	<b>TECHNICAL SPECIFICATION</b>		Nº: I-ET-3010.00-5140-712-P4X-001
	CLIENT:		SHEET: 1 of 21
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DP&T-SUP	TITLE: <b>LOW-VOLTAGE INDUCTION MOTORS FOR OFFSHORE UNITS</b>		NP-1 ESUP

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**LOW-VOLTAGE INDUCTION MOTORS FOR  
OFFSHORE UNITS**

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ESUP

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PRELIMINARY

## 1 OBJECTIVE

This specification establishes the necessary technical requirements for design, manufacture and supply of low-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 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, 2-1, 5, 6, 7, 8, 9, 11, 12, 14, 18 and 25, 27;
- IEC 60072 Dimensions and Output Series for Rotating Electrical Machines;
- IEC 60079 Explosive Atmospheres - Parts 0, 1, 7 and 14;
- IEC 60085 Electrical Insulation - Thermal Evaluation and Designation
- IEC 61892 Mobile and Fixed Offshore Units - Electrical Installations - Parts 1 and 3;

#### 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.

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

- MG1 Motors and Generators

#### 2.2.4 NFPA - NATIONAL FIRE PROTECTION ASSOCIATION (only where specified)

- NFPA-20 Standard for the Installation of Stationary Pumps for Fire Protection

#### 2.2.5 ASTM - AMERICAN SOCIETY FOR TESTING AND MATERIALS

- 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

2.2.6 ISO - INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ONLY WHERE SPECIFIED)

ISO 20816-1 Mechanical Vibration – Measurement and Evaluation of Machine Vibration - Part 1: General Guidelines

2.2.7 PRESIDÊNCIA DA REPÚBLICA DO BRASIL - CASA CIVIL

Decreto nº 4.508 de 11/12/02 - Dispõe sobre a Regulamentação Específica que Define os Níveis Mínimos de Eficiência Energética de Motores Elétricos Trifásicos de Indução Rotor Gaiola de Esquilo, de Fabricação Nacional ou Importados, para Comercialização ou Uso no Brasil e dá outras Providências

2.2.8 PRESIDÊNCIA DA REPÚBLICA - MINISTÉRIOS DE MINAS E ENERGIA, CIÊNCIA E TECNOLOGIA, DO DESENVOLVIMENTO, INDÚSTRIA E COMÉRCIO EXTERIOR

Portaria nº 553 05/12/05

2.2.9 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

Portaria 488 Dez 8<sup>th</sup> 2010

2.2.10 ANSI - AMERICAN NATIONAL STANDARDS INSTITUTE

ASME B 1.20.1 Pipe Threads, General Purposes (Inch)

2.2.11 IMO - INTERNATIONAL MARITIME ORGANIZATION

IMO IA811E Code for the Construction and Equipment of Mobile Offshore Drilling Units (MODU CODE)

2.2.12 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] 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 following oversizing factors applied to driven machine rated brake power:
- 25% for motors with rated power lower than 22kW;
  - 15% for motors with rated power between 22kW and 55kW;
  - 10% for motors with rated power higher than 55kW.
- 3.2.2. Oversizing factors lower than stipulated above shall be submitted to PETROBRAS for approval.

### 4 CONSTRUCTIVE CHARACTERISTICS

#### 4.1 ELECTRICAL CHARACTERISTICS

##### 4.1.1 RATED VOLTAGE

Unless otherwise stated in Project Documentation, the induction motors following this Technical Specification shall have rated voltage 440V 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 specified in Project Documentation, motors shall have torque characteristics as stated in IEC 60034-12 for Design N.
- 4.1.2.3. For motors with rated power 55kW and above with service type S1, the accelerating time ( $t_a$ ) at rated voltage, when DOL (direct on-line) started, shall not exceed:
- 25% of the permissible locked rotor time ( $t_{lr}$ ) at running temperature (hot start) and;
  - 25% of time  $t_E$ , 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 VSDs and soft-starters. If bypass of VSD or soft-starter with contactor is foreseen, the requirements are applicable.
  - Accelerating time ( $t_a$ ) longer 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) in succession, coasting to rest between starts.

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

4.1.2.7. For motors with rated power 55kW and above, 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 motor Project Documentation, this requirement is not applicable to motors fed from VSDs 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 the 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. Motors for loads with intermittent service shall be rated for the adequate duty type, as defined in IEC 60034-1.

#### 4.1.4 EFFICIENCY

The minimum acceptable efficiency for standard and high-efficiency induction motors shall be as defined in Brazilian Decreto nº 4.508, 11/12/02 and Portaria nº 553, 08/12/2005, as shown in Table 1. These values are the minimum for standard motors and shall be confirmed by low uncertainty methods in accordance with IEC 60034-2-1, when necessary.

Table 1 - Induction Motors Minimum Efficiency

Rated Power [kW]	Induction Motors Minimum Efficiency [%]			
	Number of Poles			
	2	4	6	8
0.75	80.0	80.5	80.0	70.0
1.1	82.5	81.5	77.0	77.0
1.5	83.5	84.0	83.0	82.5
2.2	85.0	85.0	83.0	84.0
3.0	85.0	85.0	83.0	84.0
3.7	87.5	87.5	87.5	85.5
4.5	88.0	88.5	87.5	85.5
5.5	88.5	89.5	88.0	85.5
7.5	89.5	89.5	88.5	88.5
9.2	89.5	90.0	88.5	88.5
11	90.2	91.0	90.2	88.5
15	90.2	91.0	90.2	89.5
18.5	91.0	92.4	91.7	89.5
22	91.0	92.4	91.7	91.0
30	91.7	93.0	93.0	91.0
37	92.4	93.0	93.0	91.7
45	93.0	93.6	93.6	91.7
55	93.0	94.1	93.6	93.0
75	93.6	94.5	94.1	93.0
90	94.5	94.5	94.1	93.6
110	94.5	95.0	95.0	93.6
132	94.7	95.0	95.0	-
150	95.0	95.0	95.0	-
185	95.4	95.0	-	-



## 4.2 MECHANICAL CHARACTERISTICS

### 4.2.1 ENCLOSURE

- 4.2.1.1. Motors installed in galley, laundry and accommodation rooms (dry areas) shall have minimum protection degree IP-44. Motors installed on 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 nameplates 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. It shall be acceptable manufacturer colour standard for motors with rated power up to 1.5kW included in Packages (except for fire fighting equipment, that shall follow next bullet);
  - 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 methods doubly impregnated by vacuum (VPI), doubly impregnated by immersion or singly impregnated by resin dripping.
- 4.2.2.2. The motors' insulation system shall be of 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 and IEC 60034-18.

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**4.2.3 COOLING SYSTEM**

Motors shall be TEFC (Totally Enclosed Fan Cooled – according to NEMA MG1) cooling type, independent of area classification and they shall comply with the cooling method IC411 defined in IEC 60034-6.

**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**

Motors shall comply with the requirements of IEC 60034-14.

**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 with rated power up to 150kW shall have ball or roller bearings. Motors with rated power over 150kW may 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. Motors with frame number 160 and above, as defined by IEC 60072-1, shall have bearings fitted with a greasing fitting and automatic bleeder device.

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.

**4.2.9 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 system.

4.2.9.3. Motors with sleeve bearings shall have 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 oil lubrication shall have means to avoid liquid or gaseous oil to penetrate the motor windings.

#### 4.2.10 TERMINAL BOXES

- 4.2.10.1. Unless otherwise indicated on the project documents, for motors with horizontal shaft, the Terminal Box 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 Terminal Box at 9 o'clock (designation L according to IEC 60034-7).
- 4.2.10.2. Unless otherwise stated in project documents, the cable entry shall be from bottom side. It shall be possible to install the Terminal Box 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.
- 4.2.10.3. If single-core cables are used, the removable plate and the cable glands shall be of non-magnetic material to avoid magnetic induction.
- 4.2.10.4. The internal available volume shall be enough to safe installation and connection of power and control (or signal) cables and terminals.
- 4.2.10.5. There shall be separate holes for power and control (or sensor) cables.

#### 4.2.11 GROUNDING CONNECTORS

- 4.2.11.1. Motor frames shall have one grounding connector fitted on their base, outside the Terminal Box, at the same side of the Terminal Box and indelible marked with the grounding symbol.
- 4.2.11.2. Motors fed from VSD shall have one additional grounding connector inside the Terminal Box, indelibly marked with grounding symbol.
- 4.2.11.3. 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>.
- 4.2.11.4. Motors fed from power cables above 120mm<sup>2</sup> shall have grounding connectors proper for 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 three or six power terminals, marked according to IEC 60034-8. Motors shall have an information plate in stainless steel AISI 316 showing the connection possibilities and the corresponding voltages.
- 4.2.12.2. For grounding terminals see item 4.2.11.
- 4.2.12.3. All motor cables (power and control) shall be indelibly marked inside the terminal boxes.
- 4.2.12.4. Soldered terminals shall not be used. Terminals insulating supports shall be of non-hygroscopic and non-combustible materials.
- 4.2.12.5. Control terminal blocks shall be of the indirect pressure screw type.

### 4.3 ACCESSORIES

#### 4.3.1 LIFTING EYELETS

All motors with weight above 40kgf shall be fitted with lifting eyelets.

#### 4.3.2 HEATING RESISTORS

4.3.2.1. The following motors shall have internal heating resistors:

- all motors with rated power equal to or bigger than 22kW;
- all motors installed in humid areas (e.g. pontoon pump room, main deck, and spider-deck);
- all motors installed outdoors;
- all essential motors (fed from essential switchgear or MCC).

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

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

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 Terminal Box with the label:

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

#### 4.3.3 WINDING TEMPERATURE DETECTORS

4.3.3.1. All motors with rated power above 150kW shall be fitted with six (two per phase) platinum resistance temperature detectors (RTDs), three-wire, 100Ω at 0°C.

4.3.3.2. All motors fed from VSDs shall be fitted with six (two per phase) PTC thermistors connected in series at the terminal box. For motors fed from VSDs with rated power above 150kW, the PTC thermistors shall be additional to the RTDs required on 4.3.3.1.

4.3.3.3. Winding temperature detectors shall comply with requirements of IEC 60034-11.

#### 4.3.4 BEARING TEMPERATURE DETECTORS

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

4.3.4.2. When temperature switches are required, they shall have single pole double through (SPDT) contacts, operating in order that, when one contact opens, the other closes simultaneously.

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

4.3.4.4. 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 shall be installed in the Package skid and shall be proper to external auxiliary voltage 220Vcc ungrounded. Package Panel shall comply with item 4.4.2. Trip and alarm signals shall be dry contacts, available for remote actuation.

4.3.4.5. See also item 8.2 for GIOp requirements.

#### 4.3.5 CABLE GLANDS

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

4.3.5.2. 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.

#### 4.3.6 IDENTIFICATION PLATES

4.3.6.1 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.

- 4.3.6.2 Motors with rated power from 0.75kW up to 185kW shall have an additional information plate, complying with requirements of INMETRO Portaria 488 2010 (ENCE – “*Etiqueta Nacional de Conservação de Energia*”). ENCE included in the main identification plate is acceptable.

#### 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. Motors and 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 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

Hazardous Area Classification	Zone 1	Zone 2
Type of Protection	Ex e or Ex d	Ex de
EPL	Gb	

- Notes:**
1. Type of protection Ex d shall be avoided for motors above 250kW;
  2. Unless otherwise stated, for Zone 1 Group IIC, protection Ex e shall be selected.

- 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.

#### 4.5 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 be fitted with winding temperature detectors according to item 4.3.3.
- 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 the peak voltages defined by Curve A of Figure 40 of IEC TS 60034-25. 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.

4.5.7. Means shall be provided to avoid the circulation of currents between the shaft and the bearings (see IEC TS 60034-25 as reference).

#### 4.6 PROTECTION

Manufacturers shall inform the adjustment settings for the protection functions listed in Table 3. 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 3 - 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
46	Current Unbalance	Motor Manufacturer
48	Incomplete Sequence / Locked Rotor <sup>(2)</sup>	Motor Manufacturer
49	Thermal Image (by Current Sensors)	Motor Manufacturer
49	High Temperature (by Temperature Sensors)	Motor Manufacturer
66	Starts/Hour & Time Between Starts	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. 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).

## 5 TECHNICAL DOCUMENTATION AND INFORMATION

### 5.1 DOCUMENTS FOR 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 bearings, when applicable;
- d) Data-sheet issued by PETROBRAS completely filled in with Manufacturer data;
- e) Data-sheet following template of ELECTRICAL EQUIPMENT DATA SHEET MODELS completely filled in, when not issued by PETROBRAS;
- f) Starting time calculation report including calculation of the relation  $t_a/t_{lr}$ , current-speed curves and torque-speed curves for motor and driven machine, printed on the same graphic, for motors 55kW and above. Two reports shall be presented, one for rated voltage and other for 85% of rated voltage;
- g) Temperature rise test report for motors installed in hazardous area and for motors fed from VSD or when required in Data Sheet;
- h) Permissible torque-frequency curve for motors fed from VSD;
- i) Voltage-frequency curve for motors fed from VSD;
- j) Painting method;
- k) Applicable Standards, Codes and Rules;
- l) Tests List;
- m) Spare parts list, including code numbers and unit price;
- n) 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 Supplier 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 and lubrication equipment, when applicable;
- c) Details of terminal boxes;
- d) Data-sheet issued by PETROBRAS completely filled in with Manufacturer data;
- e) Data-sheet following template of ELECTRICAL EQUIPMENT DATA SHEET MODELS completely filled in, when not issued by PETROBRAS;
- f) List of spare parts necessary for two years operation period, with code number and unit prices;
- g) List of standards applicable to design, manufacturing and testing;
- h) Drawing(s), specifications and Data Sheet for bearings, when applicable;
- i) Drawing of identification plate;
- j) Speed-torque and speed-current curves at 100% and 85% rated voltage for motors 55kW and above;
- k) Conformity certificates with valid dates (for type tests) for motors certified for installation in hazardous areas according to INMETRO Portaria 179, May 18<sup>th</sup> 2010 and Portaria 89, Feb 23<sup>rd</sup> 2012;
- l) Heating and cooling time constants (stator and rotor) for motors 55kW and above;



m) Identification plates;

n) 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) Operation 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 procedures;
- 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, IEC 61892 and Classification Society 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. Type tests (T) shall be carried out on a prototype motor or on the first of a batch of identical motors.
- 6.1.4. Routine tests (R) shall be carried out on each motor.


- 6.1.5. Special tests (S), when required, shall be carried out on each motor.
- 6.1.6. Certificate reports, approved and witnessed by Classification Societies shall be accepted by PETROBRAS for type tests.
- 6.1.7. 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.
- 6.1.8. All tests shall be recorded with a multichannel oscillograph and a test report shall be issued for analysis and approval.
- 6.1.9. All tests shall be carried out at 60Hz.

## 6.2 TESTS LIST

At least the following tests shall be carried out:

Table 4 - 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 terminal boxes internal space and components (grounding and phase terminals, 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 no-load current and losses at rated voltage and frequency		x		IEC 60034-1 and Motor Data Sheet
Measurement of efficiency by low uncertainty methods	x	X (2)		IEC 60034-2-1 and Portaria n° 553
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 for motors fed from VSD		x		IEC 60034-25

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Test	T	R	S	Method and Acceptance Criteria
Vibration and balance test, including lubrication system for motors with shaft heights 56mm or higher			x	IEC 60034-14
Withstand voltage test (test of insulation to ground) <sup>(3)</sup>	x			IEC 60034-1
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
Occasional excess current test for rated power 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
Determination of explosion pressure for Ex d motors	x			IEC 60079-1
Overpressure test for Ex d motors	x			IEC 60079-1
Test of non-transmission of internal ignition for Ex d motors	x			IEC 60079-1
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


- Notes:**
- For all witnessed tests.
  - For motors with power equal to and above 200kW.
  - 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.

### 6.3 STRING TESTS

- String tests shall be performed for all machines driven by motors when required in driven machine Project Documentation.
- The following tests (and others required in Project Documentation) shall be carried out:

Table 5 - 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 for motors fed from VSD	IEC 60034-25
Measurements at full load with rated voltage and frequency	Motor Data Sheet
Vibration and balance tests of package, including lubrication system	Zone B of ISO 10816-1 <sup>(2)</sup>
Temperature rise test of motor at full load	IEC 60034-1 and IEC 60085

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Test	Method and Acceptance Criteria
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
Performance test for motors driving fire-fighting pumps	NFPA 20

- Notes:**
1. For all witnessed tests.
  2. If driven machine manufacturer requires a different limit for vibration, the lower limit shall prevail.
  3. Unless otherwise defined, the duration of test shall be defined by driven machine Manufacturer.

## 7 ANNEX I – ABBREVIATIONS AND ACRONYMS

AFM	Material Supply Permission
DOL	Direct On-line
EPL	Equipment Protection Level
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
RM	Material Requisition
RMS	Root Mean Square
R	Routine Test
RTD	Resistance Temperature Detector
PTC	Positive Temperature Coefficient Thermistor
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 one platinum resistance RTDs, three wire 100Ω at 0°C installed on each bearing (for any kind of bearing) when driving the following loads:

- Sea water lift pumps.

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

### 8.3 BEARING VIBRATION SENSORS

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

- Sea water lift pumps (only for not-submersible type);

9.3.2. The type of sensors shall comply with the type of bearing. Sleeve bearings shall have vertical and horizontal displacement vibration sensors (µm) and roller and ball bearings shall have velocity vibration sensors (mm/s).