



**Design Specification:**

**ED-P-02.01-04**

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# HIGH VOLTAGE ELECTRIC INDUCTION MOTORS (IEC 60034)

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**SPECIFICATION REVIEWS**

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MOTORS (IEC 60034)**

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## 1. GENERAL

### 1.1. Introduction

This document is part of the latest edition of Repsol technical specifications, and refers also to the latest edition of the Standards and Codes that are mentioned and / or applicable in it. Particular aspects for each project indicated in the "Basic Design Data (B.D.D.)" document shall be transcribed to the individual Material Requisition.

The completely or partially application of this specification will be confirmed in the specific B.D.D. of each project.

At points where in this specification reference to specific paragraphs or parts of codes or standards is done, apply the latest edition of the code or standard unless otherwise stated by Repsol. The indication in this specification of the standard or code edition in force at the time it was written is aimed to clearly identify the criteria to be applied in case in later editions have been moved or deleted. Repsol shall be informed in writing in case of discrepancies between the publication mentioned in this specification and the latest edition of the Code or Standard.

### 1.2. Scope

This specification, together with the project documentation (motor project documents and project specifications), establishes the standards to be followed for the design, selection of materials, manufacture, documentation, inspections, functional testing, painting, packaging and transport of three-phase totally enclosed fan cooled squirrel-cage induction motors for voltages equal or down to 1000V.



Equipment under this specification shall be designed and manufactured as per following Codes or Standards:

- IEC 60034                      Rotating electrical machines.

Additionally, specifications listed in section "Standards and specifications of reference" shall be followed.

### 1.3. Priority order between documents


In case of conflict between documents, following order of priority shall prevail:

- Compulsory local laws and regulations (provided that in the rest of applicable documents are not more stringent criteria established)
- Project B.D.D.
- This specification
- Other referenced codes and standards.

Nevertheless, this discrepancy must be declared in writing to Repsol before continuing with the process of design / manufacturing.

### 1.4. Responsibility

Compliance with the rules and recommendations given in this Specification does not exempt partially or totally, the designers / supplier, their respective responsibilities and guarantees or any other contractual obligation.

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### 1.5. Measurement units

The measurement units to be used shall be the International System (SI), or the Anglo-saxon system of units, to be established at the beginning of the Project.

## 2. DEFINITIONS

For other terms and abbreviations included in this specification, the definitions to consider shall be the ones established in the reference IEC standard 60034.

## 3. SERVICE CONDITIONS

### 3.1. Environmental conditions

The motor shall be suitable for continuous operation to nominal power respecting the limits of temperature indicated in IEC standard 60034 located outdoors, without protection and in the following conditions:

- Altitude lower than 1000 m (3281 ft)
- Maximum temperature 40 °C (104°F)
- Minimum temperature -5 °C (23°F)
- Maximum relative humidity (daily average) 90%
- Minimum relative humidity (daily average) 50%
- Chemically aggressive atmosphere, salty, dusty and corrosive, common to industrial facilities.

More restrictive conditions will be detailed in the BDD document and/or in the particular documentation of the project (data sheets, particular requisition, etc.)

### 3.2. Power supply

Unless indicated otherwise in the project documents, the motors will be suitable for continuous running at rated output (at ambient temperature and at the voltage and frequency values defined in the project documents) with variations of voltage and frequency within the limits of "zone A" (defined in the standard IEC 60034-1), without exceeding the temperature rise defined for the insulation systems of thermal class B (80K).

Furthermore, the motors will be suitable for continuous running at rated output (at ambient temperature and at the voltage and frequency values defined in the project documents) with voltage and frequency variations exceeding the limits of "zone A", within zone B, but without exceeding the temperature rise permitted by the insulation system of thermal class B by more than 10K.

### 3.3. Starting conditions

Unless otherwise specified in the project documentation, motors shall comply with the following requirements:

- a) The motors shall be prepared on-line starting.

Based on the characteristics of the equipment being operated, the motor manufacturer shall specify any limitations and recommend the most appropriate motor for each specific case.



In those cases in which the motors are driven by a speed-regulator and in which an on-line starting is not required, a motor that doesn't fulfill exactly the on-line starting condition could be acquired, previous Repsol authorization.

- b) During starting or the re-acceleration process the supply voltage may drop to 80% of the rated value defined in the project documents. In these conditions, the torque of the motor shall not be less than 130% of the load torque (without tolerances), at any speed between 0 and that corresponds to the maximum power torque. The resistant torque to be considered shall be the resistant torque of habitual starting's conditions of the driven machine.

The manufacturer of the driven equipment shall provide the torque-speed curve.

Care shall be given to special equipment (agitators, centrifuges, extruders, etc.) which require control of starting conditions and time.



The manufacturer shall check that the motors can start with 80% of the rated voltage and with the load torque of the driven machine, in the starting time of the motor and with the starting conditions

Lack of values of the driven machine, the motors' manufacturer shall assume the results, unless it is indicated in the offer as pending.

- c) Voltage during starting shall be 80% of rated value. In the conditions specified the motors shall support the following starting sequences:
- o Three consecutive cold start attempts (with return to the condition of zero speed before the next start attempt). It shall be possible to perform an additional start after running for 20 minutes or after 45 minutes -stopped once the motor has reached normal operating temperature.
  - o Two consecutive start attempts after continuous running at rated power.
  - o Three start attempts at equal intervals during one hour, during continuous running at rated power.
  - o Motors of power greater than 1,000 kW, shall be capable of at least six (6) startings in one day without suffering damage, with 1000 startings per year as minimum.

The manufacturer shall specify the waiting time after finishing the above starting cycle before performing a new start.

During the above-mentioned starting sequences, the temperature of the stator coil shall not exceed more than 10% the insulation class limit; the rotor's squirrel-cage designed temperature must not be higher than 250 °C (482°F) or other more restrictive conditions required in the standards for Ex execution motors.

These starts shall be considered at full load of the driven machine.

## 4. TECHNICAL CHARACTERISTICS

Unless otherwise specified in the project documentation, the technical characteristics shall comply with the following requirements:

### 4.1. Starting torque


At least, the conditions described in the bullet point "Starting Conditions" shall always be fulfilled.

The starting torque for motors with power up to 500 kW will never be less than 80% of rated torque. The starting torque for motors with power over 500 kW will never be less than 60%.

### 4.2. Starting current

The locked rotor current values at rated voltage and frequency, shall be less than 660% of rated current for motors rated up to 1000 kW and less than 550% for motors of more than 1000 kW. These are maximum values of current, in these values are already included the tolerances.

Greater values require Repsol approval.

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#### 4.3. Noise level

The noise level, indicated as average pressure of sound at one meter from the surface of the motor and measured in dB(A) in accordance with the ISO 3744 recommendation, shall not exceed the limits specified in the technical specification ED-A-01.02 *Equipment noise control*. The maximum level admitted is 82dB.

If to fulfill this noise level, an acoustic protection is needed, it will be indicated in the data sheet and it will require the Repsol authorization.

If it is allowed, this acoustic protection will be removable, made of acoustic and fireproof insulation material and equipped with devices which rapid opening.

During the routine test if the required noise level is not fulfill, the manufacturer will propose to Repsol the changes to be made to the motor to fulfill it. These changes will have to be approved by Repsol, who will be able to request the repetition of the test that had been carried out before the measurement of the unfulfilled noise level.

#### 4.4. Vibrations

Motor vibration shall be measured at the points specified in the IEC 60034-14 standard. For this purpose flat areas of approximately 30x30mm (1.2"x1.2") shall be available on the casings next to the bearing supports to fix the accelerometer.

Vibration shall be measured by putting the motor on a rigid workbench and with a half-key (unless otherwise indicated in the motor Data Sheet).

The vibrations will be measured at no-load at rated voltage and frequency.

The vibration speed limits (at no-load and at full load) are defined in the standard IEC 60034-14, depending on the rated speed, demanding degree B to all motors. In exceptional cases it could be required vibration levels even lower, following the code API 541, if required in the project BDD.

If vibrations in the driven machine are to be measured continuously, the motor shall include proximity measurement probes ("non contact" type). Unless otherwise specified, each bearing shall have two probes placed at 90°. The type of probes shall be the same as the ones used on the equipment being driven.

The vibrations shall be measured as speed (mm/s).

#### 4.5. Direction of rotation



Motors that turn only in one direction are acceptable although in these cases it shall be possible to change the direction only by changing the external fan

The direction of rotation of the motor shall be defined viewed from the coupling side and shall be directly related to the phase sequence U, V, W.

The direction of rotation required in the Data Sheet, shall be marked on the motor casing with an embossed single arrow or stainless steel screwed plate on the side opposite the coupling.

The name plate shall specify the possible direction of rotation CW, CCW, or CW-CCW.


Sticky labels and painted signs are not acceptable.

#### 4.6. Pulsating current



Pulsating current in motors that drive alternative compressors shall not be greater than 40% of full load current.

If it is necessary to add a flywheel, the manufacturer of the motor shall supply the manufacturer of the driven machine with the necessary data so that the latter can produce the relevant calculations to limit the irregularity factor to lower than 1/100.

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#### 4.7. Efficiency

Manufacturer shall always offer the motors of the higher efficiency it can build, always in accordance with the technical requirement of this specification.

For the economical evaluation during purchasing process it shall be considered not only the initial cost but also the cost of the energy consumption during a period of life of 5 years for the specific working conditions of each project.

### 5. CONSTRUCTIONAL CHARACTERISTICS

#### 5.1. External dimensions

The frame and main external dimensions shall correspond to the values specified in the IEC standard 60034.

#### 5.2. Construction type

The construction type and assembly requested in the Data Sheet shall be defined in accordance with the IEC standard 60034.

#### 5.3. Degree of Protection

Motors will be enclosed. The degree of protection of frame and the terminal box against external agents shall be IP55 and IP65, respectively.

The motor shall have one of the following cooling systems while maintaining the required degree of protection:

- a) Totally enclosed type, fan outer surface cooled with finned frame
- b) Totally enclosed type, with external and internal fans and with frame with tubes
- c) Totally enclosed type, with external and internal fans and with built on air-to-air heat exchanger
- d) Totally enclosed type, with external and internal fans and with built on air-to-water heat exchanger

#### 5.4. Frame

The motor frame shall withstand all possible forces during normal starting, short-circuits and counter-phase connections and in the event of re-acceleration due to supply voltage momentary interruptions.

Unless otherwise specified in the project documentation, the frame shall be made of cast iron or corrosion-resistant steel appropriate for the most adverse environmental conditions.

#### 5.5. Rotor

The Rotors shall be made laminated

The rotor squirrel-cages shall be made of copper.


The axial force, if any, shall be absorbed by the motor bearings.

Rotors and fans shall be separately and dynamically balanced with a half-key inserted (verify with the manufacturer of the equipment being driven).

The quality of balancing shall be at least grade G2.5 according to ISO 1940

The manufacturer must specify in its quotation the type of the cage (single or double cage, deep bars, etc.).



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The rotor will be determine to allow the indicated starting conditions, even the re-start of the motor with a residual voltage of 40% and with a phase displacement of 180°.

The rotor will be free of its own axial forces.

## 5.6. Fans

In all cases the fans will be non-sparking, made of corrosion-resistant materials such as: bronze, fiberglass brass, aluminium (with cooper content < 0.2%), etc..., and they will have a thermo-stable composition, according to manufacturers' Standard.

The fan shall be uni-directional (where possible) and installed on the side opposite the coupling so that it sends air towards the coupling.

All the fans will be mounted on the motor's shaft. The cases where fans with auxiliary motors are needed require the Repsol's authorization.

The fan cover and grid shall be made of steel plate.

## 5.7. Shafts

The shaft shall be made of steel and machined (in compliance with existing standards) to receive half of the coupling.

The shaft shall be supplied complete with the corresponding key.



When the motor drives an alternative machine, the flywheel shall be calculated and supplied by the manufacturer of the driven equipment, to obtain a degree of irregularity 1/100 or lower. In these conditions, the new PD<sup>2</sup> for the complete group must be considered and whether its modification (due to the installation of these devices) changes the starting time and other conditions.

The centre holes located on the shaft ends (used during construction), shall be of adequate design to ensure their protection and avoid deterioration and conserve them in best working conditions in future eccentricity verifications.

The maximum allowed deflection, shall be established so that critical speed is reached at more than 120% of maximum operation.

- The end of the shaft shall be marked with the letter H or F, depending on whether it was balanced with half or full key.
- The shaft shall be permanently marked at the magnetic centre working with the fan installed and for the specified direction of rotation and revolutions. According to standard API 541.

## 5.8. Couplings

When required direct rigid couplings, (for example line pumps and vertical motors)then the ends of the shaft shall be made according to the instructions of the manufacturer of the driven equipment.


When required rigid coupling with flange then mechanized, drill holes and tolerances shall be made according to the instructions of the manufacturer.

Vertical motors used to drive pumps located in deep wells shall have couplings bolted to the motor shaft with an anti-turning device to avoid defects to the unit.

## 5.9. Windings and insulation

The windings shall be made of copper form-wound coils and insulated with epoxy resin and vacuum impregnated.

The installation shall guarantee that movement or distortions will not occur if there is a short-circuit between the coils and the supply leads.

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The winding insulation shall be adequate for the rated voltage specified in the project documents.

The winding terminals shall be insulated with fireproof, non-hygroscopic material.

Insulation shall be designed to support a motor re-start or re-acceleration with a phase displacement of 180° and a residual voltage of up to 40% of rated voltage (re-starting voltage value 140% of rated voltage).

Insulation system shall be class F, with temperature rise of class B.

The insulation temperatures allowed are those specified in IEC standard 60034, measured with the resistance method in relation to altitude and temperature conditions at the plant.

## 5.10. Terminal boxes

Independent terminal boxes will be provided for:



- Main power terminals.
- Terminals for connecting the centre of the star (when necessary). (It can be the same)
- Terminals for differential protection connections (They will be located in the main power terminal box).
- Space heaters
- Transformers secondary circuits for the differential protection.
- Temperature detectors.
- Level instruments, water leakage, etc.

### 5.10.1. Power terminal boxes



All terminal boxes shall be made of cast iron, or steel plate. The cover shall have neoprene joints and shall be screwed to the box.

The walls shall have a minimum thickness of 3mm (1/8")

The boxes shall have a threaded hole to which shall connect a metallic cable gland or lead-in bushing with the appropriate size to exterior diameter of the cable, if there are more than one cable three-phase or several mono-phase shall be installed a cable gland or lead-in bushing for every cable.

When a lead-in bushing is installed, the grounding of the armor of the cable shall be done by a cable clamp that shall be connected to the ground lead of the terminal box through a copper plait.

Inlet the box shall be installed the connection terminal and the trifurcation, if the supply is by three phase cable. The size shall be appropriate to allow the connection of the cables that are indicated in the data sheet, without forcing the turning radius of the cable.

The main terminal boxes shall have a fragile area so that if there is a short-circuit between terminals, the breakdown will occur in this area and always towards the motor frame, avoiding that strikes somebody who is close to the motor.

The terminal boxes will be rotatable by 90 ° steps to permit the cable arrival from the four orthogonal directions without having to work on the connection terminals and it shall be possible to remove them from the frame without removing the cable gland connection, the lead-in bushing nor the terminal connection.

The high voltage terminal connections, lead conductors and associated accessories shall withstand short-circuit conditions (minimum 0.3 secs.) defined in the project documentation for the electric system where the motor will be installed.

The separation between phase-phase and phase-earth shall comply with indications in IEC and shall be at least 90 (3.5") and 65 mm (2.5"), respectively.

The connection elements shall be made of tinned copper.

The windings shall be connected in star. The terminals for neutral shall be preferably accessible, in a separate terminal box. The box shall be placed on the side opposite the main box. When possible, both boxes shall be swappable and it shall be possible to use either of them for power feed or making the centre of the star.



If the naming sequence of windings is U, V, W – coinciding with the supply phase sequence – the direction of rotation (defined in section “Direction of Rotation”) will be to the right (CW). If the direction of rotation is opposite (CCW), the naming sequence of terminals shall be maintained.

The lead-in bushing through the motor frame to the terminal box shall be sealed to prevent the entry of moisture and foreign matter.

If the way of the cables from the stator to the terminal box pass through the pipe of the air cooling, on the route from the stator to the terminal box, shall be installed in rigid steel pipes or similar.

#### 5.10.2. Terminal box if there is differential protection

These boxes shall have the same constructive characteristics that have been indicated in the previous section for terminal boxes.



The differential protection of the motor shall carry out applying the diagram called “self balancing differential”.

These toroidal current transformers shall be installed **in the main terminal box**.

Their secondary windings shall be connected to an auxiliary terminal box independently from the high voltage box.

Other solutions apart from differential protection shall be approved by Repsol.

The whole terminal box and toroidal transformer shall be appropriate for dangerous place indicated in the data sheet of the motor.

#### 5.10.3. Auxiliary boxes

The boxes shall be of steel plate, steel alloy or stainless steel. The covers shall have neoprene joints and shall be screwed on the boxes.

The minimum thickness of the walls and of the cover shall be 2 mm (1/16”), except for the stainless steel boxes that may be 1.5 mm.

Except for stainless steel boxes, they shall have screwed holes and double seal metallic cable glands appropriate to the cable indicated in the data sheet and appropriate to the Ex protection mode of the box.

The degree of protection shall be IP 659.

They shall be installed on the opposite side of the terminal box.

Independent boxes shall be installed for the following services:

- For the heat resistance of the windings, bearings, air, and water.
- For the secondary windings of the differential protection’s current transformers.
- For level instruments, water leakage, etc.

Between the sensors and these boxes intermediate boxes are no allowed.

These services shall be able to group in one or more boxes if there is an appropriate separation between the several services and there is a Repsol approval, it must be justified in the offer by the manufacturer. The space heater’s box shall be always independent.

#### 5.11. Bearings and lubrication



a) Motors of more than 750 kW at 3.000 r.p.m., 800kW at 3.600 r.p.m., 1.050 kW at 1.500 r.p.m. and 1.150kW at 1800 r.p.m. shall have sleeve bearings. These shall be preferably self-lubricating, with an oiling ring.

The maximum allowable temperature increment (above the ambient temperature specified in the project documentation) is 40 K measuring the temperature of the antifriction metal. This temperature shall be measured with the motor running at full load and stabilized.

The sleeve bearing material shall support a superior operating temperature of 130°C (266°F).



The axial displacement of sleeve bearings in horizontal motors shall be at least 6 mm (1/4"). Only for Exd motors, lower axial displacements are allowed. The coupling to the driven machine shall be through limited axial play coupling, in accordance with the equipment manufacturer requirements.

The ends of the maximum allowed axial displacement shall be marked, facilitating information about the maximum axial thrust transmitted by the motor in both extreme positions.

The sleeve bearings shall have adequate capacity to support the axial thrust inherent to the motor, limited at 450 N for every 750 kW.

- b)** The other motors shall use ball bearings or roller bearings lubricated with grease or oil.

The bearing shall be rigid ball bearings with a play C3 or one line cylindrical bearings, the squirrel-cage shall be one piece of brass. The plays and fits shall be according to ISO 286. The bearings shall be chosen according to ISO 281 with a minimum working life L10h of 40.000 hours for 4 or 2 poles motors, and 80.000 hours for 6 or more poles motors ( all the cases considering full load)

The bearings shall be SKF or FAG. Alternatives manufacturers need Repsol's authorization.

The manufacturer shall specify the applicable re-oiling periods between oil changes or re-oiling for vertical motors and the quantity of lubricant required for the correct operation of the motor. Bearings shall not be accepted if their oiling periods are shorter than:

- Horizontal motors: 2000 hours,
- Vertical motors: 1500 hours.

It must be possible to grease the motor in operation, without need to remove any cover or accessory.

- c)** Bearing supports shall be equipped with a labyrinth seal and split deflectors.

Motors bigger than 1,100 kW shall have at least one insulated bearing. Insulated connectors shall be provided in the lubrication circuits to prevent bridge connections to ground. In motors of lesser power, bearings shall be insulated when the manufacturer considers it necessary, with prior approval from Repsol.

When the pure fog lubrication is not specified, oil-lubricated bearing supports shall incorporate a purge valve with a screw cap, as well as a constant level cup made of non-splinting glass with a TRICO or DENCO (other suppliers has to be authorized by Repsol) metallic squirrel-cage with a minimum capacity of 100 cm<sup>3</sup> (6.1 in<sup>3</sup>). Likewise they shall have several inspection holes to verify the proper operation of the rings or oil projectors as well as oil level.

All motors shall have temperature indicators on both bearings.

- d)** In addition to the local thermometer, a thermo resistance Pt 100, 3 or 4 threads on each bearing


In both cases, the temperature measured shall be the corresponding temperature of the anti-friction metal

#### 5.11.1.Lube oil system

When necessary to guarantee maximum allowed temperatures defined in the previous section the manufacturer of the motor shall supply the hole lube system according to indicated in the ED-K-04.00 "Lubrication, shaft-sealing and control-oil systems and auxiliaries" (chapters 1 and 3-oil system for general services).

The manufacturer shall specify the maximum amount of time the motor can operate with the lubrication switchboard stopped, at different room temperature values. The oil outlet flange shall have a limiter that ensures the minimum level of oil necessary. Likewise, it shall indicate the alarm and trip temperature at which the thermo resistances must be set.

If there is an oil lube system in the installation for the driven machine, the lube oil shall be given by the console of the driven machine; the manufacturer of the motor shall indicate the necessary flow and pressure for each bearing and shall give a diagram of the installation, saying piping diameters, accessories, etc.

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## 5.12. Nuts and bolts and grounding

All the nuts and bolts of up to M.8 diameter in contact with the external environment shall be made of 18/8 stainless steel. Bolts of greater diameter, if made of carbon steel, shall be protected with an electrolytic zinc or cadmium surface treatment.

The grounding terminals on motor frame shall be resistant to corrosion and able to connect a 70 mm<sup>2</sup> cross-section grounding cords, at least M10.

The grounding terminals or bolts shall be placed at both sides of the motor and will be marked with the grounding symbol.

A grounding terminal shall be placed inside the terminal box and marked with the grounding symbol.

## 5.13. Name plate

The name plates shall be made of stainless steel with embossed or stamped text, attached to the motors by bolts or screws made of the same material and easily accessible.

In addition to the data required by the IEC 60034 standard-, the plates on each motor shall display the following information:

- a) Motor net weight (kg)
- b) Type, internal clearance, and size of bearings.
- c) Time between lubrications, quantity and type of lubricant.
- d) Motor item
- e) Direction of rotation CW-CCW.
- f) H or F balancing.
- g) Motors with a protection mode for explosive atmospheres, ATEX or IEC marks, according to it comes.
- h) Reference to the equivalent oil of Repsol for lubrication. (this data can be included in the same plate or in an additional one).

Other plates shall specify:

- Indication of the admissible axial displacement
- Indication of magnetic centre and the degree of tolerance allowed by the coupling in reference to a fixed point (to verify the correction positioning of the coupling).
- Voltage, power and characteristics of the space heaters.
- Starting limitations

## 5.14. Space heaters

All motors shall have space heaters to avoid condensation inside the motor. These shall be placed so that the heat given off does not deteriorate or shorten the life of the winding insulation, and does not have an adverse effect on the windings even during long stoppage period or no-load running. The maximum surface temperature of the resistance shall be 160 °C (320°F).

The supply voltage shall be specified in the Data Sheet.

## 5.15. Accessories

Motors shall be supplied with lifting eyebolts.

Motors shall be supplied (if necessary) with anchor bolts prepared to withstand the forces caused by short-circuit and starting.



The motors with belt transmission shall be supplied with slipping slides (tightening rails) to adjust the tightening on the belt.

Motors shall have screws on the feet to level the unit. The motors shall be lined up using plates with screws welded to the bench.

Vertical motors shall have a canopy to protect from the rain mounted so that it does not affect the motor cooling.

Motors shall be equipped with two temperature detectors per phase, type Pt 100, 3 or 4 wires and all the connection terminals in the corresponding terminal box. The manufacturer of the motor shall specify the set point value recommended as an "early warning", in accordance with the winding class.

Each bearing shall be equipped with a local thermometer and with a resistance thermometer with the terminals connected to the corresponding terminal box .

It is necessary to indicate the type and position of main speed detector elements on variable speed motors, fed via frequency converters.

### 5.16. Cooling

Unless otherwise specified in the project documentation, motors shall be totally enclosed, preferably self-cooling air-air.

Fans made of sheet steel shall be acceptable as long as they incorporate non-sparking rings that guarantee perfect non-sparking behaviour of the unit.

The water-air closed-circuit cooling system shall meet the following rules:


- The cooling liquid may be located on top of the motor, coupled to the frame. However, Repsol must approve the definite location.
- The coolant shall comply with the pressure vessels standard, doing the corresponding certificate.
- Unless the documentation of the project states something different, the cooling liquid shall be calculated for the following operation conditions:
  - Temperature of water coming in 30°C (86°F)
  - Maximum thermal jump 7°C (44.6°F (7K))
  - Maximum load loss 0.85kg/cm<sup>2</sup> (12.09 psi)
  - Maximum cooling water velocity 1.5÷2.5m/s (5÷8.2 ft/s)
  - Contamination factor 0.0004h m<sup>2</sup> °C/Kcal (0.00195 h.ft<sup>2</sup> °F / BTU)
- The construction of motor and cooling system shall prevent water leaks from the cooling circuit falling directly on the motor windings; appropriate devices shall be installed. The layout of this system will prevent humidity (from leaks or otherwise) from penetrating the motor.
- The cooling system shall be easily removed for repair or cleaning. The heat exchanger shall be made with double tube. The possible leakage of the first tube shall be canalized to a receiver that allow the installation of a leakage detector.

The execution of the heat exchanger shall be proposed by the motor manufacturer and approved by Repsol.

The manufacturer's quotation shall specify the type of coolant and capacity of the motor with the cooling system out of service, and the standard to which shall it be defined and manufactured, as well as the expected flow of coolant and loss of head.

Modular coolers of the following capacities shall be accepted:

- 2 sections of 100%.
- 3 sections of 50%.
- 4 sections of 33%.
- Entry of water to the cooler shall be from below.

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- The cooling water data shall be specified in the project documentation.

The heat exchanger shall be provided with manually operated valves with position indicators to allow isolation and emptying the entire water cooling system while the motor continues in service without the heat exchanger.

The following list shows the instruments that shall be supplied with a water-air cooling system. The alarm contacts shall be normally closed.

- Water low flow switch and with switched alarm contacts.
- Local thermometers indicating the temperature of cooling water in and out and the air in the cooler.
- Water leak detector with alarm contact.

## 6. MOTORS TO BE INSTALLED IN HAZARDOUS AREAS

### 6.1. General

In addition to the requirements in this specification, the following paragraphs define the main standards that three-phase squirrel-cage induction motors shall comply with when installed in hazardous areas and specifically:

- IEC 60079-0                   Electrical apparatus for explosive gas atmospheres,
- IEC 61241-14                Electrical apparatus for use in presence of combustible dust.

Motors and main accessories shall meet the requirements defined in project documentation and shall have an official certificate issued by the Official Certification Authority.

Motors with combined protection modes are accepted (pe, "d" y "eb", "p" y "eb", etc.)

When motors are required for installation in areas, with presence of electricity-conducting dust, the degree of protection required is IP 657. These motors will be marked as required in applicable legislation.

All the motors shall have as minimum, a maximum superficial temperature T3.

The certificate of the motor shall be for the motor, Terminal box and its accessories.

#### 6.1.1. Starting conditions

In the defined starting conditions, the temperature of the motor surface temperature shall not be greater than the ignition temperature of gases present in the area.

### 6.2. Motors with protection mode "d"

The flameproof motors will be suitable for installation in explosive atmospheres with the sub grouping IIA, IIB, and IIC and for temperature class defined in the project documents.

In EU countries these motors will be category 2 marked, and shall have to fulfill the corresponding CENELEC standard.


#### 6.2.1. Standards

The design, construction and tests of the motors shall be adapted to the applicable requirements of the IEC and CENELEC standards (latest edition) and specifically:

- IEC/EN 60079-1            "d" Protection

#### 6.2.2. Degree of Protection

Motors and other accessories shall be totally enclosed, self-ventilating and with IP55 degree of protection.

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The execution shall be explosion proof and appropriate for group and temperature class of gases defined in the project.

Terminal and auxiliary boxes could be “e” protection mode.



### 6.3. Motors with protection mode “eb”

Increased safety motors shall be ready for installation in explosive atmospheres depending on the temperature class defined in the project documentation.

In EU countries these motors will be category 2 marked, and shall have to fulfill the corresponding CENELEC standard.

#### 6.3.1. Standards

The design, construction and tests of the motors shall be adapted to the applicable requirements of the IEC and CENELEC standards (latest edition) and specifically:

- IEC/EN 60079-7 “eb” Protection

For motors with type of protection “eb”, the certification of test according to the paragraph 6.2.3 of the standard IEC 60079-7 (2015) “Additional tests for motors” shall be mandatory.

In case of manufacturer doesn’t have this certificate, and only with the express approval of Repsol, the risks assessment test of table 5 “Potential air gap sparking risk assessment for cage rotor ignition risk factors” of the same standard shall be done to avoid special measures to be employed to ensure that the enclosure does not contain an explosive gas atmosphere at the time of starting.

#### 6.3.2. Degree of protection

Motors and other accessories shall be totally enclosed and self-ventilating with IP55 degree of protection. Execution type shall be of increase safety, adequate for the group and class of temperature of gases defined in the project.

#### 6.3.3. Space heaters

Space heaters shall be designed to limit the temperature on the motors surface below the value specified by the class temperature.

Space heaters shall be certified EExd or EExeb, adequate for the group and temperature class defined in the project fulfilling the requirements of section “Space Heaters”.

#### 6.3.4. Usage limitation or consideration

Before doing an evaluation for the 5.3.1 section the manufacturer shall have to guarantee the possibility of starting the motor, without special issues, like air drain or the installation of gas detectors. The utilization of these special issues requires the authorization of Repsol.

The motor shall have to be certificated for the operation conditions and usage required.



### 6.4. Motors with protection mode “ec”

Motors with this type of protection shall be ready for installation in explosive atmospheres depending on the apparatus grouping and temperature class defined in the project documentation.

In EU countries these motors will be category 3 marked

#### 6.4.1. Standards

The design, construction and tests on frames shall comply with the applicable requirements of the IEC and CENELEC standards (latest edition) and specifically:





- IEC/EN 60079-15 "n" Protection
- IEC/EN 60079-7 "ec" Protection

For motors with type of protection "ec", the certification of test according to the paragraph 6.2.3 of the standard IEC 60079-7 (2015) "Additional tests for motors", shall be mandatory.

In case of manufacturer don't have this certificate, and only with the express approval of Repsol, the risks assessment tests of table 5 "Potential air gap sparking risk assessment for cage rotor ignition risk factors" of the same standard shall be done to avoid special measures to be employed to ensure that the enclosure does not contain an explosive gas atmosphere at the time of starting.

#### 6.4.2. Degree of protection

Motors shall be totally enclosed, self-ventilating and with IP55 degree of protection

The execution shall be non-sparking and appropriate for group and temperature class of gases defined in the project. (Protection mode ec).

#### 6.4.3. Space heaters

Space heaters shall be designed to limit the temperature on the motor surface to below the value specified by the class temperature.

Space heaters shall be certified EExd or EExeb, adequate for the group and temperature class defined in the project fulfilling the requirements of section "Space Heaters".

#### 6.4.4. Limitations or usage considerations

When necessary motors for heavy starting duty (hoists, fans, mixers, etc) and frequent starting duty, the following additional requirements shall be considered:

- a) The starting torque of the driven machine under the worst environmental conditions specified by the manufacturer.
- b) Number of starting sequences specified in the project documentation.
- c) In the above-mentioned requirements, the stator's winding and rotor cage temperature shall not exceed the temperature class of the gases defined in the project.

After doing the test specified in the 5.4.1 section, the manufacturer shall have to guarantee the possibility of starting the motor without taking any special measure, like previous purging or the installation of gas detectors. The installation of this kind of special measures the authorization of Repsol is required.

The motor shall be certified for the operation conditions and usage required.

### 6.5. Motors with protection mode "px" y "pz"


Pressurized motors and their associated components (including the inlet and exhaust conduits for the protective gas) shall be ready for installation in explosive atmospheres depending on the apparatus grouping and temperature class defined in the project documentation.

In EU countries these motors will be category 2 or 3 marked and shall have to fulfill the corresponding CENELEC standard.

#### 6.5.1. Standards

The design, construction and tests on pressurized apparatus shall comply with the applicable requirements of the IEC and CENELEC standards (latest edition) and specifically:

- IEC/EN 60079-2 "px" y "pz" Protection.

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#### 6.5.2. Space heaters

Space heaters shall be designed to limit the temperature on the motors surface below the value specified by the class temperature.

It shall fulfill what is specified in section "Space Heaters".

#### 6.5.3. Supply scope

Motors shall be supplied with a complete purge and pressure system, including control panel, control and reducing pressure devices, volume flow gauge, pressure switch and any other necessary devices suitable for the inlet pressure defined in the project. The limit of supply shall be the inlet flange for piping connections.

Pressurized air shall be from a clean and dry place.

### 7. VARIABLE SPEED MOTORS

These motors will be special and the manufacturer will indicate in the corresponding project documentation that the motor is designed to be fed through a frequency converter, and will provide its type.

When using frequency converters that can generate harmonics of the 7th order or higher, the level of insulation shall be 2.3 times the rated voltage. During the dielectric test, the test voltage shall be that corresponding to this insulation level.

The insulation level shall be adequate for the harmonics generated by the speed variator and for its maximum voltage gradient.

Motors shall have at least one insulated bearing to avoid flow of current through the rotor.

The designed critical speed of bearings, shaft and fan shall be 1.25 times greater than the expected maximum operating speed.

These motors shall operate without additional ventilation within the speed margin required in the project documentation. The exceptional use of auxiliary fans when operating at low revolution shall be proposed by the manufacturer if considered necessary and requires approval from Repsol.

These motors shall have the conformity declaration or certificate, according to it comes, and the appropriate marks for de speed variator for the feeder and for the motor, for the installation in classified areas.

The noise and vibration levels in the entire speed range required shall comply as specified.

### 8. INSPECTIONS AND TESTING

#### 8.1. General


Repsol will always have the right to the assistance of the tests specified in the relevant.

The manufacturer shall submit certificates of all tests, regardless of whether Repsol witnessed or not. Certificates shall be signed by the authorized inspector before shipping.

The vendor shall give at least ten days advanced notification of a witnessed inspection or test unless otherwise specified by Repsol.

If the result of any test is not acceptable, the manufacturer shall bear the travel and lodging expenses of the Repsol inspector for test repetitions, until the test result is satisfactory.

The manufacturer shall bear the travel and lodging expenses of the Repsol inspector in the event that a witnessed test is cancelled without two (2) working day advance notification.

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Procedures of all tests that have been specified as witnessed or observed shall be submitted to Repsol for approval; tests shall not be carried out until the procedures have been approved. The test procedures shall include acceptance criteria for all the inspections, tests and checks that will be carried out during the inspections.

## 8.2. Inspection

During the construction of motors, the manufacturer shall allow access of inspection personnel to its workshops in order to verify the status of work in progress.

The inspection does not relieve the manufacturer of his guarantee and responsibility to supply satisfactory motors that comply with the requirements in this specification.

## 8.3. Test

Tests shall always be carried out at the manufacturer's workshop at its expense.

Repsol will always have the right to witness the acceptance tests.

Acceptance tests shall be always witnessed by at least a specialist of the project engineering company, or an inspector proposed by them. In this case the inspector shall be submitted to the Repsol approval.

The tests shall be carried out in accordance with the standard IEC 60079.

For motors to be installed in hazardous areas, the manufacturer will issue the certificates of the tests carried out according to IEC and CENELEC standards.

### 8.3.1. Type of test

The routine and complete tests shall be carried out according with the following program:

The routine test shall be carried out to all the motors. The complete tests shall be carried out to one motor of each power and speed.

If the result of the type test of the chosen motor is not totally satisfactory, Repsol shall be able to request the carrying out the type tests to all motors with surcharge to the manufacturer.

The tests shall be carried out to the motors and its accessories.

## 8.4. Routine tests

- a) General check of motor conformity with construction specifications and drawings approved by Repsol.
- b) Measurements of resistance of windings and space heaters (at ambient temperature), using the U-I method if possible.
- c) No-load tests at rated voltage measuring current on each phase, power consumed and speed. Power factor calculation.
- d) Visual inspection of the motor's mechanical operation at no-load (bearings, vibration, noise, bearing insulation, etc.).
- e) Check of direction of rotation and sequence of phases at the terminals.
- f) Overvoltage test.
- g) Locked rotor test at rated current to calculate locked rotor torque and current, power factor and "Te" for increased safety motors.
- h) Stator winding dielectric and insulation test. Insulation resistance at 1 minute of the whole motor earthed.
- i) Space heaters (rigidity and insulation).
- j) Electrical continuity review and verification of proper values at ambient conditions, measured using temperature resistance sensors.



- k) Vibration measurements with the motor working at no-load.
- l) Noise level measurement with the motor at no-load.
- m) If motors are equipped with instruments (for example pressure switches, temperature switches, pressure indicators, temperature indicators, etc.) these shall be calibrated separately by running the most significant tests.
- n) If the motors are equipped with forced oil lubrication bearings and the system is supplied by the motor manufacturer, the following tests shall be carried out:
  - o Hydraulic test of the circuit at a pressure corresponding to the applicable standard.
  - o Circuit operation test
  - o Check of the cleaning of the circuit
  - o Release test of the safety valves
- o) If the motors are pressurized type, the tests shall be carried out in compliance with the requirements of the IEC and GENELEC standards.
- p) Cable glands diameter check in the terminal boxes regarding to the cable defined for the project.

### 8.5. Complete test

In addition to the routine tests, the complete tests shall include:

- a) Complete tests, including the stator temperature rise test in continuous running using the direct method or using the bi-frequency method.
- b) Analysis of the electrical characteristics of the motor (current, slip, efficiency, power factor, torque-speed, etc.) at 4/4, 3/4 and 1/2 of rated load.
- c) The over speed test (value defined in the project documentation) shall be carried out on motors that will be coupled to equipment that may cause an inverse over speed.
- d) If motors are equipped with insulated bearings, the insulation resistance shall be measured.
- e) If the motors are totally enclosed with an internal fan and heat exchanger (air-water type), the cooling system test shall be carried out. The safety valve test and the hydraulic test will also be carried out as required by standards.
- f) The test certificates shall be provided for all cooling system components such as pumps (including operation tests), motors (including type tests), piping (material certificates) and instrumentation (material certificates).
- g) The polarisation index measurement shall be carried out on motors with a rated voltage greater than 7.2 kV. This verification will consist of analyzing the insulation resistance during the first and tenth minute of the power, frequency and voltage test. The Mega-Ohm meter shall be at least 2500 V.
- 4 h) Visual inspection of the bearings shall be done after the heat run test.

## 9. PAINTING

Painting shall be performed in compliance with the requirements of Repsol specifications ED-B-06.00, *Painting*, and EC-B-53.00, *Painting application*.

## 10. MINIMUM START-UP AND OPERATION SPARE PARTS

Unless otherwise indicated by Repsol, minimum spare parts for commissioning and two years of operation to provide are those indicated in the table below.

In any case, the Material Requisition shall indicate the applicable amount of each supply as well as any particularity to be considered (eg equipment not covered by a Design Specification).



**TABLA I. MINIMUM SPARE PARTS TO BE SUPPLIED**

Start up	Two year operation
A set of bearings depending on the case: -in case $d < 80$ mm (3 5/32 in) C3 (*) -always in case $d > 80$ mm (3 5/32 in) -always for clearance C4 or other special	A set of bearings depending on the case: -in case $d < 80$ mm (3 5/32 in) C3 (*) -always in case $d > 80$ mm (3 5/32 in) -always for clearance C4 or other special
A set of dimensioning friction bearings for the actual axis measure with diametral clearance indication (suitable for start up small problems)	A set of dimensioning friction bearings for the actual axis measure with diametral clearance indication (suitable for problems that involve turning and milling operations in the shaft, and bearing milling, that avoid addition of material with welding, axis straightening and its turning and milling )
Set of bearing for principal motor and auxiliaries	Exchanger auxiliaries
	Lubrication center auxiliaries


Spare parts marked with (\*) will only be purchased, preferably, in non-refinery or chemical plants, i.e. work centers with low storage of spare parts.

## 11. VENDOR'S DOCUMENTATION

Documentation to be issued by Vendor is defined in the Requisition and as a minimum shall fulfil the table included in Appendix I – *Vendor's documentation*. In addition all documents shall comply with the technical specification ED-A-09.00, *Requirements for vendor's documents preparation*

## 12. DOCUMENTATION TO BE SUBMITTED BY THE ENGINEERING COMPANY

Documentation issued by the Engineering Contractor shall follow specification ED-A-10.00, *Requirements for detail and FEL engineering drawings and documents*

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### 13. SHIPPING, PACKING AND MARKING

Material shall be prepared, labelled and sent complying with specification ED-B-01.00, *Packing, marking and shipping of equipment and materials*.

### 14. STANDARDS AND REFERENCED SPECIFICATIONS

#### 14.1. Repsol standards and technical specifications

##### 14.1.1. Design specifications

ED-A-01.02	Equipment noise control
ED-A-09.00	Requirements for vendor's documents preparation
ED-A-10.00	Requirements for detail and FEL engineering drawings and documents
ED-B-01.00	Preparation of the equipment and materials for shipment.
ED-B-06.00	Painting
ED-K-04.00	Lubrication, shaft-sealing and control-oil systems and auxiliaries.

##### 14.1.2. Construction specifications


EC-B-53.00	Painting Application
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#### 14.2. Globally relevant codes and standards

Motors and auxiliary equipment shall be designed and tested according to the IEC and CENELEC standards and/or any codes, standards and other reference documents defined in the project (Data Sheet) and specifically:

IEC 60034-xx	Rotating electrical machines.
IEC 60079-0	Explosive atmospheres - Part 0: Equipment - General requirements
IEC/EN 60079-1	Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures "d"
IEC/EN 60079-2	Explosive atmospheres - Part 2: Equipment protection by pressurized enclosure "p"
IEC/EN 60079-7	Explosive atmospheres - Part 7: Equipment protection by increased safety "e"
IEC 60079-15	Explosive atmospheres - Part 15: Equipment protection by type of protection "n"
IEC 60079-19	Explosive atmospheres - Part 19: Equipment repair, overhaul and reclamation
IEC 61241-14	Electrical apparatus for use in the presence of combustible dust – Part 14: Selection and installation.
ISO 281	Rolling bearings -- Dynamic load ratings and rating life
ISO 286	ISO code system for tolerances on linear sizes
ISO 1940	Mechanical vibration -- Balance quality requirements for rotors in a constant (rigid) state
ISO 3744	Determination of sound power levels and sound energy levels of noise sources using sound pressure
API 541	Form-wound Squirrel-Cage Induction Motors—500 Horsepower and Larger

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**15. INDEX OF TABLES INCLUDED IN THIS SPECIFICATIONS**

TABLA I. MINIMUM SPARE PARTS TO BE SUPPLIED



**16. APPENDIXES**

APPENDIX I                      VENDOR'S DOCUMENTATION



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**APPENDIX I**

**VENDOR'S DOCUMENTATION**

Description of the document/ Name	Phase			Computer file (*)	
	With the bid	During the order	Upon delivery of the equipment	Native	Other
Return of the project documents correctly filled in (guarantee data)	X				X
Summarised manufacturer specification (type and material of the frame, terminal box, rotor, windings, insulation, etc.)	X				X
Preliminary drawings of dimensions and weight.	X				X
Detailed bearing housing and protection drawings (preliminary).	X				X
Maximum heating time to reach the temperature class required with locked rotor.	X				X
Program and kind of test that can be carried out at the manufacturer's workshop.	X				X
List of recommended spare parts for two years operation, duly assessed.	X				X
Motors with a protection mode for explosive atmospheres, shall have the conformity certificate or declaration, according to it comes.	X				X
Category 2 and 3 marked motors, conformity declaration according to applicable Directive.	X				X
When dealing with Ex execution motors that do not have a prototype certificate, the manufacturer may supply the corresponding certificates after the purchase order (with the tests). The cost of the certificates (with the tests) shall be included in the supply of the motor.	X				X
Declaration of Conformity of the motor-variable speed device unit, in the case of installations in a Hazardous Area, according with the motor protection mode.	X				X
In case of Exec and Exeb motors, the certificate of gas environment test according standard IEC 60079-7 shall be issued.	X				X





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Description of the document/ Name	Phase			Computer file (*)	
	With the bid	During the order	Upon delivery of the equipment	Native	Other
Motors with sleeve anti-friction bearings; the vendor shall indicate the set point value temperatures for alarm and trip.	X				X
Relation of factories authorized to make the repair in the country of the installation.	X				X
In the case of motors greater than 500 kW and when the driven equipment is special, the following information shall be supplied:	X				X
Overload curve	X				X
Temperature to time curve during the required start-up cycles (rotor and stator) with 80% and 100% of Un, specifying maximum temperature allowed during re-acceleration at full load after a voltage drop.	X				X
Cooling to time curve with the motor stopped.	X				X
Time constant and residual voltage variation curve at motor terminals (until complete loss of voltage at terminals).	X				X
Maximum number of recommended starting attempts per day and minimum interval between them.	X				X
Maximum radial and axial displacement.	X				X
Final dimensional drawings with special details of: Design of the free shaft ends.		X			X
Final design of all details relative to attachment the motor to the foundation, specifying weight, rotor PD2 and other dynamic or static characteristics during normal operation, short-circuit and counter-phase connection, with loads distribution over the foundation.		X			X
Final design and accessories layout.		X			X
Details of terminal boxes, and connection and cabling diagrams.		X			X



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Description of the document/ Name	Phase			Computer file (*)	
	With the bid	During the order	Upon delivery of the equipment	Native	Other
Final detailed drawings of bearing housing and protection		X			X
Material supply, manufacture and assembly programs		X			X
Assembly, usage and maintenance instructions		X			X
Program of tests to perform		X			X
Type and model of sleeve (or otherwise) bearings		X			X
Specification of lubricant and Repsol equivalent		X			X
List of certified materials		X			X
Declaration of conformity to type or Type examination certificate for motors that shall be installed in hazardous areas if not supplied with the quotation		X			X
Parts drawing to identify spare parts		X			X
Maximum residual balance certificate obtained in the dynamic balancing operation.		X			X
After testing, the test protocol and execution certificate from the Official Laboratory shall be issued (if necessary).		X			X
Cooling system specification. User guide.		X			X
Quality Control Certificate		X			X
Water/air exchanger certificate.		X			X
The manufacturer of the driven equipment shall have access to the necessary data (size and weight of the rotor) to calculate the complete shaft torsion "motor-machine" in order to approve the rotor design.		X			X
Name plate drawing and facsimile		X			X
Utilities required and cooling water consumption, purging air and lubricant oil.			X		X
Bearing lubrication oil system scheme identifying the positioning of instruments and limit of supply.			X		X



Document Code:

Design Specification:

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HIGH VOLTAGE ELECTRIC INDUCTION  
MOTORS (IEC 60034)

Engineer Division

Technical Department

ELECTRICITY

SEPTEMBER 2017

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Description of the document/ Name	Phase			Computer file (*)	
	With the bid	During the order	Upon delivery of the equipment	Native	Other
Pressure and purging system scheme, identifying the positioning of control mechanisms and limit of supply, including the control panel drawing with the relevant schematic diagrams.			X		X
The data of the winding of the stator (section and of the cooper wire or plate, design details of the stator, etc.) and rotor windings, shall be accessible to Repsol, in case of necessity of reparation as per IEC 60079-19 , "R" marked.			X		X
Quality dossier			X		X

(\*) The computer format the final documents shall be sent in:

- Native: original editable format (Autocad, Microstation, MS. Excel, Word, Access, etc.)
- Other: other non-editable format, for example Acrobat PDF.