PETROBRAS	TECHNICAL SPECIFICATION	I-ET-0000.00-0000-250-P9U-002	
	CLIENTE: -	FOLHA: 1 de 12	
	PROGRAMA: RIGID OFFSHORE PIPELINES	-	
	ÁREA: -	-	
-	TÍTULO: MINIMUM REQUIREMENTS FOR BUOYANCY MODULES FOR FLOWLINES AND RISERS	EDD / EDR	
		-	

ÍNDICE DE REVISÕES

REV.	DESCRIÇÃO E/OU FOLHAS ATINGIDAS
0	REVISÃO ORIGINAL
	THIS DOCUMENT REPLACES AND SUPERSEDES I-ET-0000.00-6500-250-P9U-002=A.
A	GENERAL REVISION (HIGHLIGHTED ITEMS)
B	GENERAL REVISION
C	HIGHLIGHTED ITEMS
D	INCLUDED REQUIREMENTS FOR CONTINUOUS BUOYANCY CONFIGURATIONS IN ITEM 4.1 AND MINOR CHANGES HIGHLIGHTED.
E	MODIFICATION ON ITEMS 5.2, 5.4 AND 6

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E
DATA	30/11/2017	13/01/2020	17/05/2021	11/01/2022	26/05/2022	17/08/2022
EXECUÇÃO	BEJ8	BEJ8	UPL2	UPL2	BEJ8	BEJ8
VERIFICAÇÃO	UPL2	UPL2	BEJ8	BEJ8	C5FP	UPL2
APROVAÇÃO	CLZ2	CLZ2	CLZ2	CLZ2	CLZ2	CLZ2

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1. OBJECTIVE AND SCOPE

1.1. Objective

This technical specification establishes the minimum technical requirements for distributed buoyancy modules. Minimum requirements are specified for material selection, qualification program and manufacturing of buoyancy elements and modules.

1.2. Scope

1.2.1. The scope includes buoyancy modules for flowlines and risers.

1.2.2. This specification may also be used for material requirements for temporary applications, e.g., pipeline installation. However, any requirements specific to these applications are not addressed.

1.3. Terms and definitions

1.3.1. Terms and definitions used within this technical specification are in accordance with [6].

1.3.2. Additional terms and definitions are defined in Table 1.

Table 1 – Additional terms and definitions.

DAF	Dynamic Amplification Factor
IBL	Instrumented Buoyancy Loss
ND	Nominal Diameter
OD	Outside Diameter
SLWR	Steel Lazy Wave Riser
VIV	Vortex Induced Vibrations
WD	Water Depth

2. MATERIAL REQUIREMENTS

2.1. General

2.1.1. The requirements of this section apply to syntactic foam, composite syntactic foam and outer layer materials present in the buoyancy system. The requirements of this section have been specifically developed for systems based on the use of polyolefins (e.g., polyethylene and polypropylene) for outer layer and epoxy based syntactic and composite syntactic foams. These requirements might be used for the qualification of other material types, though consideration should be given to the need for additional requirements for other materials.

2.1.2. The manufacturer shall document the properties of syntactic foam, composite syntactic foam and outer layer materials. Syntactic foam and composite syntactic foam shall be considered single materials and therefore their properties shall be determined. Although no requirements for testing of the individual components in the syntactic foam and composite syntactic foam materials (microspheres, macrospheres, and polymer matrix materials) are specified herein, the necessity of such testing shall be addressed by buoyancy modules manufacturer at its own discretion. The manufacturer shall consider the requirements on the individual components such as all loads on the system during fabrication, installation, and operation (e.g., hydrostatic pressure loads). The individual components manufacturers shall issue quality certificates for each material.

2.1.3. The manufacturer shall ensure that syntactic foam and composite syntactic foam materials provide the specified minimum net buoyancy for the entire service life of the system, considering all loads and time dependent effects to which the system may be submitted to during fabrication, installation, and operation (e.g., hydrostatic pressure loads).

2.1.4. The manufacturer shall ensure that all buoyancy materials that may become in contact with seawater at any time during their service life are compatible with this fluid within seawater temperature and pressure ranges.

3. MANUFACTURING REQUIREMENTS

3.1. Quality control

3.1.1. The manufacturer's quality control procedures for raw materials and manufacturing shall be detailed in the manufacturer's quality plan and shall include detailed descriptions for:

a) Marking and identification: each module shall be marked with the following information, at least:
   - Project name
   - Depth rating
   - Weight in air
   - Net buoyancy
   - Serial number

b) Storage and handling;

c) Raw material, certification;

d) Manufacturing procedures;

e) Manufacturing inspection and test plan.

3.1.2. All steps in the manufacturing process shall be subjected to inspection by the manufacturer. The manufacturer's quality plan shall specify inspection points, inspection methods and acceptance criteria. Results of all inspections shall be recorded in the manufacturing inspection report by the manufacturer. The manufacturer shall record every non-conformance verified during manufacture of the buoyancy system.

3.1.3. The manufacturer shall document the manufacturing properties of the buoyancy materials at appropriate times during the manufacturing process, when relevant.

3.2. Documentation

3.2.1. The manufacturer should have available for purchaser's review at least the following documentation:

- Material design report;
- Qualification ITP;
- Qualification test report;
- Tests standards and specific tests procedures;
- Raw material certificates;
- Raw material tests reports (if applicable);
- Manufacturing quality plan;
- Material specifications.

3.2.2. The material design report shall be prepared by the manufacturer and should include at least the following:

- Design basis for material selection;
- Any premises;
- Results of all calculations/analysis performed in order to verify suitability of material for proposed application;
- Test results and data for all material properties that will be required by system designer;
- Design limits for material, including temperature and hydrostatic pressure;
- Handling and storage procedures.

4. PERFORMANCE REQUIREMENTS

4.1. General

4.1.1. The manufacturer shall ensure that the properties of the proposed buoyancy materials satisfy the corresponding performance requirements.

4.1.2. Performance requirements not specifically required by the purchaser which may affect the manufacturing and qualification of the buoyancy material shall be specified by the manufacturer.

4.1.3. Buoyancy modules may be designed either as an integral type clamp (attachment system integrated in buoyancy module body) or as a separated clamp type (buoyancy module body separated from clamping system, allowing module to rotate around the pipe). See exception on item 4.1.12.

4.1.4. Functional, installation, contingency, environmental and accidental loads necessary to perform tests specified herein shall be informed by purchaser prior to the execution of the tests, preferably in the technical specification issued by purchaser. The manufacturer shall ensure that the material properties are sufficient to resist all loads specified by the purchaser.

4.1.5. The purchaser shall specify the nominal net buoyancy required.

4.1.6. The water depth of the buoyancy system application shall be in accordance with project's specific water depth. The water depth specified shall be the maximum water depth to which the system may be exposed considering variations over buoyancy locations and tidal variations. In case of pipelines pre-laying, the maximum water depth to which the buoyancy modules are to be subjected during temporary abandonment shall be considered.

4.1.7. Manufacturer shall consider the use of a safety factor of 1.5 on the hydrostatic crush resistance.

4.1.8. The purchaser shall specify any performance requirements regarding impact on the buoyancy surfaces. Possible impact scenarios shall be addressed such as falling objects, handling and transportation, interference between buoyancy and pipelaying vessel, etc. As a minimum, impact testing as specified in Table 3 shall be performed.

4.1.9. Specific installation requirements shall be specified in the technical specification issued by purchaser depending on installation method.

4.1.10. The manufacturer shall ensure that performance requirements given herein are not affected by any requirement of buoyancy modules installation procedure.

4.1.11. Whenever riser design requires a continuous buoyancy configuration (no gap between modules) modules shall present built-in vortex suppressors devices according to the functional parameters of item 5.3 of reference [15], where applicable.

4.1.12. In a continuous buoyancy configuration the modules shall not be able to rotate around the riser.

4.1.13. In a continuous buoyancy configuration with VIV suppression device, the modules shall undergo performance tests which demonstrate the VIV suppression efficiency, in compliance with item 8.3 of reference [15]. Contractor shall present the tests results reports, containing all the data requested on item 8.3.6 of ref. [15].

4.1.14. Whenever buoyancy modules are designed for continuous buoyancy configuration, it shall be informed in the design report the calculated Overall Heat Transfer Coefficient (in $W/(m^2*K)$), based on the thermal conductivity of the materials applied and the dimensions of the module.

5. QUALIFICATION, PRE-PRODUCTION AND PRODUCTION TRIALS

5.1. General

5.1.1. The manufacturer shall carry out qualification, pre-production and production tests demonstrating that the materials selected for the specific buoyancy application meet the performance requirements for the service life, including both installation and operational conditions. The qualification and pre-production tests shall be witnessed by the purchaser or a Third Party when indicated by purchaser. All reports from the Third Party shall be available for review by the purchaser. The qualification of materials by testing shall consider all processes (and their variations) adopted to produce the buoyancy system, which may impair the properties and characteristics required by the design.

5.1.2. Only buoyancy materials manufactured with the same formulation as the materials used in the qualification testing shall be regarded as qualified.

5.1.3. The material for the test samples shall be prepared using the same processes as used during full scale manufacturing and selected from a fabricated representative volume. The manufacturer shall document the manufacturing method for the samples in the qualification test report.

5.1.4. For composite syntactic foams, the sample thickness shall be at least four times the largest macrosphere diameter in the sample. Alternatively, for macrosphere sizes which are deemed by the manufacturer to be too large for a test sample to be physically measured, a micromechanical model approach may be used to determine the composite material properties from the constituent properties. In such a case the accuracy and dependability of the results of the model shall be verified.

5.2. Qualification Trials

5.2.1. Polymers and composite materials shall be qualified through testing in accordance with section 8.5 of reference [2]. The minimum quantity of samples to be tested shall be in accordance with indicated test standard. If minimum quantity of samples is not specified in the standard, at least 5 samples shall be tested.

5.2.2. Table 2 presents additional tests to section 8.5 of reference [2], which shall also be tested during qualification.

Table 2 – Additional tests to be performed during qualification trial.

PROPERTY	STANDARD / METHOD	ACCEPTANCE CRITERIA	OBSERVATION
Composite Foam			
Flexural properties	ISO 178 or ASTM D790	To be proposed by supplier	See Table 20 of reference [2]
Net buoyancy	To be proposed by supplier	As calculated for the project ±2%	1 element
168 hours instrumented buoyancy loss[1]	Item 8.3.11 of ref. [3]	Buoyancy loss at 24h ≤ 2% At end of design life ≤ 5%	1 sample
Slamming Load test[2,3]	To be proposed by supplier	The highest between: 1. (Dry weight + counterweight) * DAF*1,5 2. 2 * buoyancy * DAF	1 module
Hydrostratic crush resistance	Item 8.3.8 of ref. [3]	Item 8.3.8 of ref. [3]	1 sample
Clamp			
Axial load[4,3]	To be proposed by supplier	Axial force at which slippage starts ≥ 1.5*DAF*(maximum axial force expected)	1 clamp
Hanging load[5]	To be proposed by supplier	No slippage after 12h when submitted to a constant load that is the greatest between: 1. (Dry weight + counterweight) *	1 clamp

[1] Procedure for IBL testing shall comply with item 8.3.11 of ref. [3], however the hold period shall be of 168 hours, and then extrapolated to design life.

[2] This test simulates the maximum slamming load that the module will experience when passing through the mean water line. It should simulate the transfer of the slamming load into the recess of the element where the internal clamp is housed (if any). It may be configured in a fashion similar to the axial clamp capacity test, although a module element shall be incorporated.

[3] Axial Load and Slamming Load tests may be joined into a single test, since it is performed on the complete assembly (pipe sample + clamp + buoyancy module).

[4] The test shall verify the clamp capacity (if buoyancy module is designed with a separated clamp) and associated safety factor against the most critical combination of load conditions for any of the installation, operation or retrieval phases.

[5] The test shall verify the clamp capacity when submitted to a constant load, the greatest load between static load during operational life and peak load from installation phase. The constant load is typically applied by a hanging mass attached to a reaction plate in direct contact with the clamp, although alternative arrangements might be used.

		DAF*1,5 2. Buoyancy * DAF*1.5	
Outer Layer (Skin)			
UV resistance (outer layer)	ISO 4892-3	Shall be suited to UV incidence in Brazil for at least 2 years	Manufacturer certificate
Melt mass-flow rate	ISO 1133-1	According to product's datasheet	Manufacturer certificate per batch

5.2.3. Metallic materials SHALL be qualified through testing in accordance with section 8.5 of reference [2].

5.3. Pre-production Trials

5.3.1. The pre-production tests shall be performed on each design of buoyancy module / clamp prototypes.

5.3.2. Results of pre-production tests shall be approved by PETROBRAS prior to production starting.

5.3.3. Table 3 presents the minimum requirements for buoyancy elements and buoyancy modules, which shall be tested during pre-production.

Table 3 Minimum requirements for buoyancy elements and buoyancy modules to be tested during pre-production trial.

PROPERTY	STANDARD / METHOD	ACCEPTANCE CRITERIA	FREQUENCY
Visual inspection	-	No defects	1 element
Dimensional verification	-	According to element's design and tolerances	1 element
Fit-up	-	According to element's design	1 module + clamp
Static load[6]	To be proposed by supplier	As calculated for the project	1 module
Bending resistance	To be proposed by supplier	As predicted for the project in accordance with pipelaying method.	1 module
Impact resistance	DNVGL-RP-F111	Sample shall be subjected to an impact energy of 3.2 kJ, or as predicted for the project in accordance with pipelaying method, whichever is greater. After the impact, sample shall have the external skin removed and no damages to the buoyancy matrix shall be observed.	1 element

5.4. Production Tests

5.4.1. Table 4 presents the tests to be performed on each design of buoyancy module / clamp during production.

[6] This test aims to verify the module resistance when subjected to a localized load, actuating on the central axis of the module.

Table 4 - Tests to be performed during production.

PROPERTY	STANDARD / METHOD	ACCEPTANCE CRITERIA	FREQUENCY[7]
Visual inspection	-	No defects	Each produced component
Dimensional verification	-	According to element's design	5% of produced components
Fit-up	-	According to element's design	1 module + clamp
Net buoyancy	To be proposed by supplier	As calculated for the project ±2%	10% of produced elements
24 hours instrumented buoyancy loss	Item 8.3.11 of ref. [3]	buoyancy loss at 24h ≤ 2% at end of design life ≤ 5%	5% of produced elements

6. REFERENCES

[1] API RP 17B, RECOMMENDED PRACTICE FOR FLEXIBLE PIPE, July 2008.

[2] API SPEC 17L1, SPECIFICATION FOR ANCILLARY EQUIPMENT FOR FLEXIBLE PIPES AND SUBSEA UMBILICALS, 2021.

[3] API RP 17L2, RECOMMENDED PRACTICE FOR ANCILLARY EQUIPMENT FOR FLEXIBLE PIPES AND SUBSEA UMBILICALS, 2021.

[4] ASTM D792, STANDARD TEST METHODS FOR DENSITY AND SPECIFIC GRAVITY (RELATIVE DENSITY) OF PLASTICS BY DISPLACEMENT, 2013.

[5] ASTM D790, STANDARD TEST METHODS FOR FLEXURAL PROPERTIES OF UNREINFORCED AND REINFORCED PLASTICS AND ELECTRICAL INSULATING MATERIALS, 2017.

[6] DNV-ST-F101, SUBMARINE PIPELINE SYSTEMS, October 2017, amended December 2017.

[7] DNV-RP-F111, INTERFERENCE BETWEEN TRAWL GEAR AND PIPELINES, October 2010.

[8] ISO 37, RUBBER, VULCANIZED OR THERMOPLASTIC – DETERMINATION OF TENSILE STRESS-STRAIN PROPERTIES, 2017.

[9] ISO 62, PLASTICS – DETERMINATION OF WATER ABSORPTION, 2008.

[10] ISO 178, PLASTICS — DETERMINATION OF FLEXURAL PROPERTIES, 2019.

7 Tested samples shall be equally distributed during production, i.e., the tests' sampling shall be homogeneously distributed along entire production.

[11] ISO 1133-1, PLASTICS – DETERMINATION OF THE MELT MASS-FLOW RATE (MFR) AND MELT VOLUME-FLOW RATE (MVR) OF THERMOLASTICS – PART 1: STANDARD METHOD, 2011.

[12] ISO 1183-1, PLASTICS – METHODS FOR DETERMINING THE DENSITY OF NON-CELLULAR PLASTICS PART 1: IMMERSION METHOD, LIQUID PYKNOMETER, 2012.

[13] ISO 13628-11, PETROLEUM AND NATURAL GAS INDUSTRIES – DESIGN AND OPERATION OF SUBSEA PRODUCTION SYSTEMS – PART 11: FLEXIBLE PIPE SYSTEMS FOR SUBSEA AND MARINE APPLICATIONS, 2007.

[14] ISO 4892-3, PLASTICS – METHODS OF EXPOSURE TO LABORATORY LIGHT SOURCES PART 3: FLUORESCENT UV LAMPS, 2016.

[15] I-ET-0000.00-0000-278-P9U-001, TECHNICAL SPECIFICATION FOR VORTEX SUPPRESSORS – “STRAKES”