 PETROBRAS	TECHNICAL SPECIFICATION		NO:	ET-2000.00-1170-277-PPQ-001		
	PROGRAM: WELLS			Sheet 1 of 11		
	AREA: WELL STRUCTURE					
POCOS/EP/ITC/ETP	TITLE: Subsea Wellhead System Sealing and Locking Assembly - Test Protocol			PUBLIC		
				POCOS/EP/ITC/ETP		


REVIEW INDEX

REV.	DESCRIPTION AND/OR LEAVES AFFECTED
0	Original edition.
A	The protection level has been changed from NP-1 to Public.
B	Review following tests and the limits of the seal's capabilities.
C	Changes to the title of the document with the addition of the text: Test Protocol. Wording changes to items: 5.3. 5.3.1, 5.3.2
D	General text review

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E
DATE	19/04/2018	30/07/2018	27/12/2019	07/06/2022	07/06/2022	
PROJECT	POCOS/CTPS/QC	POCOS/CTPS/QC	POCOS/CTPS/QC	POCOS/EP/ITC/ETP	POCOS/EP/ITC/ETP	
EXECUTION	POCOS/CTPS/QC	POCOS/CTPS/QC	POCOS/CTPS/DT	POCOS/EP/IDE/PERF	POCOS/EP/IDE/PERF	
VERIFICATION	POCOS/SPO/PEP/PROJ-EP	POCOS/SPO/PEP/PROJ-EP	POCOS/SPO/PEP/PROJ-EP	POCOS/SPO/PEP/PROJ-PERF	POCOS/SPO/PEP/PROJ-PERF	
APPROVAL	POCOS/CTPS/QC	POCOS/CTPS/QC	POCOS/CTPS/QC	POCOS/EP/ITC/ETP	POCOS/EP/ITC/ETP	


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FORM BELONGING TO PETROBRAS

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1 INTRODUCTION

The purpose of this Technical Requirements Specification, ET-R, is to define the minimum technical requirements and testing protocol of PETROBRAS for the qualification of the Subsea Wellhead System (SCPS) Sealing and Locking Assembly.

The Subsea Wellhead System Sealing and Locking Assembly are the components responsible for sealing the annular space between the high-pressure housing and the casing hanger and locking the axial movement of the casing hanger in relation to the high-pressure housing, elements commonly known as the universal sealing assembly (CVU) or emergency sealing assembly (CVE), in the case of emergency equipment.


If the locking capacity of the seal assembly itself is not sufficient to withstand the axial loading to which it will be subjected, an additional locking mechanism can be used Lock Down Bushing (LDB) or Lock Down Sleeve (LDS).

2 SCOPE

2.1 To present the technical and functional requirements for the qualification of Sealing and Locking Assemblies, for the acquisition of Subsea Wellhead Systems, in order to guarantee the correct specification of the equipment for PETROBRAS scenarios, with a focus on reliability and performance. The objectives of this ET-R are:

- 2.1.1 Confirm the capacity of the SR's locking mechanism (*lockdown* capacity).
- 2.1.2 Confirm the sealing capacity of the Sealing Set.
- 2.1.3 Confirm the system's capacity when subjected to combined pressure and axial force loads.
- 2.1.4 Confirm that the system maintains its integrity even when subjected to cyclical loads.

2.2 This specification complements the requirements of ISO 10423 / API 6A, Annex F, PR2, and API 17D, including qualification requirements for combined pressure and axial force loads and number of cycles, with the aim of reproducing possible field conditions throughout the life of the well, in order to define the system's operating envelope.


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3 REFERENCE DOCUMENTS

- 3.1 **API 6A** - *Wellhead and Christmas Tree Equipment*
- 3.2 **API 17D** - *Design and Operation of Subsea Production Systems - Subsea Wellhead and Tree Equipment*
- 3.3 **ISO 10423** - *Petroleum and natural gas industries - Drilling and production equipment - Wellhead and christmas tree equipment*
- 3.4 **ISO 14224** - *Petroleum and natural gas industries - Collection and exchange of reliability and maintenance data for equipment.*
- 3.5 **API 17N** - *Recommended Practice for Subsea Production System Reliability, Technical Risk & Integrity Management*
- 3.6 **IEC 60812** - *Analysis techniques for system reliability - Procedure for failure mode and effects analysis (FMEA)*

4 ACRONYMS OR ABBREVIATIONS

- 4.1 **CVU** **Universal** Sealing Set
- 4.2 **CVE** Emergency seal assembly
- 4.3 **AAP** High Pressure Housing
- 4.4 **SR** Casing Hanger
- 4.5 **ABP** Low Pressure Lodger
- 4.6 **BOP** *Blowout Preventer*
- 4.7 **ET** Technical specification
- 4.8 **EVE** Emergency Seal Spacer
- 4.9 **FS** Safety Factor
- 4.10 **F_{max}** Maximum permissible system axial load (*lockdown*)
- 4.11 **F_{trab}** Axial working load (*lockdown*) specified by the system's ET-RBS
- 4.12 **LDB** *Lockdown Bushing*
- 4.13 **LDS** *Lockdown Sleeve*
- 4.14 **NP** Product Number
- 4.15 **NS** Serial Number
- 4.16 **P_{trab}** Working pressure specified in ET
- 4.17 **P_{max}** Maximum test pressure from below
- 4.18 **SCPS** Subsea Wellhead System
- 4.19 **TPU** *Test Plug Universal*
- 4.20 **ISO** *International Organization for Standardization*

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- 4.21 **API** *American Petroleum Institute*
- 4.22 **ET-R** *Technical Requirements Specification*
- 4.23 **ET-RBS** *Technical Specification for the Requisition of Goods and Services*
- 4.24 **FMEA** *Failure Mode and Effect Analysis*
- 4.25 **FMECA** *Failure Mode, Effect and Criticality Analysis*
- 4.26 **FAT** *Factory Acceptance Test*
- 4.27 **IAF** *International Accreditation Forum*

5 DESCRIPTION OF FUNCTIONAL AND TECHNICAL REQUIREMENTS

5.1 All products tested must be identical to those to be supplied; scale prototypes will not be accepted. Equipment with the same functionality but with geometric differences may be approved on the basis of similarity, subject to analysis by PETROBRAS.

5.2 Equipment with metal-metal and elastomeric seals must be qualified without the elastomers or with them disabled to prove the effectiveness of the metal-metal seal.

5.3 The installation of the CVU/CVE and the additional locking device, if any, can be done by immersing them in a fluid containing 70% water and 30% glycerin. The fluid must be drained to carry out the cyclic qualification tests.

5.3.1 The injection of any sealant or lubricant will not be permitted during the qualification tests.


5.3.2 Pressure tests must be carried out with air, nitrogen or another gas.

5.4 The entire test procedure must be carried out on the same sample as the sealing and locking assembly.

5.5 The pressure and axial load values for the test will be defined as follows:

5.5.1 P_{trab} and F_{trab} - bottom and top pressure and axial load (*lockdown*) of the system will be defined in the ET-RBS by the PETROBRAS.

5.5.2 P_{max} and F_{max} - Maximum test pressure from below and maximum axial load (*lockdown*) for testing the system will be defined by the manufacturer.

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5.6 Acceptance Criteria

- 5.6.1 The pressure drop may not exceed 3% of the test pressure or 300 psi per hour, whichever is lower, or a drop proportional to these values for tests with an observation period of less than one hour.
- 5.6.2 For low-temperature pressure tests, there must be no visible leakage or presence of bubbles after the stabilization period.
- 5.6.3 Temperature conditions must meet the requirements of Annex F, item 1.10, of API 6A.
- 5.6.4 The product tested must not be deformed or damaged in any way that affects its performance.
- 5.6.5 At the discretion of PETROBRAS, all tests shall be witnessed by personnel designated by PETROBRAS and/or by an Independent Certifying Authority internationally recognized by the IAF.

5.7 Test Device Configuration

- 5.7.1 The materials, surface casings, tolerances, hardness and other characteristics of the test device must be the same as those of the equipment supplied, regarding the interfaces with the products tested. In addition, they must reproduce the conditions found in the field.
- 5.7.2 The equipment to be tested must not have any locking mechanism other than those used when installed in the well.
- 5.7.3 The installation parameters for the Sealing Set and Locking System must be the same as those used in the offshore field.
- 5.7.4 The axial displacement of the SR must be instrumented with a minimum resolution of 0.001".
- 5.7.5 The test parameters (pressure, axial load, temperature and displacement) must be constantly recorded throughout the Qualification Tests by means of digital recording devices and presented in graphical form during the test.
- 5.7.6 Measuring devices must be calibrated in accordance with ISO 10423 requirements. The calibration interval must be less than three months.

5.8 Pressure x Axial Load Operating Envelope

5.8.1 A combined Pressure x Axial Load envelope at maximum temperature must be generated for the SCPS Sealing and Locking Assembly, after the cyclic test has been carried out. The points designated for forming the envelope must be informed by the manufacturer based on numerical models and previous tests. The envelope must have at least six points with combined loading, in order to cover any combination of pressure and axial load from the equipment's technical specification, taking into account safety factors. The maximum temperature must be 121°C (250°F).

$$FS_{\text{pressure}} = 1,1$$

$$FS_{\text{axial}} = 1,1$$

5.8.2 The envelope must contain at least the following points:

- Maximum test pressure from below (P_{max}) the Seal Set, which must be at least the working pressure (P_{trab}) from below of the Seal Set multiplied by the FS_{pressure} safety factor;
- Maximum axial test load (F_{max}) of the system, this load must be at least the axial working load (F_{trab}) of the system, multiplied by the FS_{axial} safety factor;
- Six additional points of axial load (F_n) and pressure from below (P_n) combined, with values equal to or greater than P_{trab} or F_{trab} multiplied by the safety factors, according to the example in Figure 1.

At least one of the six points that make up the envelope must correspond to the point (P_{trab} ; F_{trab}), multiplied by the Safety Factor of 1.1.

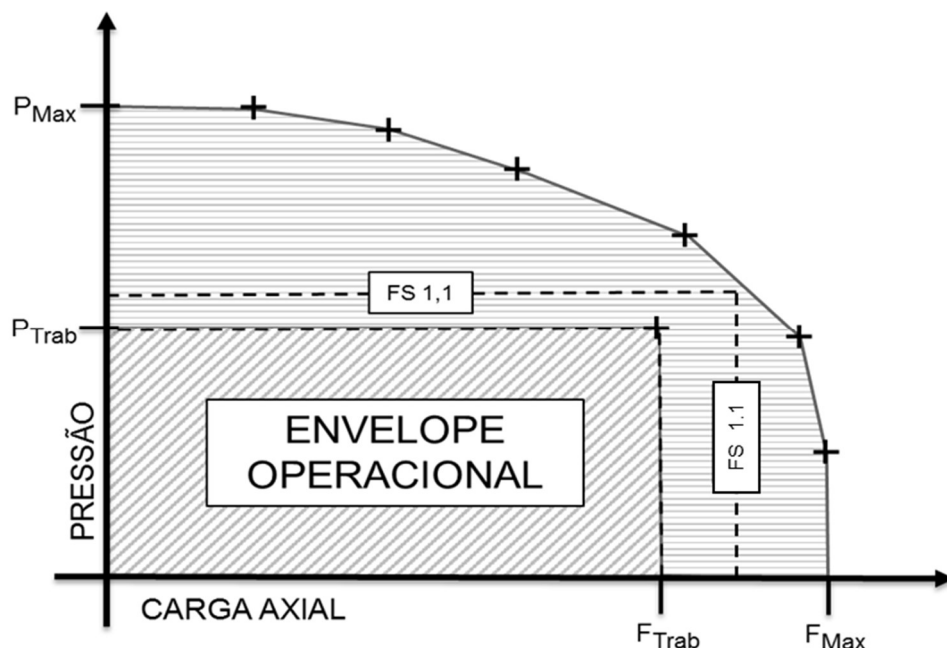



Figure 1 - Operational Envelope

5.9 Axial Loading and Pressure Cycles

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5.9.1 Cyclic Axial Loading Test at Room Temperature

- Keep the test device at ambient temperature;
- Apply the upward axial load (F_{trab}) to the SR and hold for 5 minutes;
- Relieve the axial load;
- Apply the downward axial load, equivalent to half the upward load ($-F_{trab} / 2$), to the Casing Hanger and hold for 5 minutes;
- Relieve the axial load;
- Repeat items 5.10 a) to 5.10 e) 18 more times, for a total of 19 cycles.

5.9.2 Combined Pressure Test with Axial Loading at ambient temperature


- Keep the test device at ambient temperature;
- Apply pressure P_{trab} from below. Hold for 5 minutes;
- While maintaining pressure P_{trab} , apply axial load F_{trab} from below. Maintain for 15 minutes;
- Relieve axial load F_{trab} while maintaining pressure P_{trab} ;
- Vent the pressure;
- Apply maximum working pressure from above;
- Vent the pressure from above;


Repeat items 5.9.1 and 5.9.2 more nine times, for a total of two hundred loading cycles on the system.

Note: A failed pressure test under or over the seal assembly characterizes the failure of the cyclic test.

5.10 Upward Axial Loading

- Apply the load F_{max} to the Casing Hanger from below;
- Keep the load F_{max} for 15 minutes;
- Relieve the axial load;
- Repeat items **Erro! Fonte de referência não encontrada..a)** to **Erro! Fonte de referência não encontrada..c)** two more times, for a total of three cycles.

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<p>5.11 Execution of the Pressure x Axial Load Operating Envelope</p> <ol style="list-style-type: none"> a) Raise the temperature to maximum; b) While maintaining maximum temperature, apply pressure P_n from below. Maintain for 5 minutes; c) While maintaining pressure, apply axial load F_n. Maintain for 15 minutes; d) Relieve the axial load while maintaining pressure; e) Vent the pressure; f) Using other combinations of pressures (P_n) and axial loads (F_n) from below, repeat steps (Erro! Fonte de referência não encontrada..a to Erro! Fonte de referência não encontrada..d) for a total of six combined test points, in order to produce the Combined Load Operation Envelope, as described in item Erro! Fonte de referência não encontrada... <p>5.12 Post-test analysis</p> <ol style="list-style-type: none"> 5.12.1 Once the qualification tests have been completed, the equipment must be dismantled and inspected. 5.12.2 A complete dimensional analysis of the equipment and the areas of the device that interface with the equipment must be carried out in order to compare with the dimensions recorded before the tests began. 5.12.3 Any dimensional, geometric, material or other changes to the design of the equipment tested may require a new qualification, at the discretion of PETROBRAS. <p>5.13 Recording the results</p> <ol style="list-style-type: none"> 5.13.1 All test results, inspection reports and operational envelopes for pressure and combined axial loads must be approved by the designated Independent Certification Authority. 5.13.2 All test records must be kept by the supplier for a minimum of 10 years. 5.13.3 Upon completion of the Qualification Tests, a report must be provided with all the results, analyzing the performance of the equipment for the combined and cyclic loading conditions established in the technical specification. 			

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6 DOCUMENTATION

- 6.1 The documents described below are within the scope of suitability for use and must be available for technical review and approval.
- 6.1.1 All supporting documentation for the technical requirements must be provided, in accordance with item 5 of this ET-R, and the supplier is responsible for the veracity of the information. If inconsistencies or untrue information are proven, the supplier may be penalized at discretion of PETROBRAS.
 - 6.1.2 The tests must be accompanied and validated by PETROBRAS or a third-party entity internationally recognized by the IAF, and must be substantially the same equipment (size, model and type) as that supplied to PETROBRAS.
 - 6.1.3 Technical drawings, with dimensional data of the equipment and its accessories.
 - 6.1.4 Technical catalog of the equipment.
 - 6.1.5 Equipment operating manual with data and operating limits.
 - 6.1.6 Operational procedures for installation, uninstallation, configuration and *troubleshooting*, with the appropriate risk analysis.
 - 6.1.7 Equipment inspection manual.
 - 6.1.8 Certification of compliance with the technical standards described in this ET-R, issued by a certifier accredited by an entity recognized by the IAF or compliance with the API Monogram.
 - 6.1.9 Certificate of compliance with the API SPEC 17D standard, monogrammed by the entity itself.
 - 6.1.10 Equipment FMEA, Failure Modes and Effects Analysis according to IEC 60812.
 - 6.1.11 Provide an installation history of the equipment supplied, if it has been used in the offshore field.
 - 6.1.12 Manufacturing Inspection and Test Plan (FAT and SIT).
 - 6.1.13 All documents/drawings must be updated with each revision, cancellation or inclusion. This revision must be carried out by the MANUFACTURER and the new electronic files made available.
 - 6.1.14 All documents must be made available electronically in PDF format in Portuguese or English.
 - 6.1.15 The supplier is obliged to make available to PETROBRAS at least one (1) qualified professional with knowledge of the design of the equipment, its functionality and its installation, in order to carry out the FMECA and/or risk analysis of the component tasks of the installation of the equipment or provision of services.