

	TECHNICAL SPECIFICATION	Nº: I-ET-3010.2D-1238-323-P4X-001	
	CLIENT:	AGUP	SHEET: 1 of 19
	JOB:	HIGH CAPACITY FPSO - GAS EXPORTATION ALL ELECTRIC	
	AREA:	ATAPU 2 AND SÉPIA 2	
SRGE	TITLE:	HYDROCARBON DEWPOINT CONTROL SYSTEM ROTARY COMPRESSOR	INTERNAL ESUP

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EXECUTION	CFQ2	CFQ2	CFQ2						
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TECHNICAL SPECIFICATION

Nº I-ET-3010.2D-1238-323-P4X-001

REV. B

AREA: ATAPU 2 AND SÉPIA 2

SHEET 2 of 19

TITLE: **HYDROCARBON DEWPOINT CONTROL SYSTEM
ROTARY COMPRESSOR**

INTERNAL
ESUP

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1. DEFINITIONS AND ABBREVIATIONS

1.1 DEFINITIONS:

- PETROBRAS** FPSO contracting and operating company.
- PACKAGER** Company responsible for project, assembly, construction, fabrication, test of compressor and project, assembly, tests, integration and furnishing of all other main equipment in the skid, including the auxiliaries systems.
- PURCHASER** EPC company responsible for project, assembly, erection, construction, fabrication, test and furnishing, lift, hook up, installation and integration of all Modules of FPSO, with complete and fully operative systems in accordance with the requirements of this specification, codes and standards referenced therein.
- VENDOR** Company hired by the purchaser or packager to supply of equipment, components of equipment, instruments, control systems, etc. that will be part of the main system to be supplied.

1.2 ABBREVIATIONS:

- AEPR** Automation & Electrical Panels Room
- AMS** Asset Management System
- API** American Petroleum Institute
- ASME** American Society of Mechanical Engineers
- AVM** Anti-Vibration Mounting
- BDV** Blow Down Valve
- CCR** Central Control Room (located in the Hull Accommodation)
- CCR-ATR** Central Control Room – Automation and Turbomachinery Room
- CGS** Compressor Governor System
- CGS_HMI** Human Machine Interface for Compressor Governor System
- CSS** Control and Safety System
- Cv** Coefficient flow valve
- DGS** Dry Gas Seal
- DIO** Optical Internal Distributor
- ESD** Emergency shutdown
- FAT** Factory Acceptance Test
- FGS** Fire and Gas System
- FIT** Factory Integrated Test
- FPSO** Floating Production Storage and Off-loading
- FPU** Floating Production Unit
- FST** Factory Stability Test
- HMI** Human Machine Interface
- IGCR** Inert Gas Compressor Running
- I/O** Input/Output
- LAN** Local Area Network



MCC	Motor Control Center
MMS	Machinery Monitoring System
MPA	Automatized Procedures Module (Portuguese: Módulo de Procedimentos Automatizados)
MPS	Machinery Protection System
MRT	Mechanical Running Test
OPC UA	Open Platform Communications Unified Architecture
PAS	Package Automation System
PCS	Process Control System
PLC	Programmable Logic Controller
PMS	Power Management System
PSD	Process Shutdown System
PSV	Pressure Safety Valves
PCV	Pressure Control Valves
PDCV	Pressure Differential Control Valve
P&ID	Piping and Instrument Diagram
RESD	Emergency Shutdown Relay
RFI	Radio Frequency Interference
RIO	Remote I/O Panel
SAT	Site Acceptance Test
SDV	Shut Down Valve
SGCS	Seal Gas Conditioning System
SGP	Seal Gas Panel
SLT	Sound Level Test
SIT	Site Integration Test
SOS	Supervision and Operation System
TAP	Performance Acceptance Test
TCP/IP	Transmission Control Protocol/Internet Protocol

2. GENERAL

- 2.1. Rotary compressor for Hydrocarbon Dew Point Control System Package shall be in accordance with API std 619, last edition.
- 2.2. The complete Hydrocarbon Dew Point Control System package shall be designed for minimum 30 years of operation installed on the FPSO.
- 2.3. All documents listed in Material Requisition are mandatory as well as the electrical, automation and safety requirements for Rotary compressor for Hydrocarbon Dew Point Control System package described in these documents.
- 2.4. All components of the system shall be suitable for offshore environment, throughout the whole platform service life, under all operational conditions and submitted to Unit motions and accelerations described in PETROBRAS specifications.



- 2.5. PACKAGER and PURCHASER shall be entirely responsible for material selection on items not specified by PETROBRAS and shall inform material of all main parts according to ASTM code. All bolts and nuts shall be supplied with PACKAGER and PURCHASER certificates and fully marked according to applicable ASTM standard.
- 2.6. All shop punch lists shall be cleared before shipment.
- 2.7. Equipment shall be prepared for outdoor storage according to PURCHASER specifications.
- 2.8. PACKAGER and PURCHASER shall specify the products to be used for preservation of the equipment components and spare parts, their removal and reapplication methods and the application date. Such data shall be summarized on two tags to be securely fastened on all equipment and outside of each crate. If rust preventives are required, volatile products shall not be applied.
- 2.9. Hazardous and toxic materials with associated adverse health effects shall be avoided or minimized. PACKAGER, PURCHASER and VENDORS are encouraged to promote their replacement. As the use of such materials will not be tolerated, PETROBRAS strongly recommends PACKAGER, PURCHASER and VENDOR to take all necessary measures to ensure their use is fully avoided throughout this project. Material safety data-sheets may be required by PETROBRAS any time, to demonstrate that a particular material has not been, is not and will not be used throughout all stages of this project.
- 2.10. All equipment, components and panels shall have a nameplate easy to access, to view and read. Nameplate shall be made in AISI 316 steel and bolted (with stainless steel elements) to the equipment. Layout drawings shall be submitted to PETROBRAS approval. Nameplates shall contain the following information, in Brazilian Portuguese language:
- Client name;
 - Client job;
 - Client area;
 - Supplier name;
 - Series number and model;
 - Year of manufacturing;
 - Main design and test data: pressure, temperature, voltage, rotation, etc;
 - Specific data;
 - Tag number;
 - Purchaser's requisition number (RM);
 - Purchaser's request for quotation number (RFQ);
 - Purchaser's order number (PO);
 - Empty weight;
 - Design code.
- 2.11. All safety signals shall be in Portuguese language.

3. CONSTRUCTION FEATURES

- 3.1 Recirculation will not be accepted at maximum flow.
- 3.2 Compressor bearings shall be hydrodynamic tilting pads type.
- 3.3 All bearings shall be designed to minimize oil foaming and prevent oil whirl at any operating speed.
- 3.4 Compressor connections and nozzle flanges shall be provided by removable spools to facilitate compressor remove and disassembly.
- 3.5 Clamp connections are not acceptable.

- 3.6 Drains shall be collected at a single tie-in point at package limit with valve and flanges. Drain arrangement shall provide visual access in order to verify leakage and to confirm whether the drainage operation is being accomplished or not.
- 3.7 Compressor casing shall be made of cast steel. Rotors shall be solid type, made of forged steel. Ductile material will not be accepted.
- 3.8 Equipment and piping served by cooling water shall also be design with protections/detections against scenario of lack of supply and/or overpressure and/or high cooling water temperature.

4. ACCESSORIES AND AUXILIARIES

4.1 Piping

- 4.1.1 Except where indicated, all piping and accessories within equipment package limit shall be in accordance with PACKAGER piping specification and international standards.
- 4.1.2 All auxiliary piping requiring field connections shall be brought to the skid edge and shall be flanged.
- 4.1.3 Manual block valves and spectacle / blind flanges shall be provided at all battery limits such as inlet and outlet nozzles, drain lines, etc. PACKAGER and PURCHASER consider piping standards as in I-ET-3010.2D-1200-200-P4X-001 – PIPING SPECIFICATION FOR TOPSIDE. Manual valves shall be installed at the skid edge to be operated, especially valves for draining the compressor casing. Access to the all manual valves shall be free.
- 4.1.4 All equipment shall have sufficient flexibility in all pipe and duct connections.
- 4.1.5 The interconnecting pipework between auxiliary skid and the main baseplate shall be provided by PUCHASER. The interconnections between the gas lines shall be routed above the skids. The pipes arrangement shall avoid the accumulation of liquid (siphon). Drainage shall occur in all lower parts of the piping.
- 4.1.6 A temporary T-type strainer for machine starting, removable without disassembly of the piping, shall be installed in the suction line, close to each stage of compression.
- 4.1.7 Systems/equipment isolation shall comply with Isolation Guidelines requirements from specific project's document "DESCRIPTIVE MEMORANDUM – PROCESS". See I-MD-3010.2D-1200-940-P4X-005 - DESCRIPTIVE MEMORANDUM – PROCESS.

4.2 Couplings and coupling guards

- 4.2.1 PACKAGER is responsible for all couplings within the package, including those for auxiliary equipment.
- 4.2.2 Coupling for main equipment shall be a stainless steel flexible-element, non-lubricated type.
- 4.2.3 PACKAGER and PURCHASER shall submit to PETROBRAS main equipment coupling data sheet according to API 671.



- 4.2.4 All coupling guards (including those for auxiliary equipment) shall be rigid, fully enclosed, in non-sparking material and solely fitted to equipment baseplates, not fastened. Safety coupling guards (without feet) are also acceptable. In case of failure, guards shall be able to retain broken parts, for personnel protection (OHS 1910.219 shall be complied). Coupling guards shall be designed to allow removal without disassembling the coupling and shall be constructed so that routine inspections are performed by means of strobe light, with the equipment running.
- 4.2.5 Coupling guard drains shall have sight glasses in horizontal drain lines. The coupling guard shall not be used as a normal operating lube oil drain path.

4.3 Baseplate

- 4.3.1 Baseplate shall be rigid enough to avoid permanent distortion during lifting, shipment and operation. When the baseplate is lifted, with all equipment mounted, beam deflection shall not exceed $L/400$ (L is the total baseplate length).
- 4.3.2 Driver, driven machine and transmission shall be mounted on a single baseplate. Other process equipment (including scrubber and coolers) and auxiliaries shall be mounted on the same baseplate (preferable) or provided with their own skid. PACKAGER and PURCHASER shall submit layout to PETROBRAS comments and approval.
- 4.3.3 The baseplate shall have a removable solid checkered plate or open grating top floor where required for maintenance.
- 4.3.4 All furnished skids shall be sufficiently stiff to withstand all vibration loads induced by the equipment and transfer them to the deck beams.
- 4.3.5 Skid mounted assemblies shall be constructed in order to not allowed equipment or parts be dismantled during lifting.
- 4.3.6 No equipment / component shall protrude beyond the skid limits. In cases where it cannot be avoided, required protection against mechanical damage shall be provided.
- 4.3.7 Each skid shall be provided with facilities (pad-eyes, lugs, bollards) for lifting, having suitable access for rigging. The estimated lifting load and safety factor for each point shall be informed in PACKAGER and PURCHASER proposal. Main lifting points shall not be welded to the beam flange, unless the strength level is low enough or if the beam flange has a suitable thickness.
- 4.3.8 All equipment to be mounted on skids shall allow on-field leveling and alignment using jacking screws (in both plane directions) and precision type shims. Total shim thickness shall not exceed 6.35mm and the number of shims shall be kept to a minimum. Any additional height shall be made up of solid stainless steel plate.
- 4.3.9 All skid mounted equipment containing liquids that shall be drained onto the skid area, shall be fitted with drip pan underneath the equipment and provided with flanged nozzle with sufficient slope. Drip pans draining system shall be designed considering the total deluge flow over the skid. A single drain nozzle shall be located at the skid edge with appropriate piping, blocking valve, strainer and water seal.

4.3.10 Fasteners (including washers) and shims shall be constructed in AISI 316L steel.

4.4 Support system

4.4.1 All required supporting system (including spring supports, structure, etc.) shall be supplied (for on-skid elements) or specified with all design requirements (such as loads, position, forces, etc.) by PACKAGER and PURCHASER.

4.5 Insulation

- 4.5.1 All required insulation for personnel protection or machine thermal efficiency shall be applied and provided by PACKAGER and PURCHASER.
- 4.5.2 Insulating shall ensure a temperature below 60°C over the external surface for personnel protection.
- 4.5.3 To prevent corrosion under insulation, only non hygroscopic insulation material shall be used.
- 4.5.4 In order to avoid damages during transportation and erection insulation shall be carried out after final installation in place.

4.6 Oil system

- 4.6.1 The mineral lube oil system shall be designed per API 614 for special purpose (latest edition) to supply lubricating oil to the driver, gearbox and driven equipment. Special considerations shall be given to the FPSO motion in order to guarantee bearing lube and its oil drainage during normal operation and post-lube.
- 4.6.2 Special consideration shall be given to the presence of dirt, debris and any foreign matter in sensitive parts (bearings, for instance). Provisions shall be made for by-pass of sensitive parts while system flushing operations are performed.
- 4.6.3 PACKAGER and PURCHASER shall propose its standard oil system configuration, but the configuration of the coolers and filters shall be as Oil System Data Sheet.
- 4.6.4 Lube oil system shall be monitored with PACKAGER and PURCHASER specification, international standards for this system and Oil System Data Sheet.
- 4.6.5 PACKAGER and PURCHASER shall provide sampling points for oil analysis at reservoir, supply manifold and oil return line of each equipment. Sampling facilities shall be permanent, fitted with valves installed in T-type connections, oil spill and drip collectors and spillback lines to be routed back to oil reservoir. Sampling arrangement shall enable samples taken during operation.
- 4.6.6 Except for oil pumps, all piping, tubing, wetted metallic parts and appurtenance including lube oil and control oil systems shall be in stainless steel AISI 316L.

- 4.6.7 Socket welds for piping and tubing is prohibited.
- 4.6.8 Reservoirs:
- Reservoir shall be provided with filling connections (with filter), level indicator sight glass, antifoaming devices, accessible manholes, valve drain at skid edge and include provisions for nitrogen purges;
 - All return lines shall be top entry type, extending inlet duct inside the reservoir to below minimum operating level in order to avoid foaming;
 - Reservoir shall be designed to facilitate air separation between the bearing return and pump supply;
 - Vents shall be fitted with oil vapor separator in order to recover oil due to evaporation losses and environmental protection (PACKAGER and PURCHASER shall guarantee maximal oil losses of five (5) ppm). Vents shall be dimensioned with the same size as the oil return header, at least;
 - An electric lube oil heater shall be provided, interlocked with a low-level and oil temperature control. This device shall be designed to facilitate removal without having to drain the reservoir or stop the equipment.
- 4.6.9 The configuration for pumps shall be:
- Main oil pump: Shaft-driven (preferable) or electric motor driven (AC power);
 - Stand-by pump: Electric motor driven (AC power);
 - Main and stand-by pumps shall have the same capacity;
 - If the main pump is electrically driven, then main and stand-by pumps shall be identical.
- 4.6.10 Oil coolers shall be multi-plate duplex type with changeover valve. Cooler shall have provision for future increase of the number of plates. The cooling water pressure shall be lower than oil pressure at heat exchanger interior. The material shall be selected as following:
- Stainless steel AISI 316L, if closed loop cooling water system;
 - Titanium if open loop cooling water system.
- 4.6.11 Oil filters shall be duplex (twin) with changeover valve. The canisters, transfer valves and piping for oil filter system shall be stainless steel AISI 316L construction. Filter element material shall be corrosion and water resistant. There shall be no by-pass around any filter.
- 4.6.12 Lube oil system shall have rundown tank for emergency conditions. The rundown tank shall have enough capacity for bearing cooling during coast-down time. The oil supply time by pumps and rundown tank shall not exceed fifteen minutes after the machine has stopped.
- 4.6.13 PACKAGER and PURCHASER shall inform all data and characteristics of electric load (as power, source, etc.) for each pump driver, heater, etc. in proposal phase. PURCHASER will provide all electrical utilities required by PACKAGER, considering platform available voltages as stated in I-ET-3010.00-5140-700-P4X-003 – ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS.

- 4.6.14 API data sheets for pumps and heat exchangers shall be included in proposal.
- 4.6.15 All oil vents shall be interconnected, fitted with flame arrestors and routed to a safe area. All oil drains shall also be interconnected and routed to oil reservoir.
- 4.6.16 PACKAGER and PURCHASER shall provide all data of oil system equipment and fluid as oil consumption, oil complete specification and filter elements life.

4.7 Gearbox

- 4.7.1 Gearbox shall be designed in accordance with API613 last edition. It shall be included a device to allow manually rotation of the shafts for maintenance purpose (such as shaft mechanical alignment or borescope inspection).
- 4.7.2 Gearbox shall be designed as a “stand-alone” unit, whereby no external thrust loads shall be imposed upon the gearbox by other equipment.
- 4.7.3 Shaft oil seal shall be easily accessible for removal and re-installation without removing couplings.
- 4.7.4 All bearings shall be pressure lubricated and fully replaceable at field.

4.8 Mechanical Contact Seal (MCS) system

- 4.8.1 An oil-cooled, gas tight, dual MCS system at each shaft end shall be furnished for each compressor casing.
- 4.8.2 MCS shall be furnished with complete fluid system, with all necessary instrumentation.
- 4.8.3 Seal shall be designed as a replaceable cartridge.
- 4.8.4 Carbon ring seals are not acceptable.
- 4.8.5 Seal system shall be suitable to cope with the maximum settling-out pressures with can occur during a shutdown.

4.9 Silencers

- 4.9.1 Acoustic isolation and suction and discharge piping lines shall be provided.
- 4.9.2 All Silencers (inlet and discharge) shall be in AISI 316L steel.

5. AUTOMATION

5.1 General Requirements

- 5.1.1 Package Automation System (PAS) shall supervise and control the motocompressor and its auxiliaries. PAS is part of the Hydrocarbon Dew Point System and shall be implemented at PN-UT-1238001.
- 5.1.2 Machinery Protection System (MPS), Machinery Monitoring System (MMS) interface, Asset Management System (AMS) interface and Device and Field Instrumentation are part of Package Automation System (PAS).



- 5.1.3 Package Automation System (PAS) shall be designed to ensure safe and reliable operation, performing protection, sequencing, interlocking, control and monitoring during start-up, operation, normal stop and emergency shutdown. PAS shall be furnished functionally tested, assembled and ready for connection.
- 5.1.4 Compressor will be controlled to keep gas temperature downstream of V-1238001 defined by TIC-1238003. The compressor capacity control shall operate using recirculation (through the spillback valve) in the range of 0 up to 10% and by slide valve in the range of 10% to 100%. However, recirculation through recycle valve shall be minimized.
- 5.1.5 The PAS shall be designed according to the requirements described in specifications I-ET-3010.2D-1238-323-P4X-001 – HYDROCARBON DEW POINT CONTROL SYSTEM ROTARY COMPRESSOR, I-ET-3010.2D-1238-560-P4X-001 - HYDROCARBON DEW POINT CONTROL UNIT (UT-1238001), I-ET-3010.2D-1200-800-P4X-014 - AUTOMATION INTERFACE OF PACKAGE UNITS, I-ET-3010.00-1200-800-P4X-002 - AUTOMATION, CONTROL AND INSTRUMENTATION ON PACKAGE UNITS and specifications required by international standards and Classification Society's requirements, as well as the following specifications:
- I-DE-3010.2D-1238-944-P4X-001 – HYDROCARBON DEW POINT CONTROL SYSTEM;
 - I-FD-3010.2D-1238-560-P4X-001 - HYDROCARBON DEW POINT CONTROL SYSTEM (UT-1238001);
 - 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-DE-3010.2D-5520-800-P4X-002 - AUTOMATION AND CONTROL ARCHITECTURE;
 - I-ET-3010.00-1200-800-P4X-010 - CRITERIA FOR ESTABLISHING CABLE CODES AND CABLE GLAND CODES;
 - I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS;
 - I-ET-3010.00-1200-850-P4X-002 - ASSET MANAGEMENT SYSTEM (AMS);
 - I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS;
 - I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS;
 - I-ET-3010.00-5140-700-P4X-003 - ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS;
 - I-ET-3010.00-5140-700-P4X-004 – PN-5140001 - POWER MANAGEMENT SYSTEM (PMS) FOR OFFSHORE UNITS;
 - I-ET-3010.00-5140-700-P4X-005 - REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEMS OF OFFSHORE UNITS;



- I-ET-3010.00-5140-712-P4X-001 - LOW-VOLTAGE INDUCTION MOTORS FOR OFFSHORE UNITS;
 - I-ET-3010.00-5140-712-P4X-002 - MEDIUM-VOLTAGE INDUCTION MOTORS FOR OFFSHORE UNITS;
 - I-ET-3010.00-5140-741-P4X-001 - LOW-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS;
 - I-ET-3010.00-5140-741-P4X-004 - SPECIFICATION FOR LOW-VOLTAGE GENERIC ELECTRICAL PANELS FOR OFFSHORE UNITS;
 - I-ET-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION ARCHITECTURE;
 - I-ET-3010.00-5143-700-P4X-001 – ELECTRICAL SYSTEM PROTECTION CRITERIA;
 - I-ET-3010.00-5500-854-P4X-001 - MACHINERY MONITORING SYSTEM (MMS);
 - I-ET-3010.2D-1200-800-P4X-001 - INSTRUMENTATION ADDITIONAL TECHNICAL REQUIREMENTS;
 - I-ET-3010.2D-1200-800-P4X-005 - FIELD INSTRUMENTATION;
 - I-ET-3010.00-5520-800-P4X-004 - AUTOMATION NETWORK REQUIREMENTS;
 - I-LI-3010.2D-1200-940-P4X-002 - EQUIPMENT LIST;
 - I-LI-3010.00-5140-797-P4X-001 - ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST;
 - I-MD-3010.2D-5520-800-P4X-001 - AUTOMATION AND CONTROL SYSTEM FUNCTIONS;
 - I-MD-3010.2D-5520-800-P4X-003 - AUTOMATION NETWORK DESCRIPTION.
 - I-DE-3010.00-5140-797-P4X-002 - ELECTRICAL SYSTEM AUTOMATION TYPICAL ACTUATION DIAGRAMS.
- 5.1.6 All instrumentation and alarms mentioned in the data sheets and P&IDs are the minimum required by PETROBRAS. PACKAGER and PURCHASER shall indicate other instrumentation and alarms/trips for general protection and monitoring according to their experience and for compliance with Classification Society's requirements and submit in technical proposal to PETROBRAS for approval.
- 5.1.7 All requirements for PAS shall be checked during Factory Acceptance Test (FAT) and Site Acceptance Test, according to IEC 62381.
- 5.1.8 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.

- 5.1.9 In order to guarantee adequacy to IEC-61892-7, all instruments, electrical equipment and panels installed in field open areas shall be certified to operate in Zone 2. Certified enclosures against explosive atmosphere are mandatory.
- 5.1.10 The FPSO electrical system will supply electric power to compression system according to the I-ET-3010.00-5140-700-P4X-003 – ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS.
- 5.1.11 PAS must be guaranteed during black shutdown event in the time required to complete package depressurization. This time shall be defined during detail design in accordance of the Flare System depressurization strategy. The 220 Vdc power to the PAS is be guaranteed by platform DC UPS during black shutdown event for a maximum of 30 minutes, according to I-MD-3010.2D-5140-700-P4X-001 - ELECTRICAL SYSTEM DESCRIPTIVE MEMORANDUM. If a greater time is necessary for complete package depressurization, the manufacturer must provide solutions that do not depend on the 220Vdc power supply of platform DC UPS, if applicable.

5.2 PAS system

- 5.2.1 PAS shall be capable of carrying out control, interlock, process, start-up, shutdown, normal operation and safety procedures for main machinery and auxiliary equipment, including all the necessary interfaces to Motor Control Center (MCC) and other controls and systems, such as: Control and Safety System (CSS), Power Management System (PMS), Asset Management System (AMS) and Machine Monitoring System (MMS).
- 5.2.2 PAS shall include, at least, the following functions:
- Automatic and manual start-up, loading, normal / emergency stop, purge and shutdown sequences without causing any damage to equipment or process instability;
 - Automatic change over between compressors A / B, unloading one compressore and loading other;
 - 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 indication as described in PETROBRAS specification (such as temperature, pressures, etc. indicated in P&IDs and data sheets), mainly item INSTRUMENTATION AND CONTROL of I-FD-3010.2D-1238-560-P4X-001 - HYDROCARBON DEW POINT CONTROL SYSTEM (UT-1238001);
 - Independent hourmeter and starts counter;
 - Suction gas flow for each compressor stage in m³/h;
 - Suction and discharge stages pressure control;
- 5.2.3 PAS shall be capable to send and receive signals to / from Control and Safety System (CSS) according to I-ET-3010.2D-1200-800-P4X-014 - AUTOMATION INTERFACE OF PACKAGE UNITS.
- 5.2.4 PAS shall send and receive hardwired signals to/from Electrical System according to I-LI-3010.00-5140-797-P4X-001- ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST

5.3 Machinery Protection System (MPS)

- 5.3.1 Machinery Protection System (MPS) shall be according to the API 670 latest revision.
- 5.3.2 Probe arrangement for driven equipment, gearbox and driver:
- Radial vibration: Two (2) non-contact probes for each radial bearing (X-Y signal);
 - Axial position: Two (2) non-contact probes for each axial bearing;
 - Keyphasor: One (1) phase reference transducer for every different shaft speed;
 - Casing vibration: Two (2) accelerometers for gearbox casing (one (1) over the input and one (1) over the output shaft centerline, near radial bearings); four (4) accelerometers for electric motor (two (2) for each bearing housing) for motor equipped with journal bearings and two (2) accelerometers for electric motor (one (1) for each bearing housing) for motor equipped with roller bearings;
 - Gearbox probe arrangement shall be manufacturer's standard.
- 5.3.3 Probes shall allow gap adjustment.
- 5.3.4 All bearings must have metal temperature monitoring (two sensors installed, one spare). Only where metal bearing temperature measure is not feasible, PACKAGER and PURCHASER shall propose a bearing oil outlet temperature sensor with the same alarm and shutdown signals as indicated for metal bearing temperature in data sheets.
- 5.3.5 Each channel shall be supplied with an electronic configurable time delay to avoid activation of alarm during transient signals.
- 5.3.6 All wiring shall be protected by flexible conduits to a AISI 316L steel junction box (at skid edge), neatly routed to allow machine maintenance without damaging probes and wire leads.
- 5.3.7 Extension cables shall be armored.
- 5.3.8 Oscillator-demodulators shall be mounted in an intrinsically safe junction box, if applicable.
- 5.3.9 Paired channels (XY) from the two transducers mounted at each bearing for radial shaft vibration monitoring shall be allocated at the same MPS IO card.
- 5.3.10 A controlled access set point multiplier function shall be provided with actuation by an external contact closure witch causes the alarm (alert) and shut down (danger) set points to be multiplied by a factor.
- 5.3.11 All vibration signals channels shall be allocated at the same MPS monitor of the corresponding phase reference signal channel.
- 5.3.12 MPS x MMS interface shall not use internal control panel switches. MPS shall be connected directly to MMS panel.

5.4 Machinery Monitoring System (MMS)

- 5.4.1 Machinery Protection System shall be integrated in the Machinery Monitoring System (MMS) of the FPSO, **provided by others**, according to I-ET-3010.00-5500-854-P4X-001 – MACHINERY MONITORING SYSTEM. PACKAGER and PURCHASER shall provide interface cards installed in the Machinery Protection System to allow the interconnection with the MMS (software and hardware). All vibration signals (including displacement and accelerometers) shall be available with buffer signal output.



- 5.4.2 All signals from MPS monitoring cards shall be available to send data to MMS.
- 5.4.3 In addition to the signal available through the MPS Communication Card, PACKAGER and PURCHASER shall make available the required process variable signals presented in the I-ET-3010.00-5500-854-P4X-001 – MACHINERY MONITORING SYSTEM (MMS), through the Package Fast Ethernet Network to perform the functions above in the Machinery Monitoring System.
- 5.4.4 Packager shall provide all documentation of vibration signals and configuration files of the Machinery Protection System to be implemented by the MMS Supplier for Monitoring System configuration.

6. ELECTRICAL

- 6.1 Electrical equipment and materials shall comply with requirements of I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS, I-ET-3010.00-5140-700-P4X-007 – SPECIFICATION FOR GENERIC ELECTRICAL EQUIPMENT FOR OFFSHORE UNITS, I-ET-3010.00-5140-700-P4X-009 – GENERAL REQUIREMENTS FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS, I-ET-3010.00-5140-741-P4X-004 – SPECIFICATION FOR LOW-VOLTAGE GENERIC ELECTRICAL PANELS FOR OFFSHORE UNITS, I-ET-3010.00-5140-772-P4X-002 – SPECIFICATION FOR LOW-VOLTAGE FREQUENCY CONVERTERS, SOFTSTARTERS ANF INVERTERS FOR OFFSHORE UNITS. All electrical panel shall comply with I-ET-3010.00-5140-700-P4X-005 - REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEMS OF OFFSHORE UNITS.
- 6.2 Electrical installations inside the package and the voltages to be supplied for electrical loads (motors, heaters, control panels, etc.) shall comply with requirements of I-ET-3010.00-5140-700-P4X-003 - ELECTRICAL REQUIREMENTS FOR PACKAGES FOR OFFSHORE UNITS.
- 6.3 Electrical motors shall comply with requirements of I-ET-3010.00-5140-712-P4X-001 - LOW-VOLTAGE INDUCTION MOTORS FOR OFFSHORE UNITS and I-ET-3010.00-5140-712-P4X-002 - MEDIUM-VOLTAGE INDUCTION MOTORS FOR OFFSHORE UNITS. The electrical motors shall be fed from platform normal panels.
- 6.4 The electrical communications interfaces of the package shall comply with requirements of 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, I-DE-3010.00-5140-797-P4X-002 - ELECTRICAL SYSTEM AUTOMATION TYPICAL ACTUATION DIAGRAMS, I-ET-3010.005140-700-P4X-004 – PN-5140001 – POWER MANAGEMENT SYSTEM (PMS0 FOR OFFSHORE UNITS and I-LI-3010.00-5140-797-P4X-001 – ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.



- 6.5 Equipment, accessories, piping and structures shall be grounded according to requirements of I-DE-3010.00-5140-700-P4X-003 - GROUNDING INSTALLATION TYPICAL DETAILS, I-ET-3010.00-5140-700-P4X-001 - SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS, IEC 61892-6 and IEC-60092-502. Besides these standards, for installations in hazardous area, the grounding requirements of IEC 61892-7 shall be complied.
- 6.6 Auxiliary MCCs (Motor Control Center) provided by PURCHASER shall comply with requirements of I-ET-3010.00-5140-741-P4X-001 - LOW-VOLTAGE MOTOR CONTROL CENTER AND SWITCHGEAR FOR OFFSHORE UNITS and I-ET-3010.00-5140-700-P4X-005 - REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEMS OF OFFSHORE UNITS.

7. OPERATION AND MAINTENANCE REQUIREMENTS

- 7.1 PACKAGER and PURCHASER shall make the applicable recommendations to optimize operation and maintenance, taking into account the remote location and platform general conditions. Any changes to equipment design, materials or specific spares that may improve the equipment operability, availability or reliability shall be submitted to PETROBRAS for review and approval. But PACKAGER and PURCHASER shall always comply with PETROBRAS requirements before suggest any modification.
- 7.2 The packages shall be designed so that all maintenance can be carried out with standard tools as much as possible.
- 7.3 Equipment layout shall enable easy and safe access for maintenance to all components and parts. PACKAGER and PURCHASER shall provide suitable walkways, ladders and handrails for all packages, including auxiliaries. All equipment and peripherals, especially oil reservoirs, shall have full access and inspection doors / hatches.
- 7.4 Instruments and piping accessories shall be arranged in proper location in order to allow easy access by maintenance and operation personnel. Installation of piping and cable supports next to couplings, bearings and seals shall be avoided, for instance.
- 7.5 PACKAGER and PURCHASER shall prepare detailed assembly, disassembly and maintenance procedures, describing the use of all involved lifting apparatus and including all required preventive and corrective maintenance tasks. PACKAGER and PURCHASER shall inform the need for disassembling any component or equipment in order to facilitate access for maintenance. Suitable maintenance routes shall be provided to remove the main components and auxiliaries, avoiding interference with structures, piping, cabling, electric conduits and supports, equipment, etc. This plan shall be submitted to PETROBRAS for approval.
- 7.6 PACKAGER and PURCHASER shall provide electrically driven lifting / handling devices and external structure components enabling assembly, disassembly and removal all components inside the package (compressor, gearbox, electric motor rotor, etc) with adequate and certified capacity to handle maximum maintenance weight and / or dimensions. Lifting and handling devices shall be according to I-ET-3010.2D-5266-630-P4X-001 - TOPSIDE'S MECHANICAL HANDLING PROCEDURES.



- 7.7 PACKAGER and PURCHASER shall provide special tools for all maintenance activities including tools for compressor and driver assembly, disassembly and removal.
- 7.8 PACKAGER and PURCHASER shall include in proposal a schedule stating the expected time between major overhauls.
- 7.9 PACKAGER and PURCHASER shall provide a gearbox shaft end with an adaptor in order to allow manual turning for maintenance purposes.
- 7.10 Noise control requirements
- 7.10.1 Noise control analysis is a mandatory item to be carried-out. PACKAGER and PURCHASER shall present noise data regarding items included in scope of supply.
- 7.10.2 The maximum allowable sound level shall be 90 dB(A) at one (1) meter around the unit and up to two (2) meters from the floor.
- 7.10.3 The noise control system for the package shall consider the noise radiated by inlet / outlet piping, equipment enclosure and equipment casings.
- 7.10.4 Whenever electric motor drivers are used, it shall be verified if motor fan design can be modified (e.g., use of unidirectional blades, etc.) before any apparatus are applied for noise attenuation.
- 7.10.5 In case of expected noise are higher than allowable limits, the equipment must be furnished with some noise control reduction measure and the maximum noise allowable value will be 85 dB(A). PACKAGER and PURCHASER may consider the best solution, which may include acoustic walls (open roof) and safety system requirements. In this case (open roof) no gas detection nor ventilation systems are acceptable. The use of device to comply with noise requirement must be proved to be efficient and submit to PETROBRAS approval.
- 7.10.6 For all equipment installed without acoustical enclosure, the following data will be required during proposal phase:
- Sound power level of the equipment;
 - Sound pressure level, in each of the four main directions and in one point of the top;
 - Acoustic isolation on suction and discharge piping lines shall be provided.
- 7.10.7 For all equipment installed inside acoustic enclosure, the following data will be required during proposal phase:
- Sound power level of the equipment without enclosure;
 - Sound pressure level, in each of the four main directions and in one point of the top, for the equipment plus enclosure;
 - Acoustical data of enclosure and silencers (when applicable).

8. INSPECTION AND TESTS

8.1 General requirements

- 8.1.1 PETROBRAS is entitled to inspect the package anytime during fabrication to ensure that material and workmanship are in accordance with the specifications.

- 8.1.2 Inspection of materials and / or equipment will be made by PETROBRAS or its authorized representatives.
- 8.1.3 Unless otherwise specified, all witnessed tests shall be informed, at least, 90 days before the scheduled dates.
- 8.1.4 Unless otherwise established by PETROBRAS inspector, all equipment shall be available for inspection in an unpainted state.
- 8.1.5 All PAS shall be functionally tested at supplier facilities. All control sequences and shutdown logics shall be simulated and tested against the requirements. Details of supplier standard functional test procedures shall be submitted to PETROBRAS approval.
- 8.1.6 PETROBRAS inspector shall have the right to request inspections to ensure that the equipment complies with the relevant classification society requirements.
- 8.1.7 In case any defects and / or shortcomings are found, PACKAGER and PURCHASER shall bear the full cost of such inspection and replacement as necessary. Any repair shall previously be approved by PETROBRAS. The subsequent inspection necessary to confirm the satisfactory results will be at PACKAGER and PURCHASER cost.
- 8.1.8 All process gas system welds shall be 100 % radiographically inspected and submitted to magnetic particle examination.
- 8.1.9 Seal as well as Hydrodynamic Bearings shall be removed by PACKAGER and PURCHASER after FAT and package separately with clear identification to be delivered with the main equipment in a packing suitable for long term storage for posterior PACKAGER and PURCHASER assembly.

8.2 Hydrostatic test (HT)

- 8.2.1 For all trains, parts being tested shall be externally coated with a layer of white lead carbonate or any other suitable powder to help leakage detection.
- 8.2.2 No vises or clamping devices shall be used for pressing of nozzle flanges.
- 8.2.3 PTFE tape or thread compounds shall not be used to prevent leakage of threaded plugs and connections.

8.3 Performance Test (PT)

- 8.3.1 PT shall be performed on each unit according to ISO 1217 last Edition.
- 8.3.2 The performance test procedure shall be agreed with PETROBRAS

8.4 Mechanical Running Test (MRT)

- 8.4.1 MRT shall be performed on each unit according to API STD 619 last Edition.
- 8.4.2 PACKAGER and PURCHASER shall submit to PETROBRAS a CD with vibration data recorded during MRT and all test information, including, at least: failed tests, with sweeping, starting / stopping ramp, equipment vibration signature, diagram for all bearing signals and phase angle versus speed.
- 8.4.3 The MRT procedure shall be agreed with PETROBRAS.

8.5 Sound Level Test (SLT)

- 8.5.1 The sound pressure meter shall be class I, according to IEC 61672. The characteristics of the octave filter shall be in accordance with IEC 61260. The sound pressure reading shall be made as equivalent continuous level, for 60 seconds sampling time. The recorded values shall be corrected to the nearest entire value within 1dB. A maximum deviation of 2dB will be allowed, both for the A scale weighted value and for the octave bands between 31.5 Hz and 8000 Hz.
- 8.5.2 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.
- 8.5.3 If the difference between the background noise level and the equipment sound level plus the background is less than 10dB, the measurements shall be corrected.
- 8.5.4 If the normal operating condition cannot be reached in the test facilities, PACKAGER, PURCHASER and PETROBRAS shall agree with measurements methods and values.
- 8.5.5 If the values measured and reported during the shop test are higher than the limits submitted by PACKAGER and PURCHASER and approved by PETROBRAS in proposal, PACKAGER and PURCHASER shall provide, without extra cost, sound attenuation methods in order to reach this limit, if required by PETROBRAS.

8.6 Site Acceptance Test (SAT)

- 8.6.1 Site Acceptance Test (SAT) is an offshore acceptance test to be performed when the motocompressor is able to operate after all commissioning is completed and not pending.
- 8.6.2 SAT shall be performed according to "Annex A" (Rotating Equipment Reliability Test).
- 8.6.3 PURCHASER and PACKAGER and PURCHASER shall provide all facilities, support and technical assistance for SAT. PURCHASER is responsible for any repairs required during the SAT that are not caused by factors external to the rotary compression system.
- 8.6.4 The SAT procedure shall be agreed with PETROBRAS.

9. ANNEX

- 9.1 Annex A: Rotating Equipment Reliability Test.



ANNEX A.docx