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	CLIENT: SRGE				SHEET: 1 of 29				
	JOB: -				-				
	AREA: -				-				
TITLE: API 610 CENTRIFUGAL PUMPS SPECIFICATION				INTERNAL					
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INDEX OF REVISIONS									
REV.	DESCRIPTION AND/OR REVISED SHEETS								
0	ORIGINAL ISSUE								
A	REVISED ITEMS 4.3.2, 6.13.1, 6.13.2, 6.13.4, AND INCLUDED ITEM 7.4								
B	INCLUDED ITEMS 6.6.7, 6.6.8 AND 18.3								
C	INCLUDED ITEMS 18.2.5, 18.2.15 AND 18.3, AND MODIFIED ITEM 18.5								
D	GENERAL REVISION. REVISED WHERE INDICATED.								
E	ITEMS MODIFIED: 2.2, 3, 4.1, 4.3.1, 6.2.2, 6.5.1, 6.8.8, 6.12.7, 6.16.3, 9.4.8, 14.3.2, 18.1.1, 18.2.2, 18.2.3, 18.2.10, 18.2.15 AND 18.2.17. ITEMS ADDED: 18.7 AND 18.8. ITEM REMOVED: 18.2.22. ITEMS TRANSFERRED TO 18.7: 18.2.12, 18.2.18, 18.2.19 AND 18.2.20								
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1 OBJECTIVE

1.1 This technical specification covers the minimum technical requirements for the design, materials, fabrication, assembly, inspection, testing, preparation for shipment, installation, pre-commissioning and commissioning of all electric motor driven API Std 610 centrifugal pumps.

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

2 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

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


2.2 Abbreviations

AVM:	Anti-Vibration Mounting
CUT:	Complete Unit Test
DAM:	Dynamic Acquisition Module
DFMEA:	Design Failure Mode and Effect Analysis
DLC:	Diamond-Like Crystals
g:	Gravitational acceleration
HSVD:	Hydraulic Variable Speed Drive
ITP:	Inspection and Test Plan
MFCV:	Minimum Flow Control Valve
MMS:	Machinery Monitoring System
MPS:	Machinery Protection System
NPSH:	Net Positive Suction Head
RTD:	Resistance Temperature Detector
SAT:	Site Acceptance Test
SRU:	Sulfate Removal Unit
SS:	Stainless Steel
TNF:	Torsional Natural Frequency
UCP:	Unit Control Panel (Package Control Panel)
VFD:	Variable Frequency Drive
VSD:	Variable Speed Drive

3 SCOPE OF SUPPLY

PACKAGER scope of supply shall include the following:

- Centrifugal pump;
- Electric motor driver;
- Variable Speed Drive (either HVSD or VFD), if specified on the Data Sheets;
- Mechanical seals;
- Baseplate with drain pans, lifting lugs, grounding lugs, and drains with valves;
- Couplings and coupling guards;
- Automatic Recirculation Valve (ARV) or Minimum Flow Control Valve (MFCV), if specified;
- In-skid common lube oil system for pump and electric motors, as specified on pump data sheet;
- Monitoring system, according to I-ET-3010.00-5500-854-P4X-001 – Machinery Monitoring System (MMS) and definitions in this technical specification;
- Three-point resilient mounts and AVMS, according to definitions in this technical specification and pump data sheets issued by BUYER;
- All necessary instrumentation, including accessories and supports;

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- Unit Control Panels, according to AUTOMATION INTERFACE OF PACKAGE UNITS specification [document supplied by OWNER];
- Electrical and instrumentation installation (including cable termination details, motor terminal box details, and grounding);
- Stainless steel (SS 316), copper free aluminum or non-metallic junction boxes mounted at skid edge;
- All piping and their respective utilities skids, such as lube oil, cooling medium and instrument/utility air;
- All raw materials and consumables;
- Gaskets;
- Tightening bolts and nuts;
- Nameplates made of SS 316 in Portuguese for all equipment and instruments;
- Surface preparation and painting proper for offshore installation, according to I-ET-3010.00-1200-956-P4X-002 – General Painting and DR-ENGP-I-1.15 – Color Coding;
- Spreader bars and specific handling devices for installation;
- Technical assistance during installation, pre-commissioning, start-up and commissioning phases;
- Safety signaling in Portuguese;
- All required tests at MANUFACTURER's shop;
- Preparation for shipment and preservation, including equipment handling conditioning and storage at job site;
- Consumables and special tools for assembly, disassembly, maintenance, commissioning and start-up;
- Spare parts recommended for commissioning, pre-operation, start-up, NR-13 tests and by Classification Society;
- Warranty;
- Thermal insulation for personnel protection according to I-ET-3010.00-1200-431-P4X-001 – Thermal Insulation for Maritime Installations;
- A complete engineering package including design, fabrication, inspection, testing, commissioning documentation, certification and data required on this specification and pump data sheets issued by BUYER.


4 NORMATIVE REFERENCES

Pump PACKAGE shall comply with the requirements of this technical specification, data sheets, documents as stated below and with those referred to herein. Any conflict between the requirements of this specification and related codes and standards, specification, etc. shall be presented in writing for BUYER's resolution prior to manufacturing.

4.1 Applicable Codes and Standards

The latest issue of the following codes and standards shall be fully complied with:

IOGP S-615	Supplementary specification to ANSI/API Standard 610 for Centrifugal Pumps
IOGP S-615L	Information requirements for Centrifugal Pumps
IOGP S-615Q	Quality requirements for Centrifugal Pumps
IOGP S-615D	Data sheets for Centrifugal Pumps
IOGP S-712	Supplementary Specification to API Standard 677 General-Purpose Gear Units for Petroleum, Chemical and Gas Industry Services
IOGP S-713	Supplementary Specification to ANSI/API Standard 613 Special Purpose Gear Units for Petroleum, Chemical and Gas Industry Services
API Std 610	Centrifugal Pumps for Petroleum, Petrochemical, and Natural Gas Industries
API Std 613	Special-purpose Gears for Petroleum, Chemical, and Gas Industry Services
API Std 614	Lubrication, Shaft-sealing and Oil-control Systems and Auxiliaries
API Std 670	Machinery Protection Systems
API Std 677	General-Purpose Gear Units for Petroleum, Chemicals and Gas Industry Services
API Std 682	Pumps - Shaft Sealing Systems for Centrifugal and Rotary Pumps
ASME B16.5	Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.47	Large Diameter Steel Flanges NPS 26 Through NPS 60 Metric/Inch Standard
ASME B31.3	Process Piping

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ASME BPVC Sec. VIII-1	Rules for Construction of Pressure Vessels
ASME PTC 8.2	Centrifugal Pumps
NR-10	Brazilian Government Regulation – Norma Regulamentadora N° 10, Segurança em Instalações e Serviços em Eletricidade
NR-12	Brazilian Government Regulation – Norma Regulamentadora N° 12, Segurança no Trabalho em Máquinas e Equipamentos
NR-13	Brazilian Government Regulation – Norma Regulamentadora N° 13, Caldeiras, Vasos de Pressão, Tubulações e Tanques Metálicos de Armazenamento
NR-26	Brazilian Government Regulation – Norma Regulamentadora N° 26, Sinalização de Segurança
NR-37	Brazilian Government Regulation – Norma Regulamentadora N° 37, Segurança e Saúde em Plataformas de Petróleo
Classification Society	Rules for Offshore Facilities

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

4.2 Reference Codes and Standards

The following codes and standards shall be used as reference or followed wherever they are mentioned throughout this specification:

ANSI/HI 14.6	Rotodynamic Pumps - Hydraulic Performance Acceptance Tests
API Std 541	Form-wound Squirrel Cage Induction Motors—375 kW (500 HP) and Larger
API Std 671	Special-Purpose Couplings for Petroleum, Chemical, and Gas Industry Services
API RP 691	Risk-based Machinery Management
ISO 14691	Petroleum, Petrochemical and Natural Gas Industries - Flexible Couplings for Mechanical Power Transmission - General-Purpose Applications
ISO 15156/all parts	Petroleum and Natural Gas Industries: Materials for Use in H2S-Containing environments in Oil and Gas Production
ISO 21940/all parts	Mechanical Vibration – Rotor Balancing
ISO 7146-1	Plain bearings — Appearance and characterization of damage to metallic hydrodynamic bearings
ISO 80079-36 and -37	Explosive Atmospheres – Non-electrical Equipment for Explosive Atmospheres
TEMA	Standards of Tubular Exchanger Manufacturers Association

4.3 Applicable Documents

4.3.1 Typical Project Documents


The following project documents shall be fully complied with:

General

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

Mechanical

DR-ENGP-I-1.15	Color Coding
I-ET-3010.00-1200-251-P4X-001	Requirements for Bolting Materials
I-ET-3010.00-1200-300-P4X-001	Noise and Vibration Control Requirements
I-ET-3010.00-1200-431-P4X-001	Thermal Insulation for Maritime Installations
I-ET-3010.00-1200-540-P4X-001	Requirements for Pressure Vessels Design and Fabrication
I-ET-3010.00-1200-955-P4X-001	Welding
I-ET-3010.00-1200-200-P4X-115	Requirements for Piping Fabrication Assembly and Commissioning
I-ET-3010.00-1200-956-P4X-002	General Painting

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Electrical

I-DE-3010.00-5140-700-P4X-003	Grounding Installation Typical Details
I-DE-3010.00-5140-797-P4X-001	Electrical System Automation Architecture Diagram
I-ET-3010.00-5140-700-P4X-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-3010.00-5140-712-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-3010.00-5140-772-P4X-001	Medium-Voltage Frequency Converter for Offshore Units
I-ET-3010.00-5140-772-P4X-002	Specification for Low-Voltage Frequency Converters, Soft-Starters and Inverters for Offshore Units
I-ET-3010.00-5140-797-P4X-001	Electrical System Automation Architecture
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

Automation

I-ET-3010.00-1200-800-P4X-002	Automation, Control and Instrumentation on Package Units
I-ET-3010.00-5500-854-P4X-001	Machinery Monitoring System (MMS)
I-ET-3010.00-5520-888-P4X-001	Automation Panels

Naval

I-ET-3010.00-1350-960-P4X-001	Design Requirements – Naval Architecture
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4.3.2 Specific Project Documents

The following project documents, supplied by BUYER, shall be fully complied with. Since these documents are specific to each project, their identification numbers are not unique, and their titles may vary slightly from one project to another. Project's DOCUMENT LIST shall be consulted to verify the correct document number and title.

- METOCEAN DATA
- MOTION ANALYSIS
- PIPING SPECIFICATION FOR TOPSIDE
- GENERAL SPECIFICATION FOR AVAILABLE UTILITIES
- FIELD INSTRUMENTATION
- AUTOMATION INTERFACE OF PACKAGE UNITS
- INSTRUMENTATION ADDITIONAL TECHNICAL REQUIREMENTS

5 PACKAGER RESPONSIBILITY


5.1 PACKAGER shall perform the work in accordance with the requirements of Classification Society. PACKAGER shall submit to the Classification Society all documentation in compliance with stated Rules.

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

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

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

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

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6 DESIGN REQUIREMENTS

6.1 Operation Environment

Pump PACKAGE shall be suitable for the marine environment and range of ambient conditions defined in METOCEAN DATA specification [document supplied by OWNER].

6.2 Motion Requirements

6.2.1 PACKAGER/MANUFACTURER shall design the PACKAGE in accordance with the motion requirements in the Report – MOTION ANALYSIS [document supplied by OWNER].

6.2.2 PACKAGE shall be able to withstand and operate in accordance with I-ET-3010.00-1350-960-P4X-001.

6.3 PACKAGE Requirements

6.3.1 PACKAGER shall design the PACKAGE for a 30-year life in a corrosive offshore environment without the need for replacement of any major component due to wear, corrosion, fatigue, or material failure.

6.3.2 Rotary parts, such as couplings, pulleys, and flywheels, shall feature rigid guards, made of non-sparking and non-flammable material in accordance with NR-12.

6.3.3 The consumption of utilities shall comply with the requirements of GENERAL SPECIFICATION FOR AVAILABLE UTILITIES report [document supplied by OWNER].

6.3.4 The pump PACKAGE, including all auxiliary equipment, shall be assembled to the maximum extent possible, aligned and pre-checked in PACKAGER / MANUFACTURER's shop, allowing shipment to the integration yard with minimal fieldwork.

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

6.3.6 SUPPLIER shall ensure that the area around the pump PACKAGE has enough clearance for maintenance.

6.3.7 SUPPLIER shall create a reserved area on the 3D model to avoid installation of any other equipment or accessory in this area.


6.3.8 PACKAGES installed in Classified Area shall be designed in compliance with ISO 80079-36 and ISO 80079-37 requirements.

6.3.8.1 PACKAGER shall provide a certificate confirming that the equipment and components of the package is in conformity with both standards including as minimum:

- a) Ignition Hazard Assessment Report as per ISO 80079-36;
- b) Specific requirements for the design and construction of nonelectrical and equipment type of protection as per ISO 80079-37;
- c) Equipment nameplate including ISO 80079-36 marking requirements.

6.3.8.2 PACKAGER shall attest on his own responsibility that the equipment has been constructed in accordance with the applicable requirements of the relevant standards in safety matters.

6.3.9 The following pumps configurations shall not be furnished unless approved by BUYER for the specific application:

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- Rigidly or close coupled;
- Two-stage overhung;
- Double suction overhung;
- Multistage ring-section single casing;
- Vertical (other than in-line) above 1800 rpm;
- OH1 construction.

6.4 Performance

- 6.4.1 Pumps shall be suitable for continuous operation at full load duty, unless otherwise stated in the process data sheets, without shutdown for normal maintenance, for a minimum period of one year.
- 6.4.2 For pumps specified for intermittent service shall operate for a period of 18 months without the need of preventive maintenance.
- 6.4.3 Pumps driven by electric motor with power above 150kW shall have efficiency at the rated flow above 80% for $n_s > 1500$ ($n_s > 29.1$ metric units) and above 75% for $n_s < 1500$ ($n_s < 29.1$ metric units). The pump's specific speed – n_s – shall be calculated according to API Std 610.
- 6.4.4 The NPSH required shall be at least 2.0 meters less than the NPSH available. Correction factors shall not be used.
- 6.4.4.1 BUYER may accept differences between 1.0 and 2.0 meters in NPSH required, but a witnessed NPSH required test shall be performed.

6.5 Vertical Pumps Requirements

- 6.5.1 Coupling and impellers fixing devices shall allow reverse rotation without damage to the main equipment.
- 6.5.2 Unless required per API Std 610, radial and thrust bearings shall be rolling-element type.

6.6 Pressure Casings

- 6.6.1 The direction of rotation of the impeller(s) shall be clearly marked on the casing by permanent means.
- 6.6.2 Maximum discharge pressure shall consider the additional differential pressure developed during operation with maximum specified fluid relative density and driver maximum speed.
- 6.6.3 SUPPLIER shall provide stud bolts or dowel pins to simplify the upper casing cover assembly of vertically mounted axially split case pumps.
- 6.6.4 Casing connections other than suction and discharge nozzles shall be at least DN 15 (NPS 1/2).
- 6.6.5 Threaded connections shall not be used.
- 6.6.6 The pump casing and baseplates of steel and steel alloy pumps with nozzle diameters smaller than 16 shall be designed for satisfactory performance if subjected to the external nozzle forces and moments from API Std 610 Table 5 multiplied by a factor defined in Table 1 below.
- 6.6.6.1 For nozzle diameters larger than 16" these load values shall be linearly extrapolated, and the agreement of the manufacturer is required.
- 6.6.6.2 If any of the applied load components on any of the pump's nozzles (suction or discharge) exceeds the limits defined on item 6.6.6, both nozzles shall be verified using Annex F of API Std 610. In this case, allowable loads to be considered in the equations of Annex F will be replaced by the values defined in Table 1 below.

Table 1 - Allowable nozzle loads.


Pressure rating	≤ 300# - 900#	1500# - 2500#
Nozzle load	2 * API 610	4 * API 610

6.7 Impellers

- 6.7.1 Impellers shall be fully enclosed type.
- 6.7.2 Semi-open impellers may be accepted only for low-flow, high-head pump designs.
- 6.7.3 Fully enclosed impellers shall be furnished with renewable wear rings, unless otherwise agreed by BUYER.
- 6.7.4 Renewable wear rings shall be held in place by a press fit with at least three axial screws, equally spaced.
- 6.7.5 Impellers shall be single-piece casting or forging.

6.8 Mechanical Seals

- 6.8.1 Seal Piping Plans shall be as defined in the BUYER's data sheets.
- 6.8.1.1 If the mechanical seal MANUFACTURER recommends a seal Piping Plan other than the specified by the BUYER, it shall be informed in the technical proposal and subject to BUYER's approval.
- 6.8.2 Centrifugal pumps shall be provided with cartridge-type and balanced mechanical seals, with their sleeves independent from the pump's sleeves.
- 6.8.3 Mechanical seals shall not be used as centering element of the rotary set.
- 6.8.4 Unless otherwise specified, double seal arrangements shall be used with:
- Hydrocarbon services with vapor pressure above 400 kPa (abs) at maximum operational temperature.
 - Services with H₂S, under the following conditions:
 - Concentrations above 10 ppm (mass) for pumps located indoors.
 - Concentrations above 500 ppm (mass) for pumps located outdoors. Double seal shall be non-pressurized from 500 ppm (mass) up to 5 000 ppm (mass). Double seal shall be pressurized above 5 000 ppm (mass);
 - Hydrocarbons at temperatures above their auto-ignition limit.
 - When indicated in the Pump Data Sheets.
- 6.8.5 Pumps with hydrocarbon services and single seal arrangement shall be supplied with auxiliary seal piping plan 66A (API Std 682) for leakage collection and detection.
- 6.8.6 Pumps in service with temperature over 90°C shall have means to ensure a temperature of no more than 90°C at the seal face.
- 6.8.7 Seal materials shall be the seal MANUFACTURER's recommendation for each service. If SUPPLIER specifies any of the component's materials in the Detailed Design Data Sheets, these specifications shall be validated by the mechanical seal MANUFACTURER.

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6.8.7.1 The following material selections, if recommended by the seal MANUFACTURER, shall be subject to the BUYER's approval:

- a) Hard/hard mechanical seal faces combination (e.g. SiC vs SiC).
- b) Seal faces in Tungsten Carbide.
- c) Seal faces with Diamond-like Carbon (DLC) coating.

6.8.8 Seal gland plates shall be provided with all necessary connections (complete with solid plugs) for flushing, quench, drains and venting.

6.8.8.1 If flush connections are horizontal, two symmetrical connections, separated by 180°, shall be installed.

6.8.9 Seal gland plate's solid plugs shall be of the same material as the seal plate.

6.8.10 All mechanical seals shall be furnished with close clearance, non-sparking, floating throttle bushes.

6.8.11 All sealing system elements shall be designed to withstand the maximum pressure for different arrangements (serial or in parallel) and for maximum pressure developed by the pump in case of failure in other sealing components, such as the throat bushing.

6.8.12 Mechanical seal gland plate design pressure shall be equal or higher than the pump's design pressure.

6.8.13 Axially split case-type petroleum transfer pumps shall be provided with provisions for the installation of pressure gauges in the sealing box, for pressure monitoring.

6.8.14 For single (Arrangement 1) mechanical seals operating with produced water, the MANUFACTURER shall select a seal configuration in which the springs are protected from the process fluid.

6.8.15 For pumps specified with sealing Piping Plan 62, the pump PACKAGER shall supply the quench connection with tubing and flanged termination.

6.8.16 When sealing Piping Plan 53BM is specified, it shall comply with the following requirements:

6.8.16.1 The sealing system shall have an automatic barrier fluid make-up system for each pump, including barrier fluid tank, and make-up pump, mounted on the pump skid.

6.8.16.2 Barrier fluid make-up pump shall be hydro-pneumatic type.

6.8.16.3 Barrier fluid tank volume shall be defined in compliance with the following:

- a) The tank capacity between High Level Alarm (LAH) and Low-Level Alarm (LAL) shall be sufficient to allow at least 28 days continuous operation with the maximum mechanical seal leakage defined by the seal MANUFACTURER.
- b) The tank capacity between Low Level Alarm (LAL) and Low-Low-Level Alarm (LALL) shall be sufficient to allow at least 3 hours of continuous operation with 10 times the maximum mechanical seal leakage defined by the seal MANUFACTURER.

6.8.16.4 The system shall, as a minimum, comply with the arrangement and instrumentation defined in Figure 1.

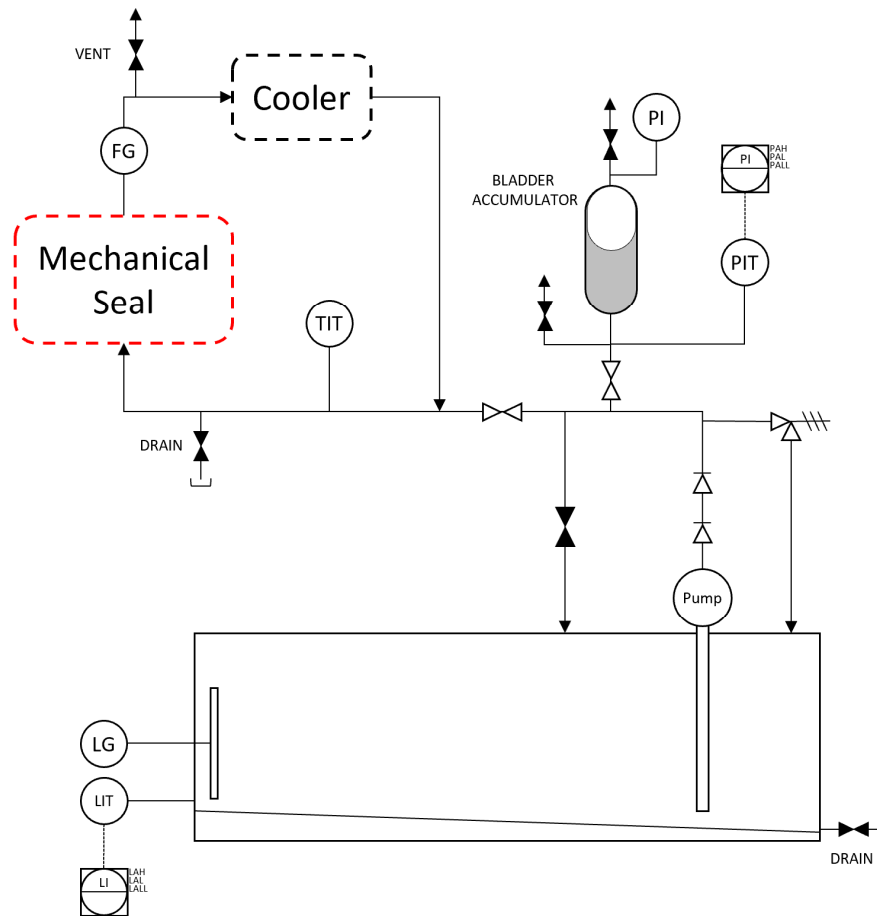



Figure 1 - Minimum arrangement and instrumentation required for seal Piping Plan 53BM.

6.9 Auxiliary Piping

- 6.9.1 Drains and vents shall have flanged valves.
- 6.9.2 Piping shall be suitably supported to the pump baseplate or mounting frame by PACKAGER / MANUFACTURER.
- 6.9.3 Pumps requiring auxiliary piping for balancing line, sealing, cooling or lube oil systems shall be provided with all necessary connections, plus all required piping and fittings, as defined on the data sheets.
- 6.9.4 Auxiliary piping in contact with the process fluid shall be made of the same material as the pump casing. All other auxiliary piping shall be made of SS 316L unless otherwise specified in pump data sheets.
- 6.9.5 PACKAGER / MANUFACTURER shall clearly indicate the locations of all connections and identify them on the pump drawing.
- 6.9.6 All auxiliary interface connections shall terminate with block valves at the edge of the skid and shall be designed to allow easy disconnection.

6.10 Bearings and Bearing Housings

- 6.10.1 Pumps with hydrodynamic bearings and with rated speed above 1800 rpm shall be supplied with pressure fed lubricating oil system.

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6.10.2 The hydrodynamic bearing lubrication system shall be in accordance with the latest edition of the API Std 614 specifications.

6.10.3 Sealed bearings filled with grease shall not be used.

6.10.4 Polyamide or other non-metallic materials shall not be used in rolling element bearings shall.

6.10.5 Bearing housings serving as oil reservoirs shall be provided with constant level oilers.

6.10.6 The recommended working oil level on bearing housings shall be accurately located and clearly marked on the outer surface of the bearing housing by permanent means.

6.10.7 Bearing housings shall be sealed against loss of lubricant and the entrance of water, steam, dust or other contaminants.

6.10.8 Seals for bearing housings shall be of the "U" type labyrinth.

NOTE The sealing element referred to as "U" type labyrinth is a sealing element with two deflectors (internal and external) that obstruct air movement through the bearing housing.

6.10.9 For pumps with rolling element bearings and oil level lubrication, cooling of bearing housings by means of water jackets shall be employed when handling fluids at a pumping temperature of 200°C or above, or when the lubricating oil temperature is likely to rise above 82°C, based on specified operating conditions and 34°C ambient temperature.

6.10.10 Bearing housings shall be prepared for permanent accelerometer or vibration probes installation.

6.10.11 Bearing housings shall have a flat surface at least 1 in. (25 mm) in diameter for the location of magnetic-based vibration-measuring equipment.

6.11 Drivers

6.11.1 Pumps shall be driven by electrical motors, unless otherwise specified in the pump data sheets issued by BUYER.

6.11.2 A direct driver shall be used. However, a gearbox may be used when the optimum pump speed is different from the nominal driver speed, if previously approved by BUYER.

6.11.3 The gear transmission unit, if provided, shall comply with the requirements of API Std 677 and IOGP S-712.

6.12 Couplings

6.12.1 Pumps shall be connected to the driver by means of a flexible spacer type coupling.


6.12.2 Flexible couplings with rubber parts shall not be used in classified area.

6.12.3 For pumps requiring power inputs greater than 500 kW, the coupling hubs shall be hydraulic taper fit. All smaller sized units shall be in accordance with MANUFACTURER's normal standard.

6.12.4 Unless otherwise specified in pump data sheets issued by BUYER, couplings and coupling mountings shall be according to:

- ISO 14691 for pumps with rolling-element thrust bearings.
- API Std 671 for pumps with hydrodynamic thrust bearings.

6.12.5 For pumps with hydraulic taper fitted coupling hubs, the MANUFACTURER shall provide a detailed procedure for coupling hubs assembly as part of the pump's maintenance manual.

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6.12.6 The MANUFACTURER shall provide a quality control report of the factory assembly as evidence that the hydraulic taper fitted coupling hubs were assembled in accordance with the correct procedures and drawings.

6.12.7 Flexible disk couplings furnished in accordance with API Std 671 shall be made of Inconel 625 flexible disks.

6.12.8 Coupling hubs and spacers shall be supplied with corrosion resistant coating, adequate for marine environment.

6.12.9 The coupling's bolts and nuts shall be made of appropriate material considering design conditions and corrosion resistance.

6.12.10 The coupling guard shall be made of a solid sheet of metallic, spark-resistant material.

NOTE Coupling guard according to PETROBRAS' patented design is preferable.

6.13 Baseplate

6.13.1 The baseplate shall have a drain-pan with a valved drain opening.

6.13.1.1 The drain-pan may be bolted to the baseplate.

6.13.1.2 The drain opening may be supplied with no valve if SELLER connects the baseplate drain directly to the UNIT's drainage system.

6.13.2 For pumps in corrosive duties, drain-pans shall be made of a corrosion-resistant material considering the pumped fluid properties.

6.13.3 For pump PACKAGES with Low-Voltage motors, the baseplates shall be designed to be completely seal welded to the support structure. Intermittent welds are not allowed.

6.13.3.1 For pump PACKAGES with Low-Voltage motors, baseplates mounted with 3-point or multipoint mounting may be accepted under previous approval by BUYER.

6.13.4 For pump PACKAGES with Medium Voltage motors, the baseplates shall be designed for 3-point or multipoint mounting.

6.14 Balancing, Noise and Vibration Control

6.14.1 Major rotating parts, such as impellers, balance drums, and couplings, shall be dynamically balanced according to ISO 21940-11, grade G2.5.

6.14.2 The complete rotor shall be dynamically balanced if the pump's maximum speed is above 3600 rpm, if it is specified on the data sheets or if it is required by the operating conditions and pump size as per API Std 610.


6.14.3 Noise and vibration control concerning human exposure shall be performed according to I-ET-3010.00-1200-300-P4X-001 – Noise and Vibration Control Requirements.

6.14.4 If specified in the BUYER data sheets, the pumps shall be supplied with AVMs.

6.14.4.1 SUPPLIER shall define if other pumps need to be mounted on AVMs, based on vibration and structure-borne noise studies.

6.14.5 Impeller balancing correction shall always be performed by means of mass removal.

6.14.6 The reduction of wall thickness on impeller design shall not exceed 30 % (at actual impeller tip), or the impeller shall otherwise be replaced.

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6.15 Pressure Vessels

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

6.16 Heat Exchangers

6.16.1 The oil pressure shall exceed the cooling water pressure on lubricating oil and sealing oil Heat Exchangers.

6.16.1.1 The lube oil pressure may be lower than the cooling water pressure if double-wall plate heat exchangers are used for lube oil cooling.

6.16.2 Pump PACKAGES with pressurized Lube Oil Systems shall be equipped with twin Oil Coolers arrangement as per API 614.

6.16.3 The switch between Heat Exchangers shall be possible with the pumps in operation.

6.16.4 Shell & tube type heat exchangers shall be considered as pressure vessels and are therefore subject to their requirements.

6.17 Special Tools and Spare Parts

6.17.1 PACKAGER shall provide spare parts required for NR-13 tests and spare parts recommended by Classification Society.

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

6.17.3 All special tools and spare parts shall have an item number in the packing list, which shall match the item number fixed on the packing.

6.17.4 PACKAGER shall provide a list containing the part numbers of every spare part within the PACKAGE for BUYER's future reference.

7 MATERIALS

7.1 Material selection shall be according to API Std 610 Annexes G and H, unless otherwise specified in pump data sheets issued by BUYER.

7.2 Additional requirements for specific pumps on this specification shall be followed.

7.3 All materials exposed to hydrocarbons containing hydrogen sulfide shall be in accordance with all parts of ISO 15156 for the lowest anticipated pH and the highest H₂S partial pressure.


7.4 Dissimilar materials in contact with an electrolyte shall be electrically isolated to avoid galvanic corrosion.

7.5 Austenitic SS pumps shall use SS 316 (UNS S31600) or SS 316L (UNS S31603) for all parts subjected to pressure or other mechanical loads.

8 ELECTRICAL

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

8.2 Electrical material shall comply with requirements of I-ET-3010.00-5140-700-P4X-002 – Specification for Electrical Material for Offshore Units.

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8.3 Electrical induction motors shall comply with requirements of I-ET-3010.00-5140-712-P4X-001 – Low-Voltage Induction Motors for Offshore Units or I-ET-3010.00-5140-712-P4X-002 – Medium-Voltage Induction Motors for Offshore Units.

8.4 Concerning electrical system voltages and quantity of feeders for motors, panels and auxiliaries, centrifugal pumps shall be fed according to definitions of I-ET-3010.00-5140-700-P4X-003 – Electrical Requirements for Packages for Offshore Units.

8.5 Grounding installations inside the PACKAGE shall comply with requirements of I-ET-3010.00-5140-700-P4X-001 – Specification for Electrical Design for Offshore Units and I-DE-3010.00-5140-700-P4X-003 – Grounding Installations Typical Details.

8.6 Medium-voltage VSDs shall comply with I-ET-3010.00-5140-772-P4X-001 – Medium-Voltage Frequency Converter for Offshore Units. Low-voltage VSDs shall comply with I-ET-3010.00-5140-772-P4X-002 – Specification for Low-Voltage Frequency Converters, Soft-Starters and Inverters for Offshore Units.

8.7 Electrical equipment shall comply with I-ET-3010.00-5140-700-P4X-007 - Specification For Generic Electrical Equipment For Offshore Units and I-ET-3010.00-5140-700-P4X-009 - General Requirements For Electrical Material And Equipment For Offshore Units

9 CONTROLS AND INSTRUMENTATION

9.1 General

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

9.1.2 PACKAGE automation type classification shall be according to AUTOMATION INTERFACE OF PACKAGE UNITS specification [document supplied by OWNER].

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

9.1.4 All sensors shall be suitable for prevailing temperatures.

9.1.5 When applicable, field amplifiers, transducers, etc., shall be installed as per PACKAGER / MANUFACTURER practices, according to the area classification and to protect them against mechanical damage.

9.2 Automation, Control and Instrumentation System Cabling

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


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


9.3 Alarms and Shutdown

The minimum alarm and shutdown functions shall be as required on the P&IDs and matrix of cause and effect.

9.4 Monitoring Requirements

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

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<p>9.4.2 Monitoring sensors for motors shall be in accordance with I-ET-3010.00-5140-712-P4X-001 – Low-Voltage Induction Motors for Offshore Units or I-ET-3010.00-5140-712-P4X-002 – Medium-Voltage Induction Motors for Offshore Units.</p> <p>9.4.3 All monitoring sensors shall be compatible with MPS/DAM, as described in I-ET-3010.00-5500-854-P4X-001 – Machinery Monitoring System (MMS).</p> <p>9.4.4 All monitoring sensors shall be supplied installed, configured, and connected to a junction box located on the pump skid.</p> <p>9.4.5 MANUFACTURER shall provide complete documentation of the sensors installed in the equipment.</p> <p>9.4.6 All monitoring sensors of P0 type PACKAGES shall be interconnected to the MPS/DAM (SUPPLIER's scope of supply), while all machinery monitoring sensors of P2 type PACKAGE UNITS shall be interconnected to the MPS/DAM (PACKAGER's scope of supply) inside the UCP (PACKAGER's scope of supply).</p> <p>9.4.6.1 All MPS and DAM shall be interconnected to the MMS of the UNIT.</p> <p>9.4.6.2 PACKAGER / MANUFACTURER shall provide all data and performance curves to be implemented by the MMS supplier for Monitoring System Configuration.</p> <p>9.4.7 For equipment with rolling-element bearings, one accelerometer for each bearing housing shall be supplied, installed and tested in accordance with API Std 670.</p> <p>9.4.8 For equipment with hydrodynamic bearings (including drivers, gearboxes and HVSDs), vibration displacement probes including their mounting and calibration shall be supplied, installed and tested in accordance with API Std 670.</p> <p>9.4.8.1 Two radial-vibration displacement probes in each bearing housing and one phase reference transducer for each different shaft speed shall be supplied for each machine with hydrodynamic bearings.</p> <p>9.4.8.2 If the pump's thrust bearing is hydrodynamic type, two axial displacement probes shall also be supplied and installed on the thrust side.</p> <p>9.4.8.3 If the pump's thrust bearing is rolling element type, one accelerometer shall be supplied and installed on the thrust bearing housing on the axial direction.</p> <p>9.4.9 Thrust and radial pump bearings shall be supplied with bearing metal temperature detectors.</p> <p>9.4.10 Thrust and radial bearings in Medium-Voltage Electric Motors shall be supplied with bearing metal temperature detectors.</p> <p>9.4.11 Bearing metal temperature detectors shall be platinum resistance RTDs, three-wire, 100Ω at 0°C.</p> <p>9.4.12 All pumps provided with a pressurized lube oil system shall have an online oil condition monitoring device to enable real-time indication of oil contamination with water and metallic residue.</p> <p>9.4.12.1 The online oil condition monitoring device shall be compatible with and connected to the MMS.</p> <p>10 PAINTING AND COLOR</p> <p>10.1 PACKAGER / MANUFACTURER paint system shall be according to I-ET-3010.00-1200-956-P4X-002 – General Painting.</p> <p>10.2 Color code adopted shall be in accordance with DR-ENGP-I-1.15 – Color Coding.</p>			

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11 NAMEPLATES

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

11.2 The nameplate information shall include, as a minimum, the following items in Portuguese:

- Purchase order and item number;
- Manufacturer and year of build;
- Equipment serial number and type;
- Rated flow;
- Rated head;
- Casing hydrostatic test pressure;
- Maximum allowable working pressure (MAWP);
- Temperature basis for MAWP;
- Driver power rating and speed;
- Design code;
- Design temperature and pressure;
- Tag number.

12 TAG NUMBERING AND TAG PLATES

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

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

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

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

13 CERTIFICATION REQUIREMENTS

13.1 Class Certification

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

13.2 Material Certification

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


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

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

14 INSPECTION, TESTING AND COMMISSIONING

14.1 Inspection and Testing

14.1.1 Inspection and testing throughout the manufacturing process shall be in accordance with the quality requirements of IOGP S-615Q. The conformity assessment system (CAS) shall be letter B.

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14.1.2 PACKAGER shall submit the Inspection and Test Plan (ITP) based on the SUPPLIER technical data sheet with witnessed inspections and tests identified.

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

14.1.4 BUYER shall witness all pump Factory Acceptance Tests carried out at the MANUFACTURER's facilities.

14.2 Factory Acceptance Test (FAT)

14.2.1 SUPPLIER shall prepare a Factory Acceptance Test (FAT) procedure and submit for BUYER approval.

14.2.2 For the Factory Acceptance Test (FAT), the PACKAGER / MANUFACTURER shall make preliminary test to ensure that all parts of the equipment are operating satisfactorily prior to the arrival of the BUYER's representative.

14.2.3 SUPPLIER shall advise BUYER of the test schedule before the planned test dates.

14.2.4 When required, SUPPLIER shall arrange with the appointed Classification Society surveyor to witness FAT.

14.2.5 Motors tests shall be in accordance with I-ET-3010.00-5140-712-P4X-001 – Low-Voltage Induction Motors for Offshore Units or I-ET-3010.00-5140-712-P4X-002 – Medium-Voltage Induction Motors for Offshore Units.

14.2.6 Monitoring systems of P2 type PACKAGE UNITS and monitoring sensors of P0 type PACKAGE UNITS shall be tested on the FAT.

14.2.7 Performance Test and Mechanical Running Test shall be carried out with job vibration sensors and signal conditioning systems.

14.2.8 Acceptance of the FAT will not be considered as the final acceptance test of the equipment.

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

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

14.2.11 The pump shall be mechanically run at the rated flow for 4 hours if, at least, one of the criteria below is met. The parameters shall be calculated as defined in API Std 610.


- nd_m factor $\geq 350\,000$.
- Energy density $> 4,0 \times 10^6$ kW/min.

14.2.12 For higher power pumps (drivers ≥ 1 MW), pump efficiency at rated flow inferred during the performance test shall not be less than the predicted efficiency on the proposal.

14.2.13 Hydrodynamic bearings shall be removed, inspected by the purchaser or his representative, and reassembled after the mechanical and performance tests are completed.

14.2.13.1 An inspection report of the hydrodynamic bearings shall be included in the documentation.

14.2.13.2 If replacement or modification of the bearings are needed after the inspections, the original test shall not be acceptable, and the machine shall be retested.

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14.2.13.3 If minor scratches occur during replacement or modification of the bearings, manual cosmetic repairs shall not be considered a cause for retest.

NOTE ISO 7146-1 may be used for guidance and bearing damage characterization.

14.2.14 Complete Unit Test (CUT)

14.2.14.1 At least one pump from the supplied set shall undergo a Complete Unit Test (String Test) as part of the FAT if it is specified in the pump Data Sheets or if any of the following conditions are fulfilled:

- a) Rated driver power above 1MW.
- b) Pumps with Variable Speed Drives (VSD).
- c) Pumps operating above 3600 rpm.
- d) Pump packages with a dedicated pressurized Lube Oil System.
- e) Pumps with mechanical seals equipped with an internal circulating device.

14.2.14.2 The following PACKAGE contract items shall be integrated and tested during the CUT:

- a) Pump skid: pump, driver, baseplate, gearbox, job coupling, lube oil system and sealing system.
- b) Variable Speed Drive, whenever applicable.
- c) Control Panel, whenever applicable.
- d) MFCV, when within the PACKAGER's scope of supply.
- e) Vibration sensors and signal conditioning systems.
- f) Temperature and pressure sensors.

14.2.14.3 The pump unit shall run at rated speed and flowrate for a minimum 4 hours.

14.2.14.4 After the stabilization of the equipment's temperatures, the pump flowrate shall be varied across its entire allowable operating range.

14.2.14.5 For pumps with VSDs, after the stabilization of the equipment's temperatures, the speed shall be varied across the entire allowable operating speed range.

14.2.14.6 The same vibration and temperature acceptance criteria from the pump Performance Test shall be applied to the CUT.

14.2.14.7 All monitored parameters shall be below the pre-defined design alarm levels during the entire duration of the CUT, except when operating conditions are outside of the allowable operating envelope.


14.2.14.8 If the PACKAGE has a Lube Oil System with redundant components (e.g. twin coolers, twin filters), the changeover between components shall be tested during the CUT.

14.2.14.9 The sound pressure level shall be measured during the CUT.

14.2.14.10 For electric motor driven PACKAGES, the tests and acceptance criteria listed below shall be carried out during the CUT at rated operating conditions.

- a) Measurement of power factor and efficiency at rated voltage and frequency in accordance with IEC 60034-2-1, or IEC 60031-2-3 for PACKAGES with VFDs.
- b) Measurement of shaft voltage in accordance with IEC 60034-1.
- c) Windings temperature rise test in accordance with IEC 60034-1.
- d) Bearing vibration measurements in accordance with API 541.
- e) Bearing temperature rise test in accordance with API Std 541.

14.2.14.11 For PACKAGES with VFDs, the tests of items a) and c) of subclause 14.2.14.10 shall also be performed in minimum speed and maximum flowrate condition.

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14.2.15 For pumps equipped with an internal circulating device in the mechanical seal, the circulating flow shall be measured during the Mechanical Running Test.

14.2.15.1 The seal circulating flow measured at the rated condition shall not deviate from the predicted circulating flow (informed by mechanical seal MANUFACTURER) by more than 10%.

14.3 Commissioning

14.3.1 PACKAGER / MANUFACTURER shall provide any necessary support for installation and commissioning of the equipment either at a shore-based fabrication yard or on the UNIT, including monitoring systems of P0 and P2 type PACKAGE UNITS.

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

14.3.2.1 The PACKAGE shall be designed to withstand all temporary operating and environmental conditions indicated informed by the SUPPLIER.

14.3.3 For services in which the operation fluid is not water, PACKAGER / MANUFACTURER shall confirm if the pump and driver system can operate with water during commissioning activities.

15 PREPARATION FOR SHIPMENT

15.1 Marking

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

15.1.2 Marking shall be such that it does not damage or impair the component. Marking may be done on the item itself or on its packing or nameplate.

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

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

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

15.2 Shipment Packing


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

15.2.2 The preparation shall make the equipment suitable for 24 months outdoor storage from the time of shipment.

15.2.3 The PACKAGE shall be protected from corrosion.

15.2.4 All open ends of piping shall be treated and closed off by plastic caps and taped.

15.2.5 PACKAGER shall submit the packing specification to the SUPPLIER for approval.

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- 15.2.6 Packing shall be in accordance with the requirements of the country to which the equipment is being shipped.
- 15.2.7 PACKAGER shall provide the procedures for unpacking, handling and installation, as well as repacking, and long-term storage requirements.
- 15.2.8 PACKAGER shall specify any limitations applicable to the transport and installation phase.
- 15.2.9 Unless otherwise advised, each item of equipment shall be checked for its suitability to resist horizontal and vertical acceleration of 0.8g in any direction during sea transportation.

16 REQUIRED DOCUMENTATION


- 16.1 PACKAGER / MANUFACTURER shall provide original documents in PDF format for all required documents.
- 16.2 Extracted figures from catalogue or manual, especially for the outline drawings of components such as couplings, mechanical seals and auxiliary equipment shall not be accepted.
- 16.3 Whenever required by BUYER, source files shall also be provided.
- 16.4 All documents required in this section shall be text searchable, including PDF files.
- 16.5 Before any document is issued by PACKAGER / MANUFACTURER, a document list shall be issued and approved by BUYER.
- 16.6 Drawings and diagrams shall use the symbols defined on I-ET-3000.00-0000-940-P4X-002 – Symbols for Production Units Design.
- 16.7 Title of all documents to be issued by PACKAGER / MANUFACTURER shall have the following format:
- First part – tag number;
 - Second part – service description;
 - Third part – document description

EXAMPLE: B-5241501A/B – Inert gas seal pump – General Arrangement Drawing

- 16.8 If PACKAGER / MANUFACTURER issues documents which contain information valid for more than one pump tag, both pump tag and service description shall be omitted and replaced by “Centrifugal Pumps”

EXAMPLE: Centrifugal pumps – Inspection and Test Plan.

- 16.9 The following documents shall be issued and approved before FAT execution. Otherwise, BUYER will not attend the FAT and will not accept its execution:
- Piping and instrumentation diagram;
 - General arrangement drawing;
 - Cross section drawing with part list, with specified axial and diametral clearances (bearings and seals);
 - Main and auxiliary equipment datasheets;
 - Weight and center of gravity datasheet;
 - Noise datasheet;
 - Performance curves;
 - Inspection and Test Plan (ITP), including auxiliary equipment;
 - Hydrostatic test procedure;
 - Painting and insulation specification;
 - Rotor dynamics analysis report (according to requirements of API Std 610);
 - FAT procedure.

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

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

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


- Mechanical seal drawing;
- Coupling drawing;
- Outline drawings of auxiliary equipment;
- Operation and maintenance manuals for main and auxiliary equipment;
- List of spare parts for commissioning and start up;
- List of recommended spare parts for two years of operation;
- List of special tools;
- List of instruments and instrumented valves;
- List of set points, alarms and shutdown;
- Logic diagrams;
- Cause and effect charts;
- Loop diagram;
- Electromechanical panel drawing;
- Memory maps;
- Automation architecture;
- Interconnection wiring diagram;
- Calculation notes of control valves, PSVs and flowmeters;
- I/O List;
- HMI screen layout;
- Calibration certificates of instruments;
- Fabrication procedures of pressure vessels classified in NR-13;
- NDT procedures of pressure vessels classified in NR-13;
- Hydrotest reports for pressure vessels classified in NR-13;
- Hydrotest report of pumps;
- NDT reports;
- Material certificates;
- Heat treatment records;
- Databook index.

16.12 Documents for electric motors shall be according to 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.

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

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

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

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

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

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

16.19 General arrangement drawings shall contain the connection list, i.e., a list with all connection tie-in points of the skids, which shall have the following minimum information:

- a) Connection identification number (which shall be represented in the drawing).
- b) Service description.
- c) Tie-in connection specification, that is, pressure rating, manufacturing standard, flange face type, connection nominal diameter and fluid.

16.20 PACKAGER / MANUFACTURER shall indicate on the general arrangement drawing the distance required for removal of all internal parts, which shall be disassembled periodically for maintenance, in accordance with recommendations on the maintenance manual.

16.21 Mechanical seal drawings shall contain a list with all connections on the seal, including identification code (which shall be represented on the mechanical seal drawing), connection description and fluid.

16.22 Mechanical seal drawings shall contain a part list with identification number of the part, description of the part and material of each part. Identification number of seal parts shall be different from the identification code of the connections.

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

16.24 For pumps with variable speed drives, the performance curve shall inform the preferred and allowable operating region for the pump's entire speed range, with all design operating conditions indicated in it.

16.25 PACKAGER / MANUFACTURER shall inform the number of impeller and diffuser vanes either in the datasheet or in the cross section drawing with part list.

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

17 COOLING AND HOT WATER CIRCULATION PUMPS ADDITIONAL REQUIREMENTS

17.1 General


Requirements in this section shall be added to sections 1-17 of this specification.

17.2 Materials

Material class shall be S-6, as per API Std 610, Table H.1.

17.3 Testing

PACKAGER / MANUFACTURER shall perform NPSH required test for one pump type of Hot Water Circulation Pumps as specified in HI 14.6 or ISO 9906 with API Std 610 additional requirements.

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18 INJECTION WATER AND SRU FEED PUMPS ADDITIONAL REQUIREMENTS

18.1 General

- 18.1.1 Requirements in this section apply to SRU (Sulphate Removal Unit) Feed Pumps, Injection Water Booster Pumps and Main Water Injection Pumps. These requirements shall be added to the sections 1-17 of this specification.
- 18.1.2 Although IOGP S-615 scope may not include pumps for this service, its requirements shall be fulfilled to the most extent possible. Requirements that cannot be fulfilled shall be presented in writing for BUYER's resolution.
- 18.1.3 Main Pumps shall be deemed as Special Purpose Pumps as per API Std 610.
- 18.1.4 A DFMEA according to API Std 691 shall be performed and presented by the PACKAGER / MANUFACTURER.

18.2 Design Requirements

- 18.2.1 Main Pumps shall be of one of these types:
- High-speed integrally geared pumps;
 - Multistage BB3 or BB5 pumps.
- 18.2.2 Booster and SRU feed pumps with rated shaft power greater than 150 kW and rated speed above 1800 rpm shall be between bearing type.
- 18.2.3 Booster and SRU feed pumps with rated shaft power greater than 300kW shall be between bearing type.
- 18.2.4 Main pumps rated speed may be higher than 1800 rpm.
- 18.2.5 Vertical booster pumps shall not be allowed.
- 18.2.6 Pumps shall be installed side by side in parallel to the longitudinal axis of the UNIT, unless otherwise stated in pump data sheets issued by BUYER.
- 18.2.7 Main pumps mechanical seals shall be suitable for operation with produced water. Springs shall be protected from process fluid and located on the quench side.
- 18.2.8 Main pumps sealing system shall be according to Piping Plans 11/62 of API Std 682.
- 18.2.9 Main pumps mechanical seal's shaft sleeve shall be fixed to the rotor shaft by means of a compression ring and positive locking device.
- 18.2.10 Main pumps' mechanical seals shall withstand the mechanical overloads generated by hydraulic transients inherent to the systems' operation.
- 18.2.11 MANUFACTURER shall inform the pump minimum flow requirements – including its dependence on rotation speed, if applicable – to enable the flow control system design and configuration.
- 18.2.12 Each pump PACKAGE, including the driver, shall be mounted on one common baseplate, which shall be fitted on the module deck by means of a three-point mounting system.
- 18.2.13 When lifting the baseplate with all equipment attached, beam deflection shall not exceed L/400, where L is the length of the baseplate.
- 18.2.14 Each pump casing drain and vent shall be flanged, valved and manifolded to a single drain at the edge of the skid.

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18.2.15 Impellers, balancing drums and similar major rotating components of Main Injection Water Pump shall be dynamically balanced to ISO 21940-11, grade G1.

18.2.16 Main Pumps shall have a visual reference (e.g., zebra tape) in a visible section of the rotating assembly to allow direct visual identification of the driver shaft rotation.

18.2.17 If head per stage of Main Pumps is above 275 m, the structural design of the pumps' impellers and diffusers shall include the following analyses, the results of which shall be made available for the BUYER in a dedicated technical report:

- a) Structural analysis to determine shroud natural frequencies, wet mode shapes, and potential for resonance. Separation on interference diagram shall be $\geq 10\%$.
- b) Impellers and diffusers hydraulic loading calculation by a Computational Fluid Dynamics (CFD) transient simulation. The simulation shall consider the actual impeller to collector vane tip clearance and the whole allowable operating range. The calculated hydraulic loading shall be applied to the components' structural model to verify fatigue life at maximum speed. The design shall consider infinite fatigue life for this analysis.

18.2.18 Main Pumps hydraulic selection shall consider the following constraints: efficiency shall be 80% or higher, suction specific speed below 11,000 (USC units) and head rise from BEP to shutoff above 15%.

18.2.19 Main Pumps with direct startup shall be designed considering the transient loads of high flow startup.

18.2.20 Baseplate and hold down bolts design, for both pump and driver, shall consider the higher torque loads resulting from startup at higher flow.

18.2.21 For pumps driven by electric motors with Variable Frequency Drives (VFDs), a torsional, steady-state, forced response analysis shall be performed as part of the Torsional Analysis Report. The analysis shall consider all resonant frequencies through 12 times line frequency.

18.2.22 The drive-end side bearings of the Main Pumps' electric motors shall be locating bearing type with axial play smaller than 1 mm.

18.2.23 Main Pump's Minimum Flow Control Valves (MFCVs) and respective orifice plates shall be specified and supplied by the Pump PACKAGER. These valves shall comply with the requirements 18.2.23.1 to 18.2.23.5.

18.2.23.1 Main Pump's MFCV shall be sized to perform their function in all operating conditions, including transients.

18.2.23.2 The MFCV's opening/closing stroke times shall be defined by the Pump PACKAGER considering the typical transient events such as pump startup and Injection Well Shutdown.


18.2.23.3 Main Pump's MFCV shall be open at failure type with body material according to recycle line material specification.

18.2.23.4 MFCV's positioner shall be contactless, smart and with 4-20 mA with HART protocol.

18.2.23.5 At least one of the MFCVs, including respective orifice plates, shall be tested during the Complete Unit Test.

18.3 Factory Acceptance Test (FAT) – Main Injection Water Pumps

18.3.1 Main Injection Water pump FAT shall be performed at rated speed.

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18.3.2 Vibration and bearing temperature data shall be continuously monitored and recorded during the shop Performance Test. The acceptance limits specified in API Std 610 are applicable to the whole duration of the test.

18.3.3 The vibration and temperatures shall be continuously monitored and recorded during the 4-h Mechanical Running Test (MRT).

18.3.4 The same vibration and bearing temperature limits applicable to the Performance Test shall be applied for the MRT.

18.3.5 The original files containing all data recorded during all steps of the FAT shall be made available for Petrobras after the tests.

18.3.6 Disassembly of the pump for any head adjustment (including less than 5 % diameter change) after test shall be cause for retest.

18.3.7 A Shop Verification of Rotor Dynamic Characteristics as per API Std 610, Annex I shall be carried out during Factory Acceptance Tests of the Main Injection Water Pumps.

18.3.8 During the CUT of Main pumps driven by electric motors with Variable Frequency Drives (VFDs), the torsional stress spectrum shall be continuously monitored and recorded during the CUT with a frequency range up to 10 times the maximum operating speed. The job monitoring system shall be used for this purpose.

18.3.8.1 The calculated primary (coupling) Torsional Natural Frequencies (TNF) shall be identified during the CUT.

18.3.8.2 The stress amplitude of any discrete frequency coinciding with a TNF shall be below the pre-defined coupling fatigue limit for any condition within the pump's operational envelope.

18.4 Materials

18.4.1 Main and booster pump materials shall be of class D2 of API Std 610, Table H.1.

18.4.2 Wetted parts materials shall be suitable for continuous or intermittent seawater and produced water service, including the requirements of ISO 15156 (all parts), according to specifications on data sheets issued by BUYER.

18.5 Lateral Analysis – Main Injection Water Pumps

18.5.1 The Lateral Analysis of Main Injection Water Pumps shall include a Damped Unbalance Response Analysis as per API Std 610, Annex I regardless of the calculated damping factor and critical speed ratio.


18.5.2 The peak-to-peak major axis displacement of the unbalanced rotor shall not exceed 35 % of the diametral running clearance at each close clearance location.

18.5.3 In addition to the conditions described in API Std 610, the Separation Margin, Damping Ratio and Allowable Displacement criteria shall be applied considering minimum and maximum bearing clearance conditions.


18.5.4 The Lateral Analysis Report shall include model data in sufficient detail to allow independent audit of the results.

18.6 Lube Oil System

18.6.1 Integrated common lube oil system for pump and motor driver shall be provided for each pump set with: pumps, suction strainers, supply and return system, vents, drains, dual full-flow oil filters, twin lube oil cooler, electrical lube oil heater, all necessary valves and instruments.

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- 18.6.2 The oil system shall supply mineral oil to the respective users and shall be mounted into the main pump baseplate.
- 18.6.3 Except as stated below, the system shall be in full compliance with API Std 614 as a General-Purpose Lube Oil System.
- 18.6.4 If the Main Pump has fixed speed, the main lube oil pump shall be shaft driven and the spare pump shall be an electrically driven (AC) pump.
- 18.6.5 The spare pump and its control logic shall be designed to be started whenever the lube oil header pressure indicates low pressure and shall be kept in operation whenever the main lube oil pump is not running.
- 18.6.6 If the Main Pump is driven by a Variable Speed Drive (VSD) both main and spare oil pumps shall be electrically driven, hence 2 x AC driven pumps shall be provided.
- 18.6.7 Tank mounted vertical oil pumps may be used.
- 18.6.8 In case of an emergency, that results in loss of all AC power, supply cooling oil shall be sustained.
- 18.6.9 Dual oil filters of SS 316L material capable of on-line changeover without disruption to the main equipment operation shall be provided.
- 18.6.10 Oil coolers shall be plate heat exchangers skid mounted. Shell and tube heat exchangers can only be used with BUYER's approval.
- 18.6.11 An oil tank electric heater shall be provided to maintain the lubricating and control oil at the minimum temperature requirements.
- 18.6.12 The electric heater shall be capable of on-line withdrawal without the necessity to drain down the oil tank.
- 18.6.13 The electric heater shall be in accordance with the voltages stated in I-ET-3010.00-5140-700-P4X-003 – Electrical Requirements for Packages for Offshore Units.
- 18.6.14 The electric heaters shall be provided with 20% redundant heating elements.
- 18.6.15 All piping shall be butt welded and at least 10% of the welds shall be radiographic tested.
- 18.6.16 The oil tank vent shall be fitted with an oil mist eliminator and return oil pipe.
- 18.6.17 PACKAGER shall supply a flame arrestor (loose item) for installation in oil tank vent by the SUPPLIER.
- 18.6.18 The Lube Oil System shall have a dedicated pressure control valve (PCV) with by-pass and block valve.
- 18.6.19 The Lube Oil System shall have a dedicated thermostatic valve for oil temperature control.
- 18.7 Monitoring System**
- 18.7.1 All bearings shall be supplied with individual temperature elements.
- 18.7.2 Spare elements shall be installed in each bearing.
- 18.7.3 In addition to the shaft vibration probes, Main Pumps shall be supplied with at least one accelerometer per bearing housing and one accelerometer installed on the pressure casing.


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- 18.7.3.1 The pressure casing accelerometer shall be located close to the annular seal element with the highest radial stiffness.
- 18.7.4 Main Pumps and SRU Feed Pumps shall have continuous monitoring of rotation speed and direction integrated to the MMS.
- 18.7.5 Indication of reverse rotation condition shall inhibit the equipment's startup and cause automatic blockage of the pump's discharge valve.
- 18.7.6 Main Pumps shall be provided with a casing temperature sensor located on the pressure casing surface as close as possible to the discharge nozzle.
- 18.7.6.1 Temperature alarm (TAH) and trip (TAHH) values shall be configured for the pressure casing surface sensor.
- 18.7.7 Main Pumps, when BB5 type, shall have a differential pressure transmitter between the balancing chamber (non-drive end side) and the pump's suction nozzle.
- 18.7.7.1 A high-level alarm only shall be associated with differential pressure measurement between the balancing chamber and the pump's suction nozzle.
- 18.7.7.2 The differential pressure transmitter shall be suitable for the system's expected transient events.
- 18.7.8 Main pumps driven by electric motors with Variable Frequency Drives (VFDs) shall have a non-contacting, phase-shift type torque transducer installed on the low-speed coupling.
- 18.7.8.1 The torque transducer and signal conditioning system shall be capable continuously monitoring both the average and cyclic torque components.
- 18.7.8.2 The cyclic torque signal shall be used for alarm only, and its mal functioning shall not compromise the operation of the equipment.
- 18.7.8.3 The manufacturer shall define the alarm levels for cyclic stress based on the estimated fatigue limit for the component's infinite life.

18.8 Gear Units

18.8.1 Hydraulic Variable Speed Drive (HVSD)

- 18.8.1.1 When required on the Basic Design datasheets, HVSDs shall be supplied to allow the pump's speed variation.
- 18.8.1.2 HVSDs shall be furnished according to API 613 wherever applicable.
- 18.8.1.3 HVSDs shall be designed as a "stand-alone" unit, whereby no external thrust loads shall be imposed upon the HVSD by other equipment.
- 18.8.1.4 HVSD shall be designed for all operating cases defined in the pump datasheet.
- 18.8.1.5 The hydraulic variable speed driver shall be designed to operate continuously at any point within the speed and torque range.
- 18.8.1.6 The equipment shall have a Nitrogen purge connection for preservation purpose.
- 18.8.1.7 Each HVSDs shall undergo a Mechanical Running Test in accordance with API 613 and it shall be witnessed by the BUYER. All real-time vibration data shall be recorded, and a copy provided to the BUYER.

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18.8.2 Gearbox

18.8.2.1 Gearbox, when applied for the Water Injection Pumps, shall be double helical, single stage designed in accordance with API 613 and IOGP S-713.

18.8.2.2 A device to allow manual rotation of the shafts shall be included for maintenance purposes.

18.8.2.3 Gearbox shall be designed as a "stand-alone" unit, whereby no external thrust loads shall be imposed upon the gearbox by other equipment.

18.8.2.4 Shaft oil seal shall be easily accessible for removal and re-installation without removing couplings.

18.8.2.5 All bearings shall be pressure lubricated and fully replaceable at field.

18.8.2.6 Each gearbox Mechanical Running Test shall be witnessed by the BUYER. All real-time vibration data shall be recorded, and a copy provided to the BUYER.

18.9 Commissioning

Main and booster pump PACKAGES shall undergo a Site Acceptance Test (SAT) in accordance with the requirements of Annex A – Rotating Equipment Reliability Test.

19 PRODUCED WATER PUMPS ADDITIONAL REQUIREMENTS

19.1 General

19.1.1 Requirements in this section shall be added to sections 1-17 of this specification.

19.1.2 Produced water pumps used to feed Injection Water Main Pumps shall also conform to the requirements of Injection Water Booster Pumps.

20 OIL TRANSFER PUMPS ADDITIONAL REQUIREMENTS

20.1 General

20.1.1 Requirements in this section shall be added to the sections 1-17 of this specification.

20.1.2 Requirements in this section are applicable to pumps that transfer crude oil from the oil treatment system to the cargo tanks of the UNIT.

20.1.3 Pumps shall be provided with a casing temperature sensor on the pressure casing surface as close as possible to the discharge nozzle.

20.2 Design Requirements

SUPPLIER shall calculate the NPSH available considering transient pressure variations at the oil treatment system.

20.3 Testing

PACKAGER / MANUFACTURER shall perform NPSH required test for one of each pump type.

21 ANNEXES

Annex A – Rotating Equipment Reliability Test.



 ANNEX A -
 ROTATING EQUIPME