PETROBRAS	**TECHNICAL SPECIFICATION**	**Nº:** I-ET-3010.1M-1252-321-P4X-001	
	CLIENT: SRGE		**SHEET:** 1 of 26
	JOB: REFERENCE BASIC DESIGN		1001056398 0010
	AREA: BÚZIOS		
DP&T-SRGE	**TITLE:** **INJECTION GAS MOTOCOMPRESSOR**		**NP-1**
			ESUP

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SUMMARY

1. GENERAL

1.1. Centrifugal compressor for Injection Gas Motocompressor package units shall be in accordance with API std 617, last edition. Centrifugal compressors for Main Gas Motocompressor package units shall also comply with the additions to, or modifications of API std 617, 7th edition, described in "Annex B" and Comments and Deviations to API 617, described in "Annex D".

1.2. PACKAGER shall consider all documents listed in Material Requisition as mandatory. Electrical, automation and safety requirements for Main Gas Motocompressor (package unit) are also described in these documents.

1.3. 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 PURCHASER specifications.

1.4. PACKAGER shall be entirely responsible for material selection on items not specified by PURCHASER and shall inform material of all main parts according to ASTM code. All bolts and nuts shall be supplied with PACKAGER certificates and fully marked according to applicable ASTM standard.

1.5. All shop punch lists shall be cleared before shipment.

1.6. Equipment shall be prepared for outdoor storage according to PURCHASER specifications.

1.7. PACKAGER 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.

1.8. Hazardous and toxic materials with associated adverse health effects shall be avoided or minimized. PACKAGER and sub-suppliers are encouraged to promote their replacement. Asbestos has been identified as detrimental to human health, especially regarding serious and often fatal diseases such as lung cancer, asbestosis and mesothelioma. Therefore, it shall not be used in the materials and equipment supplied for this project or for this plant or facility. As the use of such materials will not be tolerated, PURCHASER strongly recommends PACKAGER and sub-suppliers to take all necessary measures to ensure their use is fully avoided throughout this project. Material safety data-sheets may be required by PURCHASER any time, to demonstrate that a particular material has not been, is not and will not be used throughout all stages of this project.

1.9. All equipment, components and panels shall have a nameplate easy to access, to view and read. Nameplate shall be made in AISI 316 stainless steel and bolted (with stainless steel elements) to the equipment. Layout drawings shall be submitted to PURCHASER approval. Nameplates shall contain the following information, in Brazilian Portuguese language:

- Client name;
- Client job;
- Client area;
- Supplier name;
- Series number and model;
- Specific data;
- Tag number;
- Purchaser's requisition number (RM);
- Purchaser's request for quotation

- Year of manufacturing;
- Main design and test data: pressure, temperature, voltage, rotation, etc;
- number (RFQ);
- Purchaser's order number (PO);
- Empty weight;
- Design code.

1.10. All safety signals shall be in Portuguese language.

2. CONSTRUCTION FEATURES

2.1 Centrifugal compressors shall be radialy split case (barrel type) in accordance with API std 617 last edition.

2.2 Compressor tie-bolt type impelers are not acceptable.

2.3 Compressors with sidestream are not acceptable.

2.4 Compressor bearings shall be hydrodynamic tilting pads type.

2.5 All bearings shall be designed to minimize oil foaming and prevent oil whirl at any operating speed.

2.6 The compressor train center-line is oriented in the fore/aft direction in case of installed on a FPSO (Floating Production Storage and Off-loading).

2.7 Compressor connections and nozzle flanges shall be provided by removable spools to facilitate compressor remove and disassembly.

2.8 Grayloc type flanged connections are not acceptable. If non-standard flanges are approved by PURCHASER, respective companions shall be supplied. Sections nozzles shall be rated to the same class. Studded or Flanged connections are acceptable.

2.9 PACKAGER shall consider all operational cases, gas compositions and corrosive components content (H_2S and CO_2) for the compressor materials specification. PACKAGER shall also consider the compressor non running, cold and pressurized (with process gas) conditions and the presence of free water (even when not specified in the gas composition).

2.10 The highest compressor bearing surface metal temperature shall not exceed 100º C (212º F) at any operating condition including during MRT at maximum continuous speed.

3. ACCESSORIES AND AUXILIARIES

3.1 Piping

3.1.1 Except where indicated, all piping and accessories within equipment package limit shall be in accordance with PACKAGER piping specification and international standards.

3.1.2 All auxiliary piping requiring field connections shall be brought to the skid edge and shall be flanged.

3.1.3 Manual block valves and spectacle / blind flanges shall be provided at all battery limits such as inlet and outlet nozzles, drain lines, etc. PACKAGER considering piping standards as in I-ET-3010.1M-1200-200-P4X-001 – PIPING SPECIFICATION FOR TOPSIDE.

3.1.4 All equipment shall have sufficient flexibility in all pipe and duct connections.

3.1.5 The interconnecting pipework between auxiliary skid and the main baseplate shall be provided by PURCHASER.

3.1.6 A temporary basket particulate filter for machine starting, removable without disassembly of the piping, shall be installed in the suction line, close to each stage of compression.

3.2 Couplings and coupling guards

3.2.1 PACKAGER is responsible for all couplings within the package, including those for auxiliary equipment.

3.2.2 Coupling for main equipment shall be a stainless steel flexible-element, non-lubricated type.

3.2.3 PACKAGER shall submit to PURCHASER main equipment coupling data sheet according to API 671.

3.2.4 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. 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.

3.2.5 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.

3.3 Baseplate

3.3.1 Main baseplate shall be capable of supporting the stresses arising from platform motions and shall be provided with three (3) point supports and Anti-Vibration Mounting (AVM).

3.3.2 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).

3.3.3 Driver, driven machine and transmission shall be mounted on a single baseplate. Other auxiliaries shall be mounted on the same baseplate (preferable) or provided with their own skid. PACKAGER shall submit layout to PURCHASER comments and approval.

3.3.4 The baseplate shall have a removable solid checkered plate or open grating top floor where required for maintenance.

3.3.5 All furnished skids shall be sufficiently stiff to withstand all vibration loads induced by the equipment and transfer them to the deck beams.

3.3.6 Skid mounted assemblies shall be constructed in order to not require equipment or parts to be dismounted for lifting.

3.3.7 No equipment / component shall protrude beyond the skid limits. In cases where it cannot be avoided, required protection against mechanical damage shall be provided.

3.3.8 Each skid shall be provided with facilities (pad-eyes, lugs, bollards and spreader bar) for lifting, having suitable access for rigging. The estimated lifting load and safety factor for each point shall be informed in PACKAGER 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.

3.3.9 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.

3.3.10 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.

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

3.4 Support system

3.4.1 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.

3.5 Insulation

3.5.1 All required insulation for personnel protection or machine thermal efficiency shall be applied and provided by PACKAGER.

3.5.2 Insulating shall ensure a temperature below 60˚C over the external surface for personnel protection.

3.5.3 To prevent corrosion under insulation, only non hygroscopic insulation material shall be used.

3.5.4 In order to avoid damages during transportation and erection, insulation shall be carried out after final installation in place.

3.6 Oil system

3.6.1 A mineral oil (lube) shall designed per API 614 latest edition (with agreed deviations), integrated with HVSD, system shall be provided for lubricating driver, HVSD and driven equipment and shall include twin filters with changeover valve.

3.6.2 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.

3.6.3 PACKAGER shall propose its standard oil system configuration and inform all data and characteristics of electric load (as power, source, etc.) for each pump driver, heater, etc. in proposal phase. PURCHASER will furnish 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.

3.6.4 Emergency system shall include rundown tank. Proposed system shall have enough capacity for bearing cooling during coast-down time and shall be monitored with PACKAGER specification and international standards for this system.

3.6.5 PACKAGER 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.

3.6.6 All piping and appurtenances downstream oil filters shall be made of AISI 316L stainless steel.

3.6.7 Socket welds for piping and tubing is prohibited.

3.6.8 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 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.

3.6.9 Oil coolers shall be multi-plate duplex type. The material shall be AISI 316L stainless steel, if closed loop cooling water system is provided by PURCHASER. Cooler shall have provision for future increase of the number of plates. The cooling water pressure shall always be lower than oil pressure at heat exchanger interior.

3.6.10 The canisters, transfer valves and piping for oil filter system shall be 316L stainless steel construction. Filter element material shall be corrosion and water resistant. There shall be no by-pass around any filter.

3.6.11 The expected configuration for pumps are:

- Main oil pump: Shaft-driven (preferable) or electric motor driven (essential AC power);
- Stand-by pump: Electric motor driven (essential AC power).

3.6.12 For non shaft-driven pumps, the main and stand-by pumps shall be identical. In all cases, stand-by pumps shall have the same capacity as the main pump.

3.6.13 API data sheets for pumps and heat exchangers shall be included in proposal.

3.6.14 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.

3.6.15 PACKAGER shall provide all data of oil system equipment and fluid as oil consumption, oil complete specification and filter elements life.

3.7 Hydraulic Variable Speed Drive (HVSD)

3.7.1 HVSD shall be designed as a “stand-alone” unit, whereby no external thrust loads shall be imposed upon the HVSD by other equipment.

3.8 Pressure vessels

3.8.1 In order to avoid categorizing of any pressure vessel (and heat exchanger, where applicable) according the requirements of the Brazilian Labor Ministry regulation NR-13, when possible, the product of pressure (in mega Pascal) multiplied by the volume (in cubic meters) of any equipment shall be lower than 8. Where applicable, NR-13 calculation sheets and specific nameplates shall be provided.

3.8.2 For nozzles less than 2” in nominal diameter, forged steel couplings may be used. Couplings shall be at least class 6000#, for socket weld.

3.8.3 All nozzles having a nominal diameter of 2” or greater, shall be flanged, except when specified for butt weld in the piping.

3.8.4 The minimum nominal diameter of nozzles intended for any purpose shall be 3/4”.

3.8.5 Only full penetration welds are permitted.

3.8.6 All shell reinforcements, integral or not, shall always have the same shell P-number.

3.8.7 The minimum degree of radiographic examination for weld inspections according table UW-12 shall be full or spot.

3.9 Dry Gas Seal (DGS) system

3.9.1 DGS system shall be prepared, calculated and detailed by PACKAGER for all operating and utilities conditions (including start-up, normal and emergency shutdown, settling-out, minimum instrument air pressure, etc.).

3.9.2 PACKAGER shall furnish all technical details about DGS system during proposal phase, including seal leakage detection method.

3.9.3 PACKAGER shall include in proposal a reference list showing his experience with proposed DGS system, highlighting the units with similar services.

3.9.4 DGS system shall always assure that the seal gas pressure is positive in relation to the balance line pressure and a minimum seal gas flow across the final labyrinths to avoid seal contamination for all conditions (pressurizing, starting, operation, normal and emergency shutdown, during depressurization or when stopped pressurized – settling-out), except when compressor is stopped and depressurized.

3.9.5 DGS system shall be bi-directional tandem type with intermediate seal gas labyrinth for each shaft end, with the following configuration:

- Primary and secondary seals rotating faces material shall be made of silicon carbide, at least. PACKAGER shall use the conditioned discharge process gas as primary seal gas supply and Nitrogen as secondary seal gas supply;
- The buffer gas for the barrier seal shall be Nitrogen or instrument air;
- Separation seals shall be carbon ring non-contacting type. The purge medium for carbon rings shall be Nitrogen and shall result in a lean gas mixture on secondary seal vent line;
- Where different seal designs or pressure ratings are employed in adjacent casings on the same compressor package, the seal cartridge shall be designed to prevent the incorrect mounting in different casings.

3.9.6 PACKAGER shall provide a dedicated seal gas panel for each compressor casing.

3.9.7 All PSV and check valves on venting piping, downstream each seal, control valves and other necessary valves for DGS system shall be provided by PACKAGER.

3.9.8 All lines connected to flare system shall be capable to be isolated for maintenance of upstream equipment/accessories by means of an isolation valve (locked open) supplied by PACKAGER.

3.9.9 PACKAGER shall supply the DGS system fully fitted with piping and support on main equipment baseplate.

3.9.10 All compressor DGS system piping, valves (including internals), filter bodies and fittings shall be made from 316 stainless steel.

3.9.11 All piping, valves and fittings shall have insulation and / or heating, where applicable.

3.9.12 PACKAGER shall make the necessary provisions to guarantee uninterruptible Nitrogen supply to the compressors sealing system in order to assure a safe shutdown (any case) of all compressor units. A Nitrogen coalescer filter (2x100%) with automatic drain level control shall be provided at each seal gas panel with online changeover capability.

3.9.13 A dual fine mesh coalescers filters (2x100%) with automatic drain level control shall be provided at each seal gas panel with online changeover capability to guarantee a clean and dry seal gas. The automatic drain shall avoid the possibility of back-flow.

3.9.14 DGS system shall be provided with all control, monitoring and safeguarding instrumentation, including monitoring primary vent by pressure or flow (trip) and secondary vent by pressure (alarm only) to identify DGS damage.

3.9.15 PACKAGER shall supply any pressure control valves if necessary to guarantee minimum back-pressure at DGS primary vent line.

3.9.16 A seal gas conditioning system shall be furnished by DGS supplier and shall be designed to remove all particles and liquids from the compressor discharge gas. This conditioned gas will supply primary seal, avoiding any kind of failure. PACKAGER shall guarantee a clean gas flow, at least 20ºC above its dew point and a pressure 15 kPa higher than compressor reference gas pressure. The conditioning skid shall include as a minimum:

- Twin filter arrangement (2x100%) for solids retention;
- A dual cartridge filter (2x100%), shall be supplied with automatic drain control and on-line changeover capability;
- A dual separator / coalesce filter (2x100%), shall be supplied with automatic drain control and on-line changeover capability;
- Automatic pressure booster (2x100%) shall be provided, for unpressurized discharge conditions. PACKAGER shall offer AMPLIFLOW or other similar device subject to PURCHASER approval;
- Heat exchanger system (2x100%), with on-line changeover capability and electric heater shall be installed;
- The seal gas conditioning system components shall be furnished according to the sequence stated above (filters, booster and heat exchangers);
- PACKAGER shall provide a dedicated seal gas conditioning skid for each compressor casing mounted on the main baseplate. In case of pneumatic booster construction type, seal gas migration to the booster drive shall be avoided and vice versa;
- The seal gas conditioning system logic control shall be designed to ensure a safe and reliable operation for each compressor casing mounted on the main baseplate for all operating conditions (pressurizing, starting, operation, normal and emergency shutdown, during depressurization or when stopped pressurized - settling out), except when compressor is stopped and depressurized.

3.9.17 In order to minimize the DGS system footprint, PACKAGER may propose keeping all the appurtenances described above a solution integrating the seal gas panel with the seal gas conditioning skid to be submitted in the technical proposal to PURCHASER´s approval.

3.9.18 Drains shall be provided for all seal lines, including primary and secondary vent lines, drains shall be placed in proper position.

3.10 Pressure Relief and Drainage

3.10.1 The seal and sealing system design shall withstand the 1.2 PSV set pressure value, as minimum, from compressor suction vessel according to the P&IDs.

3.10.2 PACKAGER shall inform maximum allowable pressure for each shaft-end seal casing. PACKAGER shall provide all necessary means to perform a partial or full depressurization to flare.

3.10.3 O-ring design including material selection shall be sufficiently resistant to explosive decompression taking in account pressurization rate according API 521, large number of compressor start and stops and the minimum time between overhauls required by API and ISO 23936-2.

3.10.4 Drains with valves shall be provided for all compressor stages (impeller-diaphragm cavity), placed in proper position. The drain header shall also be provided with valve in order to configure a drain with double block to closed and opened drain. In case individual stage drains cannot be provided due to design limitations, it shall be demonstrated during the proposal phase (by means of drawings) that all inner parts will have an effective drainage. Drain arrangements shall provide visual access and sight glasses in order to verify flow and leakage and to confirm whether the drainage operation is being accomplished or not.

3.10.5 Drains with valves shall be provided for all seal gas system, placed in proper position at battery limits. The drain shall be provided with valve in order to configure a drain with double block to closed and opened drain. Drain arrangements shall provide visual access and sight glasses in order to verify flow and leakage and to confirm whether the drainage operation is being accomplished or not.

3.10.6 Coalescer filters drains (Gas Seal Panel and Seal Gas Conditioning System) with valves shall be provided for all seal gas system, placed in proper position at battery limits. The drains shall be provided with valve in order to configure a drain with double block to closed and opened drain. Drain arrangements shall provide visual access and sight glasses in order to verify flow and leakage and to confirm whether the drainage operation is being accomplished or not.

3.10.7 The connections between compressor casing, dry gas seal panel, conditioning seal gas system and seals shall be fitted with low point drains to enable liquid removal during start-up procedures.

3.10.8 PDITs associated with SDVs shall be able to indicate positive and negative values to avoid SDV opening when downstream pressure is larger them upstream pressure.

4. AUTOMATION

4.1 General requirements

4.1.1 Package Automation System (PAS) shall be designed to ensure safe and reliable operation, performing protection, control and monitoring during start-up, operation, normal and emergency shutdown. PAS shall be furnished functionally tested, assembled and ready for connection.

4.1.2 All instrumentation and alarms mentioned in the data sheets are the minimum required by PURCHASER. PACKAGER shall indicate other instrumentation and alarms for general protection and monitoring according to their experience and submit in technical proposal to PURCHASER for approval.

4.1.3 PACKAGER shall provide a local gauge board (rack) installed on the equipment baseplate, as mentioned on data sheets. Oil filled gauges shall be provided for analogical instruments subject to high vibration levels.

4.1.4 PAS shall include all required components to ensure continuous monitoring, functionally tested, assembled and ready connection.

4.1.5 PACKAGER shall supply Unit Control Panels (UCP) shipped loose. UCP will be installed at the Automation and Electrical Panels Room (AEPR) by others.

4.1.6 The unit shall have a specific feature so that the equipment cannot be restarted without manual acknowledgement of the shutdown conditions.

4.1.7 All requirements for PAS shall be checked during Site Acceptance Test, according to IEC 62381.

4.1.8 Package shall be considered as P2S type, according to Technical Specification I-ET-3010.00-1200-800-P4X-002 - AUTOMATION, CONTROL AND INSTRUMENTATION ON PACKAGE UNITS and to I-ET-3010.1M-1200-800-P4X-014 – AUTOMATION INTERFACE OF PACKAGE UNITS.

4.1.9 PACKAGER shall provide to PURCHASER 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 PURCHASER.

4.1.10 PACKAGER shall make the necessary provisions for interconnections to be installed by others, if necessary for main equipment operation and safety, including instrument signals, alarms, controls and interlocking, etc.

4.1.11 PACKAGER will be responsible for all required control and interlocking interface with the process plant outside its scope of supply, in order to guarantee the proper start-up, operation, pressurized and depressurized shutdown.

4.1.12 A hardwired output signal, related to “start request” shall be available from UCP to allow implementation of automatic field forcing in main generators, in order to reduce voltage drop during starting.

4.1.13 Proper means of electrical and environmental protection shall be applied to instruments and instrumentation-related electrical/electronic installations located in hazardous areas and/or an aggressive saline air environment. In order to guarantee adequacy to IEC-61892-7, all field instruments and other electrical instrumentation equipment installed in open areas shall be certified to operate in Zone 1. Certified enclosures against explosive atmosphere are mandatory. Remote I/O panels shall be made of AISI 316 stainless steel and installed in shelters protected from rain and wind in the respective compression modules. The panels shall have IP56 protective level and the panels internal temperature shall be kept bellow 30 degrees centigrade.

4.2 **UCP hardware**

4.2.1 Each equipment package shall have its own UCP, with monitoring and control functions for all equipment (driven machine, driver, transmission and auxiliaries). Each UCP shall operate independently, so a failure of any component within a UCP does not affect the availability of any other UCP.

4.2.2 The UCPs located at the AEPR shall have:

- IP22 protection level;
- Frontal HMI;
- Cable entry from the bottom of the panel;
- Front access doors.

4.2.3 Each UCP shall include, at least:

- One dedicated safety system and one dedicated control system, which shall be implemented using Programmable Logic Controllers (PLC);
- HMI hardware;
- First-out and reset devices;
- Main equipment and auxiliaries start-up and stop devices;
- Sound alarm;
- Start counter and independent hourmeter;
- Machinery Protection System (MPS).

4.2.4 The network switches shall be industrial manageable type.

4.2.5 Control and supervisory networks must be redundant.

4.3 **UCP software**

4.3.1 PAS shall enable changes of set points, timer presets and control parameters, forcing I/O via software, input by-passing, output override with the system in operation, without damage to the process.

4.3.2 The control system programming and configuration shall be carried out by the UCP or additionally through a laptop computer (not provided by PACKAGER). The software editor shall be provided by PACKAGER.

4.3.3 HMI software (with runtime and development licenses) shall be provided.

4.3.4 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.

4.3.5 The control system programming shall be in accordance with PACKAGER specification. PACKAGER proposal shall inform the programming language used in the system.

4.3.6 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.

4.4 **UCP system**

4.4.1 The equipment UCP 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 connect with remote I/O, machine Protection System (MPS), Motor Control Center (MCC) and other controls and PETROBRAS security systems, such as: Control and Safety System (CSS), Power Management System (PMS), Asset Management System (AMS) and Machine Monitoring System (MMS).

4.4.2 Emergency shutdown relay shall be provided to actuate directly on the driver and on the process plant SDVs.

4.4.3 The ESD from push buttons, PSD (process Shutdown System) and MPS, shall actuate the emergency shutdown relay and be used as input for UCP safety PLC.

4.4.4 Control system shall not allow undesirable nor unsafe operations.

4.4.5 UCP 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;
- 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 UCP indication as described in PURCHASER specification (such as temperature, pressures, etc. indicated in P&IDs and data sheets);
- Independent hourmeter and starts counter;
- Suction gas flow for each compressor stage in m^3/h;
- Suction and discharge stages pressure control;
- Capacity, load sharing and anti-surge control integrated (so any individual corrective action taken by one loop shall not degrade a response from other). Systems shall enable adjustment of control parameters and perform by-pass inputs automatically without causing process disturbances, keeping the plant in safe condition and providing alarms to the operator.

4.4.6 Interface for monitoring, recording and configuration for performance, Load sharing and Surge control systems shall be provided. This interface shall be capable of recording surge events and may be implemented in the HMI of the UCP or in a dedicated HMI for each compressor service, installed at Central Control Room (CCR). In case of a dedicated HMI, a fiber optic port shall be available in one of the UCPs of the compression system for this HMI interconnection. This interface shall sample variables in high speed (milliseconds), storing and displaying all analog and digital variables, alarms and events. This interface shall also present PI&D and performance maps of operating points indicated in the compressor datasheet and the distance from anti-surge control line. The following maps are required: Rc x Q (m^3/h), Pd (bar) x Q (m^3/h), Td (^oC) x Q (m^3/h), Hp (kJ/kg) x Q (m^3/h), ηp (%) x Q (m^3/h), Pot (kW) x Q (m^3/h), Hp (kJ/kg) x Qm (kg/h), ηp (%) x Qm (kg/h), Pd (bar) x Qn (Nm^3/d at 20^oC and 1 atm). This system shall be capable to have a remote client station in order to allow remote monitoring of all signals based on TCP/IP connection. One additional Ethernet network card available for PURCHASER use purpose (remote monitoring connection) and at least five (5) licenses for remote simultaneous clients are required

4.4.7 UCP shall be capable to send and receive signals to / from PAS according to PURCHASER specifications.

4.4.8 PAS shall have high reliability, integrity and availability for operation in fail safe mode in order to avoid, whenever possible, an unnecessary shutdown or loss any process variable with safety function.

4.4.9 PAS shall include on-line 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.

4.4.10 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.

4.4.11 Connectivity to external system through open communication protocols shall be MODBUS and OPC (Open Platform Communications) by Ethernet TPC/IP Protocol. All I/O variables, controllers (including performance, load sharing and surge) and first-out events shall be available.

4.4.12 The UCP interface with AMS shall be as described in I-ET-3010.1M-1200-800-P4X-014 - AUTOMATION INTERFACE OF PACKAGE.

4.4.13 UCP shall have a Remote I/O panel as described in in I-ET-3010.1M-1200-800-P4X-014 - AUTOMATION INTERFACE OF PACKAGE.

4.5 **Human Machine Interface (HMI)**

4.5.1 HMI shall allow the operator to view and acknowledge alarms and trips, protections reset, status of each I/O and intermediate variables, software monitoring / modification, system configuring, first-out of alarms and shutdowns, list of set points and parameters, analog variables, variables performance and trend, recording of all relevant data and periodic reports, events, number of starts and operation hours, I/O forcing, by-pass of inputs and override of outputs.

4.5.2 The logs shall be CSV standard in three (3) different report types:

- Daily files of digital and analog variables with 1 second sample time and three months storage;
- Hourly files of digital and analog variables with 40 milliseconds sample time and last five days storage;
- Individual ESD files of digital and analog variables with 40 milliseconds sample time and ten minutes storage time (six minutes before and four minutes after the occurrence of ESD or normal stop). The HMI shall maintain the last 200 individual files at least.

4.5.3 HMI shall comply, at least, with the following requirements:

- Industrial microcomputer installed inside the panel housing;
- One additional Ethernet network card available for PURCHASER use purpose (remote monitoring connection);
- Panel-mounted LCD color touch screen display. The CPU shall be independent from the display screen;
- Data logging and event/variable recording and storing, including any event, alarms, trips and digital/analog variables values historic for at least two months with sample time not greater than 1 second and dead band not greather than 1%;

- Listing of all incoming alarms chronologically in a directory and a user-defined actions with PLC timestamps up to miliseconds time resolution;
- Real-time measurements;
- Display of equipment schematic layout;
- Display all analog and digital variables from sharing controllers, machinery protection and machinery monitoring systems.

4.5.4 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.

4.5.5 If, for any reason, HMI have some malfunction, the control system shall continue with all its function normally. PACKAGER shall provide a hardware interface (such as a laptop computer connection) in order to establish an external communication with PLC.

4.5.6 English and Brazilian Portuguese languages shall be used on all HMI screens installed on UCP.

4.5.7 Each HMI must be capable to allow operation of any compression train in this compression system.

4.5.8 HMI software must be compatible with OSI “Plant Information-PI” software.

4.5.9 One remote HMI for each compression service shall be provided, with the same functionalities of the UCP HMI, to be installed at Central Control Room (CCR). This HMI shall be a 19" rack-mounted PC, shipped loose. A fiber optic port shall be available in one of the UCPs of the compression system for this remote HMI interconnection.

4.6 **Machinery Protection System (MPS)**

4.6.1 Machinery Protection System (MPS) shall be according to the API 670 latest revision.

4.6.2 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 hydrodynamic tilting pads and two (2) accelerometers for electric motor (one (1) for each bearing housing) for motor equipped with roller bearings.
- HVSD probe arrangement shall be manufacturer's standard.

4.6.3 Probes shall allow gap adjustment.

4.6.4 Only where metal bearing temperature measure is not feasible, PACKAGER shall propose a bearing oil outlet temperature gauge with the same alarm and shutdown signals as indicated for metal bearing temperature in data sheets.

4.6.5 Monitors shall be mounted on Unit Control Panel (UCP) at Automation and Electrical Panes Room (AEPR).

4.6.6 All vibration and temperature protection systems shall be according to Original Equipment Manufacturer (OEM) standards and API 670 compliant.

4.6.7 Each monitor channel shall be capable of continuously comparing the input signal to warning set points. The warning system shall comprise at least two (2) levels: alarm and shutdown. The exception is axial position monitor, for which shall be supplied with four (4) independent alarms and shutdown adjustable limits (two (2) for each direction).

4.6.8 The vibration signals (including displacement and accelerometers) of the whole train shall have an unfiltered output at the UCP (one per channel) for recording and maintenance purposes.

4.6.9 Each channel shall be supplied with an electronic configurable time delay to avoid activation of alarm during transient signals.

4.6.10 All wiring shall be protected by flexible conduits to a 316L stainless steel junction box (at skid edge), neatly routed to allow machine maintenance without damaging probes and wire leads.

4.6.11 Extension cables shall be armored.

4.6.12 Oscillator-demodulators shall be mounted in an intrinsically safe junction box.

4.6.13 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.

4.6.14 A controlled access set point multiplier function shall be provided with actuation by an external contact closure with causes the alarm (alert) and shut down (danger) set points to be increase by integer multiple.

4.7 **Machinery Monitoring System (MMS)**

4.7.1 Besides the control and supervisory UCP system, Machinery Protection System shall be integrated in the Machinery Monitoring System (MMS) of the FPSO, provided by others, for maintenance purposes. PACKAGER 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.

4.7.2 For a basic description, the primary function of this system is to perform analysis of the mechanical parameters: all machinery protection system signals (with possibility to make analysis like FFT, full spectrum, Bode plot, cascade and waterfall diagrams, shaft average center line, orbit, X-Y plot and experience-based vibration analysis) and auxiliary system signals (lube, seal, etc.).

4.7.3 MPS radial vibration monitoring cards shall have all available variables enabled to send data to MMS.

4.7.4 In addition to the signal available through the MPS Communication Card, PACKAGER shall make available the required process variable signals presented in the I-ET-3010.00-5500.854-P4X-001 – MACHINERY MONITORING SYSTEM, through the Package Fast Ethernet Network to perform the functions above in the Machinery Monitoring System.

4.7.5 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.

4.8 **Capacity control**

4.8.1 The Capacity control shall be performed per each compression service type.

4.8.2 Process control shall maintain the suction pressure and limit the discharge pressure of compressor trains. If the discharge pressure exceeds set point, system shall switch from suction pressure control to discharge pressure limit. These set points shall be monitored and controlled from Unit Control Panel (UCP) at Automation and Electrical Panels Room (AEPR).

4.8.3 Process control shall limit electric motor current of compressor trains. If the current exceeds set point, system shall switch from suction pressure control to electric motor current limit. These set points shall be monitored and controlled from Unit Control Panel (UCP) at Automation and Electrical Panels Room (AEPR).

4.8.4 The suction throttle valve when applicable, shall be installed upstream of the scrubber and located at outside the recycle loop.

4.8.5 PACKAGER shall furnish the Capacity control instrumentation. The instruments specification shall be submitted to PURCHASER approval, including throttle valves when specified. Valves and instrumentation shall be shipped loose for PURCHASER approval.

4.8.6 Capacity control system pressure transmitter shall have a maximum response time of 100 milliseconds.

4.8.7 The variable speed driver shall be included in capacity control loop.

4.8.8 Capacity control shall be mounted on Unit Control Panel (UCP) at Automation and Electrical Panels Room (AEPR).

4.8.9 Capacity control system shall be implemented by separated and dedicated microprocessor based system, independent of the compressor control, with hardwired interlock and network for communication purpose. The Capacity control, Load sharing control and Anti-surge systems of the compressors shall be segregated from the Control system and the Safety system PLCs.

4.9 **Load sharing control**

4.9.1 The load sharing control supplier shall be supplied according to the OEM standards.

4.9.2 The Load sharing control shall be performed by each compressor train.

4.9.3 Control system shall operate the units individually, partial units or all of them in parallel, with automatic and manual modes. Set points shall be monitored and controlled from UCP at AEPR.

4.9.4 PACKAGER shall furnish the Load Sharing instrumentation (for each train). The instruments specification shall be submitted to PURCHASER approval, including throttle valves when specified. Valves and instrumentation shall be shipped loose, for PURCHASER field assembly.

4.9.5 Load sharing system pressure transmitters shall have a maximum response time of 100 milliseconds.

4.9.6 When operating in parallel, load sharing control shall provide appropriate distribution of loads between units, so that they operate proportionally equidistant from their respective limits. Special attention shall be given to specific stages operating closer to the surge line.

4.9.7 Load sharing control shall be mounted on Unit Control Panel (UCP) at Automation and Electrical Panels Room (AEPR).

4.9.8 Load Sharing control system shall be implemented by a separated and dedicated microprocessor based system, independent of the compressor control, with hardwired interlock and network for communication purpose.

4.10 **Anti-Surge (AS) control**

4.10.1 For design purpose, PACKAGER shall consider one AS recycle line for each stage in your proposal. Overall recycle line shall not be accepted.

4.10.2 In case of water gas content, an analysis shall be made to verify the possibility of hydrate formation in the recycle line. Hot recycle (ASV upstream of the heat exchanger) shall be preferably used.

4.10.3 PACKAGER shall furnish the AS control valves with their instrumentation including transmitters (flow, pressure and temperature) for each stage and AS control system (controllers installed at UCP). The anti-surge valves instrumentation and piping associated with the valves shall be specified by AS system VENDOR. The design of the anti-surge valves, instrumentation and piping associated with the valves shall be submitted to PURCHASER and VENDOR approval, including check valves. Valves and instrumentation shall be shipped loose, for PURCHASER field assembly.

4.10.4 AS system pressure and flow transmitters shall be smart with HART protocol and maximum response time of 100 milliseconds.

4.10.5 The volume between discharge compressor, check valve (upstream heat exchanger) and AS valve shall be as minimum as possible. A double check valve shall be provided separating each compressor stage.

4.10.6 AS valves shall be sized according to process dynamic simulation to be performed by PACKAGER and submitted to PURCHASER approval.

4.10.7 The dynamic simulation shall be applied to tune the capacity and surge controls in order to optimize both controls. The dynamic simulation shall also confirm the AS configuration (valves, lines, etc.).

4.10.8 AS valves shall be sized to perform their function in all operating conditions, including transients, avoiding choke zone but not oversized in order to maintain their controllability.

4.10.9 Actuation time for AS valves, from fully closed to fully open position, shall be less than two (2) seconds and opening-closing cycle time shall be less than two (2) seconds;

4.10.10 AS control system shall be implemented by a separated and dedicated microprocessor based system, independent of the compressor control with hardwired interlock and network for communication purpose and shall be furnished with:

- The antisurge valve shall be open failure type, with linear response, class 5 balanced cage globe, ASTM-A 216 Gr WCB body material, AISI 316 seat material with “Stellite” or equivalent hardness material, no chromium coating shall be accepted and with anti-noise technology to attenuate up to 90 dBA @ 1m;
- The antisurge valve shall be mounted with high speed intelligent positioner and high flow booster to increase the precision and speed of actuation;
- The use of quick exhaust or similar system that opens the antisurge valve in an uncontrolled mode is not allowed;
- A solenoid shall be used, between the Booster and the Actuator, with high Kv to allow antisurge valve smallest stroke;
- The maximum antisurge valve opening stroke time (0 to 100%) shall be up to 1 second for valves less than or equal to 4 ", up to 2 seconds for valves greater than 4" and less than 12 " and up to 3 seconds for valve greater than 12";
- The minimum antisurge valve closure stroke time (100% to 0) shall be up to 3 seconds for a valve less than or equal to 4 ", up to 5 seconds for valve greater than 4" and less than or equal to 12 " and up to 8 seconds for valve greater than 12”;
- A maximum scan time of 0.05 seconds;
- The AS control shall be capable to detect the compressor at surge;
- In case of two (2) surge events within fifteen (15) seconds, the AS valve shall be openned through curent analog output and solenoid deenergizing, installed between booster and actuator;
- In case of four (4) surge events within thirty (30) seconds, the AS control shall stop the compressor;
- A closed loop with anti-reset windup action;
- Adaptative actions to allow the surge control line to change as a function of the displacement of the operating point, with automatic return to the original position;
- An adaptive open loop response to large and fast disturbances;
- An adaptive detection algorithm in order to protect the compressor by establishing new safety margins (more conservative than previous one) when a surge event occurs;
- An electronic decoupling algorithm used to avoid interaction between AS and the others compressors control loops;
- Automatic correction for molecular gas weight, suction pressure, suction temperature and compressor efficiency variations throughout the equipment service life;
- Devices to protect the machine even in manual operation.

4.10.11 In order to achieve good controllability, PACKAGER shall recommend and review AS line layout.

4.10.12 AS control and Capacity control / Load sharing systems from compression service shall have a decoupling capability in order to temporally reduce the capacity control action when the surge control is performed.

4.11 **Advanced Control**

4.11.1 Advanced controls are to be defined by PETROBRAS during the detail design, or during operation phase. These systems may use PETROBRAS software package, or third part packages when required, and run on computers in the automation network. The goal of advanced control is to assist operators in integrating and coordinating the various compressors in the unit's gas treatment system.

4.11.2 PACKAGER shall provide connectivity through MODBUS and OPC for the advanced control to read all critical variables of the compressor (pressures, temperatures, power, current, speed, etc.).

4.11.3 PACKAGER shall provide for the compressor suction and discharge pressure set points two 4-20mA input signals at Capacity Control. In this way, the advanced control or the operator can command the suction pressure set points. At package HMI operator shall select if the set points will be defined locally (at package HMI) or remotely (from advanced control signals). This signals (4-20mA) will be provided by the Process Control System (PCS) (not in the scope of the PACKAGER).

4.11.4 PACKAGER shall provide for each AS recycle valve a 4-20mA input signal in AS control system. This signal will go to a high value selector (override) with the output of the anti-surge (AS) control algorithm. In this way, the advanced control or the operator can command the opening of the recycle valve, even if the AS control does not need to open the valve. This override selector shall be implemented in AS control system, but the override signal (4-20mA) will be provided by the Process Control System (PCS) (not in the scope of the PACKAGER).). At package HMI, operator shall select if this remote ASV command will be enabled or not.

5. ELECTRICAL

5.1 Electrical equipment and materials shall comply with requirements of I-ET-3010.00-5140-700-P4X-002 - SPECIFICATION FOR ELECTRICAL MATERIAL AND EQUIPMENT FOR OFFSHORE UNITS.

5.2 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.

5.3 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.

5.4 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 and I-LI-3010.00-5140-797-P4X-001 – ELECTRICAL SYSTEM AUTOMATION INTERFACE SIGNALS LIST.

5.5 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 ELECYTRICAL 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.

5.6 Heather panels shall comply with I-ET-3010.00-5140-741-P4X-003 – POWER PANEL FOR THYRISTORIZED HEATER FOR OFFSHORE UNITS.

5.7 Other panels, except MCC, shall comply with requirements of 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-005 - REQUIREMENTS FOR HUMAN ENGINEERING DESIGN FOR ELECTRICAL SYSTEMS OF OFFSHORE UNITS.

6. OPERATION AND MAINTENANCE REQUIREMENTS

6.1 PACKAGER 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 PURCHASER for review and approval. But PACKAGER shall always comply with PURCHASER requirements before suggest any modification.

6.2 The packages shall be designed so that all maintenance can be carried out with standard tools as much as possible.

6.3 Equipment layout shall enable easy and safe access for maintenance to all components and parts. PACKAGER shall provide suitable walkways, ladders and handrails inside the skids, for all packages, including auxiliaries. All equipment and peripherals, especially oil reservoirs, shall have full access and inspection doors / hatches.

6.4 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.

6.5 PACKAGER shall prepare detailed assembly, disassembly and maintenance procedures, describing the use of all involved lifting and handling apparatus and including all required preventive and corrective maintenance tasks. PACKAGER 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 PURCHASER for approval.

6.6 PACKAGER shall provide electrically driven lifting / handling devices and external structure components enabling assembly, disassembly and removal all components inside the package (compressor, HVSD, 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-3010.1M-5266-630-P4X-001 – TOPSIDE´S MECHANICAL HANDLING PROCEDURES.

6.7 PACKAGER shall provide special tools for all maintenance activities including tools for compressor and driver assembly, disassembly and removal.

6.8 PACKAGER shall include in proposal a schedule stating the expected time between major overhauls.

6.9 PACKAGER shall provide a HVSD shaft end with an adaptor in order to allow manual turning for maintenance purposes.

6.10 Noise control requirements

6.10.1 Noise control analysis is a mandatory item to be carried-out. PACKAGER shall present noise data regarding items included in scope of supply.

6.10.2 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.

6.10.3 The noise control system for the package shall consider the noise radiated by inlet / outlet piping, equipment enclosure and equipment casings.

6.10.4 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.

6.10.5 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 may consider the best solution, which may include or not the supply of acoustic walls (open roof) and safety system requirements. The use of device to comply with noise requirement must be proved to be efficient and submitted to PURCHASER approval.

6.10.6 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.

6.10.7 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).

7. INSPECTION AND TESTS

7.1 General requirements

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

7.1.2. Inspection of materials and / or equipment will be made by PURCHASER or its authorized representatives.

7.1.3. Unless otherwise specified, all witnessed tests shall be informed, at least, 90 days before the scheduled dates.

7.1.4. Unless otherwise established by PURCHASER inspector, all equipment shall be available for inspection in an unpainted state.

7.1.5. All UCP 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 PURCHASER approval.

7.1.6. PURCHASER inspector shall have the right to request inspections to ensure that the equipment complies with the relevant classification society requirements.

7.1.7. In case any defects and / or shortcomings are found, PACKAGER shall bear the full cost of such inspection and replacement as necessary. Any repair shall previously be approved by PURCHASER. The subsequent inspection necessary to confirm the satisfactory results will be at PACKAGER cost.

7.1.8. All process gas system welds shall be 100% radiographically inspected and submitted to magnetic particle examination.

7.1.9. DGS as well as Hydrodynamic Bearings shall be removed by PACKAGER 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 assembly.

7.2. **Hydrostatic test (HT)**

7.2.1. 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.

7.2.2. No vises or clamping devices shall be used for pressing of nozzle flanges.

7.2.3. PTFE tape or thread compounds shall not be used to prevent leakage of threaded plugs and connections.

7.3. **Performance Test (PT)**

7.3.1. PT shall be performed on each unit and all spare bundles according to ASME PTC 10 (type 2).

7.3.2. PACKAGER shall provide balance line flow meter and division wall flow measurement during performance test.

7.4. **Mechanical Running Test (MRT)**

7.4.1. MRT shall be performed on each unit and all spares bundles according to API STD 617.

7.4.2. PACKAGER shall submit to PURCHASER 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.

7.5. **Sound Level Test (SLT)**

7.5.1. 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.

7.5.2. 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.

7.5.3. 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.

7.5.4. If the normal operating condition cannot be reached in the test facilities, PACKAGER and PURCHASER shall agree with measurements methods and values.

7.5.5. If the values measured and reported during the shop test are higher than the limits submitted by PACKAGER and approved by PETROBRAS in proposal, PACKAGER shall provide, without extra cost, sound attenuation methods in order to reach this limit, if required by PURCHASER.

7.6. **Complete Unit Test (CUT)**

7.6.1. PACKAGER shall execute CUT, including the following contract parts, at least: electric motor, gearbox, compressor, UCP, oil system and seal system.

7.6.2. CUT shall be a functional test and may be combined with others (MRT or/and PT) for test procedures optimization according PACKAGER schedule.

7.6.3. Vibration requirements (limits, acceptance, etc.) shall be the same used for MRT.

7.6.4. Motors will be tested according to electrical standards references and PURCHASER specification.

7.6.5. Control check shall be done during CUT, as part of functional test.

7.7. **Site Acceptance Test (SAT)**

7.7.1. PURCHASER will provide all facilities and technical procedures (mounting procedures, MCC, lube oil, etc.) to execute an air running, vacuum or inert gas (N2) functional test onshore for each set according to “Annex C”. PACKAGER shall provide technical assistance for all onshore SAT. Procedures and results shall be submitted for Classification Society and PURCHASER final approval.

7.7.2. In addition to the onshore SAT, an Offshore Acceptance Test shall be performed for each set according to “Annex A”.

7.7.3. Probes and monitors shall be tested and calibrated before SAT, during commissioning. Calibration curves shall be plotted and checked according to probes standards tolerances.

7.7.4. PURCHASER will perform a SLT during SAT.

7.8. **Factory Stability Test (FST)**

7.8.1. A FST per compressor type shall be performed as described in “Annex B” item 4.3.8.9.

8. ANNEXES

8.1 Annex A: Motocompressor Offshore Acceptance Test.

8.2 Annex B: Additions and Modifications to API 617.

8.3 Annex C: Inert Gas Compressor Running Test.

8.4 Annex D: Comments and Deviations to API 617.