INDEX OF REVISIONS

REV.	DESCRIPTION AND/OR REVISED SHEETS
0	Original
A	Reference [10] updated

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
DATE	APR/2021	MAY/2021							
DESIGN	SUB/ES/DCT	SUB/ES/DCT							
EXECUTION	CJME	CJME							
CHECK	CSMP/UPOV	CSMP/UPOV							
APPROVAL	CXAX	CXAX							

INDEX

1 Scope

This technical specification establishes requirements and provides additional information for the qualification program and the load-effect analysis of steel tube umbilicals to be performed under pre-qualification processes.

2 References

NOTE: Unless otherwise stated, the latest revision of the following documents must be considered.

[1] ISO 13628-5, *Petroleum and natural gas industries – Design and operation of subsea production systems – Part 5: Subsea umbilicals*

[2] I-ET-3000.00-1500-29B-PAZ-006, *Qualification of Subsea Umbilicals*

[3] LI-3000.00-1519-29B-PZ9-005, *Lista de Estruturas de Umbilicais Submarinos*

[4] I-ET-3000.00-1519-29B-PZ9-004, *Load-effect Analysis of Subsea Umbilicals*

[5] I-ET-3A26.00-1500-960-PPC-001, *Flexible Risers and Umbilicals – Fatigue Analysis*

[6] I-ET-3010.00-1519-274-PPC-001, *Riser Interference Analysis*

[7] I-ET-3562.00-1000-941-PMC-001, *Metocean Data*

[8] I-RL-3010.2B-1350-960-P4X-001, *Reference RAO*

[9] I-ET-3000.00-1500-941-PZ9-001, *PLSV 550 Ton - Technical Data and RAO Curves*

[10] I-FD-3000.00-1519-274-PLR-001, *Riser Configurations for Interference Analysis*

3 Terms, abbreviated terms and definitions

PETROBRAS adopts the same terms, abbreviated terms and definitions as in [1], with the amendments and supplements defined in this section.

3.1 Terms and definitions

departure angle
angle between the umbilical riser and the vertical plane on the top connection

horizontal projection
distance between the umbilical top connection and a specific point of the umbilical configuration (TDP, sag lowest point or hog highest point), measured on the horizontal plane

may
verbal form used to indicate a course of action permissible within the limits of this specification

metocean
meteorology(ical) and oceanography(ic)

neutral static position
configuration of the umbilical numerical model considering the specified departure angle, an intermediate draft (around 50% loading condition) for the FPU, no offset and no environmental loads

shall
verbal form used to indicate requirements strictly to be followed in order to conform to this specification

should
verbal form used to indicate that a provision is not mandatory, but is recommended as good practice

SUPPLIER
subsea umbilical supplier

vertical projection
distance between the seabed and a specific point of the umbilical configuration (sag lowest point or hog highest point), measured on the vertical plane

3.2 Abbreviated terms

DEC	design extreme condition
FAT& DOC	fatigue and design operating condition
FPU	floating production unit
Hs	significant wave height
IVA	independent verification agent
OD	outer diameter
STU	steel tube umbilicals
TDP	touchdown point
WD	water depth

4 Qualification program

According to the documentation provided in the pre-qualification process, the qualification program of the STU shall fully comply with the requirements of [2]. However, considering the umbilical structures stated in [3], the remarks on sections 4.1, 4.2, 4.3 and 4.4 apply.

4.1 Similarity considerations between US-18.1 and US-18.2

Structures US-18.1 and US-18.2 may be considered similar for qualification purpose, as long as the overall performance and the constructive parameters (armour wire design, components location within the bundle, weights, stiffnesses, OD etc.) are similar. This similarity check shall be approved by PETROBRAS. If approved, SUPPLIER is allowed to submit only one structure (US-18.1 or US-18.2) to a full qualification program and, in case of success, both structures will be considered qualified to be supplied to PETROBRAS.

4.2 Similarity consideration between US-19.1 and US-19.2

Structures US-19.1 and US-19.2 may be considered similar for qualification purpose, as long as the overall performance and the constructive parameters (armour wire design, components location within the bundle, weights, stiffnesses, OD etc.) are similar. This similarity check shall be approved by PETROBRAS. If approved, SUPPLIER is allowed to submit only one structure (US-19.1 or US-19.2) to a full qualification program and, in case of success, both structures will be considered qualified to be supplied to PETROBRAS.

4.3 Similarity considerations between US-18.1/US-18.2 and US-19.1/US-19.2

Structures US-18.1/US-18.2 may be considered similar to structures US-19.1/US-19.2 for qualification purpose, as long as this similarity is validated by an IVA and the following conditions are met:

1) the structure to go through the full qualification program shall be US-19.1 or US-19.2 and

2) this qualification program shall be successfully accomplished, following the requirements of [2].

The IVA shall verify if the design methodology proposed by SUPLLIER is applicable to both sets of structure (US-18.1/US-18.2 and US-19.1/US-19.2) and if it is in accordance with the qualification tests results.

If the qualification program of US-19.1/US-19.2 is not successfully accomplished, in order to have US-18.1/US-18.2 qualified, SUPPLIER shall review its design methodology and restart the whole process (including IVA verification) or shall submit US-18.1/US-18.2 to a full qualification program.

4.4 Similarity considerations between US-23.1 and US-19.1/US-19.2

Structure US-23.1 may be considered similar to structures US-19.1/US-19.2 for qualification purpose, as long as the overall performance and the constructive parameters (armour wire design, components location within the bundle, weights, stiffnesses, OD etc.) are similar. This similarity check shall be approved by PETROBRAS. If approved, SUPPLIER is allowed to submit only structure US-23.1 to a full qualification program and, in case of success, the three structures (US-23.1, US-19.1 and US-19.2) will be considered qualified to be supplied to PETROBRAS.

If SUPPLIER has already qualified the structures US-19.1/US-19.2, in order to have the structure US-23.1 also qualified, it shall have the similarity check approved by PETROBRAS and shall extend the previous qualification program by submitting structure US-23.1 to the crush test stated in [2]. If the crush test is successfully accomplished, structure US-23.1 will be considered qualified to be supplied to PETROBRAS.

5 Load-effect analysis

According to the documentation provided in the pre-qualification process, the load-effect analysis of the STU shall follow the requirements of [4], [5] and [6]. This section provides additional information for these analyses.

5.1 Environmental data

The WD to be considered for extreme-load, fatigue and on-bottom stability analyses is 3,100 m (three thousand and one hundred meters). Considerations on the water depth for interference analysis are given on section 5.5.

Metocean data for extreme-load, on-bottom stability and interference analyses is provided in [7]. Metocean data for fatigue analysis is defined in [5].

Friction coefficients between the risers and the seabed to be considered on all types of analyses are 0.45 for axial direction and 1.07 the lateral direction. It shall be considered a flat seabed, with no slope.

5.2 Floating production unit and interface

Movements of the FPU due to wave loading shall be according to the RAO (provided on the file “PROD1000_RAO&OUT_Rev_A.7z”, attached to this specification) and parameters defined in [8]. The sequence of columns on the RAO files, from left to right, shall be understood as following:

- wave period (in seconds);
- wave incidence angle relative to the FPU (in degrees);
- degree of freedom (“1” is surge, “2” is sway, “3” is heave, “4” is roll, “5” is pitch and “6” is yaw);
- absolute amplitude of the response variable;
- phase;
- real value of the response variable and
- imaginary value of the response variable

The RAO are provided for two different conditions, namely FAT&DOC and DEC. The FAT&DOC RAO are to be adopted for a wave loading with Hs ≤ 4.5 m, whilst the DEC RAO are to be adopted for Hs > 4.5 m. However, for sake of simplification, SUPPLIER should adopt the RAO according to the stated on Table 1.

Table 1 - Definition of RAO according to the type of analysis

	Type of analysis		
RAO	Fatigue	Extreme-load with 1-year wave loading	Extreme-load with 10-year or 100-year wave loading
FAT&DOC	X	X	
DEC			X

In case of any difficulty with this premise for the RAO, SUPPLIER and PETROBRAS may discuss other approach for this issue.

The FPU heading shall be 190 degrees, clockwise from true north.

The offsets to be considered for the extreme-load analysis shall be according to Table 2. These are total offset values, including positioning errors. Offsets for fatigue analysis shall be according to [5].

Table 2 - Offset values

	Mooring condition	
Return period	Intact	One mooring line broken
1-year	7.0% of WD	7.5% of WD
100-year	9.0% of WD	9.5% of WD

Extreme-load and fatigue analyses shall be performed considering 2 (two) different positions for the umbilical top connection on the numerical model, according to the values informed on Table 3. The umbilical azimuths to be considered are those defined in [4] for the analysis of ship shape FPU with spread mooring system [total of 6 (six) different azimuths for each connection point], for both the extreme-load and fatigue analyses. Considerations on the slots positioning for interference analysis are given on section 5.5.

Table 3 - Slots coordinates

	Coordinates(1)		
# Slot	X (m)	Y (m)	Z (m)
1	112.65	33.0	5.3
52	252.65	33.0	5.3

(1) according to the coordinate system defined in [8]

The departure angle to be considered for both slot positions – and for all azimuths – in the neutral static position is 5 degrees. However, the bellmouth angle is 7 degrees, i.e., there is a static deflection of 2 degrees on the bend stiffener in the neutral static position due to the angular difference between the bellmouth and the umbilical riser. This static deflection shall be taken into consideration for the structural analysis of extreme-load and fatigue-load conditions.

5.3 Extreme-load analysis

For the global analysis of Design Load Case D stated in [4], and angle of inclination of 12.2 degrees shall be applied around the longitudinal axis of the FPU.

For the global analysis of Design Load Case E stated in [4], it shall be considered the technical data of the installation vessel stated in [9].

5.4 Fatigue analysis

It shall be considered a service life of 30 (thirty) years for the fatigue analysis.

5.5 Interference analysis

Considering a departure angle of 5 degrees in the neutral static position, the slots coordinates on Table 3 and a WD of 3,100 m, if SUPPLIER fits the umbilical configuration within the maximum dimensions stated on Table 4 and the extreme-load and fatigue analyses are successfully accomplished, it is not necessary to perform any interference analysis.

Table 4 - Desirable maximum dimensions for STU configuration

Horizontal projection (m)			Vertical projection (m)	
Sag	Hog	TDP	Sag	Hog
897	1,005	1,386	129	140

If SUPPLIER understands that it is not feasible to design a configuration within these limiting dimensions, then it must perform a full interference analysis following the requirements of [6]. This interference analysis shall encompass scenarios A, B, and the Mooring Lines Interference Assessment stated on [10]. Information on the azimuths and slots coordinates of the neighboring risers are available on the file “Scenarios_AandB COORD REV3.xlsx”, attached to this specification. The evaluation of the pairs and trios highlighted in yellow color on the spreadsheets is considered as a minimum scope to check for interference between STU x neighboring risers and between STU x mooring lines, if SUPPLIER considers the STU configuration proposed by PETROBRAS on Figure 3 of [10] (STU in a lazy-wave configuration between the 4in Service Line and the 8in Water Injection Line, both in

a lazy-wave configuration too). If SUPPLIER intends to propose a different configuration, PETROBRAS shall be consulted to discuss and define which neighboring risers shall be considered as a minimum scope for interference analysis.

The same values of friction coefficients applied for the STU (0.45 for the axial direction and 1.07 for the lateral direction] shall be adopted for the neighboring risers for the interference analysis. Additionally, PETROBRAS informs that clashing with the straked regions of rigid risers is allowed for the 100-year environmental load cases.