensure a temperature below 60° C on the outside surface and shall be of non hygroscopic material.

9 CERTIFICATION REQUIREMENTS

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

10 INSPECTION AND TESTING

10.1 Before the hydrostatic test, a leak test with gaseous fluid shall be performed at a pressure not exceeding the design pressure. The testing methodology and acceptance criteria shall be agreed upon between PURCHASER and MANUFACTURER/PACKAGER using ASME code Section V as a basis.

10.2 Inspection and testing shall be in accordance with TEMA, ASME VIII Div. 1 and with I-ET-3010.00-1200-540-P4X-002 - REQUIREMENTS FOR PRESSURE VESSELS FABRICATION as a minimum.

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

11 PREPARATION FOR SHIPMENT

11.1 Marking

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.

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

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

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.

MANUFACTURER/PACKAGER shall submit the packing design to the PURCHASER for approval. MANUFACTURER/PACKAGER 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.

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

ANNEX 1 - TYPE OF GASKETS FOR GIRTH FLANGES

Type of Gasket	Material	Scheme
Double Jacketed Graphite Filled Gasket	Aluminum	
	Copper or Brass	
	Carbon Steel	
	[1)]Monel®	
	4-6 % Chromium	
	Stainless Steel	
Solid Metal (Grooved)	Aluminum	
	Copper or Brass	
	Carbon Steel	
	Monel® or 4-6% Chromium	
	Stainless Steel	

Notes:

1) The table above is in agreement with ASME Code Section VIII, Division 1.

2) Except as otherwise specified, gaskets for all girth flanges of heat exchangers shall be selected as follows:

a) for ratings from 150 up to and including 300, with a design temperature between 15 °C and 250 °C: double jacketed carbon steel, with flexible graphite filled gasket for flanges with male/female type facing;

b) for ratings from 150 up to and including 300, with a design temperature below 15 °C or above 250 °C, or ratings 400 and 600 for any design temperature: double jacketed austenitic stainless steel with flexible graphite filled gasket for flanges with male/female facing";

c) for ratings 600 operating gas or vapor or ratings 900 or higher for any design temperature: solid metal gasket for flanges with tongue and groove facing or tongue and groove with nubbin; in this case the gasket material shall not form a galvanic couple with the flange and its hardness shall be 30 Brinell less than the hardness of the flange facing, the following maximum hardness values being indicated according to the gasket material:

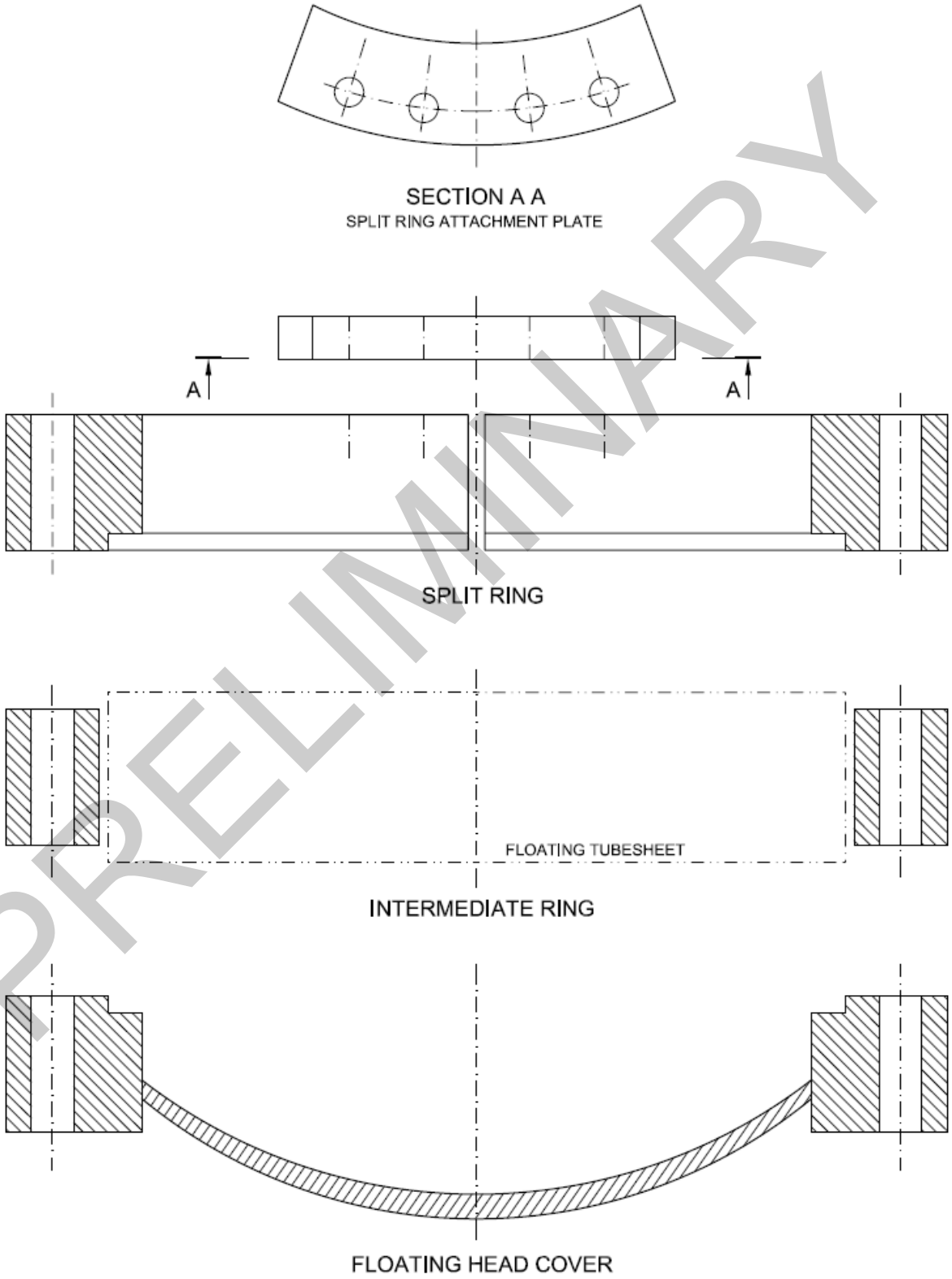
gasket material: carbon steel	max. hardness:90 HB
gasket material: stainless steel 1@ 5% Cr	max.hardness:130 HB
gasket material: stainless steel 304 or 316	max. hardness:130 HB
gasket material: stainless steel 304L or 316L	max. hardness:110 HB

d) in any type of specified gasket the nature of the fluid in contact with it shall be taken into account when the material is specified.

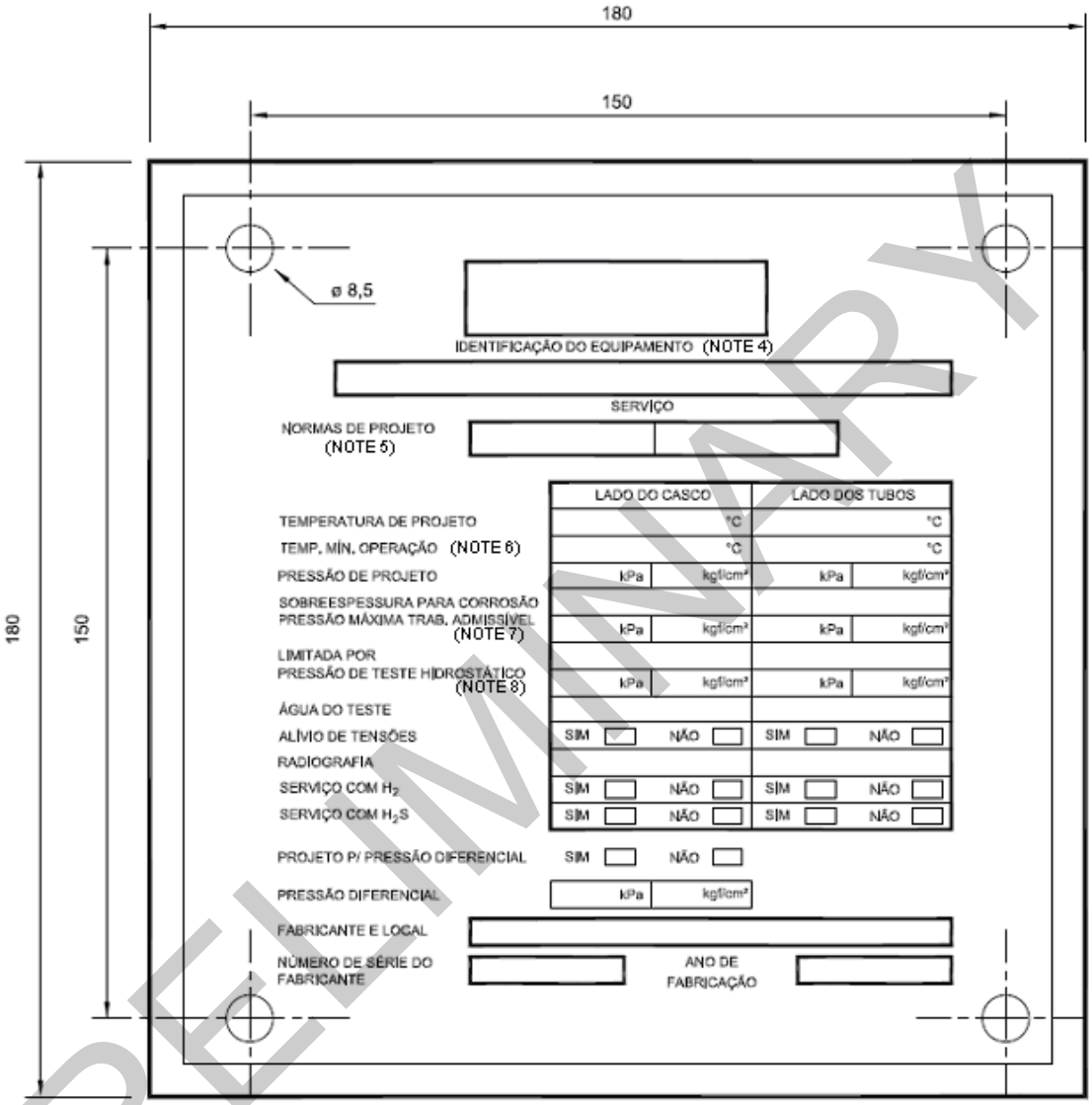
3) Gasket factor (m) and the seating stress of gaskets may be found in Appendix 2 of ASME Code Section VIII Division I.

[1)]MONEL® (metal monel): This material is property of "International Nickel Corp.". This information is provided to facilitate use of this Standard by users and shall not be construed as a recommendation of the aforementioned product by PETROBRAS. An equivalent product may be used provided it leads to the same results.

ANNEX 2 – FLOATING HEAD COVER ASSEMBLY



ANNEX 3 - NAMEPLATE FOR HEAT EXCHANGER



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 MANUFACTURER/PACKAGER about the disposition of the minimal obligatory information on the nameplate. Additional information may be included if necessary or to MANUFACTURER/PACKAGER´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 (PMTA) shall be determined for the corroded and hot condition.
8) The hydrostatic test pressure shall be determined as by ASME Code Section VIII.