### TECHNICAL SPECIFICATION

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1. OBJECTIVE

This Specification establishes the minimum requirements for design, manufacture and supply of the Emergency Generator Package for PETROBRAS Offshore Units.

2. DEFINITIONS

2.1. “Unit” is defined as the FPSO (Floating Production Storage and Offloading), FSO (Floating Storage and Offloading), SS (Semi-Submersible) or Fixed Offshore Unit.

2.2. “Package Unit” or “Package” is defined as an assembly of equipment supplied interconnected, tested and operating, requiring only the available utilities from the Unit for the Package operation.

2.3. “Packager” is defined as the responsible for project, assembly, construction, fabrication, test and furnishing of the Package.

2.4. “Manufacturer” is defined as the responsible by fabrication of equipment or components internal to the Package.

2.5. “Module” is defined as the metallic structure suitable for lift and transport, where Packages and equipment will be installed, being supplied completely mounted and pre-commissioned.

2.6. “Module Supplier” is defined as the responsible for project, assembly, erection, construction, fabrication, test and furnishing of the Module.

2.7. “Hull Contractor” is defined as the responsible for all equipment, project, assembly, construction, fabrication, test, furnishing, installations and services related to Unit Hull.

2.8. “Bidder” is defined as the responsible for the lift, hook up, installation and integration of all Modules on the Unit Hull.

3. REFERENCE STANDARDS AND DOCUMENTS

3.1. STANDARDS AND RULES

3.1.1 The Emergency Generator Package and its installations shall comply with all rules and regulations stated by Brazilian Authorities, Classification Society and International Standards, all in their last revisions. Following these mandatory requirements, the Emergency Generator Package shall comply with requirements of documents listed in 3.2 (second priority in case of conflict).

3.1.2 At the design development and for equipment specification International Standards (IEC) shall be used. When required and exceptionally, when it is clearly justified, ANSI, NEMA, IEEE and others foreign recognized standards may be used. Their use shall be restricted to specific cases and shall be previously approved by PETROBRAS.

3.1.3 IEC – INTERNATIONAL ELECTROTECHNICAL COMMISSION

IEC 60034 Rotating Electrical Machine - All parts;
IEC 60092-301 Electrical Installations in Ships – Part: 301 - Equipment - Generators and Motors (where applicable);
IEC 60092-502 Electrical Installations in Ships - Part: 502 - Tankers - Special Features (where applicable);
### 3.1.4 IEEE – INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERING

- IEEE 43: Recommended Practice for Testing Insulation Resistance of Rotating Machinery;
- IEEE 115: Guide for Test Procedures for Synchronous Machines – Part I / Part II;

### 3.1.5 IMO - INTERNATIONAL MARITIME ORGANIZATION

- IMO EA811E: Code for the Construction and Equipment of Mobile Offshore Drilling Units (MODU CODE);
- IMO IB664E: Marpol Annex VI - Regulation for the Prevention of Air Pollution from Ships and NOx Technical Code.

### 3.1.6 ISO - INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

- ISO 3046: Reciprocating Internal Combustion Engines

### 3.1.7 ASME

- ASME B16.5: Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard;
- ASME B31.3: Process Piping;
- ASME PTC17: Reciprocating Internal – Combustion Engines
3.1.8 **BRAZILIAN LABOUR AND EMPLOYMENT MINISTRY**

NR-10  Segurança em Instalações e Serviços em Eletricidade;
NR-12  Máquinas e Equipamentos;
NR-13  Caldeiras e Vasos de Pressão (where applicable);
NR-17  Ergonomia;
NR-26  Sinalização de Segurança;
NR-30  Segurança e Saúde no Trabalho Aquaviário.

3.1.9 **API – AMERICAN PETROLEUM INSTITUTE**

API 7B-11C  Specification for Internal-Combustion Reciprocating Engines for Oil-Field Service;
API 546  Brushless Synchronous Machines - 500 kVA and Larger.

3.1.10 **NFPA**


3.1.11 **AWS**

AWS D1.1  Structural Welding Code - Steel;

3.1.12 **CLASSIFICATION SOCIETY**

CS  Rules and Regulations of the Classification Society, hereafter stated as CS.

3.2. **REFERENCE DOCUMENTS**

[1] PROJECT ONE-LINE DIAGRAM
[2] I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM
[3] I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE
[4] I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS
[5] I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS
[6] I-ET-3010.00-5140-700-P4X-003 - ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS
[7] I-ET-3010.00-5140-700-P4X-005 - REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR OFFSHORE UNITS
[8] I-ET-3010.00-1200-956-P4X-002 - GENERAL PAINTING
4. GENERAL CONDITIONS

4.1. GENERAL

4.1.1 The supplier of the generator group (hereafter stated as PACKAGER) shall fill in the Data Sheet, for proposal, the hatched items and the items corresponding to the list of standards applicable to design, manufacture and testing of equipment and accessories. The other items shall be filled in after eventual purchase order.

4.1.2 All the requirements for the Emergency Generator Package shall be according to items below.

4.1.3 Emergency Generator Package shall be sized to feed the essential and emergency consumers defined by DR-ENGP-M-I-1.3 - SAFETY ENGINEERING (HOLD) when the platform is in emergency (ESD) condition.

4.1.4 All equipment, materials, accessories and installations within the Emergency Generator Package shall be certified by CS.

4.1.5 Electrical equipment installed in external safe areas, that shall be kept operating during emergency shutdown ESD-3P or ESD-3T shall be certified with the type of protection and EPL suitable for installation in hazardous areas Zone 1 Group IIA temperature T3, according to IEC 61892-7.

4.1.6 Electrical equipment internal to Package shall be sized according to requirements of I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS.

4.1.7 Electrical installations inside the Package shall comply with requirements of I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS.

4.2. ENVIRONMENTAL CONDITIONS

4.2.1 It shall be considered design ambient temperature 45°C. All components of the Generator Package shall be suitable to be installed in a marine environment.
4.3. INCLINATION REQUIREMENTS

4.3.1 The entire generator group, including accessories, shall be suitable to operate under inclination variations (static and dynamic) specified by IMO EA811E (MODU CODE) and CS.

4.4. VIBRATIONS AND ACCELERATIONS

4.4.1 Machine and its auxiliaries shall be constructed to withstand, without malfunctioning, or electrical connections loosening, complying with the requirements of CS rules and IEC 61892-1.

5. GENERATOR GROUP

5.1. GENERAL

5.1.1 The PACKAGER shall pay special attention to the lay-out of the equipment, accessories and piping around the skid, taking into account the space required for operation, maintenance and considering that the spaces and weights shall be the least possible.

5.1.2 The Generator Group shall be capable to operate depending only on its fuel system and its start-up system. No other external equipment or system shall be necessary for proper operation of the Generator Group.

5.2. SCOPE OF SUPPLY

5.2.1 At least the following systems and items shall be provided by PACKAGER:

a) Complete engine with all necessary auxiliary equipment and devices;
b) Complete AC generator with excitation system and all necessary auxiliary equipment and devices;
c) Complete skid assembly with resilient mounting for engine, generator and auxiliaries installed on a common bed plate;
d) Flexible coupling between engine and generator;
e) Vibration isolation with elastic suspension;
f) Engine local panel for control, protection and metering;
g) Software license, for controllers and electronic devices;
h) Generator local power and control panel for control, protection, metering, synchronization, power distribution and auxiliary equipment control (EGCP);
i) Engine speed governor;
j) Generator Automatic Voltage Regulator (AVR);
k) Exhaust system with silencer, expansion joints, transition piece and spark arrester, built of AISI 316L;
l) Complete dual engine starting system;
m) Complete combustion air system, including air intake filter and accessories;
n) Complete air cooling system for engine, including skid mounted radiator and shaft mounted fan;
o) All piping, fuel oil system, combustion air and exhaust gas with the diesel up to the edge of the skid;
p) Complete lubrication system, including main lubrication pump, pre-lubrication pump, pre-lubrication hand pump and fine filter;
q) Turning device and guard;
r) Engine pre-heating system by resistors;
s) Erosion/corrosion protection;
t) Unusual tools for assembly, disassembly, installation, commissioning, operation and maintenance;
u) Battery chargers and associated battery banks;
v) Spare parts for start-up, commissioning and others as recommended by CS;
w) Calculation Reports;
x) Factory and Onboard Acceptance Tests;
y) Data book with material and tests certificates;
z) Training;
aa) Supervision for start-up and commissioning.

5.2.2 The following systems and items shall be supplied by HULL CONTRACTOR:
a) Emergency start-up compressor, start-up air vessel and air piping;
b) Complete fuel (diesel oil) system, including fuel daily tank, compensation tank whenever necessary, diesel shut-off valve, pumps and filters;
c) All necessary interconnecting pipes and valves;
d) Exhaust duct built of AISI 316L stainless steel;
e) Protection against penetration of water in the exhaust duct, with valve and drain trap to prevent condensation from returning to the engine;
f) Exhaust duct isolation according to item 6.2.2;
g) Generator Room ventilation dampers.

5.3. PAINTING
5.3.1 Painting shall be proper for offshore installations, and shall comply with the requirements of I-ET-3010.00-1200-956-P4X-002 - GENERAL PAINTING. The last coat colour shall be Light Green Munsell 5G8/4.

5.4. NOISE CONTROL REQUIREMENTS
5.4.1 Noise control analysis is a mandatory item to be carried out.
5.4.2 The maximum noise pressure level inside diesel engine rooms is 105dB(A). If more than one diesel engine is installed inside this room, the maximum level acceptable is 108dB(A).
5.4.3 The noise limits shall not be exceeded by more than 2dB(A) in any situation.

5.4.4 All limits refer to broad band noise without any distinct tonal characteristics. In case of tonal characteristics, the noise level limit shall be set 5dB lower.

5.4.5 The Generator Group (engine and generator) shall be installed with resilient mounts, helical springs with the minimum vibration isolation efficiency of 95%. Exhaust duct shall be installed with flexible joints as well as flexible hangers and stabilizers. Engine shall be installed with high performance, reactive, all metallic, double walled silencer for exhaust duct and protected with an acoustic hood, if necessary.

5.4.6 HULL CONTRACTOR shall analyse the PACKAGER acoustic data, verifying if all aspects of noise control, such as silencers, hoods, pipeline wraping and silencers, were incorporated in the Package design and proposal.

5.4.7 Maximum noise level of diesel engines shall comply with table below.

Table 1 - Noise Control for Equipment

<table>
<thead>
<tr>
<th>NOISE CONTROL SYSTEM TO BE USED (1)</th>
<th>MAXIMUM NOISE LEVEL dB(A) @ 1.0m (2)</th>
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<tr>
<td>EXHAUST SILENCER</td>
<td>ENGINE CASING 105</td>
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<tr>
<td>VIBRATION ISOLATION</td>
<td>ENGINE EXHAUST 90</td>
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<td>RADIATOR 83</td>
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Notes: 1 - Proposed noise control method; 2 - Maximum noise level acceptable with the proposed noise control method.

5.4.8 Discharge of diesel generators engine driven sets should be oriented as far as possible from living quarters or from embarkation station.

5.4.9 In case noise limits are higher than allowable, the equipment must be furnished with some noise control reduction measure. PACKAGER may consider the best solution, which may include the supply of an acoustic and thermal hood, with its ventilation system and safety requirements. The use of a different device to comply with noise requirement shall be proved to be efficient and submitted to PETROBRAS approval.

5.4.10 PACKAGER shall present noise data regarding the items included in its scope of supply.

5.4.11 Noise data are required by PETROBRAS with the Proposal and after the Factory Tests, even if limits of airborne noise emission is not specified by PETROBRAS.

5.4.12 All noise data shall be always presented as a continuous equivalent level, Leq, for 60 seconds sampling time, and shall include:

- Value in dB(A);
- Linear values, not weighted, in the octave bands between 63Hz and 8,000Hz.

5.4.13 PACKAGER shall be the sole responsible for the guaranteed airborne sound emission data of the equipment within its scope of supply. These data shall be verified during the Factory Test Phase and a maximum deviation of 2 dB will be allowed, both for the A scale weighted value and for the octave bands between 63Hz and 8,000Hz.
5.4.14 For all equipment installed inside acoustic hoods, the following data are required during Proposal Phase:

- Sound power level of the equipment without the acoustic hood;
- Sound pressure level, in each of the four main directions and in one point of the top, for the equipment plus hood;
- Acoustical data of the hood and silencers.

5.4.15 For all equipment installed without acoustic hood, the following data are required:

- Sound power level of the equipment;
- Sound pressure level, in each of the four main directions and in one point of the top.

5.4.16 If the values measured and reported during the Factory Tests Phase are outside the limits submitted by the PACKAGER with the proposal, and approved by PETROBRAS, the PACKAGER shall provide the means for sound attenuation to the agreed limit. PETROBRAS reserves the right to witness the tests.

5.4.17 The procedures for sound measurement assume a condition of free field over reflecting floor. This implies that the tests will be preferably performed in an outside area, with a smooth floor made of concrete, asphalt, etc. If this condition is not satisfied, then the correction for measurements in rooms shall be applied.

5.4.18 The sound pressure meter shall be type I, according to IEC 61672-1/2. The characteristics of the octave filter shall be in accordance with IEC 61260.

5.4.19 The sound pressure reading shall be made as equivalent continuous level, Leq, for 60s sampling time. The recorded values shall be corrected to the nearest entire value within 1dB.

5.4.20 If the difference between the background noise level and the sound level of the equipment plus the background is less than 10dB, the measurements shall be corrected.

5.4.21 If the normal operating condition of the machine cannot be reached in the test stand, the PACKAGER shall perform the measurements in the possible conditions, agreeing with PETROBRAS the operational conditions of the test.

6. DIESEL ENGINE

6.1. GENERAL

6.1.1 Diesel Engine shall be designed for heavy duty, in continuous operation, with closed fresh water cooling circuit with radiator, four-stroke cycle, direct injection and turbocharger. The engine shall be capable of starting up cold or hot under load, with no dependency on external electric energy supply.

6.1.2 The diesel engine shall comply with IMO I664E MARPOL Annex VI;

6.1.3 The engine shall be rated considering "Continuous Power (COP)", as defined in ISO 8528-1.

6.1.4 The engine shall be designed, fabricated, installed, tested and operated in accordance with API 7B-11C, ISO 3046, ASME PTC 17 and CS requirements.
6.1.5 The speed governor shall be PACKAGER standard.
6.1.6 The diesel engine rated speed shall be up to 1800rpm.
6.1.7 The diesel engine shall be equipped with shaft-driven alternator for battery charger.
6.1.8 All connections between the engine and the skid (water, lubricating oil, diesel, air, etc.) shall be achieved through flexible metal-lined (such as stainless steel braid) hoses.

6.2. **EXHAUST SYSTEM**

6.2.1 Exhaust system shall be sized to avoid engine performance being jeopardized by backpressure. The exhaust system shall be complete.
6.2.2 Engine exhaust manifold shall be effectively insulated, so that the maximum external temperature, with ambient temperature 45°C shall not exceed:
   a) 60°C in parts with access by personnel;
   b) 200°C, for parts in contact with atmosphere and without access by personnel;
6.2.3 Insulation shall be done in a way to permit easy disassemble and reassemble after inspection/maintenance.
6.2.4 A silencer with integrated spark arrester shall be installed at discharge of diesel engine duct.
6.2.5 The exhaust shall be ducted out from the Unit by HULL CONTRACTOR.

6.3. **STARTING SYSTEM**

6.3.1 Two independent engine starting systems shall be included, being one electrical and other pneumatic, complying with starting cycle of NFPA 110.
6.3.2 The primary system shall be a 24VDC system as per 6.3.7. The back-up system shall be a pneumatic system as per 6.3.8. It shall be possible to select the starting system at EGCP (Emergency Generator Power and Control Panel) by means of a key-protected switch.
6.3.3 The 24VDC starting system shall be sized to allow at least 6 (six) consecutive starts. The pneumatic starting system shall be sized for at least 3 (three) consecutive starts. It shall be considered ambient temperature of 10°C, according to NFPA 110, to size the starting systems.
6.3.4 In case of failure after 3 (three) starting trials, EGCP shall sent an alarm signal to A&C, through Electrical System Controllers.
6.3.5 Emergency generator group shall be capable of being readily started in their cold condition. A fault or alarm in the marginal systems (pre-lube system, low start-up air pressure, and so on) shall not block motor automatic start.
6.3.6 Transmission of rotation from crankshaft to camshaft shall be effected through gearing.
6.3.7 Requirements for 24VDC starting systems (see item 8.8):
   6.3.7.1 This system shall comprise but not limited to the following items, supplied by PACKAGER:
   - Battery charger;
• 24VDC starting batteries;
• 24VDC starter motor;
• Starter control circuitry located in EGCP.

6.3.8 Requirements for pneumatic starting systems:

6.3.8.1. This system shall comprise but not limited to, supplied by PACKAGER:
• Pressure control valve;
• Pneumatic starting motor;
• Start-up solenoid valve with manual by-pass;
• Air filter;
• Lubrication unit;
• Breakdown and a blow down manual valves, installed in the start-up air line for depressurizing the line, right before the pneumatic starting motors, in the diesel motor skid, to prevent any accidental start of the motor during maintenance work.

6.3.8.2. The following parts of the system shall be supplied by HULL CONTRACTOR and shall comprise but not limited to:
• Air vessel (V-UG-5261501) fitted with a manometer, two safety valves, inlet and outlet nozzles, vent, drain with purge unit, stop and by-pass valves, pneumatic pressure switch with low air pressure warning device (to EGCP) and port for inspection and cleaning;
• Diesel engine driven backup air compressor (Emergency Generator Start-up Air Compressor Unit - UC-UG-5261501);
• AISI 316L stainless steel starting pipes.

6.3.8.3. The backup air compressor (UC-UG-5261501) and the air vessel (V-UG-5261501) shall be installed in the Hull Emergency Generator Room. These equipment shall be exclusively used by the Emergency Generator.

6.3.8.4. In normal operation conditions, the air vessel of the Emergency Generator shall be supplied by the Start-up Air Compressor Unit (UC-5138501) of platform, with a check valve to avoid the vessel to be depressurized by any other consumer. If a failure occurs, the vessel shall be pressurized by the Emergency Generator Start-up Air Compressor Unit (UC-UG-5261501).

6.3.8.5. The Emergency Generator Start-up Air Compressor Unit (UC-UG-5261501) shall be capable of supplying compressed air for three consecutive start attempts, each one with 10 seconds long, in thirty minutes. The compressor diesel engine shall be able to start manually and shall be independent from any external source.

6.3.8.6. The pneumatic starting systems for motor-generators shall have the capacity to operate at a minimum pressure of 10 bar.
6.4. COMBUSTION AIR SYSTEM

6.4.1 Combustion air system shall be complete and shall contain at least the following accessories:

a) Charger air cooler;
b) Inlet manifold;
c) Dry type inlet air filters;
d) Ducting and flexible connections, made of AISI 316L (fire-proofing);
e) Suitably supported ducting and piping;
f) Turbocharger, if necessary, with external bearings cooled by oil and with oil level sight-glass. If bearings are roller type, manufacturer shall indicate average guaranteed life, which shall exceed 20,000 hours;
g) Air inlet shut-off valve for overspeed, with manual reset (diesel standard).

6.4.2 The air inlet of diesel engine shall be inside the room, but shall not take hot air exhausted from electrical generator cooler.

6.5. COOLING SYSTEM

6.5.1 Diesel engine shall be supplied with complete closed engine cooling water circuit including at least the following items of equipment:

a) Radiator, mounted at the generator skid. Radiator shall be inserted in Emergency Generator Room external bulkhead by HULL CONTRACTOR, so that, with the generator in operation, no electrical fan is necessary for ventilation of the room and for package combustion and cooling system;
b) Radiator fan, driven by the engine and sized large enough to maintain at a satisfactory level the engine operating temperature and to remove the whole of the heat dissipated at the maximum power level of the diesel engine;
c) Centrifugal pump driven mechanically by the diesel engine for cooling water circulating in the closed circuit for engine. Belt driven pump shall not be accepted.
d) System for pre-heating including electric resistor, if necessary;
e) Thermostatic and three-way valves;
f) Expansion tank for hot water and make-up water, complete with level gauge and flange for connection with piping for make-up water mounted on radiator;
g) All piping, valves, filters, flexible connections and other accessories for interconnection of all equipment of cooling system;
h) All instruments required for control and proper operation of diesel engine.

6.5.2 A fault in the ventilation dampers shall not block the entree of combustion air into diesel engine.

6.5.3 HULL CONTRACTOR shall provide means to open the room dampers manually when the engine takes the combustion air inside the room.

6.5.4 PACKAGER shall inform the make-up consumption of water for cooling system.
6.5.5 Radiator fins and pipes shall be suitable for marine environment.

6.6. DIESEL OIL SYSTEM

6.6.1 Diesel Oil System shall comply with at least the following:

a) Positive displacement mechanical injection pump, driven by diesel engine shaft, with injection nozzles for the various cylinders; oil main gears pump driven by engine shaft;

b) Manual priming pump for emergency use;

c) Flexible connection with fire-protection, built of AISI 316L stainless steel;

d) Dual filter with throwaway elements, with valves for reversing flow, continuous flow type;

e) Duplex type fuel filters, with insert replaceable without interrupting the fuel supply to the engine;

f) Water/oil separator filter;

g) Diesel oil daily tank (TQ-UG-5261501) containing at least the following accessories:
   - Port for inspection and cleaning;
   - Glass with heat resistant reflex type glass;
   - Breather with flame smothering device;
   - Drain with self-closing valve and device for collecting sample;
   - Nozzles for inlet, outlet and, if necessary, return of diesel oil;
   - Nozzle for overflow unit;
   - Low oil level pneumatic switch with warning unit on local panel;
   - Level control valve;
   - Diesel oil feed blocking valve;
   - Support for nameplate;
   - Sounding pipe with stop valve and cap.

h) All piping, valves, flexible connections and other accessories for interconnection of all equipment of diesel system.

6.6.2 The inner surface of the daily tank shall be cleaned to remove oxides and any residues prior the operation. The surface preparation shall be done using abrasive blast cleaning or chemical cleaning. The cleanness shall be maintained by using inhibitors or protective coatings. In any case the protective coating or inhibitor shall be compatible with diesel oil.

6.6.3 Tank capacity shall be designed for holding at least 18 hours of consumption.

6.6.4 Diesel oil shut-off valve between daily tank and engine shall be fail-open type and shall have automatic operation in case of fire detection. A manual fuel valve between daily tank and engine shall be provided. It shall be possible to close this manual valve,
outside the emergency generator room, in case of fire inside. The operation manoeuvre of this manual valve shall be located close to fire fighting push-button of the room.

6.7. **LUBRICATION SYSTEM**

6.7.1 Lubrication system shall be furnished and shall comply with, at least, the following:

a) Gear-type main oil circulation pump driven by the engine shaft;

b) Hand-operated pre-lubrication auxiliary pump and oil pan drain;

c) Duplex lube oil filter of cartridge type with disposable elements. Filter cartridges shall be exchangeable without interrupting the oil supply to the engine;

d) All piping for interconnection, valves, drains and other auxiliaries inside the skid;

e) Filter on crankcase replenishment nozzle;

f) Pre-lubrication pump driven by AC electric motor, if necessary, and fed from EGCP;

g) Thermostatic valve or similar control device;

h) All instruments required for control and proper operation of diesel engine;

6.7.2 Engine shall have a dedicated lubrication unit.

6.7.3 In case of engines whose power rating calls for special precautions, PACKAGER must analyse the situation and tender, if necessary, for the following items:

a) Pre-lubrication pump driven by induction motor, and fed from EGCP;

b) Lubricant oil heater, heated by fresh water from the closed-circuit of the engine pre-heating circuit and lube oil heater in order to maintain the lube oil circulating at a temperature keeping the engine in a “ready-to-start” condition;

c) Centrifugal separating filter (cyclone).

6.7.4 Tender shall indicate the time required between oil changes and the oil consumption.

6.7.5 Oil pressure shall be higher than cooling water pressure.

6.8. **COUPLING AND TURNING DEVICE**

6.8.1 The coupling between the diesel engine and the generator is to be flexible type. The criterion of sizing of the couplings shall be indicated PACKAGER.

6.8.2 Coupling guard shall be rigid enough to avoid contact with moving parts.

6.8.3 The engine shall be provided with safe turning device for purposes of inspection and maintenance (tool furnished loose).

6.9. **VIBRATION LIMITS AND ISOLATION**

6.9.1 Acceptable limits of vibration valour, at engine casing, in any direction, shall not be higher than:

a) in the casing, in bearing: 11.0 mm/s RMS;

b) in the casing, on the top of cylinders: 11.0 mm/s RMS.
6.9.2 Maximum vibrations levels allowed to be transmitted to the structure shall be according to limits of Category V defined in PROJECT NOISE CONTROL REQUIREMENTS SPECIFICATION.

6.9.3 Isolation of vibration shall be part of noise control.

6.9.4 Skid shall be fixed to the structure by means of a resilient support, in order to limit the static deflection in 10mm, distributed symmetrically in relation to the engine gravity center.

6.9.5 Metallic isolators shall be installed, mesh type or not, with natural frequency between 3Hz and 9Hz and stabilizers of single or double effect, in exhaust duct.

6.9.6 PACKAGER shall inform the following data:
   a) Type of vibration isolator to be used;
   b) Static deflection of the isolator;
   c) Transmissibility of the isolator;
   d) Dynamic response analyses of assembly, with 6 degrees of freedom;
   e) Manufacturer, model and quantity of isolators to be installed.

6.9.7 Torsional vibration analysis shall be provided. Dynamic stresses transmitted to foundations shall be reduced to almost zero values. When forces or moments not taken into account in design occur in the engine, provision shall be made for a system for damping vibrations with elastic suspension suitable for reducing vibration to a minimum level in all speed ranges from the self-sustained level to 120% of operating speed. PACKAGER shall present a study containing selection of the type of suspension and maximum amplitudes of vibration of the skid, expected to occur during operation (values shall be guaranteed by PACKAGER).

6.10. SUPPORT SKID

6.10.1 One common skid base shall be provided by PACKAGER for both the diesel engine and the generator, with the diesel engine mounted on vibration pads.

6.10.2 A drip pan with a 2” drain connection shall be integrated in the support skid. The drain connection shall be combined with the day tank drip pan connection to one common drain to outside.

6.10.3 The skid shall be equipped with minimum two (2) M10 grounding stud bolt connectors welded at each corner (in recess) of the structure.

6.10.4 Package internal safety grounding system (equipment, accessories, piping and structure) shall comply with the requirements of IEC 61892-6, IEC 6092-502, and applicable Classification Society’s rules.

6.10.5 The skid shall be equipped with approved lifting eyelets.

6.10.6 The skid shall be welded to the floor after installation in the generator room.
7. ELECTRICAL GENERATOR

7.1. GENERAL

7.1.1 The electrical generator shall be synchronous, with a brushless PMG exciter, and shall be constructed according to IEC 60034-1. Generator shall comply with IEC 61892-3 and applicable CS rules.

7.1.2 The generator shall be protected against the corrosion caused by the humidity, oil vapours, and marine atmosphere characteristic of the site of installation, as indicated on the Data Sheet.

7.1.3 The generator, the exciter and the auxiliary systems shall be suitable for operating continuously at full load condition during the period of time compatible with that of the driving machine, and no lower than 10,000 hours, except when this time is explicitly defined on the Data Sheet.

7.1.4 The generator and its exciter shall be dynamically balanced and capable of withstanding over-speed of 20% above the rated value by two minutes.

7.1.5 The generator shall be capable of supplying their rated output at rated speed and at rated power factor at a voltage variation range between 95% and 105% of their rated voltage.

7.1.6 The generator shall be designed with damping winding to permit parallel operation.

7.1.7 The generator shall be designed and manufactured in order to facilitate extraction of the rotor in the horizontal direction without removal of the stator.

7.1.8 The generator shall withstand for 30 seconds a current value equivalent to at least 150% of the rated value.

7.1.9 Generator with its exciter shall be capable of maintaining a short-circuit current of at least three times its rated value for at least 2 seconds.

7.1.10 The generator shall have IP54 protection degree.

7.1.11 Emergency Generator reactances shall be defined in order to keep the short-circuit current in Essential Switchgear within the limits defined by I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS when Emergency Generation is in parallel operation with Main Generation and when Emergency Generation is in parallel operation with Auxiliary Generation.

7.2. EXCITATION

7.2.1 The thermal insulation class of the exciter shall be identical to the generator’s insulation class.

7.2.2 The generator shall have a brushless type rotating exciter. The primary supply voltage for the excitation system shall be obtained from a permanent magnet generator (PMG).

7.2.3 The rotating rectifying unit shall be supervised by a system for detecting and alarm a fault in rectification (damaged or short-circuited diodes).

7.2.4 Excitation shall be disconnected if a fault remains after disconnection of generator’s circuit-breaker.
7.2.5 The manufacturer of generator shall supply both, voltage and current transformers, and they shall be part of the excitation system.

7.2.6 The exciter terminals shall be connected in an exclusive terminal box, not containing circuits for other purposes.

7.2.7 The exciter shall have inspection windows large enough for replacement of diodes.

7.3. **INSULATION**

7.3.1 All generators windings shall have vacuum impregnated insulation, and shall be treated to resist moisture, marine atmosphere, and oil vapours.

7.3.2 The generators insulation thermal class shall be “F”, with maximum temperature rise corresponding to class “B”, unless otherwise specified on the Data Sheet.

7.3.3 The internal insulation materials shall be flame retardant and non-hygroscope. Cables used on interconnection of stator with the outgoing terminals shall also have these characteristics, and shall be with double silicone insulation.

7.3.4 The generator windings shall withstand indefinitely, without restriction for its useful lifetime, the phase-to-phase rated voltage between any phase to ground.

7.4. **BEARINGS**

7.4.1 Lubrication shall be effective under all operating conditions, including inclination variations (static and dynamic) referred on item 4.3.

7.4.2 Bearings shall be fitted with sealing devices in order to prevent leakage of lubricant inner and outer side of the generator, and to prevent ingress of water or moisture.

7.4.3 Means shall be provided to avoid the circulation of currents between the shaft and the bearings (see IEC 60034-25 as reference).

7.5. **COOLING SYSTEM**

7.5.1 The generator shall be self-ventilated, using air as cooling medium and not dependant on other systems (IC01, or IC11, or IC21, or IC31, or IC411, or IC511, or IC611, according to IEC 60034-6). The cooling air shall be impelled by fans mounted on the shaft of the generator rotor.

7.6. **TERMINALS**

7.6.1 The generator shall have six accessible power terminals, installed in order to facilitate the work of cables installation and maintenance.

7.6.2 All power terminals shall be insulated up to the connection point and the latter shall be silver coated. They shall be suitable for withstanding the thermal and dynamic effects imposed on them under any conditions of load or short-circuit and vibrations.

7.6.3 The terminals of control circuits shall be eyelet type, to avoid slackening with the vibration.

7.6.4 The generator shall be supplied with grounding terminals located outside the casing.
7.7. TERMINAL BOXES

7.7.1 General Requirements

7.7.1.1. The generator shall be fitted with independent terminal boxes sized for housing the terminals for power, neutral and control cables. The control cables shall be grouped together in terminal blocks and suitably identified. Power Terminal Box, Neutral Terminal Box and Auxiliary Boxes shall be integral part of the generator and independent from each other.

7.7.1.2. The connection boxes shall be fitted with removable plates for cables entries, made of the following materials:

- AISI 316L stainless steel for sheets intended for the running of single-phase power cables;
- Epoxy painted galvanized steel sheet for other cases.

7.7.1.3. Terminal boxes shall have enough space for entry, bending and terminations of cables in cross section and quantity indicated on Data Sheet. Each box shall be capable to withstand the mechanical stresses due to cables weight, especially when there are a large number of cables.

7.7.1.4. All terminal boxes shall be sized so that in case of short-circuit or surge protection failure inside the unit there shall be no risk to people and equipment in the neighbourhood.

7.7.1.5. All terminal boxes shall be identified with an AISI 316L stainless steel nameplate with tag and function description.

7.7.1.6. Terminal boxes shall have minimum protection degree IP42W (where W means suitable for saline, corrosive, hot and damp environment).

7.7.2 Power Terminal Box

7.7.2.1. The Power Terminal Box shall have enough space for:

- lightning-arresters and capacitors for surge protection, according to PACKAGER standard;
- metering and protection voltage transformers.

7.7.2.2. The Power Terminal Box shall be suitable for outdoor installation and under environmental conditions. The cables entries shall be at bottom side.

7.7.2.3. The Power Terminal Box shall permit access from the front side. It shall not be possible to open the box without the use of tools.

7.7.3 Neutral Terminal Box

7.7.3.1. The protection and control current transformers shall be installed inside the Neutral Terminal Box. See Figure 1 and Figure 2 (Hold).

7.7.3.2. The Neutral Terminal Box shall have the same construction and installation characteristics of the Power Terminal Box.

7.7.3.3. It is acceptable the use of a common Terminal Box for power and neutral terminals, since there is enough space for all internal components.
7.7.4 **Auxiliary Terminal Boxes**

7.7.4.1. All cables terminals for RTDs, space heaters, exciter, voltage transformers, current transformers and other auxiliary instruments shall be driven to specific auxiliary terminal boxes.

7.7.4.2. Except for the size, the auxiliary terminal boxes shall have the same construction and installation characteristics of the Power Terminal Box.

7.8. **TEMPERATURE DETECTORS**

7.8.1 Two (2) winding temperature detectors (platinum resistance RTDs, three-wire 100Ω at 0°C) per phase shall be supplied, for metering and alarm.

7.8.2 These detectors shall be suitably distributed between the stator grooves so that the cooling air will not directly affect them.

7.8.3 Wiring for all temperature detectors shall be connected to an exclusive auxiliary terminal box.

7.8.4 Each bearing shall have two temperature detectors (platinum resistance RTDs, three-wire 100Ω at 0°C).

7.8.5 EGCP shall have a temperature indicator, with selector switch for RTD’s of windings and bearing.

7.9. **SPACE HEATERS**

7.9.1 The space heaters of generator shall operate in such a manner that the internal environmental temperature is higher than the environmental design temperature, up to a maximum limit of 10°C above surrounding temperature.

7.9.2 The heating resistors shall be "shielded" type, with rated voltage of 220VAC. A notice board shall be posted up in the vicinity of the connection box bearing the words "ATENÇÃO - AQUECEDOR LIGADO EM 220 VCA" (Attention - Heater connected in 220 VAC).

7.9.3 The resistors shall be fed and controlled by EGCP, shall remain energized while the generator is stopped, causing no damage to the windings and internal parts, and shall be automatically turned off when the generator is operating.

7.10. **WIRING**

7.10.1 Conductors connected to current transformers shall be linked up with terminals permitting short-circuit.

7.10.2 The wiring coming from voltage transformers and other normally energized sources shall be connected up to protected terminal blocks containing a notice that they may be energized ("ATENÇÃO - TERMINAIS ENERGIZADOS").

7.11. **GROUNDING SYSTEM**

7.11.1 For installation in FPSO and FSO, the Emergency Generator neutral point shall be isolated from ground.

7.11.2 For installation in semi-submersible and fixed Units, the Emergency Generator neutral shall be grounded by high resistance. See PROJECT ONE-LINE DIAGRAM.
7.12. NAMEPLATES

7.12.1 The Generator nameplate shall be in AISI-316L stainless steel, containing the following data in Portuguese language:

a) Petróleo Brasileiro S.A. - PETROBRAS;

b) Nome do fabricante (manufacturer's name);

c) Número de série, código de data (serial number, date code or other indication making it possible to recognize the type of manufacture);

d) Potência nominal (rated power);

e) Tensão nominal (rated voltage);

f) Corrente nominal (rated current);

g) Reatância transitória de eixo direto, não saturada (direct transient reactance, non saturated);

h) Reatância subtransitória de eixo direto, saturada (direct sub-transient reactance, saturated);

i) Frequência nominal (rated frequency);

j) Número de fases (number of phases);

k) Sequência de fases (phase sequence);

l) Rotação nominal (rated r.p.m.);

m) Classes de temperatura dos isolamentos ou limites de elevação de temperatura (para rotor e estator) (insulation temperature classes or temperature rise limits (for rotor and stator));

n) Conexão das bobinas (connections of windings, indicated by symbols);

o) Fator de potência nominal (rated power factor);

p) Grau de proteção (protection degree);

q) Temperatura ambiente de projeto (environmental temperature);

r) Pesos de rotor e estator (weight of rotor and stator in kilograms);

7.12.2 Nameplates made of material resistant to corrosion and humidity shall be applied for identification and location of all electric equipment, panels, relays, meters and terminal boxes.

7.12.3 Nameplates shall have black lettering engraved in bas-relief against a white background, except those referring to alarm signals and hazards, which shall have white lettering on a red background.

7.12.4 All rotary equipment shall be fitted with corrosion-resistant metallic plates attached with metallic rivets.

7.12.5 Information indicated on nameplates shall be submitted to PETROBRAS for approval.

7.12.6 All safety signals shall be in Portuguese language.
8. CHARACTERISTICS OF ELECTRICAL PANELS AND EQUIPMENT

8.1. GENERAL CHARACTERISTICS

8.1.1 Panels shall have IP42W protection degree (W means suitable for corrosive, saline, hot and damp environment).

8.1.2 All accessories and components shall be immune to or protected from electromagnetic and radio-frequency interference (EMI-RFI). The panels and all their components shall comply with requirement for emission immunity stated in IEC 60533, presenting performance criterion A.

8.1.3 All metallic parts belonging to the panel and not intended to carry current shall be connected with the panels grounding busbar. The busbar shall be inside the panel and be fitted with suitable "non-welded" type connectors for gauge 25mm² stranded copper cabling at each end.

8.1.4 The partitioning of panels shall use metallic barriers, at least in the 2a form of IEC 61439-1, separating the live power entry terminals and the circuit-breaker from the remainder de-energized parts after disconnection of circuit-breaker.

8.1.5 In order to separate the risk zone (power circuits) and to avoid human contact with live parts, as stated in NR-10 rules, insulated and transparent polycarbonate barriers shall be installed. Totally screwed plates shall not be used. Alert indicating plates shall be provided, with the indication of risk and the rated voltage of circuits, as stated in NR-10.

8.1.6 The panel shall be fitted with heating elements (one to each vertical section or compartment, where closed into itself), operating at 220VAC, with external energy supply. These heaters shall be automatically controlled by means of thermostats with graduation range up to a maximum of 60°C. The circuit of each heater shall have a circuit-breaker intended to protect the circuit.

8.1.7 The panel shall be provided with an external socket for energizing the heating circuits during the storage period. This socket shall have the following label:

TERMINAIS PARA ENERGIZAÇÃO DAS RESISTÊNCIAS DE AQUECIMENTO

8.1.8 Panels shall be factory-mounted type and shall be equipped with hoisting devices at the top.

8.1.9 The maximum height, including the skid, shall not exceed 2400mm. Panel shall be self-supported. The steel sheet thickness shall be of at least 1.98 mm (14 USG).

8.1.10 The panels shall be drilled with holes to permit its attachment to the additional steel base (skid).

8.1.11 The cables entrance shall be according to installation criteria defined for the room. See project documentation.
8.1.12 Panels and its interfaces shall be designed following the requirements stated on I-ET-3010.00-5140-700-P4X-005 - REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR OFFSHORE UNITS.

8.2. ESSENTIAL SWITCHGEAR

8.2.1 Essential Switchgear shall be supplied by HULL CONTRACTOR. The generator protection shall actuate on the incoming generator circuit-breaker at this panel.

8.2.2 Undervoltage relays installed at each busbar of the Essential Switchgear shall send signals to automatically start the Emergency Generator.

8.3. EMERGENCY GENERATOR POWER AND CONTROL PANEL (EGCP) (PN-UG-5261501-01)

8.3.1 The Emergency Generator Power and Control Panel (EGCP) shall contain the Emergency Generator controller devices (manual start and stop commands, manual voltage and frequency adjustment commands, operation mode selection (automatic / manual / blocked), the protective relays, the synchronism board for manual operation (switches, lamps, metering, etc.) and the necessary starters for electrical auxiliary equipment (battery chargers, cooling fans, lube pumps, HPUs, heating equipment, etc.).

8.3.2 The Emergency Generator Power and Control Panel (EGCP) (PN-UG-5261501-01) shall comply with requirements of I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

8.3.3 The control voltage shall be 24VDC. See 8.8.

8.4. AUTOMATIC VOLTAGE REGULATOR (AVR)

8.4.1 Automatic Voltage Regulator AVR shall be micro processed type, mounted on a steel chassis suitable for assembly inside EGCP.

8.4.2 The regulator shall be proper for offshore conditions and shall be capable of operating under all specified condition of steady state and transient load, including short-circuits.

8.4.3 The regulator shall be suitable for operation in parallel with other machines of different ratings.

8.4.4 The AVR shall provide means for manual and automatic adjustment of voltage through the manual-automatic switch, internal to EGCP.

8.4.5 The reactive load sharing (when generator is running in parallel with other machines) shall be done through the droop characteristics of the generator Automatic Voltage Regulator.

8.4.6 As measured at generator terminals from no load to full load, at rated power factor, and at steady conditions, the voltage variation shall remain in the range ±3.5%.

8.4.7 The maximum transient voltage deviation at generator terminal shall remain in the range +20% -15%. The voltage deviation at generator terminals shall be restored to within ±4.0% in 5 seconds.
8.4.8 The voltage drop in the generator terminals shall not be higher than 15% on the start-up of the biggest motor. The motor data and initial load shall be specified on Data Sheet.

8.5. EMERGENCY GENERATOR CONTROLLER (EGC)

8.5.1 The Emergency Generator Power and Control Panel (EGCP) shall be designed with a unique dedicated microprocessor-based device, hereafter called Emergency Generator Controller (EGC). EGC shall be a controller dedicated to Emergency Generator Package control, shall be certified for marine offshore use and shall be approved by PETROBRAS. It shall not be accepted use of PLC for EGC.

8.5.2 The EGC shall be installed in EGCP and shall be responsible for:
   a) Running generator and driver.
   b) Automatic Synchronism and smooth load transfer;
   c) Reply engine status and protections coming from engine local control panel.

8.5.3 The EGC shall have internal clock synchronized with external signal according to I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM and I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE.

8.5.4 The EGCP shall comply with interface signals defined in I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

8.5.5 The main interfaces between the EGCP and others devices are shown in Figure 1 and Figure 2 (HOLD). Other interface signals exist, according to each interface equipment and according to project necessity. PACKAGER shall supply with all necessary interface signals.
Figure 1 - Typical Protection and Communication Diagram – Isolated System

Notes:
1 VTs shall be connected to the same phases, to allow synchronization control;
2 This diagram does not show all details of these equipment;
3 Essential switchgear configuration may be different for each project. See PROJECT ONE-LINE DIAGRAM.
8.5.6 It shall be possible to start operation of the Emergency Generator group manually, totally independent from the EGC. In order to start the Emergency Generator set, without blocking from EGC, a switch to transfer the control from EGC to manual commands shall be provided. In this situation, only the protections of the diesel engine (installed at Engine Local Control Panel), the electrical protections (installed on protection relay external to EGC), and manual commands shall be able to stop the Emergency Generator set.

8.5.7 PACKAGER shall supply documents proving that the same model of EGC have been installed in offshore environment at least for two years in similar situations, without developing any kind of problem.

8.6. ENGINE LOCAL CONTROL PANEL (PN-UG-5261501-02)

8.6.1 The diesel Engine Local Control Panel shall include the engine protection and indication devices.

8.6.2 Communication between the Engine Local Control Panel and EGCP, for transfer of monitoring signals, shall be provided, according to PACKAGER standard.

8.6.3 The control voltage shall be 24VDC. See 8.8.

8.7. STARTING AND INTERLOCKING

8.7.1 The EGCP shall receive the starting signal (“Loss of the Mains”) from the Essential Switchgear undervoltage relays (27 function) and shall close the Emergency Generator circuit-breaker in Essential Switchgear, after the starting sequence.

8.7.2 The EGCP shall be interconnected to Essential Switchgear to implementation of the foreseen interlocks. See PROJECT ONE-LINE DIAGRAM.

8.7.3 The automatic starting process, including powering of all essential loads shall not last more than 45s.

8.7.4 EGCP shall receive an emergency shutdown (ESD) discrete signal from the Fire & Gas System (FGS), in case of confirmed gas in emergency generator room air intake or confirmed fire inside the room. This signal shall inhibit the starting process of the generator when it is stopped. If the generator is running, this signal shall not stop to generator that shall be kept running. This signal shall close the ventilation dampers of the room. A pilot lamp shall be provided at EGCP indicating the status of this signal.

8.8. BATTERY AND BATTERY CHARGERS

8.8.1 Battery chargers and batteries shall comply with I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

8.8.2 Battery chargers shall be suitable for 480VAC/3ph/60Hz power supply, complete with metering (charging current & voltage), mounted inside EGCP or in an IP42 minimum enclosure and fed from EGCP.

8.8.3 Battery chargers shall provide one UAM alarm signal through voltage free contact (1A @ 24VDC) to be sent to A&C, through EGCP (included in EGCP UAM summary). This alarm signal shall include at least battery in discharge and low resistance isolation.
8.8.4 Batteries shall be located in a dedicated battery box. Sealed or VRLA type batteries shall not be used.

8.8.5 Separated sets of battery and battery chargers for control voltage (EGCP supply) and starting system shall be provided. Battery for control voltage shall also be charged by the shaft-driven alternator.

8.8.6 The autonomy of batteries for control voltage when not charging from its battery charger or shaft-driven alternator shall be at least 30 min.

8.8.7 As an alternative to shaft-driven alternator, a 100% redundant battery charger set for control voltage will be acceptable.

9. PROTECTION

9.1. PROTECTIVE RELAYS

9.1.1 Protective and lockout relays shall comply with requirements of I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

9.1.2 Protective relay shall be connected to Electrical System Controllers through fast Ethernet IEC 61850 network. See I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM and I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE.

9.1.3 Protective relay shall have internal clock synchronized with external signal according to I-DE-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE DIAGRAM and I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE.

9.2. PROTECTION

9.2.1 The protection of Emergency Generator and the Diesel Engine shall comply with I-ET-3010.00-5143-700-P4X-001 - ELECTRICAL SYSTEM PROTECTION CRITERIA.

9.3. CURRENT TRANSFORMERS (CTs) AND VOLTAGE TRANSFORMERS (VTs)

9.3.1 Current transformers and voltage transformers shall comply with I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

9.3.2 The generator manufacturer shall define and supply the CTs and VTs to allow the perfect operation of control, protection and excitation devices linked to the generator.

9.3.3 CTs and VTs shall be dry type and shall be separated for excitation systems.

9.3.4 Terminal blocks connected to CT circuits shall be supplied with means for short-circuit them when necessary.

9.3.5 CTs for protection, measurement and control shall be installed inside Neutral Terminal Box of generator.
9.3.6 VTs for protection, measurement and control shall be installed inside Power Terminal Box of Generator.

10. SYNCHRONIZATION CRITERIA

10.1. GENERAL REQUIREMENTS

10.1.1 EGCP shall provide all necessary devices and interfaces to control the Emergency Generator in order to synchronize it and establish continuous parallel operation with Main Generation and with Auxiliary Generation.

10.1.2 EGCP shall have a selector switch to select the circuit-breaker to be closed in synchronization process and simultaneously select the adequate necessary voltage (and frequency) reference signals. EGCP shall be capable to establish parallel operation through closing of the following circuit-breakers in Essential Switchgear (see PROJECT ONE-LINE DIAGRAM):

- Emergency Generator incoming circuit-breaker;
- Tie circuit-breaker in Essential Switchgear;
- Incoming circuit-breaker(s) in Essential Switchgear, related to power transformer(s) connected to Main Generation;
- Back-feed circuit-breakers in Essential Switchgear.

10.1.3 It shall be possible to control the synchronization conditions in EGCP manually through control switches to increase and decrease the voltage and frequency of Emergency Generator and through manual closing push-button for the selected circuit-breaker.

10.1.4 It shall be possible to control the synchronization conditions in EGCP automatically, through EGCP internal control of voltage and frequency of Emergency Generator and automatically closing of the selected circuit-breaker.

10.1.5 The manual and automatic closing command of the selected circuit-breaker shall be inhibited by synchronization check relay, when necessary conditions are not fulfilled.

10.1.6 Remote control of synchronization process of Emergency Generator is not required.

10.1.7 EGCP shall be capable to automatically perform the following functions:

a) Synchronism and closing the selected circuit-breaker;

b) Transference of loads to the Main (or Auxiliary) Generation system, performing the following steps:

   b1) Synchronization and parallelism of the Emergency Generator with the Main (or Auxiliary) Generation system through a selected circuit-breakers;

   b2) Load transfer from the Emergency Generator to the Main (or Auxiliary) Generation system;

   b3) Opening of the Emergency Generator circuit-breaker after load transference.

10.1.8 The automatic parallel operation with load transference shall last only a necessary time to transfer the loads from Emergency Generator to the Main (or Auxiliary) Generation.
System. Continuous parallel operation with Main Generation or with Auxiliary Generation shall be possible only if approved by Classification Society.

10.1.9 The synchronism board located at EGCP, to permit manual parallelism between Emergency Generation and Main (or Auxiliary) Generation System, shall be provided with at least the following facilities:

a) Double voltmeter;
b) Double frequency meter;
c) Synchronoscope;
d) Indicative lamp of permission for circuit-breaker closing, by relay (25);
e) Circuit-breaker's selector switch for parallelism;
f) Closing push-button for the selected circuit-breaker;
g) Frequency control switch;
h) Voltage control switch;
i) Manual/Automatic Synchronization selector switch;
j) Starting automatic synchronization process push-button;
k) Synchronizing relays (function 25) independent for automatic and manual synchronization.

11. INSPECTION AND TESTING

11.1. GENERAL REQUIREMENTS

11.1.1 Unless otherwise specified in data-sheets, at least the tests listed in Table 2, Table 3 and Table 4 shall be carried out. Engine tests shall be complemented. Tests required by CS, if not listed, are mandatory and shall be included.

11.1.2 PACKAGER shall submit the inspection and testing plan (PIT), complying with the requirements of this specification and in data-sheets, to PETROBRAS approval. PIT shall include, at least:

a) Routine, type and special tests that will be carried out during manufacturing process (TDPF);
b) Routine, type and special tests to be carried out in factory (TAF);
c) Field acceptance tests (TAC).

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

11.1.3 Certificate reports, approved by CS shall be accepted by PETROBRAS for type tests of identical equipment. Certificates presented shall be with valid dates.

11.1.4 PACKAGER shall inform consumption of lubrication oil, cooling water and diesel for the tests.

11.1.5 Tests shall be witnessed by PETROBRAS surveyors or people appointed by the latter.

11.1.6 PACKAGER shall provide for PETROBRAS all results reports of inspections and tests.
11.1.7 Unless otherwise defined in data-sheet or in Project documentation, the tolerances defined by standards shall be applicable.

11.1.8 In the tests tables, “Project documents” refers to any specific documentation related to Package issued in the Project.

11.2. **LIST OF MINIMUM TESTS**

Table 2 – Minimum Tests During Manufacturing Process (TDPF)

<table>
<thead>
<tr>
<th>(TDPF) Test List Description</th>
<th>RT</th>
<th>TT</th>
<th>ST</th>
<th>Procedure and Acceptance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verification of the technical documentation</td>
<td>X</td>
<td></td>
<td></td>
<td>Project documents</td>
</tr>
<tr>
<td>Visual inspection</td>
<td>X</td>
<td></td>
<td></td>
<td>Project documents</td>
</tr>
<tr>
<td>Verification of the calibration certificates of the instruments used in the tests</td>
<td>X</td>
<td></td>
<td></td>
<td>PIT</td>
</tr>
<tr>
<td>Generator vibration and balance tests, including operation of the bearing or lubrication system</td>
<td>X</td>
<td></td>
<td></td>
<td>IEC 60034-14</td>
</tr>
<tr>
<td>Generator stator insulation power factor test (power factor tip-up)</td>
<td>X</td>
<td></td>
<td></td>
<td>IEC 60034-27-3, or IEEE 286</td>
</tr>
<tr>
<td>Generator field windings polarity test</td>
<td>X</td>
<td></td>
<td></td>
<td>IEEE 115</td>
</tr>
<tr>
<td>Generator short-circuit check on the field winding coils</td>
<td>X</td>
<td></td>
<td></td>
<td>IEEE 115</td>
</tr>
<tr>
<td>Generator harmonic signature test</td>
<td>X</td>
<td></td>
<td></td>
<td>IEC 61000-4-7</td>
</tr>
</tbody>
</table>

Table 3 – Minimum Factory Acceptance Tests (TAF)

<table>
<thead>
<tr>
<th>(FAT) Test List Description</th>
<th>RT</th>
<th>TT</th>
<th>ST</th>
<th>Procedure and Acceptance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verification of the technical documentation</td>
<td>X</td>
<td></td>
<td></td>
<td>Project documents</td>
</tr>
<tr>
<td>Verification of the calibration certificates of the instruments used in the tests</td>
<td>X</td>
<td></td>
<td></td>
<td>PIT</td>
</tr>
<tr>
<td>Verification of the certificates of conformity of the sensors and instruments installed in the generator set</td>
<td>X</td>
<td></td>
<td></td>
<td>Project documents</td>
</tr>
<tr>
<td>Visual, dimensional inspection and verification of identification, data and safety plates</td>
<td>X</td>
<td></td>
<td></td>
<td>IEC 60034-1 and Project documents</td>
</tr>
<tr>
<td>Accessories check (e.g. heating resistance, CTs, VTs, RTDs, sensors, etc.)</td>
<td>X</td>
<td></td>
<td></td>
<td>Project documents</td>
</tr>
<tr>
<td>Measurement of generator winding resistance</td>
<td>X</td>
<td></td>
<td></td>
<td>IEC 60034-4-1</td>
</tr>
<tr>
<td>Checking the location of the magnetic center of generator</td>
<td>X</td>
<td></td>
<td></td>
<td>API 546</td>
</tr>
<tr>
<td>Air gap and eccentricity measurement of generator</td>
<td>X</td>
<td></td>
<td></td>
<td>API 546, data-sheet and this specification</td>
</tr>
<tr>
<td>Checking and marking the direction of rotation of generator</td>
<td>X</td>
<td></td>
<td></td>
<td>Driver documents and data-sheet</td>
</tr>
<tr>
<td>(FAT) Test List Description</td>
<td>RT</td>
<td>TT</td>
<td>Procedure and Acceptance Criteria</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------------------------------------------</td>
<td>----</td>
<td>----</td>
<td>-------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Phase sequence verification and terminals marking of generator</td>
<td>X</td>
<td></td>
<td>IEC 60034-1, IEC 60034-8 and ISO 8528</td>
<td></td>
</tr>
<tr>
<td>Unbalanced phase check of generator</td>
<td>X</td>
<td></td>
<td>IEC 60034-22</td>
<td></td>
</tr>
<tr>
<td>Measurement and analysis of wave form and THD of generator (harmonic signature)</td>
<td>X</td>
<td></td>
<td>IEC 60034-1, or IEC 61000-4-7</td>
<td></td>
</tr>
<tr>
<td>Test and determination of the sustained short-circuit curve of generator (short-circuit</td>
<td>X</td>
<td></td>
<td>IEC 60034-4-1 and CS</td>
<td></td>
</tr>
<tr>
<td>characteristic)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test and determination of the no-load saturation curve of generator (open-circuit voltage</td>
<td>X</td>
<td></td>
<td>IEC 60034-4-1</td>
<td></td>
</tr>
<tr>
<td>characteristic)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generator efficiency measurement</td>
<td>X</td>
<td></td>
<td>IEC 60034-2-1</td>
<td></td>
</tr>
<tr>
<td>Generator winding temperature rise</td>
<td>X</td>
<td></td>
<td>IEC 60034-1 and IEC 61892-3, or IEEE 115 Method 4 (1)</td>
<td></td>
</tr>
<tr>
<td>Cooling system check</td>
<td>X</td>
<td></td>
<td>This specification</td>
<td></td>
</tr>
<tr>
<td>Generator bearings inspection</td>
<td>X</td>
<td></td>
<td>API 546</td>
<td></td>
</tr>
<tr>
<td>Measurement of generator bearings insulation</td>
<td>X</td>
<td></td>
<td>API 546</td>
<td></td>
</tr>
<tr>
<td>Bearings temperature rise</td>
<td>X</td>
<td></td>
<td>IEC 60034-1</td>
<td></td>
</tr>
<tr>
<td>Generator vibration tests (run out, vibration on the shaft, vibration on bearings and</td>
<td>X</td>
<td></td>
<td>IEC 60034-14</td>
<td></td>
</tr>
<tr>
<td>operation of the lubrication system)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generator overspeed test (20% in excess of rated rpm, for 2min)</td>
<td>X</td>
<td></td>
<td>IEC 60034-1</td>
<td></td>
</tr>
<tr>
<td>Voltage and current on shaft of generator</td>
<td>X</td>
<td></td>
<td>IEEE 115</td>
<td></td>
</tr>
<tr>
<td>Measurement of audible noise level of complete set</td>
<td>X</td>
<td></td>
<td>IEC 60034-9 and This specification</td>
<td></td>
</tr>
<tr>
<td>Withstand voltage test of generator</td>
<td>X</td>
<td></td>
<td>IEC 60034-1-1 (2)</td>
<td></td>
</tr>
<tr>
<td>Measurement of insulation resistance of generator</td>
<td>X</td>
<td></td>
<td>IEEE 43</td>
<td></td>
</tr>
<tr>
<td>Measurement of polarization index of generator</td>
<td>X</td>
<td></td>
<td>IEEE 43</td>
<td></td>
</tr>
<tr>
<td>Generator occasional overcurrent test</td>
<td>X</td>
<td></td>
<td>IEC 60034-1 and items 7.1.8 and 7.1.9 of this specification.</td>
<td></td>
</tr>
<tr>
<td>Power factor tip-up test of generator</td>
<td>X</td>
<td></td>
<td>IEC 60034-27-3, or IEEE 286</td>
<td></td>
</tr>
<tr>
<td>Sudden three-phase short-circuit (parameter calculation) of generator</td>
<td>X</td>
<td></td>
<td>IEC 60034-4-1</td>
<td></td>
</tr>
<tr>
<td>Verification of generator protection degree (IP)</td>
<td>X</td>
<td></td>
<td>IEC 60034-5</td>
<td></td>
</tr>
<tr>
<td>Check of lubrication oil ingress inside the generator</td>
<td>X</td>
<td></td>
<td>Visual inspection</td>
<td></td>
</tr>
<tr>
<td>Measurement of generator excitation current at rated voltage, current and power factory</td>
<td>X</td>
<td></td>
<td>IEC 60034-4-1 and this specification</td>
<td></td>
</tr>
</tbody>
</table>
### Technical Specification

**No.** I-ET-3010.00-5261-700-P4X-001  
**REV.** 0  
**AREA:**  
**TITLE:** EMERGENCY GENERATOR PACKAGE FOR OFFSHORE UNITS

#### (FAT) Test List Description

<table>
<thead>
<tr>
<th>Description</th>
<th>RT</th>
<th>TT</th>
<th>ST</th>
<th>Procedure and Acceptance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Painting verification (colour, grip and thickness)</td>
<td>X</td>
<td></td>
<td></td>
<td>[8]</td>
</tr>
<tr>
<td>Generator field windings polarity test</td>
<td>X</td>
<td></td>
<td></td>
<td>IEEE 115</td>
</tr>
<tr>
<td>Generator short-circuit check on the field winding coils</td>
<td>X</td>
<td></td>
<td></td>
<td>IEEE 115</td>
</tr>
<tr>
<td>Functional and performance test of excitation system, including AVR (including Field Forcing, when required)</td>
<td>X</td>
<td></td>
<td></td>
<td>This specification</td>
</tr>
<tr>
<td>Measuring of voltage regulation during steady and transient loading and unloading</td>
<td>X</td>
<td></td>
<td></td>
<td>IEC 61892-3 and limits by 8.4.6 and 8.4.7 of this specification</td>
</tr>
<tr>
<td>Measuring of frequency regulation during steady and transient loading and unloading</td>
<td>X</td>
<td></td>
<td></td>
<td>ISO 8528-5 and limits by note (3) below</td>
</tr>
</tbody>
</table>

**Notes**

1. In case of use of or IEEE 115 Method 4, consider all criteria for open-circuit and short-circuit loading:
   a) specified voltage with terminals open;
   b) specified armature current with the terminals short-circuited;
   c) zero excitation.

2. Withstand voltage test shall be carried out immediately after temperature rise.

3. Frequency variation limits for test:

<table>
<thead>
<tr>
<th>Steady State</th>
<th>Transient State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overfrequency</td>
<td>+5.0%</td>
</tr>
<tr>
<td>Underfrequency</td>
<td>−5.0%</td>
</tr>
<tr>
<td>Overfrequency</td>
<td>+12% (*)</td>
</tr>
<tr>
<td>Underfrequency</td>
<td>−10% (**)</td>
</tr>
<tr>
<td>Recovery time</td>
<td>5 s</td>
</tr>
</tbody>
</table>

   (*) Load shedding of 100% through opening circuit-breaker.
   (***) Load step according to mean effective pressure of the engine.

#### Table 4 – Minimum Field Acceptance Tests (TAC)

<table>
<thead>
<tr>
<th>Description</th>
<th>Method and Acceptance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Checking of PIT technical documentation</td>
<td>Project documents</td>
</tr>
<tr>
<td>Verification of the calibration certificates of the instruments used in the tests</td>
<td>PIT</td>
</tr>
<tr>
<td>Visual inspection and verification of assembly and identification, data and safety plates</td>
<td>Project documents</td>
</tr>
<tr>
<td>Measurement of insulation resistance and polarization index</td>
<td>IEEE Std 43</td>
</tr>
</tbody>
</table>
**TECHNICAL SPECIFICATION**

**Title:** EMERGENCY GENERATOR PACKAGE FOR OFFSHORE UNITS

<table>
<thead>
<tr>
<th>Description</th>
<th>Method and Acceptance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete functional tests and control of equipment parameters on control panels</td>
<td>Project documents</td>
</tr>
<tr>
<td>Measurement of start-up time for load equal to 50%, 75%, 100% and 110% of engine braking power</td>
<td>45s</td>
</tr>
<tr>
<td>Measurement of power and speed for load equal to 50%, 75%, 100% and 110% of engine braking power</td>
<td>Project documents</td>
</tr>
<tr>
<td>Measurement of consumption of lube oil, coolant water and fuel oil</td>
<td>Project documents</td>
</tr>
<tr>
<td>Measurement of mechanical oscillation (vibration)</td>
<td>Project documents</td>
</tr>
<tr>
<td>Measurement of noise level</td>
<td>Project documents</td>
</tr>
<tr>
<td>Test of minimum number of starts</td>
<td>Project documents</td>
</tr>
<tr>
<td>Crankshaft deflection measurement at cold and hot condition</td>
<td>Project documents</td>
</tr>
<tr>
<td>Engine/Generator set overspeed protection test</td>
<td>IEC 60034-1</td>
</tr>
<tr>
<td>Vibration tests (run out, vibration on the shaft, vibration on bearings and operation of the lubrication system)</td>
<td>Project documents</td>
</tr>
<tr>
<td>Parallel operation, and load transference, voltage and frequency response for the biggest motor start up</td>
<td>Project documents</td>
</tr>
<tr>
<td>Tests on alarms, protection, metering devices, controls, signalling, switches and relays, including spare parts</td>
<td>Project documents</td>
</tr>
<tr>
<td>Continuous full rated load operation test (minimum 2h after temperature stabilization)</td>
<td>No failure or parameter out of range</td>
</tr>
<tr>
<td>Synchronizing tests</td>
<td>Project documents</td>
</tr>
<tr>
<td>Check of protection functions</td>
<td>Project documents</td>
</tr>
<tr>
<td>Check of lubrication oil ingress inside generator frame</td>
<td>No ingress</td>
</tr>
</tbody>
</table>

## 12. TECHNICAL DOCUMENTATION

12.1.1 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.

12.1.2 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.

12.1.3 MANUFACTURER shall list, in the data-sheet, the technical standards applied to the manufacturing and testing of the equipment, which complement the ones presented in section 3.1.

12.1.4 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.

12.1.5 Manufacturer shall provide all certification required by CS.
12.1.6 It shall be issued Brazilian Portuguese versions for all documents required by NR-12, besides the English version.

12.1.7 Documentation shall be send to PETROBRAS for approval.

12.1.8 A group of documents shall be supplied containing at least the following data:

a) Documents list;
b) List of standards applicable to the design, fabrication and tests;
c) Country of origin of the equipment;
d) List of similar previous supplies consistent with the specification requirements defined by PETROBRAS;
e) List of deviations from project documentation;
f) Utility consumption list;
g) List of all equipment, components, materials, parts, pieces, accessories and devices, with identification of manufacturer, part number and model;
h) Description service capabilities, price schedule and service support during testing, installation, commissioning, and maintenance.

i) Data sheets of all equipment duly filled out with technical data and all tests to be applied. Electrical auxiliary equipment and components shall have data-sheet issued, according to templates of I-LI-3010.00-5140-700-P4X-001 - ELECTRICAL EQUIPMENT DATA-SHEET MODELS;

j) Drawings of all equipment, showing lay-out of components, main dimensions, static and dynamic weights, center of gravity and minimum space for maintenance;

k) Specification or description of generator set protections, including settings;
l) Specification or description and diagrams of generator set lubrication system;
m) Specification of excitation system, with modules architecture, protection, communication and performance data;
n) Specification of painting system for generator and all accessories;
o) Technical catalogues of all generator components containing all information and technical characteristics;
p) List of sensors and instruments, with respective data;
q) Lifting drawings;
r) Drawings showing electrical, instruments and utilities end connections;
s) Drawings showing details of attachments and couplings;
t) Drawing showing the rotation direction;
u) One-line, multi-line, functional, logical and block diagrams for generator, excitation system, control panels and auxiliary components;
v) Power, control and instruments wiring and interconnection diagrams;
w) Complete source codes of all software related to controllers and electronic devices, including tables with parameters adjustments;

x) Mathematical models as indicated below:

- A detailed block diagram of the voltage regulator, including limiting actions and exciter blocks, to be used in dynamic performance studies of the system. Ranges for the settings and final setting of the voltage regulator shall be informed.

- A detailed block diagram for diesel generator, diesel engine and its speed regulator, to be used in dynamic performance studies (load shedding and load rejection-generation dropping studies). Ranges for the settings and final setting of the speed regulator shall be informed.

- A description of the coordinated combustion-speed regulation shall be furnished.

- Generator’s mathematical models, including all parameters.

y) Generator characteristics curves:

- Capability curves for at least 80% of rated ambient temperature, rated ambient temperature and 120% of rated ambient temperature;

- 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);

- 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), for at least 95% of rated voltage, rated voltage and 105% of rated voltage;

- Saturation curve (stator voltage x field current), for at least no load, rated load and zero power factor), at least 95% of rated voltage, rated voltage and 105% of rated voltage;

- No load characteristic curve;

- Exciter saturation curve (main rotor voltage x field current);

- Efficiency curve (efficiency x ambient temperature);

- Negative sequence curve (I2 x time);

- Overflux limit curve (V/Hz x time);

- V curves for at least 95% of rated voltage, rated voltage and 105% of rated voltage;

- 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.

z) Base forces and stress data;
aa) Location of grounding terminal(s);
b) Detailed drawings of Power Terminal Box, Neutral Connection Box, as well as details of installation and location of auxiliary boxes for control terminals;
cc) Lay-out of all holes for inlet of cables and/or conduit for all connecting boxes and panels, giving diameters of holes and characteristics of corresponding cables;
dd) Saturation curves for current transformers;
e) Curves showing voltage and frequency variations in terms of time, for sudden application of 30%, 50%, 80% and 100% of the generator rated load;
f) Calculation reports of adjustments of protection relays;
g) Calculation reports of voltage drop on start of biggest motor;
h) Final "as built" characteristics of generator group;
ii) Inspection and Tests Plan (PIT);
jj) CS Test Report;
k) Submission Noise Data presented in Forms I and II (Annex I).
ll) Starting air system calculation reports, with at least:
  • Power required by compressor unit;
  • Rack (x) pinion reduction factor;
  • Rotation of starting motor;
  • Manufacturers/model of starting motor;
  • Working pressure of starting motor;
• Consumption of compressed air, including three automatic starting cycles attempts;
• Air vessel capacity;
• Initial and final pressure in air vessel, considering three automatic starting cycles;
• Volume of air required at specified pressure;
• Requirements complying with NR-13.

mm) Spare part list recommended for 2 (two) years of operation shall be provided with the proposal, including prices;

nn) List of spare parts for commissioning and tests;

oo) List of unusual tools required for maintenance of the generator set;

pp) Calculation report of the diesel fuel consumption by engine at rated load;

qq) Calculation report of the diesel oil tank volume, indicating:
   • tank volume required;
   • period of operation without replenishment (at least 18h).

rr) Minimum height required for installing diesel tank so that oil may flow by gravity to the pump;

ss) Certificates of equipment for hazardous areas, if any.

12.1.9 It shall be furnished Operation Manuals for the control panel and devices included in generation package (EGC, AVR, Speed Governor, etc.). These documents shall be presented in English and Brazilian Portuguese. The manual contents shall include a minimum of:

a) Operation procedures;
b) Complete control and protection diagrams;
c) Logical diagrams, showing functional sequence of the control circuits for each one the operational conditions;
d) Panels interconnections diagrams;
e) Troubleshooting, repair and maintenance procedures;
f) Assembly, disassembly and installation procedures;
g) Attachment and coupling procedure manuals;
h) Lifting procedures;
i) Packing and transportation procedures;
j) Software and configurations procedures for controllers and electronic devices.
13. ABBREVIATIONS AND ACRONYMS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AISI</td>
<td>American Iron and Steel Institute</td>
</tr>
<tr>
<td>ANSI</td>
<td>American National Standard for Electric Power Systems and Equipment</td>
</tr>
<tr>
<td>AO</td>
<td>Analog Output</td>
</tr>
<tr>
<td>ASTM</td>
<td>American Society for Testing and Materials</td>
</tr>
<tr>
<td>AVR</td>
<td>Automatic Voltage Regulator</td>
</tr>
<tr>
<td>CSS</td>
<td>Control &amp; Safety System</td>
</tr>
<tr>
<td>CS</td>
<td>Classification Society</td>
</tr>
<tr>
<td>CT</td>
<td>Current Transformer</td>
</tr>
<tr>
<td>DO</td>
<td>Digital Output</td>
</tr>
<tr>
<td>EGC</td>
<td>Emergency Generator Controller</td>
</tr>
<tr>
<td>EGCP</td>
<td>Emergency Generator Power and Control Panel</td>
</tr>
<tr>
<td>HMI</td>
<td>Human-Machine Interface (current designation for MMI)</td>
</tr>
<tr>
<td>IEC</td>
<td>International Electrotechnical Commission</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>PMG</td>
<td>Permanent Magnetic Generator</td>
</tr>
<tr>
<td>VT</td>
<td>Voltage Transformer</td>
</tr>
</tbody>
</table>
14. ANNEX I - SUBMISSION NOISE DATA FORMS

FORM - I

GENERAL

| Equipment:          |                      |
| Code:               |                      |
| Supplier:           |                      |
| Proposal n°:        |                      |
| Date:               |                      |
| Submit According To Standard: |                  |
| (If Calculated Values Enclose Worksheets) |    |

OPERATING CONDITIONS (TEST)

| Flow m³/h: | Pressure (Bar Abs): |
| Rotation (rpm): | Load Condition: |
| Temperature (°C): | Control Valve Position (% Open): |

NOISE CONTROL DATA

<table>
<thead>
<tr>
<th>Enclosure</th>
<th>Manufac.:</th>
<th>Model:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muffler:</td>
<td>Manufac.:</td>
<td>Model:</td>
</tr>
<tr>
<td>Type:</td>
<td>Press. Drop</td>
<td>Face Velo</td>
</tr>
<tr>
<td>Flexible Blanket:</td>
<td>Manuf.:</td>
<td>Model:</td>
</tr>
</tbody>
</table>

ACOUSTICAL MEASUREMENT DATA

| Sound Level Meter: | Manufac. |
| Microphone | Manufac. | Serial: |
| Filter Set: | Manufac. |
| Fast | Slow | Impulse: | Leq: | Max. |

PRELIMINARY
<table>
<thead>
<tr>
<th>Guaranteed noise levels (Note 1)</th>
<th>dBA</th>
<th>Octave band centre frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>31.5</td>
</tr>
<tr>
<td>Lw</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lp (1)</td>
<td></td>
<td></td>
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<tr>
<td>Lp (2)</td>
<td></td>
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<tr>
<td>LP (3)</td>
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<tr>
<td>Lp (4)</td>
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</tbody>
</table>

ENCLOSE, I.L.
ENCLOSURE (enclosure absorption coefficient)
MUFFLER, D.I.L.

Expected vibration levels (Note 2)

Narrow band component, Yes / No

Frequency / octave band Hz: ______________________

Method / standard for noise level test:

Description of implemented noise control measures / other information:

<table>
<thead>
<tr>
<th>AS BUILT NOISE DATA</th>
<th>dBA</th>
<th>Octave band centre frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>31.5</td>
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ENCLOSE, I.L.
ENCLOSURE (enclosure absorption coefficient)
MUFFLER, D.I.L.

Special information:

Note 1
SPL  Sound pressure level in dB (re. 20µPa) at 1m distance free field conditions.

SWL  Sound power level in dB (re. 1 pW).

Note 2
VVL  Vibration velocity level in dB (re. 5x10^4 m/s) RMS on skid adjacent to support points.