PETROBRAS	**TECHNICAL SPECIFICATION**	I-ET-3010.00-1200-500-P4X-001	
	CLIENT: SRGE		SHEET: 1 of 19
	JOB:		
	AREA:		
SRGE	TITLE: **NON METALIC TANKS AND PRESSURE VESSELS DESIGN**		INTERNAL
			ESUP

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SUMMARY

1 OBJECTIVE

This Technical Specification defines minimum requirements applicable to design, engineering, materials, fabrication, inspection, testing of pressure vessels and tanks made of Fiber Reinforced Polymers (FRP).

In addition to the requirements of this technical specification, SELLER shall follow all the requirements of the Exhibit I (scope of supply), as well as Exhibit III (directives for 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 SELLER shall perform the work in accordance with the requirements of the Classification Society.

2.1.2 SELLER is responsibility to submit to the Classification Society the documentation in compliance with stated Rules.

2.1.3 Classification Society rules may only be waived upon the formal approval from the Classification Society itself and from BUYER.

2.2 CODES AND STANDARDS

2.2.1 The following codes and standards include provisions which, through reference in this text, constitute provisions of this specification. The latest issue of the references shall be used unless otherwise agreed.

2.2.2 Other recognized standards may be used, provided it can be shown that they meet or exceed the requirements of the standards referenced below. Formal approval from BUYER and from Classification Society is also required.

API SPEC 12P	Specification for Fiberglass Reinforced Plastic Tanks
API 520-Part 1	Sizing, Selection, and Installation of Pressure-relieving Devices – Sizing and Selection.
ABNT NBR 6123	Forces due to wind in buildings
ASME RTP-1	Reinforced Thermoset Plastic Corrosion Resistant Equipment
ASME BPVC	Section V – Nondestructive Examination
ASME BPVC	Section X – Fiber-Reinforced Plastic Pressure Vessels
ASME B16.1	Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125 and 250
ASME B16.5	Pipe Flanges and Flanged Fittings NPS ½ through NPS 24 Metric/Inch Standard
ASME B16.47	Large Diameter Steel Flanges NPS 26 through NPS 60 Metric/Inch Standard
ASTM D257	Standard Test Methods for DC Resistance or Conductance of

	Insulating Materials
ASTM C582	Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment
ASTM D3299	Standard Specification Filament-Wound Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks
ASTM D4097	Standard Specification for Contact-Molded Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks
ASTM D5421	Standard Specification for Contact Molded “Fiberglass” (Glass-Fiber-Reinforced Thermosetting Resin) Flanges
ASTM D4024	Specification for Machine Made “Fiberglass” (Glass-Fiber-Reinforced Thermosetting Resin) Flanges
BS EN 13121	GRP tanks and vessels for use above ground – Parts 1 to 4
PIP VEEFG001	Fiberglass Tank and Vessel Design Guidelines
PIP VESFG001	Fiberglass Tank and Vessel Specification
IEC 61892	Mobile and fixed offshore units – Electrical installations (all parts)
IEC 60092-502	Electrical installations in ships – Part 502: Tankers – Special features
ISO 3915	Plastics — Measurement of resistivity of conductive plastics

2.3 GOVERNMENT REGULATION

Brazilian Regulatory Standards are mandatory and shall prevail, if more stringent, over the requirements of this specification and other references herein.

Table 1: Government Regulation

NR-26	- Brazilian Regulatory Standard - Safety Signaling
NR-37	- Brazilian Regulatory Standard - Safety and Health in Petroleum Platforms
INMETRO	- INMETRO Resolution nº 115, March 21st 2022

2.4 DESIGN SPECIFICATIONS

Table 2: Design Specifications

DR-ENGP-I-1.15	COLOR CODING
DR-ENGP-M-I-1.3	SAFETY ENGINEERING GUIDELINE
I-DE-3010.00-5140-700-P4X-003	GROUNDING INSTALLATION TYPICAL DETAILS
I-ET-3010.00-1200-200-P4X-116	REQUIREMENTS FOR BOLTED JOINTS ASSEMBLY AND MANAGEMENT
I-ET-3010.00-1200-251-P4X-001	REQUIREMENTS FOR BOLTING MATERIALS

I-ET-3000.00-1200-940-P4X-001	TAGGING PROCEDURE FOR PRODUCTION UNITS DESIGN
I-ET-3010.00-1200-940-P4X-002	GENERAL TECHNICAL TERMS
I-ET-3010.00-1200-972-P4X-006	REQUIREMENTS FOR MANUFACTURING SURVEY INSPECTION
I-ET-3010.00-1200-970-P4X-013	COMPLIANCE WITH NR-13 AND SPIE REQUIREMENTS
I-ET-3010.00-1200-970-P4X-003	REQUIREMENTS FOR PERSONNEL QUALIFICATION AND CERTIFICATION
I-ET-3010.00-1200-956-P4X-002	GENERAL PAINTING
I-ET-3010.00-1200-970-P4X-004	NON-DESTRUCTIVE TESTING REQUIREMENTS FOR METALLIC AND NON-METALLIC MATERIALS
I-ET-3010.00-5140-700-P4X-001	SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS.

2.5 SPECIFIC DOCUMENTS TO BE SUPPLIED BY BUYER:

Table 3: Specific Documents [Supplied by BUYER]

- METOCEAN DATA
- MOTION ANALYSIS
- PROCESS DATASHEET
- GENERAL ARRANGEMENT
- GENERAL AREA CLASSIFICATION
- MATERIAL SPECIFICATION FOR TANKS

2.6 CONFLICTING REQUIREMENTS

In case of conflicting requirements between this technical specification and other cited references, the most stringent shall prevail. If necessary, the SELLER may revert to BUYER for clarification.

3 DEFINITIONS AND ABBREVIATIONS

3.1 DEFINITIONS

3.1.1 All Terms and definitions are established in the latest revision I-ET-3010.00-1200-940-P4X-002 – GENERAL TECHNICAL TERMS.

3.2 ABBREVIATIONS

FRP Fiber Reinforced Polymers
HAZOP Hazard and Operability Study
PHA Process Hazards Analyses

4 GENERAL REQUIREMENTS

4.1 OPERATION ENVIROMENT

4.1.1 The equipment shall be suitable for the environment and range of ambient conditions, including atmospheric pressure, relative humidity, rainfall, dry-bulb air temperature, characteristic monthly values and wind motions defined in METOCEAN DATA specification [document supplied by BUYER].

4.2 MOTION REQUIREMENTS

4.2.1 The necessary design data and information on motion requirements of the floating unit are given in the latest revision of MOTION ANALYSIS report [document supplied by BUYER].

4.3 EQUIPMENT LOCATION

4.3.1 Equipment location is according to the floating unit GENERAL ARRANGEMENT drawing [document supplied by BUYER].

4.4 DESIGN CONDITONS

4.4.1 SELLER shall design the equipment in accordance with the design conditions and dimensions as specified in the PROCESS DATASHEET [document supplied by BUYER].

4.4.2 If design conditions are not defined in the PROCESS DATASHEET document, SELLER shall consult BUYER for clarification.

4.5 DESIGN LIFETIME

4.5.1 SELLER shall design and fabricate the equipment for a minimum lifetime of 30 years.

4.6 SAFETY REQUIREMENTS

4.6.1 Maximum allowable pressure drop for pressure relief devices shall comply with API 520 – Part 1 requirements.

4.6.2 For area classification information see the GENERAL AREA CLASSIFICATION [document supplied by BUYER].

4.6.3 HAZOP and PHA shall be according to DR-ENGP-M-I-1.3 – SAFETY ENGINEERING GUIDELINE.

4.7 SCOPE OF SUPPLY

4.7.1 The scope of supply for the equipment shall include, but not necessarily be limited to the following:

- dedicated nozzle connections.
- grounding and lifting lugs.
- earthing boss.
- baffles.
- internals, as applicable.
- manhole.
- supports and/ or skids, when applicable.
- Nameplate.

4.7.2 If required supports for pipping and tertiary structures, does shall be installed directly

in the primary/secondary structure. No clips shall be installed at nonmetallic equipment, except for thermal insulation.

4.7.3 Tanks shall be provided with figure-8 blank (spectacle flange) at the main nozzles.

4.7.4 Tanks shall be provided with vent connections according to the applicable API standards. In case of storing flammable liquids, they shall have flame arrestors.

5 DESIGN

5.1 GENERAL REQUIREMENTS

5.1.1 Critical services are equipment that operates with flammable, combustible, lethal and toxic fluids.

5.1.2 Equipment operating with critical service shall follow the requirements of ASME RTP-1.

5.1.3 Tanks here are defined as equipment for storage of fluids with design pressure equal to atmospheric pressure. Pressure vessels are those equipment which design pressure is different from atmospheric, positive or negative, for storing or processing of fluids.

5.1.4 The criteria in Appendix NM-14 of ASME RTP-1 and Appendix 1 of ASME BPVC Section X shall be met.

5.1.5 When calculating the structural walls of the equipment, the thickness of the chemical barrier or liner, internal or external, shall not be considered as part of the calculated thickness.

5.2 PRESSURE VESSEL REQUIREMENTS

5.2.1 ASME RTP-1 and ASME BPVC Section X cover different types of equipment. The choice between one or the other shall be based primarily on the design pressure required for it:

5.2.1.1 For design pressures above 15 psig (0.103 MPa or 1.05 kgf/cm²), ASME BPVC Section X shall be followed;

5.2.1.2 For design pressures below 15 psig (0.103 MPa or 1.05 kgf/cm²) until complete vacuum, ASME RTP-1 shall be followed.

5.2.2 Pressure vessels made of epoxy resin shall be built according to ASME BPVC Section X, regardless of the design pressure.

5.2.3 In order to define the class of pressure vessel to be built, according to ASME BPVC Section X, the following points shall be evaluated:

5.2.3.1 Class I pressure vessels shall be manufactured after qualification of at least one prototype vessel that shall be subjected to destructive hydrostatic test (Burst test), where it should fail at a pressure equal to or greater than six times the design pressure after the fatigue test (100,000 cycles).

5.2.3.2 Pressure vessels designed and built according to Class II shall pass a hydrostatic test monitored by an acoustic emission test for qualification.

5.2.4 Equipment defined as pressure vessels and designed according to ASME BPVC Section X shall meet the criteria of Appendices AB and AJ.

5.2.5 Pressure vessels shall be designed and built according to Class I, II or III criteria of ASME BPVC Section X. Regarding the process of manufacturing the side (structural thickness), molding by filament winding shall be used in all the pressure vessel classes, for technical reasons regarding quality, homogeneity and optimization of materials in manufacturing.

5.2.6 For operating conditions that may give rise to fatigue loads and / or stress creep, the vessel qualification and allowable stresses shall be determined according to items in the ASME BPVC Section X for Class III vessels (Mandatory Appendix 8), even if they are Class I or II vessels.

5.3 TANK REQUIREMENTS

5.3.1 The ASTM D 3299 standard may be used also for vertical cylindrical tanks, supported directly on the ground and at atmospheric pressure, but accepting only polyester and vinyl ester resins. This is not acceptable for corrosive, dangerous fluids, with complex geometries (not cylindrical), or of large dimensions.

5.3.2 Duo-laminated equipment, when specified, shall follow ASME RTP-1 for fabrication and coating inspection regardless of pressure design.

5.3.3 Equipment designed according to ASME Section X or RTP-1, shall meet the criteria of Appendices NM-2, NM-4, NM-5, NM-7, NM-8, NM-9, NM-11, NM-12, NM-13, NM-14, NM-15 of ASME RTP-1 and appendix 1 of ASME Section X.

5.3.4 For specific cases, such as tanks of rectangular section and others, the SELLER shall apply formulas and criteria derived from applicable standards, including BS EN 13121 - Part 2. Regardless of the calculation criteria, the admissible stresses and deformations adopted shall be justified by the SELLER calculation memorial to be approved by BUYER.

5.3.5 Tanks with cylindrical cross section shall have conical bottom, with slop toward the center. Tanks with other than cylindrical cross section shall have sloped bottom. In both cases, the inclination shall be between 1:100 and 1:25.

5.3.6 Supported conical roofs shall have inclination, from the center to the shell, of 1:16. When applicable, the maximum allowable inclination is 1:6.

5.3.7 For roof design, self-weight and a load of 981 N/m² (100 kgf/m²) shall be considered, unless otherwise specified.

5.4 DESIGN LOADS

5.4.1 All pressure vessels, including its supports, shall be designed for the following conditions at least: I – Assembly; II – Manufacturer Hydrostatic Test; III – Eventual Hydrostatic Test (after field assembly); IV – Normal Operation; V – Shutdown; VI - eventual short term, and emergency loads.

The applied loads, allowable stress values and thicknesses which shall be considered for conditions listed in item 5.4.1 (for items: I to V) are given in Table 4. For each condition loads are considered to act simultaneously.

Table 4: Combination of Loads for Pressure Vessels

Condition	Loads
I - ASSEMBLY	a) vessel dead weight (Note 1); b) loads due to wind (Note 2).
II - MANUFACTURER HYDROTATIC TEST	a) internal pressure of hydrostatic test; b) vessel weight completely full of water (Note 1); c) weight of all permanent loads supported by the vessel during the test (Note 3).
III – EVENTUAL TEST (after field assembly)	a) internal pressure of hydrostatic test; b) vessel weight completely full of water (Note 1); c) weight of all permanent loads supported by the vessel during the test (Note 3). d) loads due to ship motion, when applicable. e) loads due to wind (Note 2)
IV - NORMAL OPERATION	a) internal or external design pressure at design temperature; b) weight of fluid at operating level; c) vessel dead weight; d) weight of all permanent loads supported by the vessel (Note 4); e) loads due to wind (Note 2); f) loads due to ship motion, when applicable; g) piping loads.
V - SHUTDOWN	a) vessel dead weight; b) weight of all permanent loads supported by the vessel (Note 4); c) loads due to wind (Note 2). d) loads due to ship motion, when applicable.

Note 1: It includes the shell and bonded/laminated accessories; it excludes external accessories and removable internals.
Note 2: Loads due to wind need not be considered for the horizontal pressure vessels design but shall be considered in the foundation and structure design of such vessels.
Note 3: It excludes internal and external insulation.
Note 4: It includes removable internals, internal and external insulation, external accessories and piping.

5.4.2 Wind Loading Effects

5.4.2.1 Wind loads shall be calculated according to ABNT NBR 6123 with wind basic velocity of 45 m/s.

5.4.2.2 Other standard may be used with previous BUYER approval.

5.4.2.3 In vertical pressure vessels and tanks, the effects of vibration induced by wind shall be verified in wind direction and perpendicular to wind direction.

5.4.2.4 For vertical vessels and tanks, the maximum deflection due to wind shall not exceed 1/200 of the vessel height.

5.4.2.5 Loads due to wind on platforms, ladders, piping, and other accessories attached to the shell of the equipment shall be included in the total wind load.

5.4.3 Eventual Short Term, and Emergency Loads

5.4.3.1 Equipment design shall comply with eventual short term loads foreseen by Process Design. When applicable, emergency conditions shall also be considered.

5.4.3.2 Neither eventual short term nor emergency loads need to be considered simultaneously with wind loads.

5.5 NOZZLES AND OTHER OPENINGS

5.5.1 For all equipment, or for each vessel part, which are not completely drainable through piping, a drain nozzle is necessary for complete internal drainage.

5.5.2 The equipment shall have, as a minimum, manholes or inspection holes in each pressure compartment, as shown in Table 5.

Table 5: Manholes and Inspection Holes

Internal Diameter, mm	Equipment with Internals	Equipment without Internals
ID ≤ 250 mm.	Upper flanged cover.	2 inspection holes 2" diameter.
250 mm < ID ≤ 815 mm.	Upper flanged cover (see Note).	2 inspection holes 4" diameter.
ID > 815 mm.	Manhole(s).	Manhole(s).

5.5.3 The minimum nominal diameter of manholes shall be as indicated in Table 6.

Table 6: Minimum Nominal Diameter of Manholes

Inside Diameter, mm	Equipment with or without Internals
815 ≤ ID ≤ 1220	20"
1220 < ID	24"

5.5.4 For vessels with trays, gratings or other similar parts, which are dismountable and for vessels which have a hatch, the minimum number of manholes for clean services shall be as specified in Table 7. Additional manholes shall be considered at the fluid inlet where internal piping and baffles may need frequent cleaning.

Table 7: Minimum Number of Manholes

Number of Trays or Gratings	Minimum Number of Manholes
1	1
2- 25	2
26 - 41	3
42 - 60	4
61 and higher	5 + 1 (plus one) per each 20 trays added over 60.

5.5.5 For services requiring frequent cleaning or for safety reasons, the number of manholes indicated in Table 7 may be increased, according to the severity of the service, up to a maximum of one manhole for every 6 trays.

5.5.6 For vertical vessels with a single manhole, it shall be located in the cylindrical shell at the lowest possible position. When the vertical vessel has 2 manholes, the second manhole shall be located above the upper tray or at the highest possible position. For vertical vessels with 3 or more manholes, additional manholes shall be equally spaced wherever possible along the length of the vessel and preferably located next to inlet nozzles and internal piping systems.

5.5.7 Removable tops shall preferably be flat and shall be reinforced with folds or ribs.

5.5.8 Inlet nozzles shall be sufficiently far away from the level gauge instrument to avoid level disturbances that may affect the instrument reading.

5.5.9 For towers and vertical vessels nozzle orientation, when not determined due to process reasons, shall meet the needs of the piping route. The orientation of the manholes shall meet the arrangement requirements of platforms and ladders.

5.5.10 All fasteners (bolts and nuts) shall be according I-ET-3010.00-1200-251-P4X-001 – REQUIREMENTS FOR BOLTING MATERIALS.

5.6 SUPPORT

5.6.1 Equipment, regardless of the type of bottom, shall have support designed according to the project code and BS EN 13121 - Part 3, considering the use of laminated reinforcement rings and the same material as the side or bottom. The bottom of the equipment shall have extra layers of laminate.

5.6.2 The equipment supports shall be designed for conditions of all maximum loads coinciding.

5.6.3 The load bases and weight of the design of the supports shall be considered in the calculations of the equipment design.

5.6.4 Flat bottom equipment shall be installed on a complete support foundation and shall be anchored. Anchor bolts shall have a minimum diameter of 1” (M25). Screw design / drawing shall be in accordance with ASME RTP-1, Appendix NM-4, with restriction clamps.

5.6.5 Suspended equipment shall use design methods as per ASME RTP-1, Appendix NM-5.

5.6.6 When tanks or horizontal pressure vessels require saddles for supports, a finite element analysis shall be performed to design these supports and check for excessive stresses in the hull and tops. If the equipment to be supplied is horizontal and without cradles, its support locations shall be fully reinforced and properly defined.

5.6.7 Skirt supports shall be attached to the equipment according to ASME RTP-1. All skirts shall be provided with access ports and outlets according to PIP VESFG001-01. Skirt hold down details shall be in accordance with manufacturing details of PIP VESFG001-02.

5.6.8 Any equipment that transmits dynamic loads, such as mixers / agitators operating in pressure vessels and FRP tanks or connected to those shall be installed with independent support for them. Independent support shall also be considered in the valves in the equipment inlet and outlet pipes, in addition to regions of piping specification change.

5.7 ACCESSORIES

5.7.1 All equipment, above 100 kgf in weight, shall be provided with lifting eyes. The construction of the vessel shall provide for the installation of supports for proper lifting, without compromising its integrity. These supports shall be laminated integrally and definitively to the structure of the vessel, using the same resin manufactured by the body plus the application of type E fiberglass fabrics and blankets, without

pigmentation, to allow inspection.

5.7.2 The construction of the pressure vessel shall provide specific accessories, integrated to it, for its adequate fixation to the unit floor. These accessories shall be laminated to the vessel structure, using the same resin as the body fabric plus the application of E-type fiberglass fabrics and blankets, without pigmentation, to allow inspection. Fixing to the floor and supports shall follow the recommendations of Article AA-5 of ASME BPVC Section X.

5.7.3 Those equipment capable of draining electrostatic charges, located in classified areas, shall be provided with a stainless steel plate for grounding according to I-DE-3010.00-5140-700-P4X-003.

5.7.4 A level indicator and sounding guide pipe on the shell shall be foreseen.

5.7.5 Access means, such as ladders, platforms railings etc., shall be foreseen and provided for the following conditions:

- Vents and safety or relief valves.
- Instruments that need reading at the operation location or frequent inspection.
- Manholes with centreline located at 3000 mm or higher above the floor.

5.7.6 Feed pipes inside tanks shall be placed at the opposite end of suction pipes to avoid short circuit.

5.8 GROUNDING INSTALLATION

5.8.1 Protection against static electricity shall comply with grounding requirements of IEC 61892 and Classification Society.

5.8.2 Additionally, for floating units, the requirements of IEC 60092-502 shall be complied with.

5.8.3 Grounding installation shall comply with the latest revision of I-DE-3010.00-5140-700-P4X-003 – GROUNDING INSTALLATION TYPICAL DETAILS and I-ET-3010.00-5140-700-P4X-001 – SPECIFICATION FOR ELETRICAL DESIGN FOR OFFSHORE UNITS.

6 MATERIALS SELECTION

6.1.1 The SELLER is responsible for the materials selection. In all cases, SELLER shall submit the detailed material list, including resin, fiber, liner, chemical barrier, outer layer, gaskets and bolting for BUYER approval prior manufacturing activities.

6.1.2 The selection of the resin shall be according to the chemical resistance to the fluid at the design temperature. The BS EN 13121 shall be followed.

6.1.3 SELLER shall present documented testing or field experience relevant to the specific intended use to ensure the suitability of the material.

6.1.4 The structural layer of all pressure vessels shall be built by the filament winding process.

6.2 LAMINATE STRUCTURE

6.2.1 The shell of the pressure vessel or composite tank shall consist of laminated thermoset resin, with three basic layers with different functions, as shown below:

6.2.1.1 External liner or protective layer (topcoat): This layer shall have a minimum

thickness of 2.0 mm and have anti-UV additives for 30 years of service.

a) Pigmentation shall not be permitted as radiation protection, only for colour requirements.
b) Manual fabrication (contact moulding / hand lay-up / spray-up) using E or E-CR fiberglass blankets and simple fiberglass or common polyester veil on the external surface. The reinforcement content shall be between 25 and 35% by weight.
c) For classified areas, and when there is a need to reduce the electrical resistivity, defined by the designer of the plant or unit, resin with antistatic or conductive charge shall be applied, in the amount necessary to achieve a maximum volumetric resistivity of $10^6\Omega$.m (conductive), according to ISO 3915 and / or surface resistivity of $10^9\Omega$ (antistatic), according to IEC 60092 or ASTM D257.
d) A gel coat shall be applicated with a resin resistant to UV. The use of painting is subject to previous BUYER approval.

6.2.1.2 Structural layer:

a) It shall be manufactured by filament winding or manually (tanks), using reinforcement glass fibers type E or E-CR and, if necessary, rovings of carbon fibers to reach the requirements of volumetric and surface electrical resistivity.

b) The reinforcement content shall be between 60 and 75% by mass, accepting a deviation of ± 5% due to variations in the production process.

c) The minimum thickness shall be calculated according to the standard or design code defined in this specification.

6.2.1.3 Chemical barrier (corrosion barrier) or internal liner:

a) Shall be manufactured using fiberglass mats type E-CR or C, and reinforcement content between 25 and 35% by weight.

b) In addition to the corrosion barrier, a double veil of polyester fiber, C glass or carbon shall be applied, depending on the need for electrical resistivity and fluids involved.

c) The chemical barrier shall have a minimum thickness of 2.0 mm, being specified and calculated according to BS EN 13121-2.

d) The double-veil layer, in addition to the chemical barrier, shall have a minimum thickness of 1.5 mm.

e) For duo-laminated equipment, the thermoplastic liner plays the role of the chemical barrier + double veil.

6.3 DUO-LAMINATED EQUIPMENT

6.3.1 The shell of duo-laminated equipment shall consist of laminate formed only by a structural layer, as described in 6.2.1.2 plus, a liner or internal coating of thermoplastic polymer, defined by the fluid and temperature, using BS EN 13121. If the temperature of the fluid exceeds 70 ° C, the differences that may exist between the thermal expansion coefficients of the structural laminate (FRP) and coating (thermoplastic) shall be considered in the calculation.

6.4 REINFORCEMENTS (GLASS FIBERS, CARBON FIBERS AND ORGANIC FIBERS)

6.4.1 The glass fibers used to form the reinforcement structure shall be of types E or E-CR (corrosion resistant) type, whether in the form of mats, fabrics (woven roving) or

continuous or cut rovings. The surface veil may be specified with type C fiberglass or with synthetic organic fibers (polyester). Carbon fibers shall be specified as indicated by the SELLER. Other types of fiber may be used, depending on the fluid to be stored in the equipment, requiring prior approval from BUYER.

6.4.2 The reinforcement fibers shall have a chemical treatment compatible with the resin to be used (ex: silane/siloxane agents for glass fibers), according to the fiber manufacturers' documentation.

6.4.3 Glass, carbon and synthetic organic fibers shall be stored in suitable, dry and free of impurities environments, as directed by the raw material SELLER.

6.5 RESINS, CURING SYSTEM AND ADDITIVES

6.5.1 For the definition of the best resin to be used in the manufacture of the pressure vessel or tank, according to the operating conditions, in addition to specification and dimensioning of the chemical barrier / internal liner, BS EN 13121 - Part 2 shall be used.

6.5.2 Any type of mineral load or additives shall be added to the resin, except when electrical conductivity (or anti-static), flameproof or anti-UV properties are specified in the total thickness or in the outer layers of the equipment.

6.5.3 The curing system (resin, curing agent, catalysts / initiators, accelerators / promoters) is selected according to the fluids and temperatures to be operated on the equipment, manufacturing process and thickness involved in the design of the equipment. The resin to be used both in the chemical barrier or structural thickness shall be chosen from the general types and specific grades, according to BS EN 13121 - Part 2; according to its combination of thermal, mechanical, and chemical resistance properties, ease of application, cold or hot cure, need for post-cure, function and cost. The choice of resin, curing agent, catalyst and accelerator shall be the manufacturer of the equipment, approved by BUYER.

6.5.4 When there is a need to maintain low electrical resistivity to reduce the risk of electrostatic charging, the structural layer, external liner, and corrosion barrier + internal liner / veil shall have conductive (resistivity less than 10^6 ohms) or dissipative (resistivity less than 10^9 ohms) properties, but due to the different functions of each layer, this property shall be achieved in different ways in each one of them. The definition of the antistatic / conductive additive (carbon black, graphite powder, carbon fiber, metallic powder, etc.) shall be in accordance with proof of tests on specimens of the equipment structure (laminate), by the SELLER.

6.5.5 If there is a risk of fire, requirements for flame retardant additives shall be included in the structural layer and in the external liner, and / or the application of an intumescent external coating; the latter impairing the color of the equipment (painting or pigmentation of the resin).

6.5.6 To ensure complete curing of the external surface of the equipment made of polyester or vinyl ester resins, resin with paraffin or wax (maximum 0.6% by weight) shall be applied externally (topcoat). The complete cure of the outermost layers shall be verified by a hardness test (all resins) and sensitivity to acetone (only polyester and ester vinyl based resins), according to standards indicated by the design codes.

7 MANUFACTURE

7.1 GENERAL

7.1.1 The requirements presented in the document PIP VESFG001, for the design and manufacture of heads, shells, nozzles, reinforcements, flanges, manholes, gaskets, screws, supports, reinforcement rings, internals, stairs, platforms and handrails; shall be followed, together with the basic standard or code.

7.1.2 Before starting to manufacture, the SELLER shall present certificates of origin, tests, date of manufacture and expiry date of the raw materials used (resins, catalysts, blankets, fabrics, veils and rovings of fiberglass and others).

7.2 UNIONS, CLOSURES (HEADS) AND CONNECTIONS

7.2.1 The execution of the joints or manufacturing joints and final assembly shall be carried out by the manual method "hand lay-up / contact molding" with the same resin as the equipment, reinforced with glass fibers of type E or E-CR (blankets, fabrics and rovings). For the execution of final assembly joints in the field, a specific lamination joining procedure shall be developed, providing for the field conditions, alignment devices and support.

7.2.2 The manufacturing drawings shall show the dimensional details and specific drawings of the connections of the nozzles and accessories to the equipment, as well as the cover and / or bottom of the equipment.

7.2.3 In any situation, when making joints or repairs, chemical barriers and / or liners shall be reconstituted.

7.2.4 The reinforcement layers, for all types of joints, when using fabrics and / or mats, shall have a minimum overlap of 25 mm.

7.2.5 The internal cut ends that remain exposed, shall be coated with resin with the respective veil, so that no glass fibers are exposed, and all porosities and voids are filled.

7.2.6 The connections of nozzles, manholes, joints and internal supports shall be laminated and sealed with a structure equivalent to the parts to be joined.

7.2.7 The sharp angles and corners shall have adequate radius, in order to provide an adequate distribution of stresses and to avoid sharp surfaces, according to the design standard.

7.2.8 For open tanks, the upper ends shall use a rigidity ring with the calculation and manufacture according to the design standard defined for the equipment.

7.2.9 The drilling of the flanges shall be defined according to ASME RTP-1, or ASME BPVC Section X, for minimum pressure class 50 psi (345 kPa), except when a larger class is required.

7.2.10 The flanges shall be manufactured manually on the connecting pipe itself or by a semi-automatic process and laminated to the pipe (do not use adhesive). The flange faces shall be completely flat. The screws and nuts to be supplied with the connections shall be as specified for the piping and recommended by the standards mentioned in the previous item.

7.2.11 The closed connections with blind flanges such as manholes, reserve connections,

flanged equipment and others, shall be supplied with all its accessories (screws, cases, nuts and washers) as specified for the pipe and standards from the project.

7.2.12 Flat elastomeric gaskets shall be supplied with Shore A hardness between 55 and 65. The gaskets shall fully cover the flange surface and have a minimum thickness of 3.0 mm. The material of the elastomeric joint shall be specified considering temperature, type and composition of the fluid in the equipment.

7.3 POST-CURE

7.3.1 To reduce the styrene content in polyester and vinyl ester resins when maximum chemical resistance of the resin is required (sodium hypochlorite environment, acids, bases, etc.) or low residual styrene content (no contamination of food, drinking water, etc.), a post-cure process shall be performed on the equipment, according to the procedure previously established by the SELLER.

7.3.2 The need for post-curing of pressure vessels shall be assessed by the manufacturer in its design and calculation report. In case of use of post-cure, it shall occur at a minimum temperature of 82ºC, for a minimum period of four (04) hours. Follow the instructions of the document PIP VESFG001.

7.3.2.1 When the operating temperature of the equipment is above 80ºC, the post-curing treatment is mandatory.

8 INSPECTION AND TESTS

8.1 GENERAL

8.1.1 The criteria for inspection and testing shall be in accordance with the applicable reference standards and in accordance with the specific requirements of the operations indicated below:

- Control and testing of receipt of raw materials;
- Certificates of reinforcing materials, resins and additives used;
- Reinforcement content test / Burn test;
- Acetone sensitivity test (only polyester and vinyl ester based resins);
- Barcol hardness;
- Verification of thicknesses;
- Visual and finishing inspection;
- Dimensional and tolerance inspection;
- Acoustic emission test (pressure vessels);
- Hydrostatic (pressure vessels) and leak test (tanks);
- Verification of the Identification Plate.

8.1.2 The inspection of raw materials (resins, glass fibers, catalysts, etc.) shall consist of their identification, verification of certificates issued by SELLERs and expiration dates for resins and chemicals in general. Viscosity tests, solvent content, gel time and curing time shall be applied to validate each batch of resin.

8.1.3 The tests, destructive or non-destructive, physical, thermal, mechanical and chemical, to be carried out on removed parts or on the equipment itself, to verify the properties of the laminate, for design or manufacturing quality control, are the responsibility of the SELLER and shall be fully complied with in accordance with the requirements of the basic standard.

8.1.4 The equipment manufacturer shall issue, before the start of manufacture, documentation that includes all the testing procedures to be carried out on raw materials, quality control tests during and after manufacture, in addition to the tests to be carried out to characterize laminates for use in equipment design calculations.

8.1.5 The tolerances and acceptance criteria for tests and measurements shall be in accordance with the reference standard used in the project.

8.1.6 The visual and finishing inspection shall consist of checking the details of the surface conditions of the laminates (side, tops and parts) and of the joints / joints (free of cracks, contaminants, bubbles, delamination, etc.) and the control and checking equipment accessories.

8.1.7 The dimensional inspection shall consist of checking the dimensions contained in the manufacturing drawings, according to the tolerances of the design standards.

8.1.8 For measurements of the thickness of the accessories and of the sides and tops distant from extremities, the non-destructive ultrasound (UT) technique shall be used, and the inspection procedure shall be carried out in accordance with ASME BPVC Section V, and it shall be submitted for analysis and approval by BUYER.

8.1.9 Tanks shall pass a leak test, while pressure vessels shall undergo a hydrostatic test, with or without an acoustic emission test, according to the requirements of the project code.

8.1.10 Only after final internal and external inspection of the laminate, the equipment may be painted, pigmented with an outer layer of resin or even receive thermal insulation or passive fire protection (intumescent paint), as specified in the purchase order.

8.1.11 Any structures or external surfaces in carbon steel (stairs, platforms, handrails, etc.) shall be painted or galvanized, as specified in the purchase order. External steel screws shall be coated with PTFE, lubricant or galvanized.

8.1.12 The equipment shall be delivered completely clean, externally and internally, free of oils, grease, markings, release agents, sanding powders, glass fibers, and dust in general. The interior shall be dry after testing and cleaning.

8.2 LEAK TEST (TANKS) AND HYDROSTATIC TEST (PRESSURE VESSELS)

8.2.1 The hydrostatic test shall be performed for pressure vessels in accordance with the design standard.

8.2.2 For the leak test, the tank shall be completely filled with clean water. The test shall have a minimum duration of one hour, after stabilization, at the final test pressure, unless a different time is specified in the design standard and follow Annex C of BS EN 13121 part 3.

8.2.3 The pressure of the hydrostatic test shall be according with code, measured at the top of the vessel. For safety reasons, the inspection should only occur during depressurization at a level below 70% of the test pressure or other specified by the reference standard.

8.2.4 The water to be used in the tests shall be clean, treated, free of debris and with a maximum content of 50 ppm of chloride, if there are internals in austenitic stainless steel.

8.2.5 The hydrostatic test shall be carried out with the equipment in its normal operating position. Horizontal equipment shall be tested on its support saddles, without

additional supports or cradles.

8.2.6 After the hydrostatic or leak test is finished, the vessel or tank shall be drained, dried and closed as soon as possible.

8.2.7 Pressure vessels and tall vertical tanks shall be tested in the final installation position, according to ASME RTP-1 or ASME BPVC Section X. They shall be adequately supported during the test to prevent damage.

8.2.8 Flanged joints that will not be disassembled after the test shall be tested with the specified final gasket already. If the joint is disassembled after testing and has flanges in accordance with ASME B16.5, the test joint shall be selected in accordance with the limitations of this standard.

8.2.9 If the service joint is not specified and the joint is disassembled after the test, using flanges that do not follow ASME B16.5, the test joint shall be specified by BUYER. The nominal thickness of the plate or laminate joint shall be 1/8 in (3 mm) or greater.

8.2.10 Assembly of flanged joints specified to be supplied with service joints (e.g., main joints, manholes, nozzles with blind flange), and disassembled for testing, shall be reassembled using new service joints. If these joints are shipped unassembled, new service joints for field installation shall be packed, marked and delivered with the vessel.

8.2.11 For pneumatic tests and vacuum tests, use the design standards in conjunction with document PIP VESFG001 for test procedure and acceptance criteria.

8.3 ACOUSTIC EMISSION TEST

8.3.1 Pressure vessels according to ASME RTP-1 designed for critical service and all pressure vessels Class II and III, according to ASME BPVC Section X, shall be tested by the acoustic emission method during the hydrostatic test.

8.3.2 The test shall be conducted by a qualified company or agency, approved by BUYER.

8.3.3 The acceptance criteria shall be in accordance with ASME RTP-1, Appendix M-8, or ASME BPVC Section X, Article RT-6.

8.3.4 Test procedures and equipment shall comply with ASME BPVC Section V, Article T-11.

8.4 PAINTING

8.4.1 Painting requirements shall be according I-ET-3010.00-1200-956-P4X-002 – GENERAL PAINTING.

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

9 NAMEPLATES

9.1 GENERAL

9.1.1 SELLER shall attach corrosion resistant stainless steel type 316 nameplates on each item of equipment in an accessible location, fastened with corrosion resistant stainless steel type 316 pins, and in Portuguese language.

9.1.2 The finished equipment shall have an identification plate according to ASME RTP-1

or ASME BPVC Section X, Article RS-1.

9.1.3 For the nameplates shall include, as a minimum, the following information:

- Petróleo Brasileiro S.A.;
- Purchase order number;
- Design code and year of edition,
- Manufacturer and year of build;
- Tag number;
- Service;
- Serial number;
- Installation identification;
- Hydrostatic test pressure,
- Maximum allowable working pressure,
- Resin and curing system,
- Thickness and Composition of the chemical barrier or liner (number and type of veils),
- Capacity in m3,
- Empty weight / full,
- Whether or not there was post-cure treatment.

10 TAG NUMBERING

10.1 GENERAL

10.1.1 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.

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