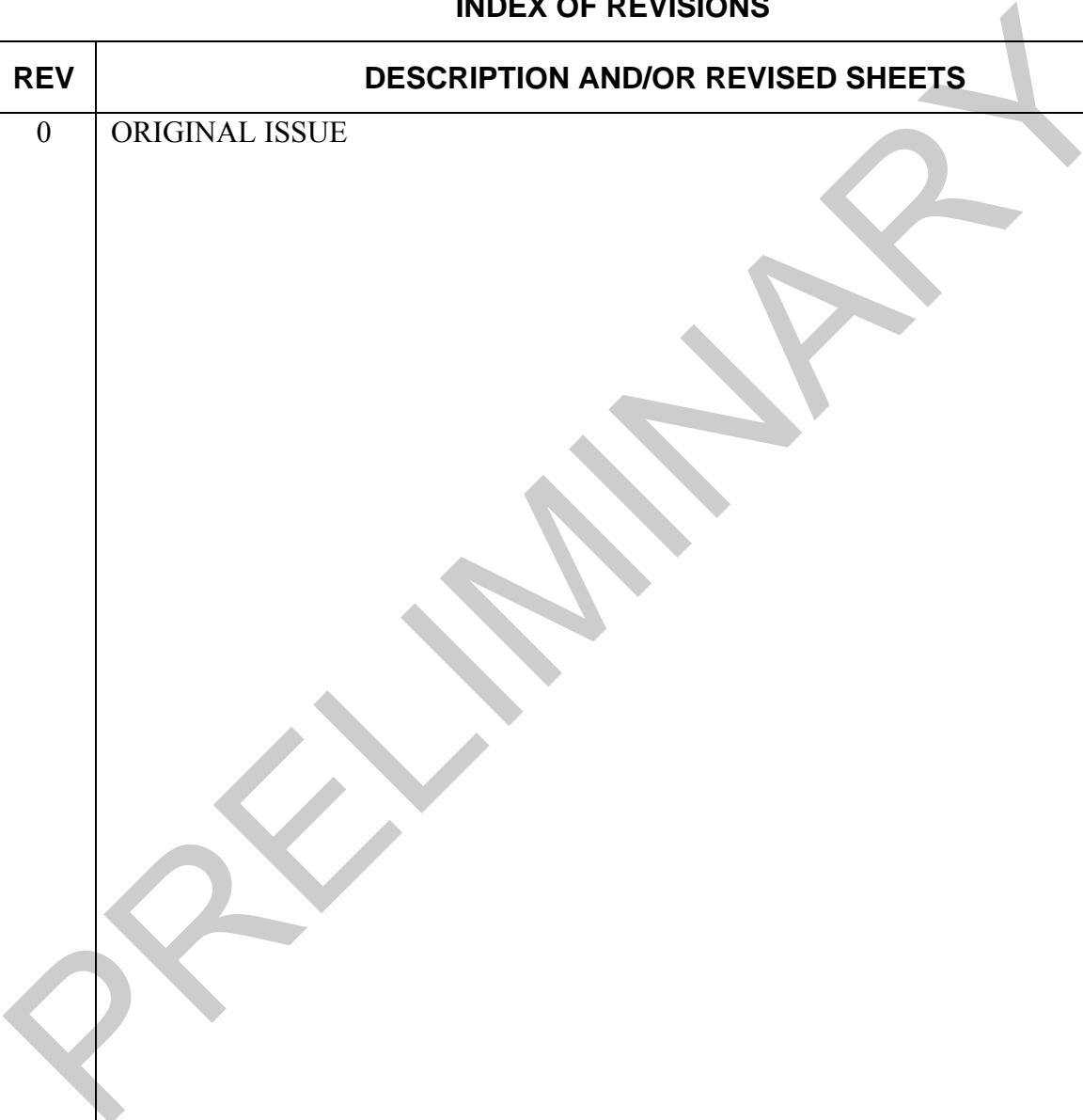
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PRELIMINARY

## 1 OBJECTIVE

This specification establishes the necessary technical requirements for design, manufacture and supply of Medium-Voltage Induction Motors for Offshore Units.

## 2 REFERENCE STANDARDS AND DOCUMENTS

### 2.1 GENERAL

- 2.1.1. The standards, codes and recommendations that shall be applied to motors design are listed below.
- 2.1.2. At motors design, national laws and regulations shall have priority, followed by IEC standards. Other standards shall be applied where specified by PETROBRAS.
- 2.1.3. Exceptionally, where it is clearly justifiable and approved by PETROBRAS, ANSI, NEMA, IEEE, VDE and others internationally recognized standards may be used.
- 2.1.4. All standards shall be used on their latest revisions.

### 2.2 CODES, STANDARDS AND RECOMMENDED PRACTICES

#### 2.2.1 IEC – INTERNATIONAL ELECTROTECHNICAL COMMISSION

- IEC 60034 Rotating Electrical Machines – Parts 1, 2, 5, 6, 7, 8, 9, 11, 12, 14, 15, 18, 25, 26, 27 and 29;
- IEC 60072 Dimensions and Output Series for Rotating Electrical Machines – All parts;
- IEC 60079 Explosive Atmospheres – Parts 0, 2, 7 and 14;
- IEC 60085 Electrical Insulation - Thermal Evaluation and Designation;
- IEC 61892 Mobile and Fixed Offshore Units – Electrical Installations – Parts 1, 3 and 7;

#### 2.2.2 IEEE – INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS (only where specified)

- IEEE Std 43 Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
- IEEE Std 522 Guide for Testing Turn Insulation of Form-Wound Stator Coils for Alternating-Current Electric Machines
- IEEE Std 1434 Guide to the Measurement of Partial Discharges in Rotating Machinery

#### 2.2.3 NEMA – NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (only where specified)

- MG1 Motors and Generators

- 2.2.4 ASTM – AMERICAN SOCIETY FOR TESTING AND MATERIALS (only where specified)
- ASTM B26/B26M Standard Specification for Aluminium-Alloy Sand Castings
- ASTM B108/B108M Standard Specification for Aluminium-Alloy Permanent Mold Castings
- ASTM B221 Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
- 2.2.5 ISO – INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (only where specified)
- ISO 20816-1 Mechanical Vibration – Measurement and Evaluation of Machine Vibration – Part 1: General Guidelines
- 2.2.6 INMETRO – INSTITUTO NACIONAL DE METROLOGIA NORMALIZAÇÃO E QUALIDADE INDUSTRIAL
- Portaria 179 May 18<sup>th</sup> 2010
- Portaria 89 Feb 23<sup>rd</sup> 2012
- 2.2.7 API – AMERICAN PETROLEUM INSTITUTE
- API Std 541 Form-wound Squirrel-Cage Induction Motors - 500 Horsepower and Larger (only where specified)
- 2.2.8 ASME – AMERICAN SOCIETY OF MECHANICAL ENGINEERS
- ASME B 1.20.1 Pipe Threads, General Purposes (Inch)
- ASME BPVC-VIII-1 Rules for Construction of Pressure Vessels Division 1
- 2.2.9 IMO - INTERNATIONAL MARITIME ORGANIZATION
- IMO IA811E Code for the Construction and Equipment of Mobile Offshore Drilling Units (MODU CODE)
- 2.2.10 ANSI/ISA – THE INSTRUMENTATION, SYSTEM, AND AUTOMATION SOCIETY
- ANSI/ISA 7.0.01 Quality Standard for Instrument Air
- 2.2.11 RULES OF CLASSIFICATION SOCIETY

### 2.3 REFERENCE DOCUMENTS

- [1] I-ET-3010.00-1200-956-P4X-001 - QUALIFICATION TESTS FOR PAINT SYSTEMS
- [2] NOISE CONTROL REQUIREMENTS SPECIFICATION
- [3] SPECIFICATION FOR AVAILABLE UTILITIES
- [4] ELECTRICAL EQUIPMENT DATA SHEET MODELS

**Note:** Documents without code in the list are documents with variations according to project characteristics. Verify in project documentation list the reference for codes of these documents.

### 3 GENERAL CONDITIONS

#### 3.1 ENVIRONMENTAL

- 3.1.1. Induction motors and their accessories shall be suitable for storage, service and installation on severe petrochemical, marine, tropical, damp and saline environment.
- 3.1.2. It shall be considered a design ambient temperature of 45°C, continuously. Motors installed inside engine room shall have design ambient temperature of 50°C, continuously. Classification Society requirements, when more restrictive, shall be complied with.

#### 3.2 RATING

- 3.2.1. Induction motors shall have rated power calculated, with service factor 1.0, considering the oversizing factor of 10% applied to driven machine rated brake power.
- 3.2.2. Oversizing factor lower than stipulated above shall be submitted to PETROBRAS for approval.

### 4 CONSTRUCTIVE CHARACTERISTICS

#### 4.1 ELECTRICAL CHARACTERISTICS

##### 4.1.1 RATED VOLTAGE

- 4.1.1.1. Unless otherwise stated in Project Documentation, induction motors following this technical specification with rated power from 150kW up to 1200kW shall have rated voltage 4kV, 3ph, 60Hz.
- 4.1.1.2. Unless otherwise stated in Project Documentation, induction motors following this technical specification with rated power above 1200kW shall have rated voltage 13.8kV, 3ph, 60Hz.

##### 4.1.2 STARTING PERFORMANCE

- 4.1.2.1. The motors shall be suitable for direct on-line start and to accelerate the related loads up to the full speed, with 85% of motors rated voltage and rated frequency.
- 4.1.2.2. Unless otherwise stated in Project Documentation, for motors with service type S1, the accelerating time ( $t_a$ ) at 85% of rated voltage, when DOL (direct on-line) started, shall not exceed:
- the permissible locked rotor time ( $t_{lr}$ ), at rated voltage and running temperature (hot start), minus 2 seconds ( $t_{lr} - 2s$ ) and;
  - the time  $t_E$  minus 2s ( $t_E - 2s$ ), for Ex e motors.

**Notes:** • Accelerating time ( $t_a$ ) shall be calculated considering direct on-line start;

- Accelerating time ( $t_a$ ) shall include the driven machine coupled and loaded at expected normal service condition;
- Running temperature means steady state operational temperature at rated load;
- These requirements are not applicable for motors fed from VSD and soft-starters. If bypass of VSD or soft-starter with contactor is foreseen, the requirements are applicable.

4.1.2.3. Maximum accelerating time ( $t_a$ ), considering DOL start at rated voltage with driven machine coupled, shall be 5s.

**Note:** Accelerating time ( $t_a$ ) bigger than these values shall be submitted to PETROBRAS approval, including protection coordination graphics and relays' settings, proving that it is possible to provide reliable protection to the motor. These protection coordination graphics are not included in motor Manufacturer scope.

4.1.2.4. Permissible locked rotor time ( $t_{lr}$ ) at rated voltage and running temperature (hot start) shall be equal to or longer than 12s.

**Note:** Shorter values of specified permissible locked rotor time ( $t_{lr}$ ) shall be submitted to PETROBRAS for approval.

4.1.2.5. The number of starts and intervals shall be:

- a) With the motor initially at ambient temperature (cold start), three (3) starts in succession, coasting to rest between starts;
- b) With the motor initially at running temperature (hot start), two (2) starts in succession, coasting to rest between starts.

4.1.2.6. After a cooling period of 30 minutes at standstill, another starting sequence of at least two successive starts shall be possible.

4.1.2.7. For machines with rated power in excess of 1600kW, deviations in requirements of items 4.1.2.5 and 4.1.2.6 may be acceptable, subject to PETROBRAS approval.

4.1.2.8. All motors shall be proper for at least one start per day for twenty five years of life time.

4.1.2.9. Unless otherwise specified in Project Documentation, the locked rotor current ( $I_{lr}$ ), at rated voltage shall not exceed 6.0 times the rated current ( $I_r$ ), accepting tolerances of IEC 60034-1.

**Note:** Unless otherwise stated in Project Documentation, this requirement is not applied to motors fed from VSD or started with electronic soft-starters devices.

#### 4.1.3 OPERATING PERFORMANCE

4.1.3.1. Motors shall operate satisfactorily under the following continuous conditions:

- a) Variation of  $\pm 10\%$  of rated voltage, at rated frequency;
- b) Variation of  $\pm 5\%$  of rated frequency, at rated voltage;

c) Combined variation of voltage and frequency of  $\pm 10\%$  of the rated values (sum of absolute values), provided the frequency variation does not exceed  $\pm 5\%$  of rated frequency.

4.1.3.2. Motors shall withstand and operate satisfactorily under the following transient conditions, based on IEC 61892-3:

- a) Variation of  $\pm 20\%$  of rated voltage with the maximum recovery time of 1.5s;
- b) Variation of  $\pm 10\%$  of rated frequency with the maximum recovery time of 5s.

4.1.3.3. Within these limits, the temperature rise shall comply with requirements of IEC 60034-1.

4.1.3.4. Current stator pulsation, when driving loads such as reciprocating pumps or compressor shall not exceed 66% of rated RMS full load current for all specified loading conditions, according to NEMA MG1.

4.1.3.5. Unless otherwise specified in Project Documentation, motors with power up to 630kW shall have torque characteristics as stated in IEC 60034-12 for Design N.

4.1.3.6. Unless otherwise specified in Project Documentation, motors above 1600kW shall have torque characteristics complying with:

- a) locked rotor torque ( $T_l$ )  $\geq 50\%T_N$ ;
- b) pull-up torque ( $T_u$ )  $\geq 30\%T_N$ ;
- c) breakdown torque ( $T_b$ )  $\geq 160\%T_N$ .

4.1.3.7. For all motors the torque at any speed between zero and that in which the breakdown torque occurs shall not be less than 1.3 times the torque of the load at the same speed.

4.1.3.8. Motor for loads with intermittent service shall be rated for the adequate duty type, as defined in IEC 60034-1.

#### 4.1.4 EFFICIENCY

4.1.4.1. Unless otherwise stated in Project Documentation, the minimum acceptable efficiency at rated voltage and full load, considering +0% tolerance, shall be as defined in Table 1.

Table 1 - Medium-Voltage Induction Motors Minimum Efficiency

Rated Power [kW]	Minimum Efficiency [%]
$\leq 300$	94.2
$> 300$ and $\leq 1200$	95.2
$> 1200$	96.4

4.1.4.2. It shall be acceptable minimum efficiency of 96%, at rated voltage and full load and considering +0% tolerance, for motors above 1200kW, when the locked rotor current ( $I_r$ ) at rated voltage is limited in Project Documentation to 4.5 times the rated current ( $I_r$ ) or lesser value.



- 4.1.4.3. It shall be acceptable minimum efficiency of 90.4%, at rated voltage and full load and considering +0% tolerance, for IP-68 motors, for sea water lift pumps.

## 4.2 MECHANICAL CHARACTERISTICS

### 4.2.1 ENCLOSURE

- 4.2.1.1. Motors installed open deck shall have minimum protection degree IP-56. Submerged motors shall have minimum protection degree IP-68. All other motors shall have protection degree IP-55.
- 4.2.1.2. Motors and terminal boxes shall have the same protection degree.
- 4.2.1.3. Unless otherwise indicated on project documents, motors with horizontal shafts shall comply with International Mounting code IM B3 (according to IEC 60034-7).
- 4.2.1.4. The following additional characteristics shall be provided:
- a) Identification nameplate of AISI-316 stainless steel;
  - b) Painting proper for offshore installations and pre-qualified according to I-ET-3010.00-1200-956-P4X-001 - QUALIFICATION TESTS FOR PAINT SYSTEMS;
  - c) Enclosure last coat colour Light Green Munsell 5G8/4, for general purpose motors;
  - d) Enclosure last coat colour Red Munsell 5R4/14, for motors driving fire fighting equipment;
  - e) Terminal boxes interior last coat colour Safety Orange Munsell 2.5YR6/14.
  - f) Sealing devices (retainers, V-ring, labyrinth, etc.) between shaft and enclosure;
  - g) Caulking at the connection cables passage through the casing;
  - h) Screws, nuts, washers and all other connecting and mounting components proper to saline aggressive atmosphere;
  - i) Non-sparking copper-free aluminium for external fans (frame and blades). The aluminium shall be ANSI 356.0 alloy according to ASTM-B26/B26M, ANSI 359.0 alloy according to ASTM B108/B108M, 6063 alloy according to ASTM-B221, or 6351 alloy according to ASTM-B221.

**Note:** Last coat colour is applicable to motor and terminal boxes. Terminal boxes in AISI 316 without painting are acceptable.

### 4.2.2 WINDINGS INSULATION

- 4.2.2.1. The windings shall be insulated according to the method doubly impregnated by vacuum (VPI). Deviations in VPI method shall be submitted to PETROBRAS for approval.
- 4.2.2.2. All coils shall have anti-corona protection, achieved using a semi-conductive tape, in the slot part of the coil.

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- 4.2.2.3. All motors with rated voltage above 6kV shall have additionally coils with stress grading.
- 4.2.2.4. For motors with rated voltage above 6kV, stator windings, including the lead connections, shall have a sealed insulation system to be capable of withstand a spray test for sealed winding conformance, according to NEMA MG1 Part 20.
- 4.2.2.5. Insulation of motors shall have Thermal Class F (155°C), or Thermal Class higher than F, with a maximum temperature rise at full load not exceeding the limit defined to Thermal Class B (130°C), according to IEC 60085. For air cooled motors, the temperature rise shall be considered related to ambient temperature (item 3.1.2). For water cooled motors, the temperature rise shall be considered related to the inlet water temperature (item 4.2.3.6) and the rules of IEC 60034-1 are applicable.

**4.2.3 COOLING SYSTEM**

- 4.2.3.1. For outdoor installation, motors with rated power below 900kW shall be TEFC (Totally Enclosed Fan Cooled – according to NEMA MG1) cooling type, independent of area classification and they shall comply with the cooling methods IC 411, IC 511 or IC 611 defined in IEC 60034-6.
- 4.2.3.2. For outdoor installation, motors with rated power 900kW and above shall have closed-circuit air-air heat exchangers and they shall comply with the cooling methods IC 51X or IC 61X (X can be any method of movement from 1 to 8) defined in IEC 60034-6. The heat exchangers shall be built into or mounted on the machine casing, always on a position to allow easy access for assembly and the fitting of a thermometer at the exchanger air outlet shall be provided.
- 4.2.3.3. Alternative proposals for motors of item 4.2.3.2 with air-water heat exchangers shall be submitted to PETROBRAS approval.
- 4.2.3.4. For indoor installation, motors with rated power below 650kW shall be TEFC (Totally Enclosed Fan Cooled – according to NEMA MG1) cooling type, independent of area classification and they shall comply with the cooling methods IC 411, IC 511 or IC 611 defined in IEC 60034-6.
- 4.2.3.5. For indoor installation, motors with rated power 650kW and above shall have closed-circuit air-water heat exchangers and they shall comply with the cooling methods IC7A1WX or, IC8A1WX (X can be any method of movement from 1 to 8).
- 4.2.3.6. If closed-circuit air-water heat exchanger is specified, the system shall comply with the "water type", "inlet water temperature" and "inlet pressure" defined in SPECIFICATION FOR AVAILABLE UTILITIES. The maximum acceptable water flow per motor is 7.5 [m<sup>3</sup>/(h.MW)].
- 4.2.3.7. Air-water heat exchangers shall be manufactured, tested and certified as required for pressure vessels and following the requirements of ASME BPVC-VIII-1 and Classification Society.
- 4.2.3.8. Unless otherwise stated in Project Documentation, air-water heat exchangers shall comply with the following requirements:

- a) Heat exchanger material of all parts in contact with cooling water (pipes, flanges, header, etc.) shall be in corrosion resistant alloy, for example, 9010 copper-nickel alloy. The fins shall be of copper or aluminium. It shall not be permitted use of carbon steel, even with internal organic coating;
- b) galvanic corrosion between dissimilar metals shall be avoided;
- c) load losses shall not exceed 0.7kgf/cm<sup>2</sup>;
- d) heat exchanger shall be built into or mounted on the machine casing, always on a position to allow easy access for maintenance;
- e) the tubing shall be double tube type so that any leakage from the internal tube will be collected by the external one. The internal tube shall be according to item a). The external tube shall be of copper, with fins of the same material. It shall be avoided galvanic corrosion between dissimilar metals.
- f) it shall be provided protection to avoid the water to be in contact with the windings, in case of leakage, crack in pipes or condensation in exchanger;
- g) it shall be provided means for draining off the water in case of leakage;
- h) an alarm system shall be provided for signalling of leakage of water between the internal and the external tube;
- i) installation of auxiliary fans shall be avoided, by all means;
- j) thermometers shall be installed at the exchanger water inlet and outlet;
- k) manometers shall be installed at the exchanger water inlet and outlet;
- l) differential pressure detectors shall be installed at exchanger water inlet and outlet;
- m) it shall be provided two inspection windows at opposite sides each other;
- n) it shall be provided facilities to perform hydrostatic test for heat exchangers and blocking valves on site, as well as for testing the water leakage alarm unit.

#### 4.2.4 MOTION AND INCLINATION LIMITS REQUIREMENTS

For floating units, motors shall operate normally within motion and inclination limits (static and dynamic) specified in IMO MODU CODE, IEC 61892 series and Classification Society rules.

#### 4.2.5 BALANCE

Motors shall be constructed so that, when running at any and every working speed, all revolving parts are well balanced;

#### 4.2.6 VIBRATION

The motors shall comply with the requirements of IEC 60034-14, unless otherwise stated on Project Documentation.

#### 4.2.7 NOISE LEVEL

- 4.2.7.1. Motors shall comply with the requirements of IEC 60034-9, and NOISE CONTROL REQUIREMENTS SPECIFICATION. The strictest requirement shall prevail.
- 4.2.7.2. Bent fan blades shall be used in the motor to achieve the noise limit, if not possible with straight fan blades.

#### 4.2.8 BEARINGS

- 4.2.8.1. All motors shall have ball, roller or sleeve type bearings, according to manufacturer standard. Bearings shall have a minimum lifetime of 25,000 hours, under rated load conditions.
- 4.2.8.2. All motors lubricated with grease shall have bearings fitted with a greasing fitting and automatic bleeder device, in accordance with IEC 60072-1.
- 4.2.8.3. Bearings shall be fitted with sealing device, in order to avoid grease leakage or penetration of water and humidity.
- 4.2.8.4. Vertical motors shall have bearings designed to withstand axial stress imposed by the driven machine.
- 4.2.8.5. Means shall be provided to avoid the circulation of currents between the shaft and the bearings (see IEC 60034-25 as reference).

#### 4.2.9 LUBRICATION

- 4.2.9.1. Ball or roller bearings shall be lubricated with grease. In this case, they shall be lubricated at the factory, in order to avoid necessity of lubrication before operation starts.
- 4.2.9.2. Sleeve bearings may be fitted with a self-lubrication or forced lubrication system.
- 4.2.9.3. Motors with sleeve self-lubricated bearings shall have a thermometer temperature indicator and a sight glass indicator for oil level.
- 4.2.9.4. When ring lubrication is used, the rings shall be so constrained that they cannot leave the shaft.
- 4.2.9.5. Motors with forced oil lubrication sleeve bearings shall have a common lubrication system with the driven machine. Packager shall provide the necessary instruments.

**Note:** For motor driving gas compressor, the bearing lubrication system shall be independent from the oil used by the sealing system of the compressor.

- 4.2.9.6. Motors with oil lubrication shall have means to avoid liquid or gaseous oil to penetrate the windings area.

#### 4.2.10 TERMINAL BOXES

- 4.2.10.1. All motors shall have two groups of terminal boxes, first one named Power Terminal Box(es) and second one named Auxiliary Terminal Box(es).

- 4.2.10.2. Unless otherwise indicated on the project documents, the Power Terminal Box(es) shall be fitted to the casing, on the left side, considering the motor viewed from the D-end, with the feet at 6 o'clock and the Power Terminal Box at 9 o'clock (designation L according to IEC 60034-7 for motors with feet).
- 4.2.10.3. Unless otherwise stated in project documents, the cable entry shall be from bottom side. It shall be possible to install the boxes on any of the four positions (from 90° to 90°), around its own axis, allowing adjustment for cable entry from top, bottom, front or rear side.
- Note:** Power Terminal Box(es) rotation is not required for Ex p motors and for motors with surge capacitors and surge arresters installed inside Power Terminal Box(es). In these cases, the cable entry side will be defined during Detailed Design.
- 4.2.10.4. Power Terminal Box(es) shall be used exclusively for power connections and installation of CTs, surge capacitors, surge arresters and partial discharge sensors.
- 4.2.10.5. Terminal Box(es) doors, above 20kg shall have lifting eyelets.
- 4.2.10.6. Auxiliary Terminal Box(es) shall be used exclusively for connection of heating resistor, control, sensors and electric protection devices.
- Note:** These boxes shall be located at the opposite side of the Power Terminal Box(es), except when linked to sensors installed inside it.
- 4.2.10.7. At the Power Terminal Box(es) the distance between terminal bushings with connectors and the cable inlet, shall be suitable to contain the cables stress-relief cones.
- 4.2.10.8. Motors shall have a removable non-magnetic plate fixed to the Power Terminal Box(es) to enable disconnection and removal of the motor to maintenance, keeping the cables terminations.
- 4.2.10.9. Soldered terminals shall not be used. The terminals insulation supports shall be of non-hygroscopic and non-combustible materials.
- 4.2.10.10. If single-core cables are used, the removable plate and the cable glands shall be of non-magnetic material to avoid magnetic induction.
- 4.2.10.11. The Power Terminal Box(es) shall be able to relief the overpressure caused by internal short-circuit.
- 4.2.10.12. For submerged motors (e.g. sea water lift pump motors), terminal boxes separated from the motor enclosure are acceptable. These boxes shall be supplied by motor manufacturer and shall be suitable for the place of installation (environment and hazardous area classification).
- 4.2.11 **GROUNDING CONNECTORS**
- 4.2.11.1. Motors enclosures shall have a grounding connector fitted on its base, outside the terminal boxes, at the same side of the Power Terminal Box(es) and indelibly marked with the grounding symbol.
- 4.2.11.2. Motors shall have one additional grounding connector inside the Power Terminal Box, indelibly marked with grounding symbol.

4.2.11.3. Motors with rated voltage above 11kV shall have one grounding connector inside the Power Terminal Box (meant for grounding the cable shield) and two grounding connectors outside the terminal boxes, fitted in symmetrical opposition. All grounding connectors shall be indelibly marked with grounding symbol.

4.2.11.4. Motors fed from power cables up to 120mm<sup>2</sup> shall have grounding connectors proper for cables with half the cross section of the power cables, with minimum 10mm<sup>2</sup>.

4.2.11.5. Motors fed from power cables above 120mm<sup>2</sup> shall have grounding connectors proper to cables with cross section 70mm<sup>2</sup>.

#### 4.2.12 TERMINALS

4.2.12.1. Unless otherwise specified in Project Documentation, motors shall be furnished with six power terminals, marked according to IEC 60034-8.

4.2.12.2. For motors fed from VSD, if self-balancing differential protection is not required, three power terminals are acceptable.

4.2.12.3. For grounding terminals see item 4.2.11.

4.2.12.4. All motor cables (power and control) shall be indelibly marked inside the terminal boxes.

### 4.3 ACCESSORIES

#### 4.3.1 LIFTING EYELETS

All motors shall be fitted with lifting eyelets.

#### 4.3.2 HEATING RESISTORS

4.3.2.1. All motors shall have internal heating resistors.

4.3.2.2. The maximum internal temperature when heating resistors are turned on shall not cause any damage to winding or insulation parts.

4.3.2.3. The heating resistors shall be shielded type, with rated voltage 220VAC for each individual resistance used. The resistors shall be suitable to 220VAC 2ph ungrounded power supply.

4.3.2.4. For motors certified for installation in hazardous areas, the temperature at surfaces with heater turned on and environmental temperature of 45°C shall not exceed the limits defined by IEC 60079.

4.3.2.5. A warning plate shall be located next to the Auxiliary Terminal Box with the label:

**ATENÇÃO!**  
**AQUECEDOR LIGADO EM 220VCA.**

4.3.2.6. The heating resistors shall not cause any damage to winding or insulation parts.

#### 4.3.3 CURRENT TRANSFORMERS

Motors with rated voltage 11kV and above shall be provided with 3 (three) window-type current transformers for self-balancing differential protection with "Wye" connection.

#### 4.3.4 WINDING TEMPERATURE DETECTORS

4.3.4.1. Motors for gas compression shall be fitted with nine (three per phase) platinum resistance temperature detectors (RTDs), three-wire, 100Ω at 0°C, embedded in the windings and complying with IEC 60034-11.

4.3.4.2. All other motors shall be fitted with six (two per phase) platinum resistance temperature detectors (RTDs), three-wire, 100Ω at 0°C, embedded in the windings and complying with IEC 60034-11.

4.3.4.3. All motors fed from VSDs shall be fitted with six (two per phase) PTC thermistors connected in series at the terminal box. The PTC thermistors shall be additional to the RTDs required on 4.3.4.2.

#### 4.3.5 BEARING TEMPERATURE DETECTORS

4.3.5.1. Motors fitted with sleeve type bearings shall have two temperature detectors installed on each bearing. The type of the detectors shall be platinum resistance RTDs, three-wire 100Ω at 0°C.

4.3.5.2. Each detector shall execute both functions: alarm and disconnection (switch off the motor).

4.3.5.3. The measuring points shall be according to IEC 60034-1.

4.3.5.4. Bearing temperature sensors shall be connected to temperature controllers supplied by Packager and installed in a Package Panel. Package Panel shall be the Package Control Panel, in case of Packages with this kind of panel. For Packages without Package Control Panel, Package Panel(s) shall be installed in the Package skid and shall be proper to external auxiliary voltage 220Vcc ungrounded. Package Panel(s) shall comply with item 4.4.2. Trip and alarm signals shall be dry contacts, available for remote actuation.

4.3.5.5. See also item 8.2 for GIOp requirements.

#### 4.3.6 PRESSURE DETECTORS

4.3.6.1. Motors with pressurised enclosure (Ex p) shall have two underpressure detectors.

4.3.6.2. Motors with oil lubricated bearings shall have lubrication oil pressure switches installed in both bearings.

4.3.6.3. Pressure detectors shall be connected to pressure controllers supplied by Packager and installed in Package Panel(s), as defined in 4.3.5.4.

4.3.6.4. Water cooled motors shall have differential pressure detectors, as defined in 4.2.3.8.

4.3.6.5. See also item 8.4 for GIOp requirements.

#### 4.3.7 VIBRATION SENSORS

4.3.7.1. Motors shall have vibration sensors installed in bearings as required by driven machine or other PETROBRAS documentation.

4.3.7.2. Vibration sensors shall be connected to vibration controllers supplied by Packager and installed in a Package Panel, as defined in 4.3.5.4.

4.3.7.3. See also item 8.3 for GIOp requirements.

#### 4.3.8 PRESSURE CONTROL SYSTEM

4.3.8.1. Motors with pressurized enclosure (Ex p) shall comply with requirements of IEC 60079-2.

4.3.8.2. Motors with pressurized enclosure (Ex p) shall be proper to air supply quality according to ANSI/ISA 7.1.01 and SPECIFICATION FOR AVAILABLE UTILITIES. If the motor requires a better air supply quality, Manufacturer shall include air treatment devices.

#### 4.3.9 CABLE GLANDS

4.3.9.1. Cable glands shall be of stainless steel AISI 316.

4.3.9.2. Unless otherwise stated, threaded joints shall be taper type, NPT with standardized tolerances according to ASME B 1.20.1. For motors certified for installation in hazardous areas, threaded joints shall comply with requirements of IEC 60079-0.

#### 4.3.10 PARTIAL DISCHARGE SENSORS

4.3.10.1. Motors with rated voltage 6kV or higher and with rated power 5MVA or higher shall be supplied with a set of three units of 80pF coupling capacitors, installed in Power Terminal Box, used as sensors for on-line Partial Discharge (PD) measurement.

4.3.10.2. Manufacturer shall be responsible to supply and install in motor, beyond the sensors, an Auxiliary Terminal Box including all devices (e.g. BNC connectors) required to allow the connection of a portable monitoring equipment (portable monitoring equipment supplied by others).

4.3.10.3. This set of sensors and Auxiliary Terminal Box shall be compatible for operation with IRIS Power Engineering monitoring systems.

4.3.10.4. For motors installed in hazardous areas, motor certification shall include the Auxiliary Terminal Box.

#### 4.3.11 IDENTIFICATION PLATE

The identification plate shall be marked according with IEC 60034-1 and the following information shall be included:

- a) PETRÓLEO BRASILEIRO S/A – PETROBRAS;
- b) PETROBRAS Unit name;
- c) Motor identification tag;
- d) PETROBRAS RM number;
- e) PETROBRAS PCM number;
- f) PETROBRAS AFM number;
- g) Frame designation;
- h) Service factor;



- i) Efficiency at 100% load;
- j) Bearings identification numbers;
- k) Permissible locked rotor time ( $t_{lr}$ );
- l) Cooling method designation;
- m) Starting torque design designation;
- n) Ratio between locked-rotor current ( $I_{lr}$ ) and rated current ( $I_r$ );
- o) Hazardous areas classification protection, according to IEC 60079-0, including time  $t_E$ , for Ex e motors.

#### 4.3.12 UNUSUAL TOOLS

Unless otherwise stated, water cooled motors shall be supplied with a tool for rotor removal. One tool per platform for each different motor is required. It is acceptable one tool for different motors, since this tool is suitable for all the motors considered.

### 4.4 ADDITIONAL REQUIREMENTS FOR MOTORS INSTALLED IN HAZARDOUS AREAS

- 4.4.1. Motors and electrical accessories installed in hazardous areas shall comply with IEC 60079 (all parts) and Inmetro Portaria 179, May 18<sup>th</sup> 2010 and Portaria 89, Feb 23<sup>rd</sup> 2012.
- 4.4.2. Electrical accessories installed in external safe or hazardous areas, which shall be kept operating during emergency shutdown ESD-3P or ESD-3T shall be certified for installation in hazardous areas Zone 1 Group IIA temperature T3.
- 4.4.3. The kind of protection Ex and the EPL required for the motor shall be selected and specified according to requirements of IEC 60079-14.
- 4.4.4. Motors with DOL shall have kind of protection Ex and the EPL selected following the criteria defined in Table 2.

Table 2 - Selection of Ex Protection and EPL for Motors with DOL

Rated Voltage [V]		Hazardous Area Classification		
		Zone 1 <sup>(2)</sup>		Zone 2
1000 < V ≤ 11000	Type of Protection	Ex e <sup>(1)</sup> or Ex pxb	Ex e <sup>(1)</sup>	Ex pzc
	EPL	Gb	Gb	Gc
V > 11000	Type of Protection	Ex pxb	Ex pzc	
	EPL	Gb	Gc	

- Notes:**
- 1. In case of selection of Ex e protection and evaluation of potential stator winding discharge risk assessment - ignition risk factors, according to IEC 60079-14, greater than 6, the motors shall be provided with pre-start enclosure ventilation to guarantee enclosure free from explosive gas at the time of starting.
  - 2. The installation of medium-voltage motors in hazardous areas Zone 1 shall be avoided.

- 4.4.5. Motors fed from VSD or soft-starters and installed in hazardous areas shall be certified as a unit association (motor-VSD-protective device, or motor-soft-starter-protective device), as required by IEC 60079-14. Alternatives foreseen in IEC 60079-14 for this certification (as a unit association) are acceptable.
- 4.4.6. Motors fed from VSDs or soft-starters shall have kind of protection Ex and the EPL selected following the criteria defined in Table 3.

Table 3 - Selection of Ex Protection and EPL for Motors fed from VSDs or Soft-starters

Rated Voltage [V]		Hazardous Area Classification	
		Zone 1 <sup>(1)</sup>	Zone 2
1000 < V ≤ 11000	Type of Protection	Ex pxb	Ex pzc
	EPL	Gb	Gc
V > 11000	Type of Protection	Ex pxb	Ex pzc
	EPL	Gb	Gc

**Notes:** 1. The installation of medium voltage motors in hazardous areas Zone 1 shall be avoided.

#### 4.5 ADDITIONAL REQUIREMENTS FOR MOTORS FED FROM VSD (VARIABLE SPEED DRIVES)

- 4.5.1. These motors shall comply with the recommendations of IEC 60034-25.
- 4.5.2. These motors shall have means to avoid or to measure the circulation of current between the shaft and the bearings sending alarm and trip signals to avoid bearing damage (see IEC TS 60034-23 as reference).
- 4.5.3. The rated power of these motors shall be defined taking into account the additional losses due to harmonic contents and the ventilation performance for the entire frequency variation range.
- 4.5.4. The rated torque of these motors shall be defined taking into account the temperature rise due to additional losses and the ratio of the VSD output voltage at motor rated frequency and the motor rated voltage.
- 4.5.5. The maximum and the minimum foreseen operational speed (or frequency) shall be informed in motor Data Sheet. Motor manufacturer shall inform the maximum and the minimum permissible speed (or frequency) and the field weakening frequency ( $f_0$ ) in motor Data Sheet.
- 4.5.6. For VSDs without dV/dt output filter, the insulation of motors shall withstand line-to-line voltage peak of 2.5 times the motor rated voltage, with rise time of 0.1µs. The insulation system of these motor shall be qualified according to IEC 60034-18-42 (with partial discharge), complying with impulse voltage insulation class C/B, as defined in IEC TS 60034-25. Manufacturer shall ensure insulation suitability, considering cable length and VSD pulses rise-time and amplitude, upgrading the insulation class if necessary. Use of VSDs without dV/dt output filter shall be submitted to PETROBRAS approval.

## 4.6 PROTECTION

### 4.6.1 GENERAL PROTECTION

Manufacturers shall inform in Motor Data Sheet the adjustment settings for the protection functions listed in Table 4. Unless otherwise stated, the relays responsible for the protection functions shall be included in scope of supply of the Manufacturer of the panel which feeds the motor.

Table 4 – Adjustment Settings to be Informed

#### Protection Function - Adjustment Settings to be Informed

Nº	Description	Responsible for Information
27	Undervoltage	Motor Manufacturer
37	Undercurrent or Underpower <sup>(1)</sup>	Pump Manufacturer
38	Bearing High Temperature	Motor Manufacturer
39	High Vibration <sup>(2)</sup>	Motor Manufacturer/ Driven Machine Manufacturer
46	Current Unbalance	Motor Manufacturer
48	Incomplete Sequence or Locked Rotor <sup>(3)</sup>	Motor Manufacturer
49	Thermal Image (by Current Sensors)	Motor Manufacturer
49	High Temperature (by Temperature Sensors)	Motor Manufacturer/ Pump Manufacturer
63A	Compressed Air Underpressure <sup>(4)</sup>	Motor Manufacturer
63Q	Lube Oil Underpressure <sup>(5)</sup>	Motor Manufacturer
66	Starts/Hour & Time Between Starts	Motor Manufacturer
87	Differential Current <sup>(6)</sup>	Motor Manufacturer

- Notes:**
1. Only for pump loads. The 37 function setting shall be based on the electric current driven at minimal permitted flow and on the maximum time at shut-off when starting. This function shall have a time delay during start condition;
  2. This protection function is required for motors driving gas compressors and when required by driven machine or other PETROBRAS documentation;
  3. Trip time for motors with protection Ex e (increased safety) shall be shorter than  $t_E$  according to IEC 60079-7 for Group IIA, Class T3 (200°C);
  4. Only for motors with pressurised enclosure Ex p. Two underpressure detectors, supplied by Motor Manufacturer;
  5. Only for motors with lubed oil bearings;
  6. Only for 11kV motors and above. CTs for self-balanced differential protection shall be supplied installed in the Power Terminal Box.

### 4.6.2 SURGE PROTECTION

Unless otherwise specified in Project Documentation, the following requirements shall be applied:

- Motor windings shall comply with the insulation levels defined by IEC 60034-15;
- Surge arresters and surge capacitors shall be used to protect motors with rated voltage 3.3kV and above, against switching surges;
- Surge arresters shall be selected to limit the magnitude of the surge voltage to the lesser between the motor insulation surge withstand and the basic impulse level (BIL) of the system;

- Surge arresters and surge capacitors shall be installed inside the Power Terminal Box of the motor;
- Surge arresters and surge capacitors design operational temperature shall be at least 10°C above the internal temperature of the Power Terminal Box, when the motor is at rated load and steady state condition;
- Motors with Ex certification shall be certified with surge arrester and surge capacitors installed inside Power Terminal Box and the certification shall cite the surge components inside the Power Terminal Box;
- Motor manufacturer shall inform the temperature inside the Power Terminal Box in steady state and full load condition;
- Alternative locations for surge arresters and surge capacitors shall be submitted to PETROBRAS approval;
- Motors fed from soft-starters and from VSD shall not have surge capacitors and surge arresters;
- The surge arresters rated voltage shall be selected according to the Unit grounding system.

## 5 TECHNICAL DOCUMENTATION AND INFORMATION

### 5.1 DOCUMENTS TO PROPOSAL

The following documents and information shall be annexed to the proposal for the motor and all related equipment and accessories:

- a) Preliminary dimensional drawings, including weights;
- b) Technical catalogue;
- c) Preliminary dimensional drawing and technical information for air-water and air-air coolers, when applicable;
- d) Information about air-water coolers, including water flow data (minimum, maximum, operational), water speed (minimum, maximum, operational).
- e) Preliminary dimensional drawing and technical information for bearings, when applicable;
- f) Preliminary dimensional drawing and technical information for pressurisation system, when applicable;
- g) Data-sheet issued by PETROBRAS completely filled in with Manufacturer data;
- h) Data-sheet following template of ELECTRICAL EQUIPMENT DATA SHEET MODELS completely filled in, when not issued by PETROBRAS;
- i) Starting time calculation report including calculation of the relation  $t_a/t_r$ . Current-speed curves, torque-speed curves for motor and driven machine and power factor-speed curve, printed on the same graphic. At least two reports shall be presented, one for rated voltage and other for 85% of rated voltage;

- j) Report of potential stator winding discharge risk assessment - ignition risk factors, for Ex e motors, according to IEC 60079-14;
- k) Temperature rise test report for motors installed in hazardous area and for motors fed from VSD or when required in data-sheet;
- l) Permissible torque-frequency curve for motors fed from VSD;
- m) Voltage-frequency curve for motors fed from VSD;
- n) Electrical and mechanical parameter list in p.u. for motors above 600V, including:
  - locked-rotor, pull-up and breakdown torques;
  - rotor inertia moment;
  - rotor time constants;
  - power factor at locked-rotor and at rated conditions;
  - motor electrical model with reactances, resistances, slip dependence, current dependence.
- o) Painting method;
- p) Air quality requirements and air treatment devices data;
- q) Applicable Standards, Codes and Rules;
- r) Tests List;
- s) Spare parts list, including code numbers and unit price;
- t) Mean Time to Repair (MTTR).

**Note:** All warning and safety instructions shall be issued in Portuguese language, or in English and Portuguese languages.

## 5.2 DOCUMENTS FOR APPROVAL

The following documents and information shall be submitted for PETROBRAS approval, after Packager definition, for the motor and all related equipment and accessories:

- a) Dimensional drawings with all views, cross-sections, connections, terminals location, instruments and accessories location, forces, tolerances, weights, fixation holes, disassembling required space;
- b) Wiring diagram(s) for motor, instruments, panels, sensors, lubrication and pressurisation equipment, when applicable;
- c) Saturation curves for current transformers (if any);
- d) Details of Power and Auxiliary Terminal Boxes;
- e) Data Sheet issued by PETROBRAS completely filled in with Manufacturer data;
- f) Data Sheet following template of ELECTRICAL EQUIPMENT DATA SHEET MODELS completely filled in, when not issued by PETROBRAS;
- g) List of spare parts necessary for two years operating period, with code number and unit prices;
- h) List of standards applicable to design, manufacturing and testing;

- i) Drawing(s), specifications and Data Sheet of heat exchanger unit in the case of motors with "air-water" cooling;
- j) Drawing(s), specifications and data-sheet for bearings, when applicable;
- k) Drawing(s), specifications and data-sheet for pressurisation system, when applicable;
- l) Drawing of identification plate;
- m) Speed-torque and speed-current curves at 100% and 85% rated voltage;
- n) For motors 750kW and above, and all centrifugal compressor drivers:
  - Time-current curves showing the allowable starting condition and continuous operation at rated voltage and rated ambient temperature (or rated cooling water temperature for water cooled motors).
  - Temperature-time (or current-time) curves, at rated ambient temperature (or rated cooling water temperature for water cooled motors), showing the required stator and rotor limits and the cool-down time after:
    - Three consecutive starts, with the first start at ambient temperature (cold start) with the sequence: first start; accelerating until rated speed; stop command coasting to rest; second start; accelerating until rated speed; stop command coasting to rest; third start; accelerating until rated speed; keep operating with full load;
    - Two consecutive starts with the first start at running temperature (hot start), with the sequence: first start; accelerating until rated speed; stop command coasting to rest; second start; accelerating until rated speed; keep operating with full load.
- o) Protection study including the compatibility of protection devices with permissible thermal times at ambient (cold start) and running (hot start) temperatures, in case of Packager propose different values of the specified ratio in item 4.1.2.2.
- p) In case of Packager propose air-water heat exchanger, study with advantages and disadvantages of the system, with considerations of dimensions, weight, maintenance, price, etc.
- q) Detailed information about air-water coolers, including calculation report and water flow data (minimum, maximum, operational), water speed (minimum, maximum, operational).
- r) Heating and cooling time constants (stator and rotor).
- s) Report of potential stator winding discharge risk assessment - ignition risk factors, for Ex e motors, according to IEC 60079-14;
- t) Air quality requirements and air treatment devices data;
- u) Conformity certificates with valid dates (for type tests) for motors certified for installation in hazardous areas, according to INMETRO Portaria 179, May 18th 2010 and Portaria 89, Feb 23rd 2012.
- v) Identification plates;
- w) 3D model files.

**Note:** All warning and safety instructions shall be issued in Portuguese language, or in English and Portuguese languages.

### 5.3 DOCUMENTS AFTER APPROVAL

Assembly, Installation, Operation and Maintenance manuals shall be furnished, after documentation approval, containing at least the following information:

- a) Technical specifications for the motor, all components and accessories, in accordance with the approved requirements (as built);
- b) Details regarding any spare units;
- c) Installation procedures;
- d) Storage and preservation treatment procedures;
- e) Operating procedures;
- f) Procedures for preventive and corrective maintenance of motor and all accessories, including list of necessary tools;
- g) Technical reports of all tests;
- h) Starting, operational and stopping procedures, including permissible number of starts per time, procedures before starting and procedures after normal and abnormal stopping;
- i) Lubrication plan with recommended lubricating oil or grease.
- j) Lifting procedures;
- k) Bearings and seals disassembly and assembly procedures;
- l) Rotor disassembly and assembly detailed procedures, with drawings and weights of each part, lifting drawings, support drawings to receive each disassembled part, drawings of activity sequences, lifting heights, etc.
- m) Conformity certificates with valid dates (for routine and special tests) for motors installed in hazardous areas according to INMETRO Portaria 179, May 18<sup>th</sup> 2010 and Portaria 89, Feb 23<sup>rd</sup> 2012;
- n) As built and certified version for all documents cited in items 5.1 and 5.2.

**Note:** All warning and safety instructions shall be issued in Portuguese language, or in English and Portuguese languages.

## 6 INSPECTION AND TESTS

### 6.1 GENERAL

- 6.1.1. Motors shall be tested in accordance with the recommendations of IEC 60034, IEC 60079 and IEC 61892 standards.
- 6.1.2. The tests listed below and the tests listed in motor Data-sheet are the minimum list of tests. In case of conflict, Data-sheet list of tests shall prevail.
- 6.1.3. Tests required by Classification Society shall be carried out.

- 6.1.4. Type tests (T) shall be carried out on a prototype motor or on the first of a batch of identical motors;
- 6.1.5. Routine tests (R) shall be carried out on each motor;
- 6.1.6. Special tests (S), when required, shall be carried out on each motor;
- 6.1.7. Certificate reports, approved and witnessed by Classification Societies shall be accepted by PETROBRAS for type tests;
- 6.1.8. All tests shall be documented, giving information about the maker, type, serial number, insulation class, all technical data necessary for the application of the motor and the results of the tests;
- 6.1.9. All tests shall be recorded with a multichannel oscillograph and a test report shall be issued for analysis and approval.
- 6.1.10. All tests shall be carried out at 60Hz.

## 6.2 TESTS LIST

At least the following tests shall be carried out:

Table 5 - Minimum Tests List

Test	T	R	S	Method and Acceptance Criteria
Verification of technical documentation <sup>(1)</sup>	x	x	x	
Verification of accuracy certificates of instrumentation of tests <sup>(1)</sup>	x	x	x	
Verification of data on name plate and visual inspection. <sup>(1)</sup>	x	x	x	IEC 60034-1 and this ET
Verification of painting (colour, thickness and adhesion)		x		I-ET-3010.00-1200-956-P4X-001 - QUALIFICATION TESTS FOR PAINT SYSTEMS
Verification of degree of enclosure protection (IP)	x			IEC 60034-5
Verification of magnetic center for motors with sleeve bearings			x	API 541
Verification of terminal boxes internal space and components (CTs, grounding and phase terminals, isolators, capacitors, surge arresters, etc.)	x			This ET
Verification of Certification Reports for Ex motors		x		Applicable IEC and Inmetro Portaria 179/2010 and Portaria 89/2012
Verification of Certification Reports of group motor/VSD or motor/softstarter for motor installed in hazardous area		x		IEC 60079-14
Verification of process of insulation	x			This ET
Measurement of insulation resistance and polarization index			x (2)	IEEE Std 43
Measurement of loss tangent ( $\tan \delta$ and $\Delta \tan \delta$ ) of insulation		x (2)		IEC 60034-27-3
Measurement of winding's resistances (cold condition)		x		IEC 60034-1
Measurement of air gap for rated power $\geq 375\text{kW}$			x	API 541
Measurement of partial discharge for rated voltage $\geq 6\text{kV}$ and rated power $\geq 5\text{MVA}$		x		IEC 60034-27-1
Measurement of no-load current and losses at rated voltage and frequency		x		IEC 60034-1 and Motor Data-Sheet
Measurement of efficiency		x		IEC 60034-2-1



	<b>TECHNICAL SPECIFICATION</b>	Nº. I-ET-3010.00-5140-712-P4X-002	REV. 0	
	AREA:	SHEET: 25 of 28		
	TITLE:	MEDIUM-VOLTAGE INDUCTION MOTORS FOR OFFSHORE UNITS		
			NP-1	
			ESUP	
Test	T	R	S	Method and Acceptance Criteria
Measurement of power factor at rated voltage and frequency for 100%, 75% and 50% of rated load.	x			Motor Data Sheet
Measurement of noise	x			IEC 60034-9 and NOISE CONTROL REQUIREMENTS SPECIFICATION
Measurement of locked-rotor current and torque at rated voltage and frequency			x (2)	This ET and Motor Data-Sheet
Measurement of pull-up and breakdown torques and their relative slips	x	x (2)		IEC 60034-12 and Motor Data-Sheet
Measurement of shaft voltage		x		IEC 60034-25
Vibration and balance test, including lubrication system for motors with shaft heights 56mm or higher			x	IEC 60034-14 <sup>(3)</sup>
Sealed winding conformance test (spray test) for rated voltage $\geq$ 6kV			x	NEMA MG1
Withstand voltage test (test of insulation to ground) <sup>(4)</sup>		x		IEC 60034-1
Turn insulation test (test of insulation between turns of coils)		x		IEEE 522
Steep front impulse test of coil interturn insulation <sup>(5)</sup>		x		IEC 60034-15
Open circuit secondary induced voltage test for wound rotors		x		IEC 60034-1
Bearing insulation test, when applicable			x	Bearing Manufacturer
Direction of rotation test		x		IEC 60034-1
Overspeed test	x			IEC 60034-1
Temperature rise test at full load	x			IEC 60034-1 and IEC 60085
Temperature rise test for sleeve bearings		x		IEC 60034-1 and limits by Bearing Manufacturer
Hydrostatic test of air-water heat exchanger for water cooled motors		x		ASME BPVC-VIII-1
Occasional excess current test for motors up to 315kW	x			IEC 60034-1
Momentary excess torque test	x			IEC 60034-1
Temperature rise test at full load for Ex motors	x			IEC 60079-0
Maximum overpressure test for Ex p motors	x			IEC 60079-2
Leakage test for Ex p motors		x		IEC 60079-2
Purging test for Ex p motors	x			IEC 60079-2
Minimum overpressure test for Ex p motors	x			IEC 60079-2
Test of ability to limit internal pressure for Ex p motors	x			IEC 60079-2
Determination of starting current ratio $I_A/I_N$ and time $t_E$ for Ex e motors	x			IEC 60079-7
Impulse ignition test for Level of Protection "eb" stator insulation systems, for Ex e motors	x			IEC 60079-7
Steady state ignition test for Levels of Protection "eb" and "ec" stator insulation systems, for Ex e motors	x			IEC 60079-7
Cage rotor test for Ex e motors	x			IEC 60079-7
Black out test (only after winding repair due to voltage withstand or insulation test failure)			x	IEEE STD 1434
<b>Notes:</b> 1. For all witnessed tests; 2. For motors with power equal to and above 200kW. 3. Method and acceptance criteria shall be changed from IEC 60034-14 to API 541 when so requested in the motor Project Documentation;				

4. When temperature rise test is carried out the withstand voltage test shall be carried out immediately after that.  
The withstand voltage test at full voltage on acceptance shall not be repeated in any winding. Additional tests, when necessary, shall follow the requirements of IEC 60034-1.  
Repairs on endwindings, in case of up to two failures during tests are acceptable. In case of more than two failures on endwindings or failure in the part of the coil to be inserted into slots, the coil shall be rejected and replaced by a new one;
5. Alternative tests may be proposed to verify withstand level, according to the insulation technology used. These alternative tests shall be submitted to PETROBRAS approval.


### 6.3 STRING TESTS

- 6.3.1. String tests shall be performed for all machines driven by motors with power equal to or bigger than 1200kW and for machines with smaller power when required in motor or in driven machine Documentation.
- 6.3.2. If the String Tests are not contracted, the related tests shall be carried out during factory tests as Special Tests.
- 6.3.3. The places where the String Tests shall be performed are defined in Motor Data-Sheet.
- 6.3.4. The following tests (and others required in data-sheets) shall be carried out:

Table 6 - String Tests

Test	Method and Acceptance Criteria
Verification of technical documentation <sup>(1)</sup>	
Verification of accuracy certificates of instrumentation of tests <sup>(1)</sup>	
Measurement of noise	IEC 60034-9 and NOISE CONTROL REQUIREMENTS SPECIFICATION
Measurement of power factor at rated voltage and frequency for 100%, 75% and 50% of rated load.	Motor Data Sheet
Measurement of shaft voltage	IEC 60034-25
Measurements at full load and rated voltage and frequency	Motor Data-Sheet
Vibration and balance tests of package, including operation of lubrication system	Zone B of ISO 20816-1 <sup>(2)</sup>
Temperature rise test at full load	IEC 60034-1 and IEC 60085
Bearing temperature rise test	IEC 60034-1 and Limits by Bearing Manufacturer
Temperature rise test at full load for Ex motors	IEC 60079-0
4 hours continuous operation at full load <sup>(3)</sup>	IEC 60034-1 and limits by IEC 60085

- Notes:**
1. For all witnessed tests;
  2. If driven machine manufacturer requires a different limit for vibration, the lower limit shall prevail;
  3. The longer between this time and time required in driven machine Documentation shall prevail.

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## 7 ANNEX I – ABBREVIATIONS AND ACRONYMS

AFM	Material Supply Permission
BIL	Basic Impulse Level
CT	Current Transformer
DOL	Direct On-Line
EFI	Earth Fault Indicator
ET	Technical Specification
FPSO	Floating, Production, Storage and Offloading Unit
FSO	Floating, Storage and Offloading Unit
IEC	International Electrotechnical Commission
IEEE	Institute of Electrotechnical and Electronic Engineers
$I_r$	Locked rotor current
INMETRO	Instituto Nacional de Metrologia Normalização e Qualidade Industrial
$I_r$	Rated current
NEMA	National Electrical Manufacturers Association
PCM	Material Purchase Order
PD	Partial Discharge
RM	Material Requisition
RMS	Root Mean Square
R	Routine Test
RTD	Resistance Temperature Detectors
SPDT	Single Pole Double Through
S	Special Test
$t_a$	Acceleration time
$T_b$	Breakdown torque
$t_E$	Time, in seconds, taken for an A.C. motor or stator winding, when carrying the initial starting current $I_A$ , to be heated up to the limiting temperature from the temperature reached in rated service at the maximum ambient temperature (based on IEC 60079-7)
TEFC	Totally Enclosed Fan Cooled
$T_l$	Locked rotor torque
$t_{lr}$	Permissible locked rotor time
$T_N$	Rated torque at rated speed and rated output power
T	Type Test
$T_u$	Pull-up torque
VSD	Variable Speed Drive

## 8 ANNEX III - ADDITIONAL REQUIREMENTS FOR COMPLIANCE WITH GIOP

### 8.1 GENERAL

- 9.1.1. The following requirements shall be included in order to compliance with GIOP (Integrated Management of Operations - “*Gerenciamento Integrado de Operações*”).

## 8.2 BEARING TEMPERATURE DETECTORS

9.2.1. Motors shall have platinum resistance RTDs, three wire 100 $\Omega$  at 0°C installed on the bearings (for any kind of bearing) when driving the following loads:

- Main injection water pumps;
- Booster injection water pumps;
- Cooling water circulation pumps - classified area;
- Sea water lift pumps;
- Main gas compressors;
- Exportation gas compressors;
- Injection gas compressors;
- Vapour recovery compressors.

9.2.2. The quantity and the position of temperature detectors shall comply with item 4.3.5.1.

## 8.3 BEARING VIBRATION SENSORS

9.3.1. Motors shall have vibration sensors installed in both bearings when driving the following loads:

- Main injection water pumps;
- Booster injection water pumps;
- Sea water lift pumps (only for not-submersible type);
- Cooling water circulation pumps - classified area;
- Main gas compressors;
- Exportation gas compressors;
- Injection gas compressors;
- Vapour recovery compressors.

9.3.2. The type of sensors shall comply with the type of bearing. Sleeve bearings shall have vertical and horizontal displacement vibration sensors ( $\mu\text{m}$ ) and roller and ball bearings shall have velocity vibration sensors (mm/s).

## 8.4 BEARING PRESSURE SENSORS

9.4.1. Motors with sleeve bearings shall have lubrication oil pressure transducers installed in both bearings when driving Main Injection Water Pumps.

9.4.2. When the pump package monitors the lubrication oil system and this signal is available for remote monitoring, the requirement above is not mandatory.