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1. OBJECTIVE

This specification establishes the minimum conditions required for the design, manufacture, inspection, commissioning, testing and delivery of main synchronous generators, excitation equipment, grounding resistor, set of accessories, auxiliary equipment, protection and instruments assembled in generator frame intended to be part of Main Turbogenerator PACKAGES for PETROBRAS UNITS.

This specification does not define requirements for the following components: Turbogenerator Control Panels (TGCP), turbines, couplers, speed reducers, machinery protection system, or any other accessories or auxiliary equipment out of generator frame. Such requirements can be found in technical specifications related to the mentioned components.

2. GENERAL

2.1. DEFINITION OF TERMS

Within the contents of this Specification:

"CLASSIFICATION SOCIETY" means such authority or organisation appointed to ensure conformity with all requirements necessary to obtain certification or classification of the goods and/or services described herein.

"FIELD FORCING" means a feature of reinforcing the generator field applied before starting of a large motor to assist in reducing voltage drop.

See also I-ET-3010.00-1200-940-P4X-002 – GENERAL TECHNICAL TERMS.

2.2. ABBREVIATIONS

PMS Power Management System.

AVR Automatic Voltage Regulation.

TGCP Turbo Generator Control Panel (applicable to both gas and steam turbines).

CS Classification Society.

CT Current Transformer.

VT Voltage Transformer.

EPL Equipment protection level.

Level of protection provided by an "Ex" equipment, certificate for installation in classified areas, such as Ga, Gb, Gc, Da, Db or Dc, according to IEC 60079-0 and IEC 60079-14.

RT Routine Test – Test carried out on all units supplied.

TT Type Test – Test carried out on a piece of equipment representing the other equipment, aiming to demonstrate that they meet the specified conditions not covered by routine tests.

NOTE: A generator is representative of the others if it is completely identical in relation to rated values and construction. Type tests may be considered equally valid, if carried out in equipment that presents some deviations of rated values or other characteristics. These deviations shall be subject to agreement between MANUFACTURER and PETROBRAS.

ST	Special Test – Tests other than type or routine tests, performed by agreement between MANUFACTURER and PETROBRAS.
TDMP	Tests During Manufacturing Process, carried out during the equipment manufacturing process.
TCDG	Tests of Complete Driver-Generator set or String Tests, carried out at a location defined by PACKAGER.
FAT	Factory Acceptance Tests, carried out at the equipment manufacturing site.
SAT	Site Acceptance Tests, carried out at the equipment definite location.
THD	Total Harmonic Distortion.
ITP	Inspection and Testing Plan.
PMG	Permanent Magnet Generator.
PD	Partial Discharges
PDEV	Partial Discharges Extinction Voltage
PDIV	Partial Discharges Inception Voltage
VPI	Vacuum Pressure Impregnation
ESA	Electrical System Automation

3. CODES, STANDARDS & REFERENCE DOCUMENTS

The equipment shall comply with all rules and regulations stated by Brazilian Authorities, Classification Society and International Standards. Following these mandatory requirements, the equipment shall comply with requirements of this technical specification and the documents listed in 3.2.

Any deviation from this specification or the standards and reference documents shall be clearly identified by PACKAGER and agreed by PETROBRAS.

3.1. CODES, STANDARDS AND RECOMMENDED PRACTICES

3.1.1. IEC – INTERNATIONAL ELECTROTECHNICAL COMMISSION

IEC 60034-1	Rotating Electrical Machine - Ratings and Performance;
IEC 60034-2-1	Rotating Electrical Machines - Part 2-1: Standard Methods for Determining Losses and Efficiency from Tests (Excluding Machines for Traction Vehicles);
IEC 60034-3	Rotating Electrical Machines - Part 3: Specific Requirements for Synchronous Generators Driven by Steam Turbines or Combustion Gas Turbines;
IEC 60034-4-1	Rotating Electrical Machines - Part 4-1: Methods for Determining Electrically Excited Synchronous Machine Quantities from Tests;
IEC 60034-5	Rotating Electrical Machines - Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code);
IEC 60034-6	Rotating Electrical Machines - Part 6: Methods of Cooling (IC Code);

IEC 60034-7	Rotating Electrical Machines - Part 7: Classification of Types of Construction, Mounting Arrangements and Terminal Box Position (IM Code);
IEC 60034-8	Rotating Electrical Machines - Part 8: Terminal Markings and Direction of Rotation;
IEC 60034-9	Rotating Electrical Machines - Part 9: Noise Limits;
IEC 60034-15	Rotating Electrical Machines - Part 15: Impulse Voltage Withstand Levels of Form-Wound Stator Coils for Rotating a.c. Machines;
IEC 60034-16-1	Rotating Electrical Machines – Part 16-1: Excitation Systems for Synchronous Machines – Definitions;
IEC 60034-18-1	Rotating Electrical Machines - Part 18-1: Functional Evaluation of Insulation Systems - General Guidelines;
IEC TS 60034-25	Rotating Electrical Machines – Part 25: AC Electrical Machines used in Power Drive Systems – Application Guide;
IEC 60034-27-1	Rotating Electrical Machines – Part 27-1: Off-line partial discharge measurements on the winding insulation;
IEC TS 60034-27-2	Rotating Electrical Machines – Part 27-2: On-line partial discharge measurements on the stator winding insulation of rotating electrical machines;
IEC 60034-27-3	Rotating electrical machines - Part 27-3: Dielectric dissipation factor measurement on stator winding insulation of rotating electrical machines;
IEC 60034-29	Rotating Electrical Machines - Part 29: Equivalent Loading and Superposition Techniques - Indirect Testing to Determine Temperature Rise;
IEC 60050-411	International Electrotechnical Vocabulary - Chapter 411: Rotating Machinery;
IEC 60079	Explosive atmospheres – All Parts;
IEC 60085	Electrical insulation – Thermal evaluation and designation;
IEC 60092	Electrical Installations in Ships - All Parts;
IEC 60255-149	Measuring relays and protection equipment – Part 149: Functional requirements for thermal electrical relays;
IEC 60270	High-Voltage Test Techniques - Partial Discharge Measurements;
IEC 60364-4-41	Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock;
IEC 60533	Electrical and Electronic Installations in Ships - Electromagnetic Compatibility (EMC) – Ships with a Metallic Hull;
IEC 60751	Industrial Platinum Resistance Thermometers and Platinum Temperature Sensors;
IEC 61000-4-7	Electromagnetic Compatibility (EMC) – Part 4-7: Testing and Measurement Techniques – General Guide on Harmonics and Interharmonics Measurements and Instrumentation, for Power Supply Systems and Equipment Connected Thereto;
IEC 61000-2-4	Compatibility Levels in Industrial Plants for Low-Frequency Conducted Disturbances;

IEC 61800-3	Adjustable Speed Electrical Power Drive Systems – Part 3: EMC Requirements and Specific Test Methods;
IEC 61869	Instrument transformers – All Parts;
IEC 61892	Mobile and Fixed Offshore Units - Electrical Installations - All parts.

3.1.2. API – AMERICAN PETROLEUM INSTITUTE

API STD. 546	Brushless Synchronous Machines - 500 kVA and Larger;
API STD. 670	Machinery Protection Systems.

3.1.3. IEEE – INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERING

IEEE C57.32	Requirements, Terminology, and Test Procedure for Neutral Grounding Devices;
IEEE 43	Recommended Practice for Testing Insulation Resistance of Rotating Machinery;
IEEE 115	Guide for Test Procedures for Synchronous Machines Including Acceptance and Performance Testing and Parameter Determination for Dynamic Analysis;
IEEE 286	Recommended Practice for Measurement of Power Factor Tip-Up of Electric Machinery Stator Coil Insulation;
IEEE 522	Guide for Testing Turn Insulation of Form-Wound Stator Coils for Alternating-Current Electric Machines;
IEEE 1799	Recommended Practice for Quality Control Testing of External Discharges on Stator Coils, Bars, and Windings.

3.1.4. IMO - INTERNATIONAL MARITIME ORGANIZATION

IMO I810E	Code for the Construction and Equipment of Mobile Offshore Drilling Units (MODU CODE).

3.1.5. ISO - INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO 281	Rolling Bearings – Dynamic Load Ratings and Rating Life;
ISO 7919-3	Mechanical vibration – Evaluation of machine vibration by measurements on rotating shafts - Part 3: Coupled industrial machines;
ISO 10816-3	Mechanical vibration – Evaluation of machine vibration by measurements on non-rotating parts – Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15000 r/min when measured in situ;
ISO 12944-2	Paints and varnishes – Corrosion protection of steel structures by protective paint systems - Part 2: Classification of environments.

3.1.6. SECRETARIAT OF LABOUR - BRAZILIAN MINISTRY OF ECONOMY

NR-10	Segurança em Instalações e Serviços em Eletricidade;
NR-12	Segurança no Trabalho em Máquinas e Equipamentos;
NR-17	Ergonomia;

NR-26 Sinalização de Segurança;

NR-37 Segurança e Saúde em Plataformas de Petróleo.

3.1.7. **ASME**

ASME B1.20.1 Pipe Threads, General Purpose (Inch);

ASME B16.5 Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24 Metric/Inch Standard;

ASME BPVC VIII-1 Rules for Construction of Pressure Vessels.

3.1.8. **NEMA - NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION**

NEMA MG 1 Motors and Generators;

3.2. REFERENCE DOCUMENTS

[1] PACKAGE TECHNICAL SPECIFICATION

[2] I-ET-3010.00-1200-300-P4X-001 – NOISE AND VIBRATION CONTROL REQUIREMENTS

[3] I-ET-3010.00-5140-700-P4X-001 – SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS

[4] I-ET-3010.00-5140-700-P4X-002 – SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS

[5] I-ET-3010.00-5140-700-P4X-003 – ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS

[6] I-ET-3010.00-5140-700-P4X-005 – REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEMS OF OFFSHORE UNITS

[7] I-ET-3010.00-1200-956-P4X-002 – GENERAL PAINTING

[8] I-LI-3010.00-5140-700-P4X-001 – ELECTRICAL EQUIPMENT DATA-SHEET MODELS

[9] SPECIFICATION OF AVAILABLE UTILITIES

[10] I-ET-3010.00-5400-947-P4X-002 – SAFETY SIGNALLING

[11] I-ET-3010.00-5143-700-P4X-001 – ELECTRICAL SYSTEM PROTECTION CRITERIA

[12] I-ET-3010.00-5140-775-P4X-001 - REQUIREMENTS FOR ELECTRICAL GENERATION EXCITATION SYSTEM FOR OFFSHORE UNITS

[13] DR-ENGP-I-1.15 – COLOR CODING

[14] I-ET-3010.00-1200-940-P4X-002 – GENERAL TECHNICAL TERMS

[15] I-ET-3010.00-5140-700-P4X-007 – SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS

[16] I-ET-3010.00-5140-700-P4X-009 – GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS

[17] I-ET-3010.00-5140-713-P4X-001 – SPECIFICATION FOR TRANSFORMERS FOR OFFSHORE UNITS

[18] ELECTRICAL SYSTEM DESCRIPTIVE MEMORANDUM

Note**:** Documents without code in the list are documents with variations according to project characteristics. Verify in project documentation list the reference for codes of these documents.

4. GENERAL REQUIREMENTS

4.1. GENERAL

4.1.1 Unless otherwise specified in the project documentation, the generator and its auxiliary systems shall be designed and manufactured for a minimum life period of 30 years.

4.1.2 The sizing of equipment shall consider periods of continuous operation in rated conditions with minimum duration of 24000 hours without interventions for preventive or corrective maintenance requiring the equipment to stop.

4.1.3 Requirements for shaft coupling, base skid and safety grounding connections will be defined in PACKAGE TECHNICAL SPECIFICATION.

4.1.4 The equipment and installation shall comply with requirements of I-ET-3010.00-5140-700-P4X-005 – REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEMS OF OFFSHORE UNITS.

4.1.5 It shall not be acceptable out of date or obsolete equipment or components. Technical support and supply of replacement parts shall be guaranteed for ten (10) years.

4.1.6 PETROBRAS shall have full access to the whole documentation and data related to the Package, including (but not limited to) diagrams, source codes of software, licenses, firmware updates, passwords, configurations, parameterizations, controls, PLC files, alarms, events registers, etc.

Note: The software licenses shall be perpetual. Software licenses with expiration date are not acceptable.

4.2. HAZARDOUS AREAS

4.2.1 Generators for installation in classified areas of flammable gases shall have an "Ex" protection type certification in accordance with applicable legislation in force in Brazil and IEC 60079 and IEC 61892-7.

4.2.2 Even when placed in external safe areas, electrical equipment that is required to remain operational in an emergency shutdown ESD-3P or ESD-3T shall as a minimum be certified with the type of protection and EPL suitable for installation in hazardous areas Zone 2 Group IIA temperature T3. Alternatively, means shall be provided to automatically switch such equipment off in case of gas detection in its vicinities.

4.2.3 Generators with pressurized enclosure (Ex p) shall be proper to air supply quality according to ANSI/ISA 7.1.01 and SPECIFICATION FOR AVAILABLE UTILITIES. If the generator requires a better air supply quality, Manufacturer shall include air treatment devices.

4.2.4 Certificates shall comply with requirements of I-ET-3010.00-5140-700-P4X-009 – GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

4.3. ENVIRONMENTAL CONDITIONS

4.3.1 Generators, as well as all their accessories and auxiliary equipment, shall be able to operate in an environment with relative humidity between 15% and 95%, and with the temperature conditions defined in I-ET-3010.00-5140-700-P4X-009 – GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

4.4. INCLINATION REQUIREMENTS

4.4.1 The generator employed in a floating maritime UNIT shall be able to operate under slope variations (static and dynamic) and acceleration conditions specified by the IMO MODU CODE, IEC 61892-5 and Classification Society.

5. MECHANICAL REQUIREMENTS

5.1. LIFTING CHARACTERISTICS

5.1.1 The housing of the generator shall have devices which allow the hoisting of the equipment assembled with all its integral parts.

Note: Parts with mass of more than 25 kg, shall have its own hoist devices (e.g.: detachable exciter, heat exchanger, terminal box caps, panels, etc.).

5.1.2 The generator shall be designed and manufactured in such a way as to allow the rotor to be extracted horizontally, at operational site, without need of removal of the stator.

Note: The tools necessary for the rotor extraction at the operating site shall be provided.

5.2. SPEED LIMITS

5.2.1 The generator shall be supplied with devices to prevent the transmission of dynamic mechanical stresses to the set's base up to 120 % of rated speed.

5.2.2 The generator and its exciter shall support an overspeed of 20 % above the rated value for 2 minutes.

5.3. CORROSION PROTECTION AND PAINTING SYSTEM

5.3.1 The generator and its control and protection panels shall be corrosion-resistant due to environmental characteristics and/or service conditions as indicated in the datasheet.

5.3.2 Painting shall be in accordance with the requirements of I-ET-3010.00-5140-700-P4X-009 – GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

5.3.3 The mounting and fastening elements shall be manufactured in AISI 316L stainless steel.

5.4. DEGREE OF PROTECTION (IP CODES)

5.4.1 Unless otherwise specified in project documentation, the generator shall have minimum IP-56 protection degree in the housing, exciter, power, auxiliary terminal boxes and accessories, when installed in an external environment of floating UNITS, according to IEC 60034-5. When installed in fixed UNITS the minimum protection degree shall be IP-55. When installed in utilities rooms or machinery rooms the minimum protection degree shall be IP-54.

5.4.2 Through-hole mounting of auxiliary components (e.g., terminal boxes, electrical conduits, cable trays, tubing or any other devices) onto the generator enclosure or its terminal boxes is not allowed. The auxiliary components shall be attached to the enclosure in such a way that the IP (Ingress Protection) rating of the generator is not affected. Measures shall also be taken to avoid galvanic corrosion due to the dissimilarity between the materials of the fixing elements and the generator enclosure and its terminal boxes.

5.4.3 For accessories and auxiliary electrical equipment see requirements in I-ET-3010.00-5140-700-P4X-009 – GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

5.5. NOISE

5.5.1 Generators shall comply with requirements of IEC 60034-9, PACKAGE TECHNICAL SPECIFICATION and I-ET-3010.00-1200-300-P4X-001 – NOISE AND VIBRATION CONTROL REQUIREMENTS. The strictest requirement shall prevail.

Note: For generators installed inside "hood", the acceptance criterion refers to the level of audible noise measured externally to the "hood".

5.6. VIBRATION AND BALANCE

5.6.1 The generator shall be designed, manufactured, and tested in factory to be approved in assembly and field tests for the vibration levels established by IEC 61892, CS and PACKAGE TECHNICAL SPECIFICATION.

5.6.2 If the PACKAGE TECHNICAL SPECIFICATION does not define limits, the limits of Zone A/B of ISO 7919-3 or ISO 10816-3 shall be considered.

5.7. BEARINGS

5.7.1 Bearing shall be calculated for a minimum uninterrupted operation L10 (ISO 281) of 50000 h.

5.7.2 Generator shall be supplied with magnetic centre location indicator and acceptable axial displacement limit.

5.7.3 For grease lubricated bearings, they shall be provided with nipples-pin re-lubrication system, with fitting antechamber or natural drainage device for excess grease output.

5.7.4 Oil lubricated bearings shall be provided with level viewfinders for ring, speckle or similar ring lubrication cases, and flow display for each bearing in the case of forced lubrication.

5.7.5 Sleeve bearings shall be provided with sealing devices in order to avoid contamination of the internal components of the generator and to ensure the required protection degree.

5.7.6 Bearings of generators installed in non-hazardous areas shall be electrically insulated. In this case, the rotor shaft shall be provided with a grounding brush.

5.7.7 For generators installed in hazardous areas, only the non-drive end bearing shall be electrically insulated.

5.8. COOLING METHODS (IC CODES) AND VENTILATION

5.8.1 The generator shall have cooling method (IC code) according to the data-sheet indicated and in accordance with the requirements of IEC 60034-6.

5.8.2 Unless otherwise indicated in project documentation, cooling method shall be IC8A1W, using fresh water according to definitions of SPECIFICATION OF AVAILABLE UTILITIES of the project.

5.8.3 Unless otherwise specified in project documentation, the specific cooling water flow shall not exceed 2 m³/h/MVA.

5.9. TUBULAR AIR/WATER HEAT EXCHANGER

5.9.1 Unless otherwise specified in project documentation the heat exchanger shall be manufactured and tested according to ASME BPVC VIII-1 and CS.

5.9.2 Unless otherwise specified in project documentation, the generator shall contain two heat exchangers with individual capacity of at least 80% of the rated power of the generator.

5.9.3 Unless otherwise stated in project documentation, air-water heat exchangers shall comply with the following requirements:

a) The heat exchanger shall be of double-tube type so that any leakage from the internal tube will be collected by the external one;

b) The inner parts in contact with the cooling water shall be of a 9010 Cu-Ni corrosion resistant alloy;

c) The external tube shall be of copper, with fins of the same material;

d) Dissimilar metals shall not be in contact to prevent galvanic corrosion;

e) Load losses shall not exceed 0.7kgf/cm²;

f) Heat exchanger shall be built into or mounted on the machine casing, always on a position to allow easy access for maintenance;

g) It shall be provided protection to avoid the water to be in contact with the windings, in case of leakage, crack in pipes or condensation in exchanger;

h) The length of the tube beam of the heat exchanger shall be greater than the width of the generator housing, so that the heads, mirrors and joints are located externally to the housing, and that if leakage occurs in those items, there is no ingress of water into the housing;

i) It shall be provided means for draining off the water in case of leakage;

j) An alarm system shall be provided for signalling of leakage of water between the internal and the external tube;

k) Installation of auxiliary fans shall be not be acceptable;

l) Thermometers shall be installed at the exchanger water inlet and outlet;

m) Manometers shall be installed at the exchanger water inlet and outlet;

n) Differential pressure detectors shall be installed at exchanger water inlet and outlet;

o) It shall be provided two inspection windows at opposite sides each other;

p) It shall be provided facilities to perform hydrostatic test for heat exchangers and blocking valves on site, as well as for testing the water leakage alarm unit.

5.9.4 The water speed limit of 2.5 m/s shall not be exceeded to avoid erosion.

5.9.5 The external leak collector shall be equipped with two level sensors (redundancy), for indication of leakage in the generator. There shall be a drain (above the level sensor adjustment point) to be kept open, to prevent unsigned or high-flow leaks from causing system filling and overflowing into the generator housing.

5.9.6 The drain to which item 5.9.5 refers shall be provided with adequate means (for example, a “knee” tubing) to avoid ingress of dripping water into the generator housing during normal operation.

5.9.7 There shall be a drain to be kept closed, for exhaustion of the collector.

5.9.8 A warning plate shall be installed on the collector, in AISI 316L stainless steel, with a yellow background and black letters, informing which drain shall be kept open and which drain shall be kept closed. Entries shall start with the word 'attention' and shall use letters with a minimum of 15 mm in height.

5.9.9 The heat exchanger shall be built with features and position that facilitate access and maintenance. The heads (caps) and beam shall be removable. All tubes shall be accessible for cleaning and pipes presenting leaks shall allow plugs or seal stoppers to be blocked.

5.9.10 There shall have connections to vent and drain.

5.9.11 All threaded connections shall be supplied with metallic plugs suitable for temperature and operating pressure.

5.9.12 The screws subjected to pressure shall conform to the applicable pressure and specified operating temperature standards. Unless otherwise specified in project documentation the screws shall be manufactured in stainless steel type A193-B8M (AISI 316).

5.9.13 The connecting flanges of the external water inlet and outlet tubes shall meet the technical, dimensional, pressure class and flange requirements according to ASME B16.5.

5.10. NAMEPLATE BOARDS, IDENTIFICATION AND SAFETY WARNINGS

5.10.1 The nameplate shall be stainless steel AISI 316 containing, in addition to the information indicated by IEC 60034-1, the following data:

a) total mass;
b) mass of the rotor;
c) Mass of the heat exchanger;
d) Date of manufacture;
e) Petróleo Brasileiro S.A.- PETROBRAS;
f) Name of the PETROBRAS Business Unit (UN);
g) "TAG" of the generator;
h) Material Requisition number (RM);
i) Purchase order number (PC) or purchase order of goods and Services (PCS) in cases of purchase processes directly carried out by PETROBRAS.

5.10.2 The data, identification and warning plates of the generator, as well as its fastening screws, shall be manufactured from AISI 316 stainless steel.

5.10.3 The data plates, identification and warning of the generator shall be fixed in non-detachable locations of the frame so that, no changes can occur during maintenance work.

5.10.4 The generator shall have a specific plate, containing an arrow indicating the direction of rotation, installed on the side attached to the drive. The requirements of this plate shall meet the requirements indicated in this standard on data boards, identification and warning. They shall be accessible for reading.

5.10.5 The data boards, identification and warning of the generator shall have their data embossed in bas-relief. These plates and the system of recording or marking of the data or figures used shall withstand chemical attacks, the specified environmental characteristics and shall remain legible for the entire predicted time of life of the generator.

5.10.6 Generator terminals and neutral boxes shall have a warning plate according to the following: "PERIGO: ALTA TENSÃO. NÃO ABRA QUANDO ENERGIZADO".

5.10.7 Complementary warnings, including those required by NR-10 and NR-12, shall be in accordance with I-ET-3010.00-5140-700-P4X-009 – GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

5.11. POWER, NEUTRAL AND AUXILIARY TERMINAL BOXES

5.11.1 The generator shall be provided with independent boxes for line terminals, neutral terminals, exciter and auxiliary closures, sized for wrapping the terminations of the power cords and the control cables and signals.

5.11.2 The power terminal box shall be able to withstand the overpressure resulting from a three-phase short circuit within it, according to the value reported on the data-sheet, with duration of 0.1s. If a rupture device is used for the relief of the pressure, it shall not compromise the degree of protection (IP) of the housing and the discharge of the resulting gases shall not be directed to places where the staff is normally present.

5.11.3 Power terminal box shall have insulating barriers between phases.

5.11.4 The terminal boxes shall have sufficient space to accommodate cable termination kits, cable curves, surge capacitors, lightning arrestors, protection and measurement transformers, heating resistors and grounding equipment. With specific regard to the power terminal box, the general arrangement drawing shall indicate in detail the cable routing inside the box.

5.11.5 Terminal boxes shall be scaled so that the internal temperature is adequate to the operational limits of these components without compromising their useful life.

5.11.6 Terminal boxes shall have cable inputs by means of cable glands, in quantities and dimensions according to the data-sheet. In cases of conical threaded inputs of the NPT type, these shall conform to the ANSI/ASME B1.20.1 requirements. For power terminals, cable input holes shall be on a removable non-magnetic plate so as to allow cable disconnection without damaging the terminations.

5.11.7 Unless otherwise indicated in project documentation, the power terminal box shall be attached to the casing on the left-hand side, when facing the generator at the coupling end. The constructive, assembly and position form of the terminal boxes shall be according to IEC 60034-7 (IM code).

Note: For non-sheltered installations, exits from the boxes by the top are not accepted.

5.11.8 Power terminal boxes shall be supplied with insulators made of non-hygroscopic materials.

5.11.9 Unless otherwise defined in project documentation, terminal boxes spacing and design, shall consider the following equipment:

a) Three surge capacitors (line side);

b) Three lightning arrestors (line side);

c) Three-phases VTs with respective fuses for AVR (line side);

d) Three-phases double secondary VTs with respective fuses for protection and measurement (line side);

e) Two-phases CTs for AVR (line side);

f) Three bus-type CTs for measurement (line side) (line side);

g) Three partial discharge couplers (line side).

h) Three bus-type CTs for differential protection 87. CT's for differential (neutral side);

i) Three bus-type CT's with two secondary windings (one suitable for measurement and one for protection) (neutral side);

j) Grounding transformer and grounding resistor (neutral side);

Notes:

1) Three identical CTs for differential protection 87 shall be supplied loose, to be installed in main switchgear;

2) Burdens of CTs and VTs shall have extra capacity of 50VA to external (PMS) connection.

5.11.10 Undrilled extended tinned copper bars, with support, shall be provided on lower portion of terminal box, with a minimum vertical distance of 700 mm between bus bars and cable entry plate.

5.12. INSPECTION WINDOWS

5.12.1 Generator shall have openings with removable caps (coupled and uncoupled sides) and suitable pathways to allow inspection by borescope.

5.12.2 These openings shall give access to rotor core ends, stator end windings, and connections of phase leads to the coils.

5.12.3 Inspection access shall be provided, allowing a visual inspection of the bearings, exciter and replacement of the rotating diodes.

5.12.4 Machine design shall allow inspection of the air gap between stator and rotor. Inspection shall be possible at both ends.

6. ELECTRICAL REQUIREMENTS

6.1. ELECTRICAL CHARACTERISTICS

6.1.1 The generator shall be synchronous.

6.1.2 The generator and the excitation system shall comply with requirements of voltage regulation defined by IEC 61892, as detailed below, unless otherwise stated in PETROBRAS documentation:

- Steady-state ±2.5% (1) (2)
- Transient -15% to +20% (1) (3)
- Transient recovered voltage ±2.5% (1) (3)
- Maximum transient recovery time 1.5s (1)

Notes:

1) related to rated voltage (IEC 61892-3);
2) for all loads from zero to rated load at rated power factor (IEC 61892-3);
3) for transient load steps, see PACKAGE documentation.

6.1.3 The generator shall operate in such a way as to meet its primary function, under rated load operating condition, without reducing the life of the electrical insulation system, continuously within the voltage and frequency variation ranges for the Zone (A) indicated in IEC 60034-1. The generator shall also be able to operate satisfactorily within the limits of Zone B according to IEC 60034-1.

6.1.4 The generator shall be able to operate continuously under unbalanced system conditions, provided that:

a) The current in none of the phases exceeds the rated value;

b) The relationship between the negative sequence component and the rated current does not exceed the values determined in IEC 60034-1.

6.1.5 The generator shall be able to operate continuously in the grounding conditions of the electrical system in which it shall be installed, with the maximum zero-sequence harmonic currents.

Note: The maximum zero-sequence harmonic currents shall take into account the zero-sequence voltage generated by the generator/system and the grounding resistor capacity.

6.1.6 Unless otherwise approved by PETROBRAS, salient-pole generators shall be provided with damper windings.

6.1.7 Unless otherwise specified in the Project documentation, the generator shall be designed considering 3 phases, 60Hz and rated power factor equal to 0.8 inductive. For rated voltage, see Project documentation.

6.1.8 Generators shall have minimum efficiency at rated operating conditions (apparent power, power factor, voltage and frequency) in accordance with Table 1.

Table 1 — Minimum Efficiency of Synchronous Generators at Rated Operating Conditions

Machine Configuration	Minimum Efficiency Value %
2 poles	98,0
4 poles	97,5
6 poles / 8 poles	97,0

6.1.9 When operating under rated conditions (apparent power, power factor, voltage and frequency), generators shall comply with voltage waveform THD and individual harmonic distortion limits of IEC 61000-2-4, Class 1, as required in IEC 61892-1.

6.1.10 Synchronization criteria will be defined in PACKAGE TECHNICAL SPECIFICATION.

6.2. THERMAL CHARACTERISTICS

6.2.1 The stator, rotor and complete excitation system of the generators shall withstand the following conditions of overcurrent:

- 300% of stator rated current, with zero power factor, during 2 s;
- 150% of stator rated current, with rated power factor, for 30 s.

6.2.2 The generator shall be able to withstand negative sequence current components and current harmonics as required in IEC 60034-1.

6.2.3 The generator shall be able to withstand a harmonic content of I_{2eq}/I_N of, at least, 25% of the levels established in IEC 60034-1 for the operation of synchronous machines under unbalanced conditions.

Notes:

1) I_{2eq} and I_N are, respectively, the equivalent overall negative sequence RMS current and the rated stator current, as defined in IEC 60034-3;
2) The harmonic content of I_{2eq} shall be calculated as indicated in IEC 60034-3.

6.3. WINDINGS INSULATION SYSTEMS

6.3.1 The insulation of the stator, exciter and rotor windings shall be of class F or higher, according to the requirements of IEC 60085 and IEC 60034-18-1. However, the temperature of the hottest point of each of the generator windings shall not exceed the temperature limit of class B insulation (IEC 60034-1), considering the operation of the generator at rated voltage, current, frequency, power factor and ambient temperature conditions.

6.3.2 Alternatively, for the rotor, it is acceptable the insulation temperature class H and the temperature of the hottest point of the rotor winding shall not exceed the temperature limit of class F insulation (IEC 60034-1).

6.3.3 The temperature rise shall be considered related to the inlet water temperature and the rules of IEC 60034-1 are applicable.

6.3.4 Stator winding shall be impregnated either by VPI (Vacuum Pressure Impregnation) or Resin Rich.

6.3.5 All stator coils of generators rated 3 kV or above shall have anti-corona protection, achieved by using a semi-conductive tape, in the slot part of the coil. For generators rated 4 kV or above, the stator coils shall also be provided with field stress grading tape in addition to anti-corona protection.

6.3.6 For generators rated 4 kV or above, the stator winding, including the lead connections, shall be designed and manufactured to withstand a spray test for sealed winding conformance, in accordance with the procedures established in NEMA MG 1.

6.4. EXCITATION SYSTEMS

6.4.1 The excitation system shall comply with requirements of I-ET-3010.00-5140-775-P4X-001 - REQUIREMENTS FOR ELECTRICAL GENERATION EXCITATION SYSTEM FOR OFFSHORE UNITS.

6.5. PROTECTION

6.5.1 For protection and control panel and for driver protection requirements, see PACKAGE TECHNICAL SPECIFICATION.

6.5.2 Unless otherwise specified in project documentation, the generator and auxiliary components shall be supplied with necessary sensors and devices to comply with at least the protective functions defined in I-ET-3010.00-5143-700-P4X-001 – ELECTRICAL SYSTEM PROTECTION CRITERIA.

7. AUXILIARY AND CONTROL EQUIPMENT

7.1. GENERAL

7.1.1 Auxiliary equipment design criteria are defined in the following documentation:

- I-ET-3010.00-5140-700-P4X-003 – ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS;

- I-ET-3010.00-5140-700-P4X-002 – SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS;

- I-ET-3010.00-5140-700-P4X-009 – GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS;

- PACKAGE TECHNICAL SPECIFICATION.

7.2. PROTECTION, CONTROL AND MONITORING PANEL

7.2.1 Protection, control and monitoring panel requirements are defined in PACKAGE TECHNICAL SPECIFICATION.

7.3. SYNCHRONIZING SYSTEM

7.3.1 See PACKAGE TECHNICAL SPECIFICATION.

7.4. INSTRUMENT TRANSFORMERS

7.4.1 Generators shall be supplied with voltage transformers (VT) and current transformers (CT) for protection and measurement, as specified in the data-sheet.

7.4.2 Instrument transformers shall comply with I-ET-3010.00-5140-700-P4X-007 – SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS.

7.5. ANTI-CONDENSING HEATING RESISTORS

7.5.1 The generators and terminal boxes shall have heating resistors operating so that the internal temperature is above the condensation temperature and, at least 30°C below the insulation system temperature class, when the generator is off.

7.5.2 Unless otherwise specified in project documentation, the power supply voltage of the heating resistors shall be 220 Vac isolated (IT system).

7.6. MONITORING AND MEASURING INSTRUMENTS AND SENSORS

7.6.1 The instruments and sensors for monitoring and measuring the generator and auxiliary systems shall meet the requirements of the API STD. 670.

7.6.2 Unless otherwise specified in project documentation, the connections of the instruments, sensors, vents and drains shall use conical NPT type threads, with a diameter of 3/4 of an inch.

7.6.3 The sensor circuits' cables shall be shielded to avoid the effects of electromagnetic interference.

7.6.4 The sensor circuits' cables shall be installed allowing replacement without the need of opening the generator housing (except the circuits of the winding temperature sensors).

7.6.5 The temperature sensors shall be of type RTD Pt-100 (Platinum 100 ohms @ 0 °C) 3 wires and shall meet the requirements of IEC 60751.

7.6.6 The stator winding temperature shall be monitored using nine (three per phase) embedded three-wire Pt-100 detectors. All these RTDs shall be directly connected to the generator protection relay provided by PACKAGER and installed in TGCP.

7.6.7 Each bearing shall be monitored using two three-wire RTDs (double-bearing sensor is acceptable). The position of RTDs shall be in accordance with IEC 60034-1.

7.6.8 All the RTDs required in item 7.6.7 shall be directly connected to the temperature controllers provided by PACKAGER and installed in TGCP.

7.6.9 If required on project documentation, bearing thermometers for temperature indication shall be supplied.

7.6.10 The reading instruments provided shall have their scale in unity of the international system of units.

7.6.11 Unless otherwise specified in project documentation, the air/water exchanger shall be supplied with 4 RTD-type sensors for remote indication of the temperature of inlet and outlet of water or air and cooling air (one RTD per each point).

7.6.12 If required in project documentation, the air/water heat exchanger shall be supplied with a pressure transmitter, standard 4 to 20 mA, in order to monitor the pressure difference between the inlet and the water outlet of the heat exchanger.

7.6.13 Generators with hydrodynamic bearings shall have two radial vibration sensors per bearing ("proximitors").

7.7. PARTIAL DISCHARGE MONITORING

7.7.1 Generators with rated voltage equal to or greater than 6 kV and rated power equal to or greater than 5 MVA shall be fitted with continuous online partial discharge monitoring system using a set of 80 pF coupling capacitors.

7.7.2 Generator manufacturer shall provide the coupling capacitors, the coupling capacitors terminal box, the continuous monitoring system measuring device and the continuous monitoring system measuring device terminal box.

7.7.3 The coupling capacitors shall be installed inside the power terminal box of the generator complying with IEC TS 60034-27-2 recommendations.

7.7.4 Terminal boxes of the coupling capacitors and of the continuous monitoring system measuring device shall be installed on the generators enclosure.

7.7.5 The maximum length of the coaxial cable between the coupling capacitors and the continuous monitoring system measuring device terminal box shall be according to the requirements of the continuous online PD monitoring system's manufacturer.

7.7.6 The continuous monitoring system shall be able to automatically separate stator winding PD from noise and disturbances using methods indicated in IEC TS 60034-27-2.

7.7.7 The continuous monitoring system shall be able to generate trending of the Qm measurements for each phase of the generator.

Note: Qm is the Largest Repeatedly Occurring PD Magnitude (as defined by IEC TS 60034-27-2), recorded by the measuring system which has the pulse train response in accordance with IEC 60270 and considering 10 pulses per second.

7.7.8 The continuous monitoring system shall include a dedicated connection to the multipurpose ethernet network for interfacing with the Electrical System Automation (ESA).

7.8. TERMINALS AND CONNECTORS FOR POWER, CONTROL AND GROUNDING CABLES

7.8.1 The generator shall be supplied with two grounding terminal(s) placed on the outer side of the housing at opposite sides and indelibly marked with grounding symbol. Terminals shall be proper for copper cables with the cross section defined in data-sheet.

7.8.2 The generator shall have an additional grounding terminal inside each of the power and neutral terminal boxes.

7.8.3 The generator shall be supplied with power terminals, in quantity and dimensions according to project documentation.

7.8.4 All connectors shall be supplied and secured (so that they are not lost in transport) inside the power and neutral terminal boxes.

7.8.5 Cable construction and colour shall follow the requirements established in I-ET-3010.00-5140-700-P4X-002 – SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS.

7.8.6 Cable sizing and tagging shall follow the requirements of I-ET-3010.00-5140-700-P4X-001 – SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS.

7.9. GROUNDING RESISTORS AND TRANSFORMERS

7.9.1 Each main generator neutral point shall be grounded by high resistance with transformer. Grounding transformer, grounding resistance and respective sensors and relays shall be located inside generator neutral terminal box.

7.9.2 Grounding transformers and resistors shall comply with the requirements of I-ET-3010.00-5140-713-P4X-001 – SPECIFICATION FOR TRANSFORMERS FOR OFFSHORE UNITS and I-ET-3010.00-5140-700-P4X-007 – SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS, respectively.

7.9.3 Unless otherwise defined in project documentation, grounding transformer and grounding resistor rated values shall be defined in respective data-sheets.

8. INSPECTIONS AND TESTS

8.1. GENERAL

8.1.1 MANUFACTURER shall submit for PETROBRAS approval the inspection and testing plan (ITP), meeting the requirements indicated in this specification and in datasheet. ITP shall list:

a) Routine, type and special tests that will be carried out during manufacturing process (TDMP);

b) Routine, type and special tests to be carried out in factory (FAT);

c) If required, the complete driver-generator set tests (TCDG or String Tests), to be carried out at location defined by PACKAGER;

d) Site acceptance tests (SAT).

Note: ITP shall indicate the applicable standards and the acceptance criteria for each measurement and test to be carried out.

8.1.2 Manufacturer shall permit PETROBRAS to witness the tests.

8.1.3 Certificate reports approved by CS shall be accepted by PETROBRAS for type tests of identical equipment.

8.1.4 The certificates presented shall be with valid dates.

8.1.5 Unless otherwise defined in project documentation or in other PACKAGE documents, the tolerances defined by standards shall be applicable.

8.2. MINIMUM TEST LIST

8.2.1 Unless otherwise specified in project documentation, the tests listed in Table 2, Table 3 and Table 4 shall as a minimum be carried out. Tests required by CS, if not listed, are mandatory and shall be included.

Table 2 — Testing During Manufacturing Process (TDMP)

(TDMP) Test List description	RT	TT	ST	Procedure and acceptance criteria
Verification of the technical documentation	X			Project documents
Visual Inspection	X			Project documents
Verification of the calibration certificates of the instruments used in the tests	X			ITP
Rotor balancing (1)	X			[1] or ISO 7919-3 or ISO 10816-3
Stator insulation power factor test (power factor tip-up)	X			IEC 60034-27-3 or IEEE 286
Lightning impulse voltage withstand test of the main insulation (2) (8)	X			IEC 60034-15
Impulse voltage withstand test of the interturn insulation (2) (8)	X			IEC 60034-15
Hydrostatic heat exchanger test	X			ASME BPVC VIII-1
Field windings polarity test	X			IEEE 115

(TDMP) Test List description	RT	TT	ST	Procedure and acceptance criteria
Short-circuit check on the field winding coils	X			IEEE 115
Conformity test of sealed winding (spray-test) (3)			X	NEMA MG 1
Visual corona test (black-out test) (3)			X	IEEE 1799
Hot spot detection test on stator magnetic package (stator core-test")	X			API-546
Measurement of stator end-winding structural dynamics at standstill (4)	X			IEC 60034-32
Turn insulation test (between turns of coils) (7)		X		IEEE 522
Partial discharge on sample coils (2)			X	IEC 60034-27-1, and limits by note 5
Partial discharge on complete stator	X			IEC 60034-27-1, and limits by note 6

Notes: 1) Complete set, including fan, exciter, PMG, etc.

2) Applicable to generators with rated voltage greater than or equal to 6 kV. Consider two additional coils (sample coils) identical to those manufactured for the generator, selected randomly and tested outside the stator. If at least one reel fails, the total set of coils shall be rejected and the manufacturing process shall be evaluated.

3) Applicable to generators with rated voltage equal to or greater than 4kV.

4) Applicable to generators with rated power equal to or greater than 25 MVA.

5) The Largest Repeatedly Occurring PD Magnitude (Qm as defined by IEC 60034-27-1), recorded by a measuring system which has the pulse train response in accordance with IEC 60270 and considering 10 pulses per second, shall be less than or equal to 8 ηC (or 80 mV) for phase-to-ground rated voltage.

6) The Largest Repeatedly Occurring PD Magnitude (Qm as defined by IEC 60034-27-1), recorded by a measuring system which has the pulse train response in accordance with IEC 60270 and considering 10 pulses per second, shall be less than or equal to 25 ηC for phase-to-ground rated voltage and less than or equal to 50 ηC for phase-to-phase rated voltage. During the test the PDIV and PDEV voltage levels shall be recorded according to IEC 60034-27-1.

7) Coils shall be tested at the following stages of machine manufacture:

a) After coil installation, wedging and bracing, but before any connections have been made (applicable to all coils of each winding);

b) After the stator has been completely impregnated and all connections have been made and insulated (applicable to each phase of the machine).

8) At the completion of the tests, one of the sample coils of the batch of identical coils shall be cut for inspection into at least three segments at the following locations:

- Slot portion;
- End-winding portion at the interface between anti-corona and stress grading protections;
- End-winding portion containing only the stress grading protection.

Table 3 — Factory Acceptance Tests (FAT)

(FAT) Test List description	RT	TT	ST	Procedure and acceptance criteria
Checking the ITP technical documentation	X			Project documents
Verification of reports and certificates of conformity for Ex generators and accessories	X			IEC 60079 and applicable legislation
Verification of the certificates of conformity of the sensors and instruments installed in the generator and calibration instruments used in the tests	X			ITP and Project documents
Visual, dimensional inspection and verification of identification, data and safety plates	X			Project documents
Accessories check (e.g. heating resistance, CTs, PTs, RTDs, water leakage sensors, vibration sensors)	X			Project documents
Measurement of winding's resistance (cold condition)	X			IEC 60034-1
Checking the location of the magnetic center	X			API 546
Measurements of the main machine and exciter air gaps	X			API 546, data-sheet and this specification
Checking and marking the direction of rotation	X			Driver documents and data-sheet
Verification of phase sequence and terminal markings	X			IEC 60034-1 and IEC 60034-3
Unbalanced phase check	X			≤ 1,0%
Measurement and analysis of voltage waveform total (THD) and individual harmonic distortions	X			IEC 60034-1, IEC-61000-2-4 and IEC 61892-1
Test and determination of the sustained short-circuit curve	X			IEC 60034-4-1 and CS
Test and determination of the no-load saturation curve	X			IEC 60034-4-1
Tests for the construction of no-load V curve			X	API 546
Efficiency measurement	X			IEC 60034-2-1
Winding temperature rise		X		IEC 60034-1 and IEC 60034-29

(FAT) Test List description	RT	TT	ST	Procedure and acceptance criteria
Cooling system check (leakage, flow, pressure and coolant speed).	X			This specification
Bearing temperature rise	X			IEC 60034-1
Vibration tests (run out, shaft vibration, bearing housing vibration and operation of the lubrication system)	X			This specification
Bearing housing natural frequency test		X		API 546
Overspeed test	X			IEC 60034-1
Voltage and current on shaft	X			IEEE 115
Measurement of audible noise level	X			This specification
Voltage withstand test	X			IEC 60034-1
Measurement of insulation resistance	X			IEEE 43
Measurement of polarization index	X			IEEE 43
Measurement of shaft current and bearing insulation	X			IEEE 115
Occasional excess current test		X		IEC 60034-1
Dielectric dissipation factor measurement on stator winding insulation (European approach) or Power factor tip-up test (American approach)	X			IEC 60034-27-3 or IEEE 286
Sudden three-phase short circuit (parameter calculation) (4)		X		IEC 60034-4-1
Verification of the protection degree (IP)		X		IEC 60034-5
Bearings inspection	X			API 546
Check of lubrication oil ingress inside the generator	X			Visual inspection
Painting verification (colour, grip and thickness)	X			[7]
Unbalanced response test			X	API 546
Short-circuit withstand test (2)			X	IEC 60034-1
Functional and performance test of excitation system at no load, including AVR (and Field Forcing signal, when required)		X		This specification
Partial discharge measurement (1)	X			IEC TS 60034-27-2, and limits by note 3

Notes 1) Applicable for generators with rated voltage equal to or greater than 6kV and rated power equal to or greater than 5MVA. The coupling capacitors installed in the machine shall be used during the tests. The measurement equipment bandwidth shall be suitable to the 80 pF coupling capacitors.

2) By agreement with the MANUFACTURER.

3) The Largest Repeatedly Occurring PD Magnitude (Qm as defined by IEC TS 60034-27-2), recorded by a measuring system which has the pulse train response in accordance with IEC 60270 and considering 10 pulses per second, shall be less than or equal to 330mV.

4) The quantities corresponding to the saturated state of the machine shall be obtained from a test performed at rated armature voltage.

If, due to limitation of testing facilities, it is not possible to attain rated armature voltage, sudden-short circuit tests shall be performed, at least, at three different voltage levels, and the quantities determined for each test. The values thus obtained are then represented against their corresponding open-circuit voltage before short-circuiting, and the approximate rated armature voltage quantity is found by extrapolation.

Table 4 — String tests (TCDG)

Test List description	Test procedure and acceptance criteria
Checking the ITP technical documentation	Project documents
Verification of the calibration certificates of the instruments used in the tests	ITP
Visual inspection and verification of assembly and identification, data and safety plates	Project documents
Vibration tests (run out, vibration on the shaft, vibration on bearings and operation of the lubrication system)	Project documents
Continuous operation tests (including full load temperature rise)	ITP
Measurement of insulation resistance and polarization index	IEEE 43
Heat exchanger leakage verification	ITP
Measurement of excitation current at rated load	IEC 60034-4-1 and this specification
Measurement of voltage and frequency regulation at transient and continuous load conditions (including "Field Forcing" when required)	IEC 61892-3 (voltage) PACKAGE documents (frequency) and CS
Functional test of alarms, measuring devices, control, signalling, keys and relays for the control panels.	Project documents
Generator harmonic signature test	IEC 61000-4-7 and IEC 61800-3
Check of lubrication oil ingress inside the generator (2)	Visual inspection
Checking the protection functions	Project documents

Notes 1) Complete requirements for TCDG are defined in PACKAGE TECHNICAL SPECIFICATION.

2) Including check of proper installation of siphon in lube oil piping before generator bearing inlet points.

9. SPARE PARTS AND TOOLS

9.1. SPARE PARTS

9.1.1 PACKAGER shall include in the scope of supply all spare parts required for start-up and commissioning.

9.1.2 PACKAGER shall supply spare parts required by CS, if any.

9.2. UNUSUAL TOOLS

9.2.1 PACKAGER shall supply all unusual tools required for installing, commissioning, operation and maintenance of the equipment specified.

10. TECHNICAL DOCUMENTS

10.1. GENERAL REQUIREMENTS

10.1.1 Data filled in data-sheet issued by PETROBRAS are mandatory. In case of divergence between the data-sheet issued by PETROBRAS and this specification, data-sheet data prevails.

10.1.2 If there is no generator data-sheet issued by PETROBRAS, the template of I-LI-3010.00-5140-700-P4X-001 – ELECTRICAL EQUIPMENT DATA-SHEET MODELS shall be used.

10.1.3 MANUFACTURER shall list, in the data-sheet, the technical standards applied to the manufacturing and testing of the generator, which complement the ones presented in section 3.

10.1.4 The data-sheet fields, filled by the MANUFACTURER for BID may consider tolerances according to project requirements. As built data-sheet shall be filled in with final measured and tested data.

10.1.5 MANUFACTURER shall provide all certification required by CS.

10.1.6 The Brazilian Portuguese versions of the documents requested by this specification shall be issued only if so indicated in I-ET-3010.00-5140-700-P4X-001 – SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS.

10.2. DOCUMENTS TO PROPOSAL

At least the following technical documents and information shall be included to the proposal:

a) Documents List;

b) List of standards applicable to the design, fabrication and tests;

c) Country of origin of the equipment;

d) Data-sheets of generator and accessories completely filled out with technical data and all tests to be applied;

e) Generator characteristic curves;

f) Drawing indicating the main dimensions, the weight of the generator and all its subsystems (panels, heat exchangers, filter, excitation system, lubrication, etc.);

g) Drawing with main information on the generator's heat exchanger;

h) Information about air-water coolers, including water flow data (minimum, maximum, operational), water speed (minimum, maximum, operational).

i) Specification or description of generator protections;

j) Specification or description of generator lubrication system;

k) Specification of excitation system, with modules architecture, protection, communication and performance data;

l) Simplified transfer functions for excitation and governing systems, including the settings of parameters and gains associated to voltage and speed controllers;

m) Specification of painting system for generator and all accessories;

n) Technical catalogues of all generator components containing all information and technical characteristics;

o) List of sensors and instruments, with respective data;

p) List of unusual tools required for maintenance of the generator;

q) List of recommended spare parts for two (2) years operation with separate prices for each item;

r) List of spare parts for commissioning and tests;

s) List of similar previous supplies consistent with the specification requirements defined by PETROBRAS;

t) List of deviations from project documentation;

u) Utility consumption list;

v) Description service capabilities, price schedule and service support during testing, installation, commissioning, and maintenance.

10.3. DOCUMENTS TO BE SUBMITTED FOR APPROVAL

At least the following documents and information shall be submitted to PETROBRAS approval, besides updated revisions of documents listed in item 10.2:

a) Documents list;

b) Dimensional drawings of all (generator, terminal boxes, auxiliary boxes, heat exchanger, exciter, panels, lubrications auxiliaries, etc.) and each component, with at least:

- all dimensions;
- static and dynamic weights;
- centre of gravity;
- minimum free space for maintenance, assembly and disassembly;
- lifting devices;
- electrical power, control and instruments inlets, outlets and connections positions and data;
- utilities connections positions and data;
- internal components layout, dimensions and details;
- instruments positions and connections;
- fixing and coupling devices details;
- rotating direction.

c) One-line, multi-line diagrams, functional and block diagrams for generator, excitation system, panels and auxiliary components;

d) Complete transfer functions for excitation and governing systems, including the settings of parameters and gains associated to voltage and speed controllers;

e) Protection adjustment parameters data (including detailed calculation reports);

f) Power, control and instruments wiring and interconnection diagrams;

g) Generator characteristic curves;

- Capability curves for at least 80% of rated temperature in cooling water, rated temperature in cooling water and 120% of rated temperature in cooling water;
- Capability curves for at least 95% of rated voltage, rated voltage and 105% of rated voltage;
- Stator thermal limits (stator current x time);
- Rotor thermal limits (field current x time);
- Magnetic package damage curve due to ground fault (current through stator core lamination x time);

  Note: The region of the chart where the fault durations lie below 1s shall be enlarged until an interval of less than 50 ms is achieved for the time scale. The resulting view shall be presented in a separate drawing.
- Efficiency curves (efficiency x power) for at least power factors of 0.8, 0.85, 0.9 and 1.0;
- Short-circuit characteristic curve (Stator current x Field current);
- Saturation curve (stator voltage x field current);
- No load characteristic curve;
- Exciter saturation curve (main rotor voltage x field current);
- Efficiency curve (efficiency x load), for at least 0.8, 0.85, 0.9 and 1.0 power factor;
- Efficiency curve (efficiency x cooling water temperature);
- Negative sequence curve (I_2 x time);
- Overflux limit curve (V/Hz x time);
- V-curves at no-load and at 25%, 50%, 75% and 100% of machine rated load, as a minimum;
- Stator current decrement curves – field response (stator current x field current), including symmetrical three-phase short-circuit, DC component of three-phase short-circuit and field current;
- Stator current decrement curves – field response (stator current x field current), including symmetrical three-phase short-circuit, DC component of three-phase short-circuit and constant field current;
- Stator current decrement curves – field response (stator current x field current), including symmetrical line-line short-circuit, DC component of line-line short-circuit and field current;
- Stator current decrement curves – field response (stator current x field current), including symmetrical line-line short-circuit, DC component of line-line short-circuit and constant field current;
- Stator current decrement curves – field response (stator current x field current), including symmetrical line-ground short-circuit, DC component of line-ground short-circuit and field current;
- Stator current decrement curves – field response (stator current x field current), including symmetrical line-ground short-circuit, DC component of line-ground short-circuit and constant field current;
- Voltage and frequency variations as a function of time for sudden application of 30 %, 50 %, 80 % and 100 % of the generator's rated load;
- Voltage and frequency variation limits curve, showing allowable zones;

- Output power curve (output power x cooling water temperature), for at least temperature rise class B and temperature rise class F.

h) Detailed information about air-water coolers, including calculation report and water flow data (minimum, maximum, operational), water speed (minimum, maximum, operational).

i) Base forces and stress data;

j) Operation manuals, including controls procedures;

k) Troubleshooting manuals;

l) Repair and maintenance (predictive, preventive and corrective) procedure manuals;

m) Assembly and disassembly procedure manuals;

n) Attachment and coupling procedure manuals;

o) Lifting procedure manuals;

p) Packing, storage and transportation procedures manuals;

q) List of all equipment, components, materials, parts, pieces, accessories and devices, with identification of manufacturer, part number and model;

r) Generator data-sheet, duly completed;

s) Complete stator winding data form, containing at least:

- number of coils and winding connection scheme;
- number of parallel circuits;
- number of turns per coil and strands per turn;
- thickness of main and strand insulations;
- stranded conductors sizes;
- length of iron including vents;
- finished coil dimensions in slot, with details of anti-corona and stress grading protections at the coil end turns.

Note: The form shown in Annex J of API 546 shall be preferably used to present the data required above.

t) Generator's mathematical models, including all parameters;

u) Electrical auxiliary equipment and components data-sheet filled out, according to templates of I-LI-3010.00-5140-700-P4X-001 – ELECTRICAL EQUIPMENT DATA-SHEET MODELS;

v) Lubrication oil system diagrams and details;

w) Inspection and testing plan (ITP);

x) Test procedures (including all the tests indicated in Table 2, Table 3 and Table 4);

y) Current transformer saturation curves;

z) Grounding transformer saturation curves;

aa) Test reports;

bb) Certificates of equipment for hazardous areas;

cc) Detailed description of the equipment, including all accessories;

dd) List of risks to personnel and environment related to the equipment, including pollutant emissions at rated capacity;

ee) List of risks related to changing or override of protections and safety devices;

ff) List of risks related to use of equipment out of design conditions;

gg) Procedures during emergency conditions;

hh) List of safety equipment and components, including expected lifetime for each item.

11. DESIGN REVIEW

11.1. GENERAL

11.1.1 For those generators indicated in the ELECTRICAL SYSTEM DESCRIPTIVE MEMORANDUM, manufacturers shall provide detailed technical information about the equipment in specific design review meetings with PETROBRAS.

11.1.2 Design Review meetings shall be held by the generator manufacturer at the time documents and data are available for approval by purchaser. The meetings shall include PETROBRAS, electric machine manufacturer, turbine manufacturer, packager, seller and other sub-suppliers as required.

11.2. DETAILED DESCRIPTION

11.2.1 The main objective of these specific design review meetings is to solve technical issues, avoiding future failures or problems in the equipment or during integration with other equipment.

11.2.2 Design review meetings shall occur before fabrication, during fabrication, before factory acceptance test, before site acceptance test or at any additional moment required by PETROBRAS.

11.2.3 The items to be covered by the Design Review meetings shall include at least:

a) Contract data and datasheet information;

b) Generator characteristic curves as described in paragraph “g)” of item 10.3;

c) Generator time constants and reactances;

d) Method of efficiency determination and guarantee of efficiency;

e) Inertia of the machine and coupled equipment;

f) Ex certification, where applicable;

g) Stator winding, including its insulation system;

h) Rotor winding, including its insulation system, mechanical design, fits, construction, balance;

i) Shaft design stress, short circuit torques;

j) Torsional and lateral critical speed analysis, and rotor sensitivity analysis (response to an intentional unbalance);

k) Foundation and base stiffness;

l) Coupling type and coordination;

m) Bearing and seal details;

n) Bearing and coupling insulation;

o) Lubricating oil type and oil inlet temperature range;

p) Minimum test list;

q) “Witness” and “review” points for inspections and tests;

r) Data for performance of electrical power system studies;

s) Complete transfer functions for excitation and governing systems, including the settings of parameters and gains associated to voltage and speed controllers;

t) Excitation system design and interconnection with other equipment;

u) Review of generator drawings, and, where applicable, P&IDs and auxiliary subsystem drawings (including those for heat exchangers);

v) Installation and commissioning procedures;

w) Packaging, shipping, and long-term storage.