INDEX OF REVISIONS

REV.	DESCRIPTION AND/OR AFFECTED SHEETS
0	Original Emission

Note 1: Revised by CLW4, U3FL, DVLY, RHCG, B2N8, HR7O

	REV. 0		REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
DATE	08/05/2023								
DESIGN	SP&BS								
EXECUTION	CXS2								
CHECK	Note 1								
APROVAL	UR6A								

SUMMARY

1 PURPOSE

1.1 This Technical Specification (TS) defines the minimum requirements for design, manufacturing, testing and acceptance of SUBSEA HIGH-VOLTAGE ELECTRICAL MOTOR and its accessories that shall be part of the Subsea Processing & Boosting Systems (SP&BS).

1.1.1 This TS covers all activities related to the motor as a unit, i.e., activities to be performed before the motor integration in the subsea pump element.

1.2 This TS is part of a document package for SP&BS bid and product development purposes.

1.2.1 This TS shall be referred in full for Subsea Electrical Power System (SEPS) detailed design and interfaces with other SP&BS equipment.

2 TERMS, DEFINITIONS, ACRONYMS AND ABREVIATIONS

2.1 For the purposes of this TS, the following Terms and Definitions apply.

Dataroom: One or several meetings when SUPPLIER presents paper copies of the documents not available for PETROBRAS in electronic format for PETROBRAS verification and comments.

2.2 For the purposes of this TS, the following Acronyms and Abbreviations apply.

BF: Barrier Fluid
CFD: Computational Field Dynamics
CP: Cathodic Protection
FAT: Factory Acceptance Test
FEA: Finite Element Analysis
FMECA: Failure Mode Effect and Criticality Analysis
HV: High-Voltage (voltages equal or greater than 1kV)
ITP: Inspection and Test Plan
PREN: Pitting Resistance Equivalent Number
QA: Quality Assurance
QC: Quality Control
RIM: Reliability and Integrity Management
ROV: Remotely Operate Vehicle
SEPS: Subsea Electrical Power System
SP&BS: Subsea Processing and Boosting System

TMA: Technology Maturity Assessment

TRC: Technical Risk Categorization

TRL: Technology Readiness Level

TS: Technical Specification

VFD: Variable Frequency Drive

VPI: Vacuum Pressure Impregnation

WM: Wet-mateable

3 REFERENCE DOCUMENTS

3.1 PETROBRAS' Documents

Doc. Nr.	Title
[1] RM	Material Requisiton(s) with technical aspects and scope specific to the project
[2] SEPS Technical Specification NOTE 01	Subsea Electrical Power System
[3] I-ET-3000.00-1500-700-PEK-002	Subsea High-Voltage Power Connection System
[4] SP&BS Technical Specification NOTE 01	Subsea Processing & Boosting System
[5] ET-3000.00-1500-600-PEK-006	Requisitos Gerais de Equipamentos Submarinos
[6] I-ET-3000.00-1500-800-PEK-019	Subsea Motor-Pump Transducer System
[7] ET-3000.00-1500-600-PEK-008	Instalação de Equipamentos Submarinos

NOTE 01: Technical Specification specific of the bidding process.

3.2 Industry Codes, Standards, Rules and Regulations

The latest issue of the reference standards shall be used unless it is specified in the table below or otherwise agreed. Other recognized standards may be used, provided it can be shown that they meet or exceed the requirements of the standards referenced below. Variations or alternatives, if proposed, shall be submitted to PETROBRAS for approval before SEPS detailed design starts.

Doc. Nr. or Author	Title
[8] API RP 17N, 2nd Ed. June 2017, Addendum 1 May 2018	Recommended Practice on Subsea Production System Reliability, Technical Risk, and Integrity Management
[9] API RP 17Q, 2nd Ed. May 2018	Recommended Practice on Subsea Equipment Qualification
[10] API Standard 541	Form-wound Squirrel Cage Induction Motors – 375 kW (500 Horsepower) and Larger
[11] API Standard 546	Brushless Synchronous Machines – 500kVA and Larger
[12] API 610, 11th Ed. July 2011	Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries

[13] ASME BPVC	Boiler and Pressure Vessel Code
[14] BSI PD 5500	Specification for unfired fusion welded pressure vessels
[15] DNVGL-RP-B401	Cathodic Protection Design
[16] IEC 60034-1	Rotating electrical machines – Part 1: Rating and performance
[17] IEC 60034-15	Rotating electrical machines – Part 15: Impulse voltage levels of form-wound stator coils for rotating a.c. machines
[18] IEC 60034-25	Rotating electrical machines – Part 25: AC electrical machines used in power drive systems – Application guide
[19] IEC 60034-27-3	Rotating electrical machines – Part 27-3: Dielectric dissipation factor measurement on stator winding insulation or rotating electrical machines
[20] IEC 60502-2	Power Cables with extruded insulation and their accessories for rated voltages from 1kV (U_m=1,2kV) up to 30kV (U_m=36kV) – Part 2: Cables for rated voltages from 6kV (U_m=7,2kV) up to 30kV (U_m=36kV)
[21] IEEE Std. 43	Recommended Practice for Testing Insulation Resistance of Electric Machinery
[22] IEEE Std. 112	Standard Test Procedure for Polyphase Induction Motors and Generators
[23] IEEE Std. 522	Guide for Testing Turn Insulation of Form-Wound Stator Coils for Alternating-Current Electric Machines
[24] ISO 15156-3	Petroleum and natural gas industries – Materials for use in H_2S- containing environments in oil and gas production – Part 3: Cracking-resistant CRAs (corrosion-resistant alloys) and other alloys.
[25] ISO 21457	Petroleum, petrochemical and natural gas industries – Materials selection and corrosion for oil and gas production systems
[26] ISO 21940-11	Mechanical vibration – Rotor balancing – Part 11: Procedures and tolerances for rotors with rigid behaviour
[27] NACE SP0108	Standard Practice Corrosion Control of Offshore Structures by Protective Coatings
[28] NORSOK M-501	Surface preparation and protective coating

4 SUBSEA HV ELECTRICAL MOTOR TECHNOLOGY MATURITY ASSESSMENT

4.1 SUPPLIER shall design the Subsea HV Electrical Motor for the design pressure as stated in [1].

4.2 SUPPLIER shall design motor shaft with, at least, 10% margin over its maximum operational shaft power considering all operational speed and load ranges of the SP&BS application.

4.3 Subsea HV Electrical Motor design, manufacturing and testing shall be based on

SUPPLIER´s previously qualified HV Electrical Motor.

4.3.1 Any changes, differences, and adjustments in the Subsea HV Electrical Motor design when compared with previously qualified motors, shall be clearly presented in the Technology Maturity Assessment (TMA) Report and in the Qualification Assurance Report, as per sections 4.4 and 4.5, respectively.

4.4 SUPPLIER shall perform a TMA, as per [8] and [9], of the Subsea HV Electrical Motor design to evaluate each element technical risk and maturity in line with the SP&BS application characteristics, safety, and performance goals.

4.4.1 TRL shall be assessed using the design requirements stated in this TS. Each element gap to assure TRL 4 shall be identified, and the qualification tests needed to assure TRL 4 shall be clearly identified and performed as part of detailed engineering phase, as stated in [2] and [4].

4.4.2 TRC shall be assessed using, at least, the change risk factors stated in [8] for equipment and for procedures. SUPPLIER shall implement actions in its RIM for each change risk factor classified as ‘A – Very High’ or ‘B – High’ to reduce it, at least, to ‘C – Medium’, as stated in [2] and [8].

4.4.3 SUPPLIER shall present the Subsea HV Electrical Motor TMA Report in the first SEPS Technical Meeting, together with the action plan with detailed scope and schedule to be performed during Detail Design stage to assure TRL 4 achievement before element manufacture starts and to assure TRC C achievement during all project life cycle stages, from Detail Design to Operation.

4.5 SUPPLIER shall provide a Qualification Assurance Report, as per [9], of the Subsea HV Electrical Motor design informing, as a minimum, the following:

4.5.1 Stator description and materials used.

4.5.2 Rotor description and materials used.

4.5.3 Bearings description and materials used.

4.5.4 Sensors and monitoring system description.

4.5.5 Motor nominal nameplate characteristics using Datasheet as per [10] for induction

motors and as per [11] for permanent magnet motors as a motor characteristic´s check list reference.

4.5.6 Motor qualification test program goals, requirements and acceptance criteria summary including the complete list of test procedures and test reports with document number, title, revision, and emission date.

4.5.7 A summary of the qualification claims in relation to specified goals and requirements.

4.5.8 A summary of the evidence and related document number, title, revision, and emission date, to support the qualification claims above.

4.5.9 Improvements arising from motor manufacture and assembly procedures, tools, and facilities.

4.5.10 Improvements arising from qualification testing and assessment.

4.5.11 Improvements in QC/QA procedures.

4.5.12 Potential motor and motor component´s weaknesses, residual risks, and uncertainties.

4.6 PETROBRAS, as its own discretion and during all project phases, may ask for a *dataroom* to verify any document listed in the TMA Report.

5 DESIGN REQUIREMENTS

5.1 Only three-phase subsea liquid filled motor based on SUPPLIER´s previously qualified HV Electrical Motor for application in subsea boosting systems with pressure design class 5kpsi or greater shall be used.

5.1.1 The Subsea HV Electrical Motor shall be designed and manufactured according to the previously qualified motor as stated in Subsea HV Electrical Motor TMA and Qualification Assurance Report, according to item 4 of this TS.

5.1.2 SUPPLIER shall submit to PETROBRAS evaluation any changes, differences, and adjustments in any aspect of the motor's supply chain and manufacture statements (drawings, materials, tools, procedures etc.) together with a criticality analysis of the impact of the change on motor TRL and TRC. Additionally, SUPPLIER shall provide a Management of Change action plan to ensure that the change is consistent with

reliability, integrity, and technical risk.

5.1.3 A criticality analysis shall be performed to changes in any aspect of the motor´s supply chain and manufacturing process that could alter inspection and test criteria or invalidate previous motor qualification.

5.1.4 Qualification testing shall be undertaken for any change in the motor's design or manufacture premises that reduces the TRL to below 4 or increase the risk in any one of the TRC equipment or procedure change factor as defined in [8] to B or A.

5.2 Motor shall be designed for application with non-sinusoidal and variable frequency voltage and to tolerate any transient condition including emergency shut down and failures in the power supply. Reference shall be made to [18].

5.2.1 SUPPLIER shall provide detailed information about motor characteristics in all operation conditions (e.g., during startup, stop and fault transients, during steady-state operation in all range of continuous operation conditions) during detailed design stage.

5.2.2 Operational range and respective alarm and trip levels shall be defined by SUPPLIER and shall comply with all operation conditions detailed by SUPPLIER to fully fulfill the SP&BS safety and performance requirements.

5.2.3 SUPPLIER shall provide a criticality analysis of the motor design against VFD output characteristic and umbilical power cable characteristics and ensure that no additional temperatures, vibrations, and insulation stresses occur and affect motor reliability.

5.3 Service life, operational water depth and ambient water temperature shall be according to [4].

5.3.1 Planned maintenance intervals shall not be less than 5 years.

5.3.2 General subsea equipment design requirements shall be according to [5].

5.4 Induction motors shall comply with [10] performance and test criteria.

5.5 Permanent magnet synchronous motors shall comply with [11] performance and test criteria.

5.6 Motor shall withstand an overspeed of 1.1 times the maximum continuous operation speed.

SUPPLIER shall specify a Trip Speed Limit so that the overspeed limit cannot be reached in service.

5.7 The motor winding may be either VPI process form wound or resin rich form wound or fully insulated cables.

5.7.1 Windings shall be adequately supported, braced, and blocked to withstand, without damage, the dynamic stresses occurring during short-circuit directly on motor terminals and to limit winding vibration throughout the motor speed and load operating range to avoid subsequent damage to the winding insulation.

5.7.2 The end-windings shall be supported or strapped in a way sufficient to avoid harmful vibration.

5.7.3 Windings and neutral point insulation shall be uniform.

5.7.4 The maximum continuous operation temperature of the winding shall be limited, at least, to 10°C below the actual thermal class of the motor winding insulation when the motor is operating in worst thermal condition regarding load, harmonics, and barrier fluid system.

5.7.5 The design shall assure proper cooling of windings in areas where cables are bundled together.

5.7.6 Cable pigtails to the power penetrators terminations shall allow for minimum 10 connections/disconnections between the windings and the HV power penetrators. If requirement cannot be met, SUPPLIER shall ensure that cable/pigtail length is sufficient to allow for 10 re-terminations.

5.7.7 Motor HV penetrators, jumper assembly and WM connectors shall be according to [3].

5.8 Motor cooling system:

5.8.1 Fouling and scaling shall be considered in the design. If SUPPLIER analysis indicates need of cleaning the cooling coils subsea during motor service life, the cooling coils shall be accessible on the outside for flushing/cleaning with ROV.

5.8.2 Provision shall be made to allow the cleaning of the cooling coils topside, after

retrieval.

5.8.3 Provisions shall be made for complete venting and vacuuming of the cooling system prior to delivery.

5.8.4 The same design requirements for motor casing regarding pressure, temperatures and water depth shall apply for cooling coils.

5.8.5 The rheological and heat transfer properties of coolants must be thoroughly evaluated to consider the effects of pressure and temperature and their suitability for subsea use. Oil-based fluids should also be evaluated for gelation and other thermal effects.

5.8.6 The motor cooling system design shall be dimensioned to allow full load testing during FAT.

5.9 Vibrations, tensions, and compressions shall not impair the later function or quality of the subsea motor, during storage, transportation, installation, and retrieval, and throughout designed service life.

5.10 Mechanical seals:

5.10.1 The BF System shall be designed to allow differential pressure across the mechanical seals in each motor-pump unit, controlled by subsea barrier fluid control valve, of at least 40 (forty) bar above the worst-case differential pressure between barrier fluid and process fluid as per [4]. The final value shall be evaluated together with the dynamic analysis of the transient behavior of the SP&BS and BF system according to [4]. BF pressure shall be kept higher than process pressure in all operational conditions detailed by SUPPLIER to fully fulfill safety and performance requirements.

5.10.2 The mechanical seals shall be designed for the same static absolute pressure as the motor housing plus a margin of 1.5 times the static absolute pressure. The seals shall also be designed to withstand a static differential pressure of 1.5 times the maximum differential pressure in service both from barrier fluid to process as well as the other way around.

5.10.3 SUPPLIER shall include in the motor design report the mechanical seal leakage flow at rated condition.

5.10.4 For static sealing requirements, elastomeric seals may be used provided sufficient

measures are taken to prevent extrusion under differential pressure.

5.10.5 All mechanical seals shall be tested at operating conditions of the application prior to assembly.

5.11 In the case of a flexibly coupled motor shaft being used, a rotordynamic analysis of the electric motor shall be performed by SUPPLIER and submitted for PETROBRAS' in the form of a Technical Report for PETROBRAS' approval. The Rotordynamic Report shall contain the following information and analyses, as a minimum:

5.11.1 Lateral natural frequencies of the rotor and associated mode shapes and damping factors, with acceptance criteria as per Annex I.1 of [12].

5.11.2 Build the rotor critical speed map (undamped analysis), with acceptance criteria as per Annex I.1 of [12].

5.11.3 Build the rotor Campbell diagram (damped analysis), with acceptance criteria as per Annex I.1 of [12].

5.11.4 Evaluate the unbalance responses and associated amplification factors, with acceptance criteria as per Annex I.1 of [12].

5.11.5 Rotor geometry and dynamic coefficients in enough detail to enable the analysis' independent audit.

5.12 In case of rigidly coupled motor shaft a combined rotordynamic analysis – torsional and lateral – shall be performed for the entire shaft system with motor and driven equipment.

5.13 SUPPLIER shall consider as part of the shaft analysis the axial, radial and torsional stresses produced as a result of VFD voltage and current power supply.

5.14 The mechanical and electrical run-out in the proximity probe tracks shall not exceed the values defined in [10] and [11].

6 MATERIAL REQUIREMENTS

6.1 SUPPLIER shall prepare a materials selection report and present it to PETROBRAS, before manufacturing starts.

6.2 Casing materials shall be selected according to [25]. All sea water exposed surfaces shall

have a CP system according to [15]. The electrical continuity of the CP system shall be measured and documented.

6.3 Corrosion resistant surface coatings shall be applied to the housing and structure of the motor to preserve the life of the CP system. Reference shall be made to [27], [28] and their associated standards.

6.4 Generally, CP should form part of the anti-corrosion regime for the entire structure to prevent incompatibilities between the motor CP system and the structure to which it is mounted. If this is not the case, seawater exposed materials, not protected by CP, shall possess PREN>40.

6.5 Materials for sealing faces for non-pressure compensated enclosures shall be a seawater resistant alloy with a PREN>40.

6.6 Materials for sealing faces for pressure compensated enclosures shall be TRIM HH with a minimum layer of 3mm. Moreover, requirements from [24] shall be met.

6.7 Sealing faces in alloys with PREN<40 and other surfaces that rely on CP shall be properly preserved to avoid pitting corrosion during manufacture, transportation, and storage.

6.8 All forging materials shall possess adequate ductility and fulfil the minimum impact requirements as given by [14] or [13].

6.9 Non-metallic materials, such as elastomers, thermoplastics, epoxy resin and polyester resin shall be compatible with each other as well as with the barrier fluid, process fluid, cleaning fluid or gas with which they may be in contact.

6.10 Some elements may be tested as a component directly following the reference standards whilst other assembled components may be tested similarly in the same type of media but criteria for pass/non-pass may be different. An example of an assembled component is a complete motor coil as fitted in the motor with associated cables, crimps, and insulated terminations. A minimum of 5 items of each component shall be tested for statistical purposes.

7 INSTRUMENTATION AND MONITORING IN OPERATION

7.1 Failure of any part in the instrumentation and monitoring system shall not lead to a reduction in the motor functionality.

7.2 Motor shall have the instrumentation and monitoring functions when in subsea operation according to [6], as a minimum.

8 TRANSPORTATION, HANDLING, AND INSTALLATION REQUIREMENTS

8.1 Subsea equipment installation requirements shall be according to [7].

8.2 Acceleration/shock recorders and any protective devices or locks shall be installed and supervised during transport and installation up to the moment of final lifting of the subsea motor for deployment.

8.3 Maximum ambient air storage, handling, and transportation temperature: 60°C.

8.4 Minimum ambient air storage, handling and transportation temperature shall be defined by SUPPLIER considering subsea motor manufacturing and testing facilities local environmental conditions.

8.5 SUPPLIER shall produce a document clearly outlining the correct procedures for transportation, receipt inspection, lifting, storage, installation, final inspection, deployment operation and retrieval.

8.6 Minimum 2 years storage onshore and minimum 1 year storage subsea, in addition to the specific design service lifetime. SUPPLIER shall provide detailed procedures for operations, handling and preservation required for the storage period, including maintenance and preservation procedures for retrieved motors.

9 DESIGN ANALYSES REQUIREMENTS

9.1 The subsea motor, including its accessories, shall be subjected to an electromagnetic, thermal, pressure, fluid dynamic and mechanical analyses, covering all intended operational conditions. The analyses shall verify that the worst-case design loads that have been identified by SUPPLIER to fully fulfill safety and performance requirements do not exceed electromagnetic, thermal, pressure or mechanical limitations for any material. The analysis shall include:

9.1.1 All modelling assumptions for the analysis and the design.

9.1.2 A FMECA to identify possible failure modes, especially those with a safety, environmental or performance critical impact.

9.1.3 Worst-case design loads (test, storage, handling, installation/retrieval, and operation) including fault scenarios and demonstrate sufficient margin of safety against failure modes that have been identified.

9.1.4 Resonance, dynamic and torsional analysis across the operating speed range. Reference shall be made to section 4.4.5 of [10].

9.1.5 Possible nonlinear material properties.

9.1.6 Mechanical and thermal effects of calcium deposits, marine growth, and debris.

9.1.7 Motor data relevant to the CP analyses, such as surface areas (coated/uncoated), surface temperature, type of coating etc.

9.1.8 A description of welding, sealing and corrosion protection, including surface treatment solutions.

9.1.9 FEA for any hydraulic, pressure or thermal fit components to ensure geometries are within tolerance over the operating range of the motor.

9.1.10 Fluid dynamic analysis to stablish motor drag losses as a function of speed in the motor gap and its windings' end turn regions.

9.2 In the thermal analysis the effect of speed, pressure and any marine growth or calcium deposits etc. shall be considered. An ambient water current velocity of 0 m/s shall be used. The analysis shall cover, as a minimum:

9.2.1 Analysis shall be performed, at least, at 3 points of operation: at rated power, at minimum continuous speed and at maximum continuous speed.

9.2.2 Maximum continuous temperatures of insulating materials and windings temperature rises.

9.2.3 Maximum continuous hot spot temperature.

9.2.4 Maximum temperature at the surface of the motor cooler.

9.2.5 Thermal losses due to fundamental and harmonic currents.

9.3 The material selection, properties, and limitations used in the analysis shall be identified

and documented based on fabrication processes that are qualified, recognized, and repeatable. This is also applicable for bonding between materials.

9.4 A description of welding, sealing and corrosion protection, including surface treatment solutions.

9.5 Analysis (such as FEA) for any hydraulic, pressure or thermal fit components to ensure geometries are within tolerance over the operating range of the machine.

9.6 Fluid dynamic analysis. Drag losses as a function of speed and process conditions should be calculated in the motor gap and its windings' end turn regions. If fluid dynamics analytical tools are used, their simplifying assumptions should be validated by experimentation, test data or by more detailed CFD models.

9.7 SUPPLIER shall produce a Design Analyses Report as part of the Subsea HV Electrical Motor Databook to be delivered to PETROBRAS.

10 INSPECTION AND TEST GENERAL REQUIREMENTS

10.1 SUPPLIER shall provide adequate inspection and monitoring points during manufacturing and testing to determine the performance, capacity, and efficiency at selected operating conditions of the motor and its components to enable a comparison of the results with the values and conditions that have been guaranteed by SUPPLIER.

10.1.1 Inspection and monitored point during manufacturing shall provide evidence that materials and manufacturing process complied with design premises.

10.1.2 Monitored points during test shall also provide evidence that motor is inside its operational envelope, e.g., hot spot temperatures, vibration, voltage, and current distortions that supports its reliability target.

10.1.3 Testing shall verify the thermal, cooling and vibration characteristics at the most critical operating points of the motor loading.

10.1.4 Testing shall verify the thermal, cooling and vibration at the most critical motor power supply distortion.

10.2 The tests specified in this TS shall be performed on the motor assembly, before it is integrated into the subsea pumping element.

10.3 Unless specified otherwise, the acceptance criteria for the tests in this TS shall be those given in the reference standards.

10.4 In addition to SUPPLIER´s own inspection and testing requirements, SUPPLIER shall perform the inspections and tests presented in items 11 and 12 of this TS.

10.4.1 The complete Subsea HV Electrical Motor ITP shall be presented for approval during SEPS Technical Meetings at detail design stage.

11 TEST DURING SUBSEA MOTOR ASSEMBLY

11.1 For cable wound stators the sample tests of cable, cable joints and splices in Table 11.1A and the cable FAT tests in Table 11.1B shall be performed prior to motor assembly, as a minimum. FAT tests of the stator in Table 11.1C and 11.1D shall be performed, as a minimum.

11.1.1 At least, 3 samples of cable, cable joint and cable splice shall be submitted and successfully pass tests in Table 11.1A.

Table 11.1A – Stator cable, joints, and splices sample tests

Test	Test procedure reference
Conductor examination and check of dimensions	[20]
Electrical Resistance of conductors	[20]
Insulation Thickness Measurement	[20]
Semi-conductive Layer Thickness Measurement	[20]
Semi-conductive Layer Resistivity Measurement	[20]
Voltage Test	[20]
Partial Discharge Test	[20]

Table 11.1B – Stator cable FAT

Test	Test procedure reference
Electrical Resistance of Conductors	[20]
Insulation Resistance and Polarization Index	[10]
Partial Discharge Test	[20]
Voltage Test	[20]

Table 11.1C – Cable wound stator test prior to neutral connection

Test	Test procedure reference
Electrical Resistance of Conductors	[20]
Insulation Resistance of each phase to ground	[21]
Insulation Resistance of each phase to phase	[21]
Surge Test	[23]

Table 11.1D – Cable wound stator tests after neutral connection

Test	Test procedure reference
Electrical Resistance of Conductors	[20]
Insulation Resistance of the three phases to ground	[21]
Surge Test	[23]

11.2 For resin rich form wound stators, the following tests shall be performed, as a minimum:

11.2.1 Sample tests as per [17] on, at least, 2 coils. In case of failure, SUPPLIER shall investigate the cause and repeat the test in another sample. Stator assembly shall start only after sample tests have been successfully performed.

11.2.2 Tests in Table 11.2A before impregnation.

11.2.3 Tests in Table 11.2B after impregnation.

Table 11.2A – Resin rich form wound tests before impregnation.

Test	Test procedure reference
Dielectric dissipation factor on 10% coils	[19]
Dielectric dissipation factor on complete windings	[19]
Insulation Resistance of each phase to ground before starpoint connection	[21]
Insulation Resistance of each phase to phase before starpoint connection	[21]
Surge Test	[23]

Table 11.2B – Resin rich form wound tests after impregnation.

Test	Test procedure reference
Insulation Resistance of each phase to ground, if star point is accessible	[19]
Insulation Resistance of the three phases to ground	[19]
Polarization Index	[21]
Withstand Voltage	[16]
Dielectric dissipation factor	[19]
Surge Test	[23]

11.3 For rotor of induction motors, as a minimum, SUPPLIER shall elaborate detailed procedures based on relevant material and manufacturing process applicable for the verification and quality assurance of rotor bars, rotor shorting ring and retaining ring materials and method of attaching.

11.4 For rotor of permanent magnet motors, as a minimum, SUPPLIER shall elaborate detailed procedures based on relevant material and manufacturing process applicable for the verification and quality assurance of magnet´s material and method of attaching.

11.5 For all motor types, the inspection test requirements in Table 11.5A shall be performed during assembly, as a minimum.

Table 11.5A – Inspection tests during assembly

Inspection Requirement	Test procedure reference
Stator Core Test	[10] - [11]
Rotor balance assessment	[26]
Inspection of equipment and piping for cleanliness prior to assembly	By SUPPLIER
Electrical and mechanical runout of rotor	[10] - [11]
Final assembly running clearances	[10] - [11]
Measurement of axial float	By SUPPLIER

11.6 SUPPLIER shall produce an Assembly Report as part of the Subsea HV Electrical Motor Datasheet to be delivered to PETROBRAS.

12 SUBSEA MOTOR FAT

12.1 At least, the FAT listed in Table 12.1A shall be performed.

12.1.1 FAT shall be performed after complete assembly of the motor unit.

12.1.2 A sample of the barrier fluid shall be collected just before FAT starts and just after the last FAT test is concluded. A complete comparative analysis of physical, chemical, and dielectric, when applicable, barrier fluid characteristics shall be performed. SUPPLIER shall elaborate detailed procedure using relevant standards and with clear indication of fluid characteristics´ acceptable range.

Table 12.1A – Subsea motor unit FAT

Test	Test procedure reference
Stator windings temperature	By SUPPLIER
Bearings temperature	[16]
Stator windings resistance - cold	[22]
Stator windings insulation resistance - cold	[21]
Temperature rise test	[16]
Mechanical loss test	[22]
Motor load test at variable speed	By SUPPLIER covering, at least, 25% - 50% - 75% - 100% - 105% of rated speed
Full load test	[22]
Speed-torque and speed-current curves	[22]
Vibration measurement	Throughout FAT test as per 12.2.
Locked rotor test	[10] - [11]
Over-speed test	[10]

12.2 The shaft radial vibration shall be monitored during the entire FAT, and the following acceptance criteria shall apply:

Overall unfiltered pk-pk amplitude	$< 30\% \, C_b$	Accepted
	Between 30% and 50% of C_b	Must be analyzed and reported by the manufacturer and sent for Petrobras' approval.
	$> 50\% \, C_b$	Not accepted
Discrete subsynchronous frequency pk-pk amplitude	$< 6\% \, C_b$	Accepted
	$> 6\% \, C_b$	Must be analyzed and reported by the manufacturer and sent for Petrobras' approval.

C_b : Diametral bearing clearance

12.3 SUPPLIER shall produce a FAT Final Report, with detailed test procedures and reports, as part of the Subsea HV Electrical Motor Databook to be delivered to PETROBRAS.

13 SUBSEA MOTOR DATABOOK

13.1 SUPPLIER shall provide the Subsea HV Electrical Motor Databook before SP&BS installation including, as a minimum:

13.1.1 Subsea HV Electrical Motor Qualification Assurance Report as per item 4.5 of this TS.

13.1.2 Criticality analysis report of performed changes in motor design as per item 5 of this TS.

13.1.3 Transportation, receipt transportation, lifting, storage, installation, final inspection, deployment, and retrieval detailed procedures as per item 8 of this TS.

13.1.4 Design report as per item 9 of this TS.

13.1.5 Inspection and testing reports as per sections 11 and 12 of this TS.