PETROBRAS	**TECHNICAL SPECIFICATION**	No. I-ET-3010.00-5262-330-P4X-001	
	CLIENT: -		SHEET: 1 of 19
	JOB: -		
	AREA: -		
SRGE	TITLE: **SEA WATER DUMP LINE TURBOGENERATOR**		ESUP
			INTERNAL

INDEX OF REVISIONS

REV.	DESCRIPTION AND/OR REVISED SHEETS
0	ORIGINAL ISSUE

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
DATE	JAN/31/24								
EXECUTION	HR7O								
CHECK	DVHD								
APPROVAL	CXM6								

SUMMARY

1. OBJECTIVE

1.1. This technical specification covers the minimum technical requirements for the design, materials, fabrication, inspection, testing, preparation of shipment, installation, pre-commissioning and commissioning of SEA WATER DUMP LINE TURBOGENERATORS.

1.2. These requirements shall be complied with, in conjunction with other applicable SUPPLIER's Documents and Standards.

2. DEFINITIONS AND ABBREVIATIONS

2.1. Definitions

All terms and definitions are established in the latest revision I-ET-3010.00-1200-940-P4X-002 – General Technical Terms.

2.2. Abbreviations

CS: Classification Society
DAM: Dynamic Acquisition Module
FRP: Fiber Reinforced Plastic
g Gravitational acceleration
MMS: Machinery Monitoring System
MPS: Machinery Protection System
NPSH: Net Positive Suction Head
MROP: Minimum Required Outlet Pressure
P&ID: Piping and Instrumentation Diagram
RPVC: Rigid Polyvinyl Chloride
SS: Stainless Steel
UCP: Unit Control Panel

3. SCOPE OF SUPPLY

PACKAGER scope of supply shall include, but not necessarily be limited to, the following items:

- Submerged Turbine and Electric Generator assembly with anodes;
- Design of anodic protection, in order to ensure a 5-year system protection;
- Flanged riser pipes (pipe stack) with internal & external anodes, centralizers and coating;
- Centralizers for turbine set and pipe stack;
- Cartridge type Mechanical Seal;
- Top plate to interface with caisson top plate with built-in power tube and inlet pipe;
- Long radius inlet elbow with junction box;
- Turbine Throttle Valve;
- Vacuum-breaker valve and drain with valves;
- Cu-Ni 90/100 turbine outlet strainer;
- Cooling, lubrication and sealing systems;
- Hypochlorite injection line on the outlet of the turbine to prevent marine microorganisms and bacteria.
- Power and control junction boxes to interface topside/caissons.
- All necessary instrumentation, including accessories and mechanical supports;
- Electrical and instrumentation installation (including cable termination details, motor terminal box details, and grounding);
- All raw materials and consumables;
- Gaskets;
- Tightening bolts and nuts;
- Nameplates in Portuguese for all equipment and instruments;
- Surface preparation and painting appropriate for offshore environment, according to I-ET-3010.00-1200-956-P4X-002 – General Painting and DR-ENGP-I-1.15 – Color Coding;
- Spreader bars and specific handling devices for installation;
- Technical assistance during installation, pre-commissioning, start-up and commissioning phases;
- Safety signaling in Portuguese;
- All required tests performed at MANUFACTURER's shop;
- Coupling, assembly and alignment;

- Preparation for shipment and preservation, including equipment handling, conditioning and storage at job site;
- Consumables and special tools for assembly, disassembly, maintenance, commissioning and start-up;
- Spare parts recommended for commissioning, pre-operation, start-up, NR-13 tests and as per Classification Society;
- Warranty;
- A complete engineering package including design, fabrication, inspection, testing, commissioning documentation, certification and data required on this specification and Turbogenerator data sheets issued by BUYER;
- Other items as per SEA WATER DUMP LINE TURBOGENERATOR data sheets.

4. NORMATIVE REFERENCES

4.1. General

4.1.1. All equipment shall comply with the requirements of this technical specification, data sheets, documents, codes and standards as stated below and with those referred to herein.

4.1.2. All equipment parts and details not complying with any of these requirements shall be informed on a "*Deviation List*". Otherwise they will be considered as "Agreed", and so required.

4.1.3. Any conflict between the requirements of this specification and related codes and standards, specification, etc. shall be presented in writing for BUYER's resolution prior to manufacturing.

4.2. Applicable Codes, Standards and Governmental Regulations

The following codes and standards shall be fully complied with:

API RP 582	Welding Guidelines for the Chemical, Oil, and Gas Industries
API STD 610	Centrifugal Pumps for Petroleum, Petrochemical, and Natural Gas Industries
API STD 670	Machinery Protection Systems
API STD 682	Pumps – Shaft Sealing Systems for Centrifugal and Rotary Pumps
API STD 541	Form-wound Squirrel Cage Induction Motors – 375 kW (500 Horsepower) and Larger
API-RP-2A	Planning, Designing and Constructing Fixed Offshore Platforms Working Stress Design
ASME B16.47	Large Diameter Steel Flanges NPS 26 Through NPS 60 Metric/Inch Standard
ASME B16.5	Pipe Flanges and Flanged Fittings NPS ½ Through NPS 24 Metric/Inch Standard
ASME B31.3	Process Piping
AISC 335-89	Specification for Structural Steel Buildings Allowable Stress Design And Plastic Design
ASME BPVC VIII-1	Rules for Construction of Pressure Vessels
AWS D1.1/D1.1M	Structural Welding Code – Steel
IEC 60034	Rotating Electrical Machines
IEC 60092-502	Electrical Installation in Ships-Tankers-Special Features
IEC 60193	Hydraulic Turbine, Storage Pumps and Pump-Turbines – Model Acceptance Tests
IEC 61892-all parts	Mobile and Fixed Offshore Units – Electrical Installation
INMETRO	Portaria n° 115, March 21st 2022
ISO 15156-all parts	Petroleum and Natural Gas Industries: Materials for Use in H2S-Containing environments in Oil and Gas Production
NR-10	Brazilian Government Regulation – Norma Regulamentadora Nº 10, Segurança em Instalações e Serviços em Eletricidade)
NR-12	Brazilian Government Regulation – Norma Regulamentadora Nº 12, Segurança em Instalações e Serviços em Máquinas e Equipamentos)
NR-13	Brazilian Government Regulation – Norma Regulamentadora Nº 13, Caldeiras, Vasos de Pressão, Tubulações e Tanques Metálicos de Armazenamento)
NR-26	Brazilian Government Regulation – Norma Regulamentadora Nº 26, Sinalização de Segurança)
NR-37	Brazilian Government Regulation – Norma Regulamentadora Nº 37, Segurança e Saúde em Plataformas de Petróleo)
TEMA	Standards of Tubular Exchanger Manufactures Association Classification Society Rules for Offshore Facilities

Brazilian Government regulations are mandatory and shall prevail, if more stringent, over the requirements of this specification and other references herein. PACKAGER/MANUFACTURER shall comply with any other government regulations stated in the Contract and not listed above.

4.3. Applicable Documents

The following design documents shall be fully complied with:

4.3.1. Typical Documents

- **General**

I-ET-3000.00-0000-940-P4X-002	Symbols for Production Units Design
I-ET-3000.00-1200-940-P4X-001	Tagging Procedure for Production Units Design
I-ET-3010.00-1350-940-P4X-001	Systems Operation Philosophy

- **Safety**

DR-ENGP-M-I-1.3	Safety Engineering
I-ET-3010.00-5400-947-P4X-002	Safety Signaling

- **Mechanical**

DR-ENGP-I-1.15	Color Coding
I-ET-3010.00-1200-251-P4X-001	Requirements for Bolting Materials
I-ET-3010.00-1200-540-P4X-001	Requirements for Pressure Vessels Design and Fabrication
I-ET-3010.00-1200-955-P4X-001	Welding
I-ET-3010.00-1200-200-P4X-115	Requirements for Piping Fabrication Assembly and Commissioning
I-ET-3010.00-1200-956-P4X-002	General Painting
I-ET-3010.00-1200-751-P4X-001	Anodes Specification for Mechanical Equipment
I-ET-3010.00.1200-200-P4X-003	Design, Construction and Assembly of FRP Piping
I-ET-3010.00-1200-300-P4X-001	Noise and Vibration Control Requirements

- **Electrical**

I-DE-3010.00-5140-700-P4X-003	Grounding Installation Typical Details
I-DE-3010.00-5140-797-P4X-001	Electrical System Automation Architecture Diagram
I-ET-3010.00-5140-700-P4X-002	Power Installation Typical Details
I-ET-3010.00-5111-712-P4X-001	Submersible Induction Motors for Sea Water Lift Pumps for Offshore Units
I-ET-3010.00-5140-797-P4X-001	Electrical System Automation Architecture
I-ET-3010.00-5140-700-P4X-003	Electrical Requirements for Packages for Offshore Units

- **Instrumentation and Automation**

I-ET-3010.00-1200-800-P4X-002	Automation, Control and Instrumentation on Package Units
I-ET-3010.00-1200-800-P4X-013	General Criteria for Instrumentation Projects
I-ET-3010.00-5500-854-P4X-001	Machinery Monitoring System (MMS).

- **Naval**

I-ET-3010.00-1350-960-P4X-001	Design Requirements – Naval Architecture

4.3.2. Specific Project Documents

This section specifies documents that are referenced along the text and are part of a specific project. For that reason, the document identification number is not yet defined and may vary according to project. The document title may also vary slightly from one project to another. Project DOCUMENT LIST shall be consulted in order to verify the correct document number and title.

- **General**

– DOCUMENT LIST
– GENERAL ARRANGEMENT (DRAWING)
– METOCEAN DATA

- **Process / Safety**

– SEA WATER DUMP LINE TURBOGENERATOR (DATASHEET)

- GENERAL SPECIFICATION FOR AVAILABLE UTILITIES
- SEA WATER DUMP LINE TURBOGENERATOR (P&ID)
- AREA CLASSIFICATION – GENERAL

- **Mechanical**

- PIPING SPECIFICATION FOR TOPSIDE
- TOPSIDE'S MECHANICAL HANDLING PROCEDURES

- **Structure**

- SEAWATER CAISSONS (DRAWING)

- **Instrumentation and Automation**

- AUTOMATION INTERFACE OF PACKAGE UNITS

- **Naval**

- MOTION ANALYSIS

5. PACKAGER RESPONSIBILITY

5.1. PACKAGER / MANUFACTURER is responsible for the complete design, fabrication, inspection, testing, and supply of the components and spares, in full compliance with the requirements of this specification, its attachments and all applicable codes, standards and regulations referenced and, where applicable, the requirements of the Classification Society.

5.2. PACKAGER / MANUFACTURER is responsible for equipment certification and approval as required by Classification Society rules. CS rules may only be waived upon the formal approval from the CS itself and from BUYER.

5.3. PACKAGER / MANUFACTURER shall communicate directly with Classification Society and provide all documentation necessary to obtain approvals. BUYER shall be copied on all correspondence between PACKAGER / MANUFACTURER and Classification Society.

5.4. PACKAGER / MANUFACTURER shall obtain approval for all parts of their work as required by Classification Society before shipment of the equipment to the shipyard.

5.5. PACKAGER shall assume sole contractual and total engineering responsibility for the items supplied.

5.6. PACKAGER's responsibility shall also include but not be limited to:

- Resolving all engineering questions and/or problems relating to design and manufacture.
- Providing details as requested, for the main and auxiliary equipment, relating to design and manufacturing.
- Training.

5.7. Compliance by the PACKAGER with the provisions of this specification does not relieve the PACKAGER's responsibility to furnish equipment and accessories of a proper mechanical design suited to meet the specified service conditions.

5.8. PACKAGER is responsible for all coordination with MANUFACTURERS and collections of all details, drawings and data to achieve optimum design and full submission of all documents requested in this specification.

5.9. PACKAGER / MANUFACTURER shall indicate all installation and commissioning activities that require PACKAGER / MANUFACTURER's supervision, and submit them for BUYER approval.

6. DESIGN REQUIREMENTS

6.1. Design Life

6.1.1. Equipment shall be designed for a 30-year life in a corrosive offshore environment without the need for replacement of any major component due to weather, corrosion, fatigue, or material failure.

6.1.2. PACKAGER / MANUFACTURER shall include a schedule stating the expected time between major overhauls.

6.2. Safety Requirements

6.2.1. Personnel safety protection shall be provided according to Brazilian Government Regulations (NR).

6.2.2. All safety signs, warning signs and notices shall be in Brazilian Portuguese and shall be provided where risk of personnel injury exist.

6.2.3. Safety signaling shall be in full compliance with I-ET-3010.00-5400-947-P4X-002, "*Safety Signaling*".

6.2.4. For area classification see the drawing AREA CLASSIFICATION – GENERAL [document supplied by BUYER].

6.2.5. Mandatory safety items, as established in DR-ENGP-M-I-1.3, "*Safety Engineering*", shall be considered complementary requirements, to the pertinent extent. In case of items in conflict with this document, BUYER shall be consulted.

6.2.6. HAZOP and PHA shall be performed according to DR-ENGP-M-I-1.3, "*Safety Engineering*".

6.2.7. Double block & bleed arrangements are required for isolation of equipment in piping classes of 300# and above.

6.3. Environmental Conditions

6.3.1. The equipment supplied shall be suitable for the marine environment and range of ambient conditions defined in METOCEAN DATA [document supplied by BUYER].

6.4. Motion and Acceleration Requirements

6.4.1. The necessary design data and information on motion requirements are given by MOTION ANALYSIS [document supplied by BUYER].

6.4.2. PACKAGE shall be able to withstand and operate in accordance with I-ET-3010.00-1350-960-P4X-001, "*Design Requirements - Naval Architecture*".

6.4.3. PACKAGER / MANUFACTURER shall design the PACKAGE to operate under inclination conditions as per Classification Society rules. These conditions may occur simultaneously.

6.4.4. Pipe stack design shall comply with motion and acceleration requirements, in order to avoid impacts against inner caisson surface and avoid damage to auxiliary piping (cooling, sealing, etc.).

6.5. Equipment Location

6.5.1. The turbine shall be installed submerged inside of steel caissons, at a location defined on GENERAL ARRANGEMENT drawing [document supplied by BUYER], supplied and fitted by SUPPLIER.

6.5.2. The design of the turbogenerator and pipe stack assembly shall ensure the turbine minimum operational submergence, as defined by the MANUFACTURER, in all draft conditions.

6.5.3. The turbine shall be fully contained inside the caisson, which will be lengthened until the vessel hull bottom.

6.5.4. PACKAGE layout and arrangement shall be designed to allow ease of operation and maintenance, and to maximize safety.

6.6. Operability

6.6.1. The PACKAGER and the SELLER shall interact to ensure that all resources are available in the UNIT to allow safe and reliable operation of the Turbogenerator, including startup and shutdown scenarios.

6.7. PACKAGE Requirements

6.7.1. The utility requirements and consumption of the equipment shall be clearly defined by PACKAGER. This information shall also be included in the quotation. The consumption of utilities shall comply with the requirements of GENERAL SPECIFICATION FOR AVAILABLE UTILITIES [document supplied by BUYER].

6.7.2. Turbogenerator PACKAGE, including all auxiliary equipment, shall be assembled to the maximum extent possible, aligned and pre-checked in MANUFACTURER'S/ PACKAGER'S shop, allowing shipment to the integration yard with minimal field integration activities.

6.7.3. Turbogenerator PACKAGE shall be manufactured, inspected and verified to comply with all specifications mentioned in Normative References and Classification Society regulations. Turbogenerator PACKAGES shall be supplied complete, approved by CS and ready for erection on board.

6.7.4. For foreign made equipment, the standard manufacturing parts (couplings, mechanical type seals, bearings) shall be purchased from Manufacturers with representative branches located in Brazil, with service parts and maintenance workshops.

6.7.5. The design of the Turbogenerator shall comply with standards and reference documents listed at section NORMATIVE REFERENCES.

6.7.6. The Turbogenerator assembly shall be of vertical construction and installed inside of steel caissons, supplied and fitted by SUPPLIER.

6.7.7. PACKAGER shall design and supply a capacity control system including throttle valve and flow metering instrument.

6.7.8. PACKAGER shall provide a throttle valve calculation report, ensuring adequate sizing for startup and continuous operation conditions.

6.7.9. PACKAGER shall design and supply the overspeed protection system.

6.7.10. Sodium hypochlorite shall be routed to the turbine outlet through the top plate, along the pipe stack.

6.7.11. Material selection for hypochlorite injection piping shall be sent for BUYER approval. For FRP piping system requirements refer to I-ET-3010.00-1200-200-P4X-003, "*Design, Construction and Assembly of FRP Piping*".

6.7.12. PACKAGER / MANUFACTURER shall provide strainers at the outlet of the turbine and any other opening that communicates with the outlet.

6.7.13. Turbogenerator re-assembling after the generator or turbine disassembly shall require alignment only in radial direction. The Turbogenerator assembly parts shall provide alignment in the axial direction. Alignment-positioning jackscrews shall be provided in accordance with API Std 610 requirements for vertically suspended pumps.

6.7.14. Anti-corrosion system shall comply with the following requirements:

a) The system shall ensure the corrosion protection of the entire extent of the Turbogenerator assembly, including pipe stack, and the submerged sections of the caissons considering at least 5 years of operational availability.

b) The system shall include sacrificial anodes and coating to be designed, supplied and installed by the Turbogenerator PACKAGER / MANUFACTURER.

c) Sacrificial anodes shall comply with I-ET-3010.00-1200-751-P4X-001, "*Anodes Specification for Mechanical Equipment*" and the coatings shall comply with I-ET-3010.00-1200-956-P4X-002, "*General Painting*".

d) PACKAGER / MANUFACTURER shall provide a descriptive report detailing the analyses performed and obtained results which ensure adequate cathodic protection for the entire section of the turbogenerator assembly and caissons.

6.7.15. The design of selected anodes shall be suitable to erosive action of the flow.

6.7.16. PACKAGER shall carry out a Torsional Critical Speed Analysis complying with the requirements and acceptance criteria of API 610.

6.7.17. PACKAGER shall carry out a Lateral Rotordynamic Analysis complying with the requirements and acceptance criteria of API 610.

6.7.17.1. The Turbogenerator's runaway speed shall be considered as the rotor maximum operating speed for the Lateral Analysis.

6.7.17.2. The Turbogenerator's runaway speed shall be defined as the rotor speed at maximum water flowrate and minimum torque condition (open circuit breaker).

6.8. Performance

6.8.1. PACKAGE shall be designed for flow and head conditions specified in datasheets SEA WATER DUMP LINE TURBOGENERATOR [document supplied by BUYER].

6.8.2. The rated flow shall be located within 90% and 110% of the turbine's best efficiency point.

6.8.3. The Turbogenerator shall be designed to operate at rated flow with the minimum draft and considering the variation of the sea wave height.

6.8.4. PACKAGE shall be designed to operate at a maximum flow of at least 130% of rated flowrate. MANUFACTURER shall inform the minimum required outlet pressure (MROP) at this condition.

6.8.5. A draft tube may be installed at the turbine outlet to optimize hydraulic power recovery.

6.8.6. The turbine may have adjustable Inlet Guide Vanes for capacity control.

6.9. Turbine Casing

6.9.1. The whole turbine casing shall have a pressure rating allowing it to be tested at the hydrostatic test pressure of the upstream system design pressure by mounting blinds on the outlet and the inlet flange.

6.10. Generator

6.10.1. General

6.10.1.1. The generator and all auxiliary systems shall be suitable for continuous operation at full load and for a time interval compatible with that of the driving machine and no lower than 40,000 hours.

6.10.1.2. The generator shall be dynamically balanced and capable of withstanding the Turbogenerator's runaway speed for 2 (two) minutes.

6.10.1.3. The generator shall be capable to supply power under normal operation when connected to a switchboard with voltage bus variation in the range between 95% and 105% of rated voltage of the latter.

6.10.1.4. Unless otherwise specified in the datasheet, the generator's switchboard, terminal box and accessories shall have minimum IP56W protection degree, 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 IP55W. When installed in utilities rooms or machinery rooms the minimum protection degree shall be IP54W. The suffix W is only applicable for terminal boxes.

6.10.1.5. The generator performance under short-circuit current condition shall be evaluated in order to keep the short-circuit current in its switchboard within the limits defined by ET-3010.00-5140-700-P4X-001, "*Specification for Electrical Design for Offshore Units*" when:

a) Generator is in parallel operation with Main Generation;
b) Generator is in parallel operation with Auxiliary Generation;

6.10.2. Electrical Characteristics

6.10.2.1. The generator shall be constructed according to API Std 541 and IEC 60034-1. Additionally, it shall comply with IEC 61892-3 and applicable Classification Society rules.

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

a) The current in any of the phases does not exceed 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.

6.10.2.3. The generator shall be able to operate continuously in the grounding conditions of the electrical system to which it will be connected.

6.10.2.4. The minimum rated efficiency to be serviced for rated operating conditions (apparent power, power factor, voltage and frequency) shall be as per datasheet and agreed with PETROBRAS.

Note: The efficiency values are subject to the tolerances indicated in IEC 60034-1.

6.10.2.5. The generator shall comply with THD and individual harmonic limits, both for voltage and current as per IEC 61892-3.

6.10.3. Insulation

6.10.3.1. The generator windings shall have vacuum impregnated insulation and shall be designed and constructed to be compatible with the barrier fluid defined by the manufacturer.

6.10.3.2. Both stator and rotor windings insulation shall be class F or higher, as per IEC 60085 and IEC 60034-18-1. However, the temperature at the windings hottest point shall not exceed class B insulation temperature limit (see IEC 60034-1), considering the operation at rated operating conditions.

6.10.3.3. All coils shall have stress grading and anti-corona protection, achieved using a semiconductive tape, in the slot part of the coil.

6.10.4. Nameplate Boards, Identification and Safety Warnings

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

a) Petróleo Brasileiro S.A. - PETROBRAS;
b) Nome do fabricante (*manufacturer name*);
c) Data de Fabricação (*date of manufacture*);
d) Name of the PETROBRAS Business Unit (UN);
e) "TAG" of the generator;
f) Número de série, código de data (*serial number, date code or other indication making it possible to recognize the type of manufacture*);
g) Número da Requisição de Material (*Material Requisition number - RM*);
h) Número da Ordem de Compra ou de Bens e Serviços (*Purchase order number – PC or purchase order of goods and Services – PCS, in cases of purchase processes directly carried out by PETROBRAS*)
i) Potência nominal (*rated power*);
j) Tensão nominal (*rated voltage*);
k) Corrente nominal (*rated current*);
l) Frequência nominal (*rated frequency*);
m) Número de fases (*number of phases*);
n) Sequência de fases (*phase sequence*);
o) Rotação nominal (rated *r.p.m.*);
p) 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*));
q) Conexão das bobinas (*connections of windings, indicated by symbols*);
r) Fator de potência nominal (*rated power factor*).

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

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

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

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

6.10.4.6. Complementary warnings, as required by NR-10 and NR-12, shall be verified in PROJECT ARCHITECTURE MATERIALS AND EQUIPMENT SPECIFICATION, I-ET-3010.00-5400-947-

P4X-002 - SAFETY SIGNALLING and I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

6.11. Coupling and Guards

6.11.1. The Turbogenerator shall be either of close-coupled type or flexibly coupled with flexible disc type coupling.

6.12. Cooling, Lubrication and Sealing Systems

6.12.1. Submerged type electric generators shall comply with the following requirements:

6.12.1.1. Barrier fluid shall be biodegradable and properly selected to ensure adequate cooling, lubrication and sealing during turbine normal operation.

6.12.1.2. Cooling and lubrication systems shall be over pressurized to avoid seawater ingress during installation, start-up, shutdown and normal operation.

6.12.1.3. Cooling, lubrication and sealing/return fluid lines shall be supplied in metallic tubing. Flexible hoses may only be used in sections above the maximum water line.

6.12.1.4. Mechanical seal design shall be of cartridge type and suitable for turbine pressure surges during normal starting and shutdown procedures, avoiding generator contamination due to sea water and debris accumulation.

6.12.1.5. Oil-based generator lubrication/cooling media shall not be used.

6.12.1.6. Water based generator lubrication/cooling shall not be used.

6.12.2. Electric generators mounted on the top plate shall comply with the following requirements:

6.12.2.1. Radial and thrust bearings shall be oil lubricated and of rolling element type.

6.12.2.2. Intermediate line-shaft bearings (spider bearings) shall be able to run dry during shut down and startup transients, during which air might still be in the dump line. PACKAGER shall define the adequate dry-run time to be considered for this condition.

6.13. Piping and Caisson

6.13.1. All piping with sea water as process fluid shall be designed, fabricated, and inspected in accordance with ASME B31.3 and the PIPING SPECIFICATION FOR TOPSIDE [document supplied by BUYER]. Threaded connections shall not be used.

6.13.2. All connections shall be located above the top plate and provided with flanged connections according to ASME B16.5 and the PIPING SPECIFICATION FOR TOPSIDE [document supplied by BUYER]. Locations, size, and rating of all connections shall be clearly defined by PACKAGER / MANUFACTURER.

6.13.3. PACKAGER / MANUFACTURER shall install centralizers with reduced clearance between the turbine and the inner caisson surface.

6.13.3.1. Centralizers radial clearance shall not exceed 10 mm.

6.13.3.2. The centralizer pads shall be made of nonmetallic material and shall be designed to withstand mechanical loads during start-up, shutdown, normal operation and assembly / disassembly procedures, ensuring that no direct metal to metal contact will occur between turbine casing and caisson.

6.13.4. PACKAGER / MANUFACTURER shall provide prior to installation the drawing of the centralizer, with dimensional tolerances, from which a template shall be manufactured by SUPPLIER. This drawing shall contain the dimensional tolerances of the caisson, both in diameter and length. Template manufactured by SUPPLIER shall be used to check if the caisson dimensions comply with the specification and tolerances.

6.13.5. Sealing/return lines and external power/instrumentation cables shall be positioned close to the central region of the centralizers and clamped to the main pipe stack, away from the inner caisson surface, and routed along the length of the pipe stacks.

6.13.6. The Turbogenerator assembly shall be provided with adequate clearance between centralizers and the internal caisson surface to guarantee the stiffness of the set against lateral movements inside the caisson, without compromising the assembly / disassembly.

6.13.7. PACKAGER / MANUFACTURER shall provide a report with modal analysis and structural calculations for the fatigue analysis of the top support of the pipe stacks, considering permanent / transient operation, their submergence and movements of the UNIT.

6.14. Manufacturing

6.14.1. All materials and equipment shall be new and from BUYER's Approved Manufacturer's List. Any material used in the fabrication of the PACKAGE from an unapproved MANUFACTURER will be rejected, removed and replaced at PACKAGER/ MANUFACTURER's expense.

6.14.2. All equipment and components shall be manufactured up to two years before the delivery date at most.

6.15. Noise and Vibration

6.15.1. Noise and vibration control concerning human exposure shall be performed according to I-ET-3010.00-1200-300-P4X-001, "*Noise and Vibration Control Requirements*". Noise data is required for the final proposal and after the FAT.

6.16. Pressure Vessels

6.16.1. Pressure vessels within Turbogenerator PACKAGE shall be in accordance with I-ET-3010.00-1200-540-P4X-001 – Requirements for Pressure Vessels Design and Fabrication.

6.17. Special Tools and Spare Parts

6.17.1. All special tools necessary for the installation, alignment, operation or maintenance of the equipment shall be supplied upon PACKAGE delivery.

6.17.2. Spare parts required for NR-13 tests and those recommended by Classification Society shall be provided.

6.17.3. If the Classification Society has no requirements but only a guide list for spare parts, this guide list shall be understood by PACKAGER / MANUFACTURER as mandatory requirement together with MANUFACTURER's recommendation and shall be furnished at no extra cost to BUYER.

6.17.4. All special tools and spare parts shall be detailed in the packing list and shall be consistent with the lists issued for the engineering documentation.

6.17.5. Special tools and spare parts shall have an item number in the packing list, which shall match the item number fixed on the packing.

6.18. Maintenance Handling

6.18.1. PACKAGER / MANUFACTURER and SUPPLIER shall follow the requirements for maintenance handling on TOPSIDE MECHANICAL HANDLING PROCEDURES [document supplied by BUYER].

6.18.2. PACKAGER / MANUFACTURER shall supply spreader bars, slings and specific handling devices for installation and maintenance with the applicable certificates.

6.18.3. All necessary maintenance lift beams shall be provided to facilitate safe and easy maintenance.

6.18.4. SUPPLIER shall design all structural components, including calculation report and detailing drawings. SUPPLIER shall fabricate and assembly the support structures in accordance with AISC 335-89 – Specification for Structural Steel Buildings Allowable Stress Design and Plastic Design and API-RP-2A - Planning, Designing, and Constructing Fixed Offshore Platforms Working Stress Design.

6.18.5. Lifting pad eyes shall be designed in accordance with project Classification Society or Marine Warranty Surveyor Rules.

7. MATERIALS

7.1. Turbogenerator material selection shall be according to API Std 610 Table H Class D2 or Bronze Nickel Aluminum alloy.

7.2. Turbine outlet strainer's material shall be Cu-Ni 90/10 alloy and it shall be electrically isolated. The strainer design shall provide flow velocities within Cu-Ni 90/10 alloy velocity limit. Polymeric materials are not accepted.

7.3. Dissimilar materials in contact with an electrolyte shall be isolated to avoid galvanic corrosion. The only exception shall be the interface between the Turbogenerator assembly and the caisson, which shall be electrically connected to ensure the effectiveness of the cathodic protection.

8. ELECTRICAL

8.1. All electrical equipment shall be manufactured and tested in compliance with Classification Society and IEC requirements, unless otherwise stated.

8.2. Electrical equipment and materials shall comply with I-ET-3010.00-5140-700-P4X-002, "*Specification for Electrical Material and Equipment for Offshore Units*" and I-ET-3010.00-5140-700-P4X-003, "*Electrical Requirements for Packages for Offshore Units*".

8.3. In the case of induction generator, such electric machinery shall comply with I-ET-3010.00-5111-712-P4X-001, "*Submersible Induction Motors For Sea Water Lift Pumps For Offshore Units*.

9. CONTROLS AND INSTRUMENTATION

9.1. General

9.1.1. Package Automation System (PAS) shall supervise and control the generator and its auxiliaries.

9.1.2. Package Automation System (PAS) shall be designed to ensure safe and reliable operation, performing sequencing, interlocking, protection, control and monitoring during starting, operation, normal stop and emergency shutdown. The PAS shall not allow undesirable nor unsafe operations. PAS shall be furnished functionally assembled and tested.

9.1.3. PACKAGER / MANUFACTURER shall ensure that the equipment is properly certified for the specified classification. For further information see FIELD INSTRUMENTATION specification [document supplied by BUYER].

9.1.4. PACKAGE automation type classification shall be according to AUTOMATION INTERFACE OF PACKAGED UNITS specification [document supplied by BUYER] .

9.1.5. The PACKAGE automation, control and instrumentation shall fully comply with I-ET-3010.00-1200-800-P4X-002, "*Automation, Control and Instrumentation on Package Units*" and I-ET-3010.00-1350-940-P4X-001, "*Systems Operation Philosophy*".

9.1.6. All instrumentation and alarms/trips mentioned in the data sheets and P&IDs are the minimum required by PETROBRAS, as well as required by international standards. PACKAGER and BIDDER may indicate other instrumentation and alarms/trip for general protection and monitoring, according to their experience and for compliance with Classification Society requirements and submit them to PETROBRAS for approval.

9.1.7. All requirements for PAS shall be checked during Factory Acceptance Test (FAT), Factory Integration Test (FIT) and Site Acceptance Test (SAT) according to IEC 62381 and Classification Society rules.

9.1.8. The classification of PAS according to automation interface shall be as per Technical Specification AUTOMATION INTERFACE OF PACKAGE UNITS and I-ET-3010.00-1200-800-P4X-002, "*Automation, Control and Instrumentation on Package Units*".

9.1.9. PACKAGER and BIDDER shall provide to PETROBRAS all keys, drivers, manuals, installation media and licenses of all software inside package, including all development tools. No software access restrictions will be accepted by PETROBRAS.

9.1.10. All proper means of electrical and environmental protection shall be applied to all instruments and electrical equipment, particularly those located in hazardous areas and/or an aggressive saline air

environment. Instruments and electrical equipment shall comply with IEC 60079 and they shall be at least IP 56.

9.1.11. In order to guarantee adequacy to IEC 61892-7, all instruments, electrical equipment and panels related to automation and instrumentation installed in outdoor areas shall be certified with the type of protection and EPL suitable for installation in hazardous areas Zone 2, Group IIA, temperature T3.

9.1.12. PAS shall not be restarted without manual acknowledgement of the shutdown conditions.

9.2. PAS SOFTWARE

9.2.1. The control system HMI shall enable changes of set points, timer presets and control parameters, input by-passing, output override with the system in operation, without damage to the process.

9.2.2. The control system programming and configuration shall be carried out by the HMI or, additionally, through a laptop computer (not provided by PACKAGER or PURCHASER) with software editor. The software editor shall be provided by PACKAGER.

9.2.3. PACKAGER shall provide HMI supervisory software (runtime and development tool) running on Windows environment, compatible with the size of the application and in its latest version. Software shall be supplied, installed, configured in the HMI and provided with complete manuals / electronic media. Software licenses shall also be provided.

9.2.4. Access to configuration and programming shall be protected by change management tools, including specific passwords with several levels, such as: general, operation, maintenance and engineering. All passwords shall be delivered to PETROBRAS with no access restrictions.

9.2.5. The alarm annunciator units shall comply with ISA-18.1, according to the sequence F2M-1 (manual reset first out with no subsequent alarm flashing and silence pushbutton. Alarm Management Systems shall comply with ISA -18.2).

9.2.6. The control system programming shall be in accordance with PETROBRAS specification. PURCHASER proposal shall inform the programming language used in the system.

9.2.7. PACKAGER shall develop and supply an HMI Study Report considering Human Factors, usability and Safety aspects.

9.3. PAS SYSTEM

9.3.1. PAS shall be capable of carrying out start-up, normal operation, normal stop, emergency shutdown and safety procedures for generator and auxiliary equipment, also including all the required interfaces to connect with Protective Relays, Machinery Protection System (MPS), Hull Generator Auxiliary Loads Motor Control Center (MCC) and other controls and security systems, such as: Control and Safety System (CSS), Power Management System, Asset Management System (AMS) and Machinery Monitoring System (MMS).

9.3.2. PAS shall include, at least, the following functions:

- Automatic and manual start-up, normal/emergency stop, purge and emergency shutdown sequences without causing any damage to equipment or process instability;
- Speed monitoring;
- Indication and recording of unit malfunction / shutdown, event signals and all machinery sequences (such as start-up, normal stop, etc.);
- Monitoring and control of all variables, alarms and shutdown signals with HGCP HMI indication, as described in PETROBRAS specifications (such as temperature, pressures, etc. indicated in P&IDs and data sheets);
- Generator voltage, amperage and frequency monitoring;
- Generator amperage control;
- Automatic generator stop under PMS request (discrete signal);
- Active / reactive power output readings.
- PAS shall send and receive hardwire signals to/from CSS (Control and Safety System) according to AUTOMATION INTERFACE OF PACKAGE UNITS SPECIFICATION.

9.3.3. PAS shall send and receive hardwire signals to/from Electrical System according to I-LI-3010.00-5140-797-P4X-001, "*Electrical System Automation Interface Signals List*".

9.3.4. PAS shall include online testing and self-diagnosis facilities, in order to allow the maintenance technician identify failures, enabling corrective maintenance without causing unit shutdown and avoiding operation without any safety function.

9.3.5. In case of power failure, system shall retain all programs and data as well as interface software for a minimum of six months, not being necessary to reconfigure the system after power restore. During a power failure, all outputs shall be automatically changed to their safe position.

9.3.6. Generator protection relays shall be synchronized as per I-ET-3010.00-5140-797-P4X-001, "*Electrical System Automation Architecture*" and I-DE-3010.00-5140-797-P4X-001, "*Electrical System Automation Architecture Diagram*". The synchronism shall be integrated to A&C clock.

9.3.7. Connectivity to external system through open communication protocols shall be MODBUS and OPC UA (Open Platform Communications Unified Architecture) by Ethernet TPC/IP Protocol. All I/O variables, controllers and first out events shall be available. A full list of available digital signals shall be provided for PETROBRAS.

9.3.8. The philosophy for PAS integrating into the control and operation systems of its installation site is defined at AUTOMATION INTERFACE OF PACKAGED UNITS SPECIFICATION, AUTOMATION AND CONTROL ARCHITECTURE DIAGRAM, I-ET-3010.00-1200-800-P4X-002, "*Automation, Control and Instrumentation on Package Units"*, I-DE-3010.00-5140-797-P4X-001, "*Electrical System Automation Architecture Diagram*", I-ET-3010.00-5140-797-P4X-001, "*Electrical System Automation Architecture*" and I-LI-3010.00-5140-797-P4X-001, "*Electrical System Automation Interface Signals List*".

9.3.9. The control system shall include generator electrical protective relays and others dedicated protections. Generator protection shall comply with I-ET-3010.00-5143-700-P4X-001, "*Electrical System Protection Criteria*".

9.3.10. External supply for power, control, lighting and heating of HGCP shall comply with I-ET-3010.00-5140-700-P4X-003, "*Electrical Requirements for Packages for Offshore Units*", including autonomy time, in case of systems supplied from UPS. Manufacturer shall include any necessary voltage converters in case of necessity of different values. Deviations shall be submitted for PETROBRAS approval.

9.3.11. Optical converters shall be provided for external network communication for each HGCP panel. Optical fiber communications cables shall be also provided for communicating the different control modules.

9.3.12. The PAS interface with AMS shall be as described in AUTOMATION INTERFACE OF PACKAGED UNITS SPECIFICATION.

9.4. Automation, Control and Instrumentation System Cabling

9.4.1. In addition to requirements of I-ET-3010.00-1200-800-P4X-002 *Automation, Control And Instrumentation On Package Units*, Automation, Control and Instrumentation cables shall comply with the following requirements:

9.4.1.1. All wiring within the limits of the enclosure shall be clearly marked on the wire and at the terminal.

9.4.1.2. All cabling between the driver and the local gauge board shall be furnished. All cables and cable routes shall contain at least 20% of the extra capacity.

9.5. Alarms and Shutdown

9.5.1. The minimum alarm and shutdown functions shall be as required on the P&ID SEA WATER DUMP LINE GENERATION [document supplied by BUYER] and on the specification AUTOMATION INTERFACE OF PACKAGED UNITS [document supplied by BUYER].

9.5.2. PACKAGER/MANUFACTURER shall provide temperature monitoring system for electric generator bearings, and signals shall be addressed to MPS.

9.5.3. PACKAGER/MANUFACTURER shall inform bearing temperature sets for alarm and shutdown.

9.5.4. Submersible type electric generators shall have suitable instrumentation to provide an alarm in the event of either seawater ingress or loss of generator cooling fluid.

9.5.5. Relays shall be provided in the control panels to isolate the remote start and stop contacts from the control panel's voltage.

9.5.6. For a list of signals exchanged between PACKAGE and the automation systems, consult the specification for AUTOMATION INTERFACE OF PACKAGED UNITS [document supplied by BUYER].

9.5.7. SUPPLIER shall demonstrate that alarms and trips can be tested without the need to disconnect piping and/or electrical connections or use jump wires.

9.6. Monitoring Requirements

9.6.1. The equipment that shall be monitored and the monitoring requirements shall be according to I-ET-3010.00-5500-854-P4X-001, "*Machinery Monitoring System (MMS)*".

9.6.2. All monitoring sensors shall be compatible with MPS/DAM, as described in I-ET-3010.00-5500-854-P4X-001, "*Machinery Monitoring System (MMS)*".

9.6.3. All monitoring sensors shall be supplied installed, configured, and connected to a junction box located on the Turbogenerator package.

9.6.4. MANUFACTURER shall provide complete documentation of the sensors installed in the equipment.

9.6.5. Submersible type generators shall have an online barrier fluid condition monitoring system capable of detecting contamination with water and solid particles. This system shall be compatible with and connected to the MMS.

9.7. POWER SYSTEM PROTECTIVE DEVICES

9.7.1. Protective Relays

9.7.2. 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*".

9.7.3. Protective relay shall be connected to Electrical System Automation 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*".

9.7.4. 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*".

9.7.5. Protection

9.7.6. The protection of Generator shall comply with I-ET-3010.00-5143-700-P4X-001, "*Electrical System Protection Criteria*" and I-DE-3010.00-5143-946-P4X-001, "*Medium-Voltage Systems Protection Diagram*".

9.7.7. Alarms shall precede shutdown functions. Shutdown shall comprise both turbine intake valve shut-off and generator disconnection from the power system.

9.7.8. Current (CT's) and Potential Transformers (PT's)

9.7.9. Generator shall be supplied with dry type current (CT's) and potential (PT's) transformers for both protection and measurement purposes.

9.7.10. Instrument transformers shall comply with I-ET-3010.00-5140-700-P4X-002, "*Specification for Electrical Material and Equipment for Offshore Units*".

9.7.11. The generator manufacturer shall define and supply the CT's and PT's to allow proper system operation and protection.

9.7.12. Terminal block connected to CT secondary winding shall be supplied with means for short-circuiting them, when necessary.

10. PAINTING AND COLOR

10.1. PACKAGER / MANUFACTURER paint system shall be according to I-ET-3010.00-1200-956-P4X-002, "*General Painting*".

10.2. Color code adopted shall be in accordance DR-ENGP-I-1.15 – Color Coding.

10.3. Defects arising within the guarantee period shall be subject to an allowance of 1 %, representing wear and tear. For system failure in excess of this, PACKAGER / MANUFACTURER liability shall include complete pre-treatment and repainting.

11. NAMEPLATES

11.1. PACKAGER / MANUFACTURER shall attach corrosion resistant SS 316 nameplates on main and auxiliary equipment in an accessible location, fastened with corrosion resistant SS 316 pins, and in Brazilian Portuguese language.

11.2. For pressure vessels, columns and filters the nameplates shall be according to I-ET-3010.00-1200-540-P4X-001 – Requirements for Pressure Vessels Design and Fabrication.

11.3. For other equipment the nameplates shall include, as a minimum, the following information:

- Petróleo Brasileiro S.A. – PETROBRAS;
- Installation identification;
- Tag number;
- Service;
- Purchase order number;
- Manufacturer and year of build;
- Equipment serial number and type;
- Main data for design, operation and testing (power, pressure, volume, temperature, speed, flow rate), where applicable;
- Specific requirements;
- Design code;
- Empty and operating weight.

11.4. Valves, instruments and orifices shall have a nameplate with tag number and serial number in accordance with I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS.

11.5. All technical data on nameplates shall be in metric units. Pressure shall be indicated in kPa for pressure vessels.

11.6. Auxiliary equipment shall have nameplates in accordance with respective technical specifications defined on NORMATIVE REFERENCES.

12. TAG NUMBERING

12.1. Tagging of all instrumentation, electrical, mechanical and piping items, including valves, shall be according to I-ET-3000.00-1200-940-P4X-001, "*Tagging Procedure for Production Units Design*".

12.2. Tag plates shall be supplied with number and description in Portuguese.

12.3. All tag plates shall be made from SS 316 material.

12.4. Valves, instruments and orifices shall be tagged with the applicable number only.

12.5. Tag numbers for remaining auxiliary equipment shall be defined in detail design after approval of BUYER.

13. CERTIFICATION REQUIREMENTS

13.1. Class Certification

PACKAGER / MANUFACTURER shall supply a Classification Society Certificate of compliance with Rules requirements for the Turbogenerator PACKAGE

13.2. Material Certification

13.2.1. PACKAGER / MANUFACTURER shall obtain all necessary certification of the equipment.

13.2.2. PACKAGER/ MANUFACTURER, through the independent certifying authority, shall supply all certificates related to the materials, inspections, tests and qualification activities detailed in the approved Quality Plan.

13.2.3. Certificates for pressure-containing parts, impellers and shafts shall include chemical analysis and mechanical properties of the materials.

14. INSPECTION, TESTING AND COMISSIONING

14.1. Inspection and Testing

14.1.1. PACKAGER / MANUFACTURER shall perform all required inspection and testing in accordance with the referenced design code, considering also as a reference the test code mentioned on NORMATIVE REFERENCES. In addition to those, PACKAGER / MANUFACTURER shall comply with the applicable project specifications listed herein, at datasheet and Material Requisition.

14.1.2. PACKAGER / MANUFACTURER shall submit the Inspection and Test Plan (ITP) based on the technical datasheet with witnessed inspections and tests identified.

14.1.3. PACKAGER / MANUFACTURER shall ensure that all the witnessed inspection requirements by the Classification Society are fully accommodated and the due notice requirements are satisfied.

14.1.4. BUYER shall witness SEA WATER DUMP LINE TURBOGENERATOR performance test and hydrostatic test of vessels classified in NR-13 within the PACKAGE.

14.1.5. The following tests or certificates shall be included in PACKAGER / MANUFACTURER scope and will be verified by BUYER:

- Materials of construction of the PACKAGE (vessels, heat exchangers, turbine, generator, etc.) for conformity with the requirements of the specification.
- Piping, fittings and valves materials and fabrication, which shall conform to specification.
- Radiographic, dye penetrant, magnetic particles, ultrasonic inspection of welds on the pressure retaining parts of the equipment, and steel structures.
- Approval of the relief valve settings and witness of their testing after setting.
- A visual check of the assembly of the PACKAGE, with special notice to:
  - The thickness of the pressure retaining parts meets or exceeds the quoted design thickness.
  - Any repairs.
  - Dry-film thickness quoted.
  - The general appearances, materials, workmanship and standard of finish are acceptable.
  - Dimensional check.
  - Alignment to be demonstrated.

14.2. PACKAGE Functional Test

14.2.1. A full functional test of each completed package shall be performed. The satisfactory operation of all indicators, selectors and controllers shall be demonstrated.

14.2.2. The correct operation of all controllers, alarm and fault protection equipment and indicators shall be demonstrated and, if necessary, fault simulations.

14.2.3. In addition, following tests shall be included in PACKAGER / MANUFACTURER scope:

- Electrical continuity and insulation checks on all wiring and earthing continuity;
- Functional checks on all instruments and valves;
- Control panel tests.

14.3. Factory Acceptance Test (FAT)

14.3.1. PACKAGER / MANUFACTURER shall prepare a FAT procedure for the package and submit for BUYER approval. FAT procedure shall consider as a reference the test code mentioned on NORMATIVE REFERENCES.

14.3.2. PACKAGER / MANUFACTURER shall make preliminary test to ensure that all parts of the equipment are operating satisfactory prior to the arrival of the BUYER's representative.

14.3.3. BUYER representatives will witness the FAT. PACKAGER / MANUFACTURER shall invite Classification Society surveyor for FAT.

14.3.4. Each Turbogenerator, including spares if purchased, shall undergo a witnessed 4 hours continuous Mechanical Run Test at the rated point.

14.3.4.1. The equipment's Mechanical Run Test shall be carried out for the Turbogenerator as a Complete Unit.

14.3.4.2. The test shall be carried out with turbine outlet pressure equivalent to the minimum draft condition.

14.3.4.3. During this run, PACKAGER / MANUFACTURER shall record and approve vibration and temperature monitoring data from mutually and previously agreed parameters.

14.3.4.4. Vibration and bearing temperature measurements shall be included on FAT report.

14.3.5. A witnessed Performance Test shall be carried out on each Turbogenerator unit.

14.3.5.1. The performance test shall include a minimum of 5 (five) test points at rated speed: (1) at rated flow as per the turbine datasheet; (2) maximum flow rate (as per item 6.8.4); (3) at minimum recommended flow rate, at which electric power approaches zero; (4) between points 1 and 2; (5) between points 1 and 3.

14.3.5.2. Rated flow (1) shall be tested with a turbine outlet pressure, P^t_{outlet}, defined as

$$P^t_{outlet} = P^t_{vapor} + P^s_{outlet} - P^s_{vapor} \quad ,$$

where P^t_{vapor} correspond to the fluid vapor pressure at test conditions and P^s_{outlet} and P^s_{vapor} correspond to turbine outlet pressure and fluid vapor pressure at site conditions, respectively.

14.3.5.3. Maximum recommended flow rate (2) shall be tested with the minimum required outlet pressure (MROP), as informed by the MANUFACTURER.

14.3.5.4. The performance values calculated during the test shall be corrected to the design operational temperature conditions as per IEC 60193 prior to the application of the acceptance criteria.

14.3.5.5. The acceptance criteria shall be as per Table 1.

Table 1 – Turbine performance test acceptance criteria.

	Flow	Head	Electric power
(1) Rated flow	+/- 5%	+/- 3%	- 5%
(2) Maximum flow rate		+/- 4%	-

14.3.5.6. The Performance Test shall be carried out using the throttle valve supplied with the PACKAGE.

14.3.6. If it is found necessary to dismantle any equipment after a test for repair or replacement of components, the test shall be invalidated and repeated.

14.3.7. Acceptance of shop tests shall not constitute a waiver of requirements to meet the field tests under specified operating conditions, nor shall inspection relieve the PACKAGER / MANUFACTURER of his responsibilities in any way whatsoever.

14.3.8. Acceptance of the FAT shall not be considered as the final acceptance test of the package unit.

14.4. Commissioning

14.4.1. SUPPLIER shall be responsible for pre-commissioning and commissioning of the equipment/system.

14.4.2. Final acceptance shall be on satisfactory completion of commissioning tests as specified by BUYER.

14.4.3. PACKAGER / MANUFACTURER shall provide any necessary support for installation and commissioning of the equipment either at a shore based fabrication yard or on the UNIT, including monitoring systems of the PACKAGE.

14.4.4. SUPPLIER shall provide all consumables necessary to allow commissioning in the environment conditions of the shipyard.

14.4.5. SUPPLIER shall inform PACKAGER / MANUFACTURER regarding any specific commissioning conditions for the equipment, i.e., conditions in which the equipment will have to operate temporarily, including environmental conditions such as extreme ambient temperatures, if they are different from the conditions defined in the data sheet. The PACKAGE shall be designed to withstand such conditions.

14.4.6. PACKAGE shall undergo a Reliability Acceptance Test Criteria (SAT) on site, in accordance with the requirements of Annex A.

15. PREPARATION FOR SHIPMENT

15.1. Marking

15.1.1. All items supplied to this specification shall be adequately marked for identification against a certificate or relevant test documentation.

15.1.2. Marking shall not damage or impair the component.

15.1.3. Items that cannot be identified shall be rejected. Rejected items may be re-certified by carrying out all relevant testing, with prior approval of the BUYER.

15.1.4. As a minimum, the following identification shall be provided:

- Project number;
- Manufacturer's name;
- Purchase order number;
- Shipping weight;
- Item number;
- Classification Society surveyor's stamp.

15.2. Shipment Packing

15.2.1. The equipment shall be supplied tested, flushed and preserved and, if practical, already charged up with coolant and lubricants.

15.2.2. The equipment shall be securely packed for shipment from PACKAGER / MANUFACTURER's location to the actual equipment destination.

15.2.3. All items shall be protected from handling damage either by protective packing with cartons, crates, etc. or by securing to pallets.

15.2.4. All material shall be packed in a way that handling with forklift truck or crane is possible.

15.2.5. If there is a risk of damage to valves and other appurtenances during transportation, they shall be disconnected and tagged. All components shall then be securely packed as above.

15.2.6. Vulnerable instruments shall be removed and separately packed for shipment.

15.2.7. The preparation shall make the equipment suitable for 24 months outdoor storage from the time of shipment. The PACKAGE shall be protected from corrosion.

15.2.8. All openings shall be covered or capped to protect the inside from dust, rust and moisture. Dryer shall be enclosed in the package for absorption of moisture.

15.2.9. Flanged openings shall be provided with gasketed metal closures securely fastened with bolts or clamps.

15.2.10. All internally unpainted carbon steel pressure vessels and piping shall be protected with corrosion inhibitor prior to shipment. If necessary, PACKAGER / MANUFACTURER shall provide instructions to remove the corrosion inhibitor prior to the commissioning.

15.2.11. PACKAGER shall submit the packing design and packing list to the BUYER for approval. PACKAGER shall issue during engineering stage the packing list, which shall contain the item number of each part supplied loose.

15.2.12. The packing list shall clearly show:

- UNIT name;
- BUYER's order number;
- BUYER's item number;
- Partial or complete delivery for each order number;
- Description;
- Number of packages;
- Gross weight of each package.

15.2.13. Spare parts and special tools packed separately shall be clearly marked with "Spare Parts" or "Special Tools" respectively.

15.2.14. PACKAGER shall inform the declared weight, rigging plan, materials and type of pesticide used in the package.

15.2.15. Each package shall be clearly marked with its gross weight, to enable safe handling.

15.2.16. Packing shall be in accordance with the requirements of the country to which the equipment is being shipped.

15.2.17. PACKAGER shall provide the procedures for unpacking, handling and installation, as well as repacking, and long-term storage requirements.

15.2.18. PACKAGER shall specify any limitations applicable to the transport and installation phase.

15.2.19. Unless otherwise advised, each item of equipment shall be checked for its suitability to resist horizontal and vertical acceleration of 0.8 G in any direction during sea transportation.

15.2.20. The rust preventives list shall give instructions for removal of preventives where required, and necessary procedures to be imposed during storage.

15.2.21. Transportation bracing/support should be used where necessary and shall be clearly identified as temporary.

15.2.22. PACKAGER / MANUFACTURER shall provide a Delivery Specification, which shall describe all loose items furnished in a completely or not completely assembled condition.

15.2.23. Delivery Specification shall clearly indicate BUYER's order number in the headlines and item number for each loose item shipped by the SUPPLIER.

15.2.24. One copy of the delivery specification shall follow the goods, one copy to be sent to the shipyard and one copy to be sent to the BUYER.

16. REQUIRED DOCUMENTATION

16.1. PACKAGER / MANUFACTURER shall provide original documents in PDF format for all required documents. Extracted figures from catalogue or manual, especially for the outline drawings of components such as couplings, mechanical seals and auxiliary equipment shall not be accepted. Whenever required by BUYER, source files shall also be provided.

16.2. All documents required in this section shall be text searchable, including PDF files.

16.3. Before any document is issued by PACKAGER / MANUFACTURER, a document list shall be issued and approved by BUYER. This is required in order to guarantee the correct document numbering.

16.4. Drawings and diagrams shall use the symbols defined on I-ET-3000.00-0000-940-P4X-002, "*Symbols for Production Units Design*".

16.5. The following documents shall be provided during technical proposal by PACKAGER / MANUFACTURER in their preliminary version:

- General arrangement drawing;
- Cross section drawing;

- Datasheet;
- Performance curves, including Head, Power and efficiency versus flowrate.

16.6. Title of all documents to be issued by PACKAGER / MANUFACTURER shall have the following format:

- First part – tag number;
- Second part – service description;
- Third part – document description

EXAMPLE: TG-5262001 – Sea Water Dump Line Turbogenerator – General Arrangement Drawing

16.7. If PACKAGER / MANUFACTURER issues documents which contain information valid for more than one turbine tag, turbine tag and service description shall be omitted and replaced by “Sea Water Dump Line Turbogenerator”

EXAMPLE: “Sea Water Dump Line Turbogenerator” – Inspection and Test Plan.

16.8. The following documents shall be issued and approved before FAT execution. Otherwise, BUYER will not attend the FAT and will not accept its execution:

- Piping and instrumentation diagram;
- General arrangement drawing;
- Cross section drawing with part list;
- Main and auxiliary equipment datasheets;
- Weight and center of gravity datasheet;
- Noise datasheet;
- Performance curves;
- Utility consumption list and heat dissipation;
- Inspection and Test Plan (ITP), including auxiliary equipment;
- Hydrostatic test procedure;
- Painting and insulation specification;
- Rotor dynamics analysis report (according to requirements of API Std 610);
- Fatigue analysis report for pipe stack top support, considering normal operation and transient events;
- Vacuum-breaker valves calculation report;
- FAT procedure.

16.9. The following documents shall be issued and approved before delivery of the PACKAGE. Otherwise, BUYER will not attend to the receiving inspection, and will not accept the PACKAGE:

- Nameplate drawings;
- Noise report;
- FAT report;
- Handling drawing for installation;
- Installation manual;
- Instruments and instrumented valves datasheets;
- Packing list.

16.10. The following documents shall be issued and approved before issuance of the Databook. Otherwise, BUYER will not accept the Databook:

- Mechanical seal drawing;
- Coupling drawing;
- Outline drawings of auxiliary equipment;
- Operation and maintenance manuals for main and auxiliary equipment;
- List of spare parts for commissioning and start up;
- List of recommended spare parts for two years of operation;
- List of special tools;
- List of instruments and instrumented valves;
- List of set points, alarms and shutdown;
- Logic diagrams;
- Cause and effect charts;

- Loop diagram
- Electromechanical panel drawing;
- Memory maps;
- Automation architecture;
- Interconnection wiring diagram;
- Calculation notes of control valves, PSVs, thermowells and flowmeters;
- I/O List;
- HMI screen layout;
- Calibration certificates of instruments;
- Fabrication procedures of pressure vessels classified in NR-13;
- NDT procedures of pressure vessels classified in NR-13;
- Hydrotest reports for pressure vessels classified in NR-13;
- Hydrotest report of turbines;
- NDT reports;
- Material certificates;
- Heat treatment records;
- Databook index.

16.11. In the case of induction generator, the electric machinery related documents shall be as per I-ET-3010.00-5140-712-P4X-001, "*Low-Voltage Induction Motors for Offshore Units*" and/or I-ET-3010.00-5140-712-P4X-002, "*Medium-Voltage Induction Motors for Offshore Units*", otherwise PETROBRAS shall be consulted.

16.12. Installation, operation and maintenance manuals shall be issued in Brazilian Portuguese. PACKAGER / MANUFACTURER may choose to issue one single manual with installation, operation and maintenance instructions.

16.13. Installation manual shall contain all recommendations for preservation during storage on erection stage. If PACKAGER / MANUFACTURER fails to provide this information on the installation manual, any damages due to the lack of preservation will be PACKAGER / MANUFACTURER's responsibility.

16.14. Installation manual shall contain a list of all consumables to be used for erection, commissioning and start up.

16.15. Maintenance manual shall contain the specification of lubricant fluids and periodicity of replacement.

16.16. Maintenance manual shall contain instructions to assemble and disassemble each major piece of the equipment, such as mechanical seal, rotor and bearings. This information may be provided on a separate manual for the piece as well.

16.17. PACKAGER / MANUFACTURER may choose to include specific commissioning instructions on the operation manual, or to issue a separate document, such as a procedure, for commissioning instructions.

16.18. Operation manual shall contain, among other information, the control system description of the PACKAGE.

16.19. General arrangement drawings shall contain the connection list, i.e., a list with all connection tie-in points of the skids, which shall have the following minimum information: Connection identification number (which shall be represented in the drawing), connection description, tie-in connection specification that is, pressure rating, manufacturing standard, flange face type, connection nominal diameter and fluid.

16.20. Mechanical seal drawings shall contain a list with all connections on the seal, including identification code (which shall be represented on the mechanical seal drawing), connection description and fluid. Mechanical seal drawings shall contain also a part list with identification number of the part, description of the part and material of each part. Identification number of seal parts shall be different from the identification code of the connections. For example, identification codes can be letters and parts identified by numbers.

16.21. PACKAGER / MANUFACTURER shall inform either in the datasheet or in the performance curve the flow rates defining the preferred operation region and the allowable operation region of the equipment.

16.22. Each material certificate and NDT report provided shall be preceded by a PACKAGER / MANUFACTURER sheet, informing to which part of the equipment the document refers.

16.23. All inspections, NDTs and tests predicted by PACKAGER in the Inspection and Test Plan shall have a report, which shall be included in the Databook.

17. ANNEXES

ANNEX A – ROTATING EQUIPME

Annex A – Rotating Equipment Reliability Test.