



**HELLENIC GAS
TRANSMISSION
SYSTEM OPERATOR**

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**TECHNICAL JOB
SPECIFICATION**

381/1

REVISION 0

DATE 05/04/2011

HIGH PRESSURE (HP) TRANSMISSION SYSTEMS

ELECTRIC MOTORS



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QUALITY ASSURANCE PAGE

CHANGES LOG

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REFERENCE DOCUMENTS

EU Directives:

- 2006/42/EC Machinery Directive
- 2004/108/EC Electromagnetic Compatibility (EMC)
- 2006/95/EC Low Voltage Directive (LVD)
- 94/9/EC Explosive Atmospheres (ATEX)

ELOT EN 60034-1

[Rotating electrical machines - Part 1: Rating and performance]

ELOT EN 60034-5

[Rotating electrical machines - Part 5: Degrees of protection provided by integral design of rotating electrical machines (IP code) – Classification]

ELOT EN 60034-6

[Rotating electrical machines - Part 6: Methods of cooling (IC-Code)]

ELOT EN 60034-7

[Rotating electrical machines - Part 7: Classification of types of construction, mounting arrangements and terminal box position (IM code)]

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IEC 60072-2

[Dimensions and output series for rotating electrical machines]

ELOT EN 60079-1

[Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures "d"]

ELOT EN 60079-2

[Explosive atmospheres - Part 2: Equipment protection by pressurized enclosure "p"]

ELOT EN 60079-11

[Explosive atmospheres - Part 11: Equipment protection by intrinsic safety "i"]

ELOT EN 60079-7

[Explosive atmospheres - Part 7: Equipment protection by increased safety "e"]

ELOT EN 60027

[Letter symbols to be used in electrical technology]

ELOT EN ISO 1680

[Acoustics - Test code for the measurement of airborne noise emitted by rotating electrical machines]

ELOT EN EN 60079-10

[Electrical apparatus for explosive gas atmospheres - Part 10: Classification of hazardous areas]

ELOT EN 60079-0

[Electrical apparatus for explosive gas atmospheres - Part 0: General requirements]

ELOT EN 61672

[Electroacoustics - Sound level meters]

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1.0 SCOPE

1.1 This Specification covers selection, manufacture and testing of induction motors, used to drive pumps, compressors and other mechanical equipment as required for chemical process plants, power plants & off-site facilities.

This Specification applies to motors for use in non classified location and/or in locations classified with hazard of fire or explosion. This Specification is an integral part of each Material Requisition (MR) covering individual motors or groups of motors.

1.2 DEFINITIONS

Unless otherwise specified, it applied to:

- Low voltage (LV) motors with rated voltage ≤ 1000 V a.c.
- Medium voltage (MV) motors with rated voltage >1000 v.a.c.

PART 1 – GENERAL REQUIREMENTS

2.0 GENERAL

2.1 This Specification covers selection, manufacture and testing of induction motors, used

Part 1 includes general requirements and statements common to general purpose motors and to motors protected against the hazard of explosion or fire; the specific requirements and statements relevant to the latter, including definitions, are covered in Part 2.

2.2 Unless otherwise specified in the MR, motors shall comply with the construction and testing requirements set for by the following EU Directives and European Standards:

- **2006/42/EC** Machinery Directive
- **2004/108/EC** Electromagnetic Compatibility (EMC)
- **2006/95/EC** Low Voltage Directive (LVD)
- **94/9/EC** Explosive Atmospheres (ATEX)
- **ELOT EN 60034**
- **IEC 60072**
- **ELOT EN 60079**

In addition motors shall comply with the relevant Standards officially recognized in the country of origin; should conflict exist between the applied IEC or ELOT EN Standards, the Material Requisition and this Specification, Vendor/Manufacturer shall apply to Owner.

2.3 Information and data from Vendor/Manufacturer shall be given adopting the metrical system. In particular the letter symbols used shall comply with the **ELOT EN 60027**.

2.4 This Specification deals further particular requirements concerning manufacture and operating characteristics, in addition to the applicable Standards.

2.5 If specified in the Material Requisition, Vendor/Manufacturer of motors shall contact directly Vendor of driven equipment (copy of letters to Contractor) in order to exchange any information required for the perfect matching of the set features; BOTH MOTOR

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AND DRIVEN EQUIPMENT VENDORS WILL BE JOINTLY RESPONSIBLE FOR THE SATISFACTORY PERFORMANCE OF THE SET AS A WHOLE. Such joint responsibility shall be mandatory in the following cases.

- MV motors with sleeve bearings, to solve problems concerning end float, thrust bearings, coupling, etc.
- MV motors with forced lubrication common with driven equipment.
- Motors driving reciprocating machine.
- Motors driving fans and other machines with high inertia.
- Motor driving reaccelerated machines with slow down brake torque constant, or increasing with decrement of speed.

3.0 ENVIRONMENT CONDITIONS

Unless otherwise specified in MR, motors shall be suitable for the following environmental conditions.

3.1 Ambient temperature

- maximum not exceeding 47°C (dry bulb)
- minimum not less than - 24°C

3.2 Relative humidity

100% with presence of condensate (temperature climate).

3.3 Atmosphere

Ambient air shall be assumed to be salty atmosphere of petrochemical and chemical plants with presence of corrosive agents. (Exact condition shall be specified in MR) .

3.4 Altitude

The height above sea level shall be assumed not exceeding 1000 m and shall be conventionally shown in the MR 0,000 m.

3.5 Cooling water

Temperature and characteristics of cooling water shall be specified in MR.

4.0 PERFORMANCE REQUIREMENTS

4.1 Rating

Rated output values shall be in KW; motor data by Vendor shall be referred to rated output at 40°C ambient temperature as per **IEC 60072**. Motors shall be capable of providing their rated output with duty type, supply system variations, starting duty and torque requirements as specified below.

Rated values of motors shall be referred to rated output at 40°C:

- rated current,
- breakway starting current in p.u. (per unit value) referred to rated current, torque values in p.u.
- power factor and efficiency.

4.2 Duty type

- Continuous running.

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Motors shall be suitable for either continuous running or stand by duty at the specified environment conditions.

After a period of rest not exceeding 6 months, motors shall be suitable to be energized without check of their insulation conditions.

- Intermittent and short-time duty.

Such type of duties shall be specified in MR with reference to **ELOT EN 60034-1**. In any case the requirements of paragraph 4.2.1 shall be met.

4.3 Supply system

Motors shall be capable of providing their rated output under system variations as stated below:

- voltage range : $\pm 5\%$ (**ELOT EN 60034-1**)
- frequency range : $\pm 5\%$
- combined frequency and voltage range : $\pm 5\%$

Under b) and c) conditions, the increase of temperature rise shall be as per case a).

Motors shall be suitable for short period operation with exceptional voltage variations not exceeding $\pm 10\%$ of rated voltage, without permanent damage to the insulation. The duration of each abnormal operation period shall be limited to 30 min, with a maximum yearly duration not exceeding 100 h.

4.4 Starting duty

Unless otherwise specified in MR, motors shall be suitable for direct on line full voltage starting.

- Number of starts.

Unless otherwise specified, motors shall be suitable for the starting duties as follows with ambient temperature of 40°C:

- two consecutive starts plus an additional one spaced of 20 minutes with motor initially at ambient temperature and with supply condition as stated in paragraph 4.3 (as during process start-up);
- two consecutive starts with motor at rated temperature and with voltage at motor terminals as stated in paragraph 4.5 (as during automatic control or reacceleration).

Unless otherwise specified, motors shall be capable of performing the above stated number of starts with a coupled load having brake torque and inertia as follows:

- brake torque is a quadratic function of the speed,
- inertia of the driven equipment is 2, 4, 6, 8 times the inertia of the motor-rotor for motors having 2 and respectively 4, 6, 8 poles.

4.5 Torque and current requirements

Unless otherwise specified, the motor torque shall be capable of accelerating the driven equipment, having inertia and brake torque as per paragraph 4.4 with the following supply conditions:

- 75% of rated voltage applied to motor terminals for LV motors with direct on line starting,
- 80% of rated voltage applied to motor terminals, for MV motors with direct on line starting.
- 80% of rated voltage applied to in-put terminals of the autotransformer, or of the reactance, for motors with reduced voltage starting.

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Manufacturer/Vendor to consider the actual torque decrease due to saturation as function of voltage applied to motor terminals.

Tolerances on rated motor data

Values declared by Manufacturer/Vendor for breakway, pull-up and pull-out torques, for breakway starting current, for slip and inertia are to be considered rating figures; unless otherwise specified in MR, these values shall be kept within the tolerance limits stated by **ELOT EN 60034-1**.

Manufacturer/Vendor shall be responsible to check starting time for critical situations such as heavy duty starting at reduced voltage of sets with high inertia and/or high brake torque and to inform about the calculated starting times (refer to paragraph 2.5).

4.6 Insulation

The insulation shall be in accordance with applicable **ELOT EN** Standards and IEC Recommendations/Standards and suitable for the ambient condition at 40°C. Class A insulation shall not be accepted.

Unless otherwise specified in MR, MV motors shall be connected to resistance rounded systems and shall be provided with instantaneous ground fault protections.

Motors with encapsulated windings shall be provided with temperature sensitive devices embedded in the windings. Manufacturer/Vendor to furnish details.

Motors shall be capable of withstanding without any damage the reenergization at rated voltage with a residual voltage at motor terminals not less than 40%, unless heavier conditions are specified in MR.

4.7 Cooling

Cooling method shall be specified as per **ELOT EN 60034-6**.

The ventilation openings of totally enclosed machines with external fans shall have a mechanical protection degree not less than IP 20 on air inlet and IP 10 on air outlet openings.

Solid foreign bodies shall be prevented from falling vertically through the ventilating openings.

For motors with independent separate coolers Manufacturer/Vendor shall specify the required cooling-air flow, its pressure loss between motor, in and outlet flanges and its temperature rise referred to the specified inlet temperature.

Besides, Manufacturer/Vendor shall indicate in the bid:

- maximum allowable time during which the motor can furnish the rated output with 50% and without any forced air flow,
- maximum continuous output the motor can furnish with 50% and without any forced air flow.

Motors rated above 1000 KW with air-water heat exchanger (unless otherwise specified in MR), shall have a two section exchanger, each section sized for 70S of the rated output.

Manufacturer/Vendor shall indicate in the bid:

- the required water flow, its pressure drop inside the exchanger(s) and outlet temperature, with both sections in service and with only one,

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- the maximum allowable operating time at rated output and the maximum continuous output with one section of exchanger out of service.

4.8 Vibration

Unless otherwise specified in MR, the vibrations measured on the bearing housing along three orthogonal axes (transversal, vertical and axial 3, shall be Kept within the "usable values" shown on Table 1 & 2 (Curves are taken from Standard 2056 August 1960 issued by the Verein Deutscher Ingenieure).

Motors shall be statically and dynamically precision balanced; the use of solder or similar deposits for balancing is not acceptable.

4.9 Noise

Unless otherwise specified in MR, noise levels shall not exceed the limits shown in **ELOT EN 60034-9**; the figures specified for motor rated 400 KW shall be applied to motors rated over 400 KW. Refer also to Job spec 900/4.

The noise level shall be determined by using "A-weighting curve" (**ELOT EN 61672**) and the sound levels shall be expressed in dB (A).

The test shall be performed in accordance with **ELOT EN ISO 1680**.

Manufacturer/Vendor shall supply the actual noise spectrum of offered motors. If to comply with the noise limits specified by applicable **ELOT EN** Standards or in MR, motors shall be equipped with special fans or with silencing devices, or special design motor shall be considered, Manufacturer/Vendor shall quote the price of standard motor and the extra price for the said provisions of for the special design motor.

4.10 Special requirements

For motors driving reciprocating machines Manufacturer/Vendor shall check that the combined installation will have sufficient inertia:

- to keep the irregularity factor within the values specified by the Manufacturer/Vendor of the driven equipment,
- to limit the variations of the current to values not exceeding 66% of the peak value of the rated full load current, unless otherwise specified.
- to keep thermal and dynamic stresses within allowable limits.

If an increase of the natural motor inertia is needed, motor Manufacturer/Vendor shall study and agree with Manufacturer/Vendor of the driven equipment the technically as well as economically most convenient solution, requested to obtain the required total flywheel effect.

Weather-protected motors (denoted by IP W 24) shall be fitted with air filters; filters shall be easily inspectable and removable while motor is running and they shall be suitable for one month continuous operation between successive cleanings. Suitable sensors (thermoswitch, flow-switch, etc.) to give an alarm when filters are dirty, shall be Included in the supply.

If specified in the MR that the motors shall be controlled with vacuum contactors. Manufacturer/Vendor shall furnish a suitable type of insulation and specify characteristics of surge suppressors if deemed necessary to prevent high frequency oscillations on closing due to prestrike.

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5.0 MOUNTING ARRANGEMENT AND ENCLOSURES

5.1 Mounting arrangement

The mounting arrangement shall be specified as per ELOT EN 60034-7.

5.2 Enclosure (degree of mechanical protection)

The enclosure shall be specified as per ELOT EN 60034-5. Unless otherwise specified, any rotating and/or live part shall have minimum protection degree IP 20.

6.0 CONSTRUCTION REQUIREMENTS

6.1 Rotor

The shaft end shall be suitably machined for the coupling type specified in MR. The coupling half will be keyed on by motor Manufacturer/Vendor, only if required in MR.

6.2 Bearings

Ball or roller bearings shall be grease lubricated; they shall be preferably "for life" type, or with grease nipples suitable for lubrication while the motor is running. The regreasing interval shall not be less than 4.000 h.

Rolling bearings shall be guaranteed for a life period of at least 24.000 h., provided that vibrations of the set don't exceed the "usable" limit (see paragraph 4.8). When axial and/or radial thrusts exist, special bearing shall be used to guarantee the above life period.

Sleeve bearings shall be used only where required by speed and rating of the motor; they shall be oil-lubricated, preferably by means of oil rings, fitted with constant level oilers and level indicators.

Forced lubrication should be avoided for the small size motors.

If forced lubrication is needed, a common lubrication system shall be provided both for motor and driven equipment; this system shall be generally supplied by the Manufacturer/Vendor of driven equipment. The control devices of the system shall be agreed for each single case (see paragraph 2.5).

For horizontal sleeve bearings motors, without axial thrust bearings and for motors with axially unrestrained roller bearings, Manufacturer/Vendor shall specify that motors require a limited end-float coupling. Manufacturer/Vendor shall quote separately the thrust bearing, when the MR specifies that end float cannot be limited by the driven equipment.

Manufacturer/Vendor shall specify the maximum permissible end float; a warning plate shall be fastened to the bearing housing at the coupling end and the shaft shall have a reference notch, for axial centering of the rotor. In any case it shall be possible to perform the test and run-in on the uncoupled motor.

Provisions shall be foreseen for testing the air gap at each end of the motor.

In general, bearing shall be selected taking into account the heaviest operating duty in MR (axial and radial thrusts due to the driven equipment and coupling type, such as belts, chains, etc.).

Motors for outdoor installation in rain, shall have bearings properly protected to prevent moisture or dirt from entering inside the motor; vertical motors shall be fitted with rain protection cover.

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Motors driving equipment operating at very high temperatures (e.g. pumps for hot fluids), shall have coupling side bearing cooled by means of a suitable fan keyed on the shaft, when specified in MR.

6.3 Motor enclosure

Motor enclosure shall be suitable for withstanding all stresses that can occur during starting, normal operation, sudden stops, short circuit and restarting in phase opposition with the residual voltage specified in paragraph 4.6 or in MR.

6.4 Terminal boxes

Terminal boxes shall be large enough to allow the easy connection of the supply cables specified in MR.

Terminal boxes shall have mechanical protection not less than IP 55.

Terminal boxes for paper insulated oil impregnated cable terminations or, in general, for compound filled terminations, shall allow the removal of motor without any damage to the terminations.

Connections of space-heaters and other auxiliary devices shall be brought out into separate auxiliary terminal boxes.

Terminals shall be properly identified as per **ELOT EN 60034-8**.

Terminal boxes shall be rotatable through four times 90°C, without changing the internal connections.

Terminal boxes location and mounting shall be as specified in MR; if not specified, they shall be located on the right side facing coupling end, or on the top. Manufacturer/Vendor's drawings shall show the actual location of terminals boxes.

Terminal connectors in main and auxiliary boxes shall be antiloosening types.

6.5 Painting and rust-preventing protection

Motor surfaces shall be properly treated for the specified environmental conditions.

The surfaces shall be treated as follows:

- one coat of primer paint.
- two coats of intermediate paint,
- two coats of oil resistant finishing paint.

Unless otherwise specified in MR, color shall be Manufacturer/Vendor's standard, possibly opaque grey.

The internal parts shall be painted or treated to make them corrosion resistant.

All bolts nuts, tags and plates shall be made of corrosion resistant material.

7.0 ACCESSORIES

7.1 Motors over 20 kg shall be provided with one or more lifting eyebolts.

7.2 Motors fitted with unidirectional fans shall have a corrosion resistant tag on non-driving end with an arrow showing rotation direction. Furthermore, the tag shall show the correspondent phase sequence.

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Alternatively this Information may be shown on the additional rating plate (see para 8.2).

- 7.3 Motors with sleeve bearings shall have provisions to measure either the air gap between rotor and stator or shaft eccentricity at both ends.
- 7.4 Unless specified in MR, motors rated 5000 KW or more, or having a core length of 1 m or more, shall be provided with six thermo resistance type temperature detectors; detectors shall be fitted with surge diverters. Unless otherwise specified, the thermo resistances shall be platinum, 100 ohm at 0°C, $3,84 \times 10^{-3}$ ohm/°C.
- 7.5 Ground bolts shall be provided on terminal box side of the frame and inside the main terminal box. Motors with top-mounted terminal box shall have ground bolts on both sides. Ground bolts shall be properly identified and shall have at least 6 mm diameter.
- 7.6 Space heaters
Open motors for intermittent duty in moist ambient, especially if MV motors shall be fitted with space heaters, which shall be sized to keep the inner temperature some degrees higher than ambient temperature, when the motor is at rest.
Space heaters shall be also provided whenever motor Manufacturer/Vendor deems them necessary (refer also to paragraph 4.2).
The use of an insulation type which doesn't require space heater to comply with the specified environment and service conditions is recommended.
Unless otherwise: specified in MR, space heaters shall be suitable for 380 V, single or three-phase supply.
- 7.7 Control devices, if any, for lubrication, ventilation, pressurization or etc, shall be included in the bid and described in detail.
- 7.8 For motor rated 1500 KW and above, Manufacturer/Vendor shall Indicate in the bid if installation of surge diverters and capacitors at motors terminals is necessary and shall give separately quotation for them.
- 7.9 Drain opening shall be provided and located where condensate water may collect.
- 7.10 Motors with belt or chain coupling shall be fitted with slide-rails.
- 7.11 Special tools required for proper erection and maintenance shall be quoted separately by Manufacturer/Vendor for each type of motor.

8.0 RATING PLATES

Two corrosion-resistant plates (stainless steel, bronze, brass) shall be fastened to the motors; there shall be indelibly engraved the following data.

8.1 Main plate

Rating plate shall be in accordance with **ELOT EN 60034-1** and with applicable Standard.

8.2 Additional rating plate

The rating plate shall show the following:

- Rated output in KW referred to 40°C ambient temperature.
- Full-load current at rated output in A referred to 40°C ambient temperature,
- Allowable frequency and voltage variation,

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- Breakway starting current in A,
- Breakway torque in p.u. referred to rated output at 40°C,
- Direction of rotation and correspondent phase sequence & rotation,
- Class of insulation and allowable temperature-rise,
- Mechanical protection (IP...),
- Type of lubrication, if required,
- Motor item,
- Further data as required for the particular case.

9.0 TESTS

Extent and method of tests to be carried out shall be as specified by applicable **ELOT EN** Standards; at any rate the minimum extent shall be as listed in Table 3.

9.1 Type test

Unless otherwise specified, type test (test on prototype) is only request for motors with any type of protection against hazard of fire or explosion (see part 2).

9.2 Acceptance test

The acceptance-routine test shall include the tests specified on Table 3.

Manufacturer/Vendor shall submit, to Contractor, for comments and approval, the test methods to be adopted, at least thirty working days prior to the date fixed for the final acceptance test.

Extent of acceptance-routine tests.

On Table 3 extent of tests is given for "short-test" and "complete test".

All motors shall undergo the short test.

The complete test will be generally carried out on one sample for each group of motors of the same type, voltage and output rating.

Unless otherwise specified, complete test shall be carried out on motors above 150 KW and/or MV motors. The samples to undergo the complete test will be selected by Contractor's Inspector.

10.0 DOCUMENTS AND OTHER INFORMATION REQUIRED FROM VENDOR /MANUFACTURER

10.1 Information by Manufacturer/Vendor

Manufacturer/Vendor shall furnish for each motor information and data listed on Table 4 and in MR.

10.2 Data concerning the foundations

The dynamic forces, to be used for foundation sizing, shall be given for the following conditions for all motors rated more than 500 KW:

- starting at full voltage,
- short circuit,
- reacceleration in phase opposition with the maximum considered residual voltage at the motor terminals.

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11.0 GUARANTEED QUANTITIES

Guarantees shall be given only upon the quantities considered in the applicable **ELOT EN** Standards and for the conditions there specified.

Unless otherwise required, any other quantity or special condition specified in addition to, or waiving from the applicable **ELOT EN** Standards, have to be considered as informative.

12.0 SPARE PARTS

12.1 Unless otherwise specified in MR, Manufacturer/Vendor shall quote for each type and size of motor at least the following spare parts:

- bearings,
- fans,
- bushings,
- part of winding (for motors over 1500 KW),
- accessories (if any)

Additional spare parts can be suggested by Manufacturer/Vendor.

12.2 Any spare shall comply with the original specification and tests, and shall be suitable for replacing the relevant part as originally fitted.



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**PART 2 – REQUIREMENTS AND PRESCRIPTIONS FOR MOTORS
 PROTECTED AGAINST THE HAZARD OF EXPLOSION OF FIRE**

13.0 GENERAL

Part 2 includes additional requirements and prescriptions relevant to motors with any type of protection against the hazard of explosion or fire due to a mixture of air and flammable gases or vapours that may occur in the locations in which motors are installed.

These motors shall meet the general requirements set for in Part 1 of this Specification.

13.1 Classification of hazardous locations

Classification of hazardous locations will be according to **ELOT EN 60079-10**.

13.2 Types of protection considered

Types of protection considered are the following:

- Ex-d, explosion proof (flameproof),
- Ex-p, pressurized,
- Ex-e, increased safety,
- Non-sparking,
- Ex-i, intrinsic safety (for sparking and arcing devices).

13.3 Standards and regulations

Unless otherwise specified in MR, motors with type of protection Ex-d, Ex-p, Ex-e shall comply with the construction and testing requirements according to:

- **ELOT EN 60079-1**
- **ELOT EN 60079-2**
- **ELOT EN 60079-7**
- **ELOT EN 60079-8**

For devices with protection type Ex-i (intrinsic safety) **ELOT EN 60079-11** shall be considered.

Manufacturer/Vendor shall declare on his own responsibility the suitability of the devices to the specified application.

Unless otherwise specified in MR, motors with type of protection non-sparking shall comply with the additional requirements set for in paragraph 17.

13.4 Test reports and protocols

Manufacturer/Vendor of motors with type of protection Ex-d and Ex-e shall exhibit the reports relevant to the tests carried out on the prototype by a testing station approved by the national authority of the country of origin or by an other appropriate authority and shall produce routine-acceptance test protocols as specified by the applied IEC Recommendations and by the applied Standards of the country of origin.

Manufacturer/Vendor of motors with type of protection non-sparking shall, on his own responsibility, carry out the type and routine-acceptance tests specified in paragraph 19.

14.0 **EXPLOSION PROOF MOTORS** (Flame proof motors) **Ex-d**

14.1 Definition

These motors shall have their active parts contained in one or more explosion proof enclosures and shall have sparking external ventilating fans.

Enclosures are grouped according to the dimensions of the gaps between their joints surfaces as follows (**ELOT EN 60079-1**), Table III. Groups of enclosures: II A, II B and II C.

14.2 Additional prescriptions

External ventilating fans and covers protecting air flow openings shall be constructed in such a manner and shall be so arranged and fastened that no rubbing of rotating parts against stationary ones can occur. The clearance shall be as per **ELOT EN 60079-11**. Fans shall be made of corrosion resisting ductile material (brass, bronze, aluminium, plastic). Aluminium shall not contain more than 0,2% of copper.

Plastic fans shall be made of a reinforced thermo-setting plastic and shall be sufficiently conducting to prevent the accumulation of static charges.

Main and auxiliary terminal boxes and auxiliary devices (such as space heaters, thermo-switches, bearing oil-level-switches etc.) and wiring external to motor enclosure shall be with type of protection Ex-d, with characteristics at least equivalent to those prescribed for the motor enclosure.

Auxiliary devices may be also with type of protection intrinsic safety (Ex-ib), provided that they are declared and tested by Manufacturer/Vendor as suitable for the application. If in MR is specified that motors shall be installed in a location classified class 1 division 2, terminal boxes may be with type of protection Ex-e and intrinsically safe devices Ex-ib may be used.

Surfaces, which may come in contact with explosive mixture, shall be such to prevent the accumulation of static charges.

15.0 **PRESSURIZED MOTORS Ex-p**

15.1 Definitions

Pressurized motors are motors in which the entry of flammable gases or vapours is prevented by maintaining the air or other non-flammable gas (safety fluid) within the enclosure at a pressure above that of the external atmosphere.

Pressurized motors may be:

- totally enclosed with, primary coolant in closed circuit; motor may be frame surface cooled or with heat exchanger, or
- inlet and outlet ducts (or pipes) ventilated.

Pressurized totally enclosed motors shall have an enclosure with minimum mechanical protection degree IP4S and shall be permanently connected to a source of clean air or other non flammable gas. During operation any point of the motor enclosure, where the entrance of external atmosphere may be expected, the minimum overpressure of the safety fluid shall not be less than 5 mm of water gauge. The motor shall have provisions of scavenging it before starting with a flow of safety fluid in order to make a complete renewal of the internal atmosphere before energization.

Duct (or pipe) ventilated pressurized motors shall have the enclosure flanged to cooling and pressurizing air ducts (or pipes). Inlet duct (or pipe) shall be connected to an

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external supply system of clean air capable of supplying the air flow quantity requested to cool the motor and to keep in any point of the motor enclosure and of the inlet and outlet ducts (or pipes), where the entrance of external atmosphere may be expected, the minimum over pressure of 5 mm of water gauge. The internal overpressure shall be controlled by means of louvers on-outlet flange of the motor or by means of an outlet duct (or pipe) equipped with louvers at the discharge point.

Duct (or pipe) ventilated - pressurized motors equipped with louvers directly mounted on the motor discharge flange (the air discharges in the surrounding of the motor) shall be permitted in class 1, division 2 locations only.

15.2 Additional prescriptions

Limiting surface temperatures shall be kept within the permissible limits consistent with the temperature class also during service conditions specified in paragraph 4.

Terminal boxes not included in the pressurized system or included in the pressurized system, but housing circuits which may be energized before scavenging or when pressurization is off, shall be with protection type Ex-d in class 1, division 1 and Ex-d or Ex-e in class 1, division 2 locations, suitable for the specified conditions.

Totally enclosed pressurized motors, shall have external ventilating fans as specified in paragraph 14.2.

Space heaters installed in motor enclosure or in air ducts (or pipes) , if in service when the pressurization is off, shall be with protection type Ex-d in class 1, division 1 locations and Ex-d or Ex-e in class 1, division 2 locations, suitable for the specified conditions.

Sparking and/or arcing devices (such as pressure-switches, flow-switches, thermo-switches etc.) installed outside pressurized motor enclosure, ducts (or pipes) shall be with protection type Ex-d, or Ex-ib (intrinsic safety); the same devices installed inside ducts (or pipes), if requested to operate ' when the pressurization is off, shall be Ex-d or Ex-ib (intrinsic safety).

Manufacturer/Vendor shall include in the quotation auxiliary devices necessary to control scavenging and pressurization.

Surfaces, which may come in contact with explosive mixtures, shall be such to prevent the accumulation of static charges.

16.0 INCREASED SAFETY MOTORS Ex-e

16.1 Definitions

Increased safety motors are motors for which additional measures are applied, so as to give increased security against the possibility of excessive temperatures and of the occurrence of arcs and sparks in parts and components which do not produce arcs or sparks in normal service.

16.2 Additional prescriptions

Limiting temperatures as specified by **ELOT EN 60079-7** shall be considered also for conditions specified in paragraph 4.

In case of motors with critical rotor (during the time t_E the rotor reaches the limit temperature before the stator), Manufacturer/Vendor shall indicate it in the bid.

It shall be Manufacturer/Vendor's responsibility that the limiting temperatures are not exceeded in specified conditions; Manufacturer/Vendor shall indicate in the bid the starting time if higher than t_E .

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External ventilating fans shall be made of materials as specified in paragraph 14.2.

Space heaters shall be Ex-d or Ex-e suitable for the specified conditions.

Sparking and/or arcing devices (such as thermo-switches, bearing oil level-switches etc.) shall be Ex-d or Ex-ib.

Surfaces, which may come in contact with explosive mixtures, shall be such to prevent the accumulation of static charges.

17.0 **NON-SPARKING MOTORS**

17.1 Definitions

Mechanically and electrically non-sparking motors are normal industrial motors which do not produce arcs or sparks or excessive temperature on external surface in normal operating conditions, including starting and reacceleration with supply and service conditions as specified in paragraph 4.

17.2 Additional prescriptions

For non-sparking motors with enclosure less than IP 45 the requirements specified in paragraph 17.1 shall apply also to the internal parts, such as rotor cage and internal ventilating fans.

External ventilating fans and covers protecting air flow openings' shall be constructed in such a manner and shall be so arranged and fastened that no rubbing of rotating parts against stationary ones can occur.

External ventilating fans shall be made of materials as specified in paragraph 14.2. This same applies to internal ventilating fans, if the enclosure is less than IP 45.

Space heaters shall be as specified paragraph 16.2.

Sparking and or arcing devices shall be as specified in paragraph 16.2.

Surface which may come in contact with explosive mixtures shall be such to prevent the accumulation of static charges.

18.0 **ADDITIONAL PLATE OR MARKING**

Additional plate or marking shall be in accordance with applicable **ELOT EN** Standards and as follows:

- a) For Ex-d motors the marking shall be in accordance with **ELOT EN 60079-1**.
- b) For Ex-p motors the auxiliary equipment with type of protection Ex-d and Ex-e, if any, shall be individually marked as per paragraph a) and c) respectively.
- c) For Ex-e motors the marking shall be in accordance with **ELOT EN 60079-7** and the auxiliary equipment with type of protection Ex-d, if any, shall be individually marked as per paragraph a).

19.0 **ADDITIONAL TESTS**

Motors protected against the hazard of explosion or fire shall undergo the additional tests listed in Table 5 besides those specified in Table 3.

- a) For Ex-e motors the cost of heating run test and of measuring the time t_E shall be included in the price of the motor.

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b) If Manufacturer/Vendor can produce type or individual acceptance test certificates issued by a testing station approved by national authority, the amount of tests may be reduced by agreement with Contractor.

20.0 ADDITIONAL DOCUMENTS AND INFORMATION

The following further documents and information shall be furnished, beside those indicated in paragraph 10, if required.

- a) For motors Ex-d:
 - drawing of labyrinth glands sleeve bearings, or ball or roller bearings,
 - cable entry type and drawings.
- b) For motor Ex-p:
 - inlet pressure for normal operation and for scavenging,
 - recommended safety fluid flow for scavenging and duration,
 - pressure drop between the inlet and outlet flanges,
 - temperature rise of coolant referred to inlet temperature.

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PART 3 – ADDITIONAL REQUIREMENTS FOR MOTORS OVER 10.000 KW

21.0 MOTORS BEARINGS

Horizontal motor bearings shall be split capsule type sleeve bearings with split bearing brackets. Design shall permit bearing replacement without removing the bottom bearing bracket.

Motor bearings shall be insulated to prevent the circulation of shaft currents through the bearings.

22.0 BEARING TEMPERATURE SUPERVISION

Motors shall be equipped with bearing temperature relays, one relay per bearing. Relays shall be set to operate when the bearing temperature exceeds the maximum safe operating limit.

Each relay shall be mounted in an enclosure on the motor, and shall have double throw contacts for operating purchaser's alarm. The operating temperature shall be marked on the relay nameplate. The enclosure shall be suitable for the specified area classification of the motor location.

Motors shall be equipped with bearing thermometers, one thermometer per bearing. Thermometers shall be dial type, mounted on the motor enclosure, with bulbs arranged to measure the same temperature as that to which the temperature relays are sensitive.

23.0 DIFFERENTIAL RELAYS

Motors shall have provisions for differential relay protection. Protection shall be of the self-balancing type utilizing only one set of current transformers located in the motor.

Three window-type current transformers shall be mounted within the motor terminal box with insulating strips for centering the motor leads in the transformer windows. Manufacturer/Vendor shall complete all primary circuits through the transformer windows and provide leads for connection to motor feeder cables.

24.0 ROTOR DYNAMIC BALANCE

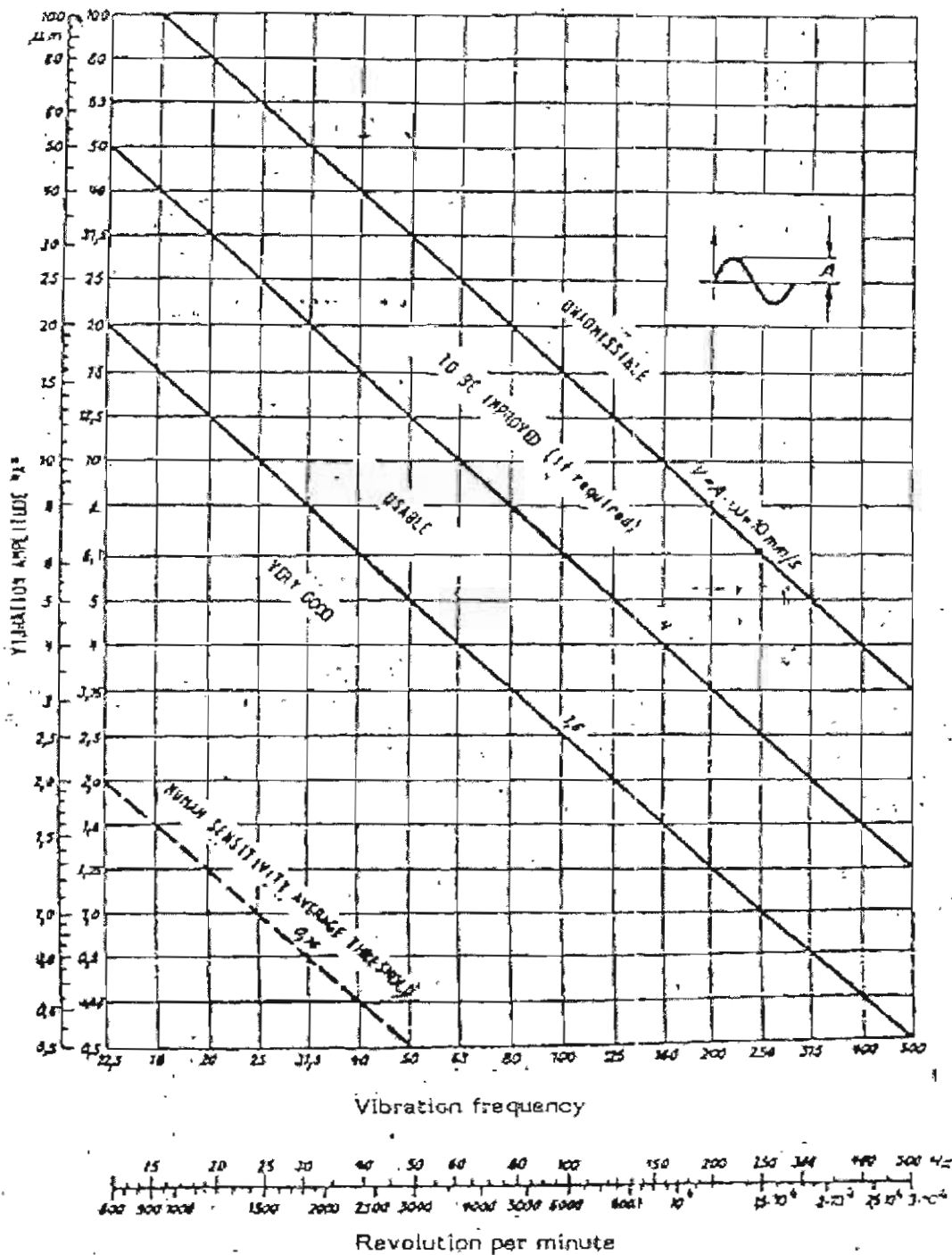
Motor rotor shall be dynamically balanced before motor assembly, in a balancing machine, preferably with all shaft or rotor mounted fans installed. Fans not installed during rotor balancing shall be dynamically balanced separately in a balancing machine.

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TABLE 1 - DIAGRAM OF MOTOR VIBRATION VALUES



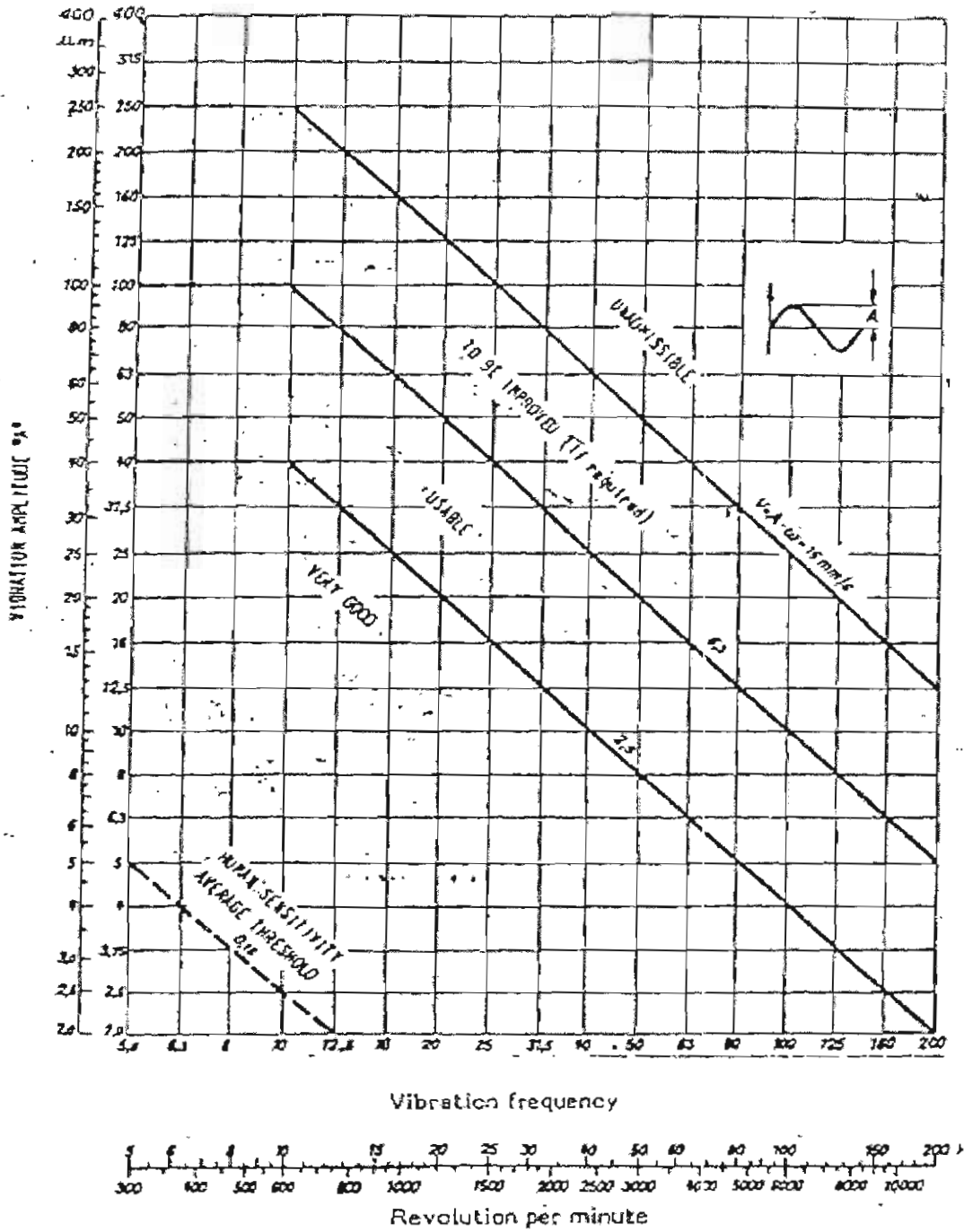
CURVES APPLICABLE TO MOTORS RATED ≤ 300 kW

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TABLE 2 DIAGRAM OF MOTOR VIBRATION VALUES



CURVES APPLICABLE TO MOTORS RATED ≥ 300 kW

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| TABLE 3 | | LIST OF TESTS | |
|--|------------|----------------|--|
| DESCRIPTION | Short test | Complete test | |
| 1. Measurement of windings resistance at ambient temperature (40°C) | | √ | |
| 2. Measurement of installation resistance | | √ | |
| 3. Dielectric (high voltage) test | √ | √ | |
| 4. Determination of current: at no- load at rated output at locked-rotor | √(1) | √ √ √(1) | |
| 5. Full-load heat run | | (2) | |
| 6. Determination of power factor: at locked – rotor at ½, ¾, and 4/4 of rated output | | √ √ | |
| 7. Determination of efficiency at ½, ¾ and 4/4 of rated output | | √(3) | |
| 8. Determination of slip: at no-load at rated output load | | √ √ | |
| 9. Measurement of breakaway torque | | √(1) | |
| 10. Determination of torque versus speed curve | | (2) | |
| 11. Check of direction of rotation and phase sequence | √ | √ | |
| 12. Overspeed test | | (2) | |
| 13. Sight control of bearings and vibrations at no load | √ | | |
| 14. Measurement of vibrations at no-load | √ | | |
| 15. Measurement of vibrations at rated output | | √(2) (4) | |
| 16. Air-flow pressure –drop measurement on forced ventilated motors | | (2) | |
| 17. Sight complete dimensional and mechanical check including terminal box location and mechanical protection degree | √ | √ | |
| 18. Test of mechanical protection degree | | (2) | |
| 19. Check of nameplate data | √ | √ | |
| 20. Short circuit test on the terminal boxes | | (2) | |
| 21. Measurement of axial float and thrust for horizontal sleeve bearing motors | | √(5) | |

(1) Test may be carried out at reduced voltage, if agreed with Contractor.
 (2) Test to be quoted separately and to be carried out only if requested in MR.
 (3) Method of test to be agreed between Manufacturer/Vendor and Contractor.
 (4) Motor and bearings shall be at rated temperature.
 (5) If applicable.

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| TABLE 3.1 | | LIST OF TESTS FOR MOTORS OVER 10.000 KW | |
|--|-------------------|--|--|
| DESCRIPTION | Short test | Complete test | |
| 1. Measurement of windings resistance at ambient temperature (40°C) | | √ | |
| 2. Measurement of installation resistance | | √ | |
| 3. Dielectric (high voltage) test | √ | √ | |
| 4. Determination of current: at no- load at rated output at locked-rotor | √(1) | √ √ √(1) | |
| 5. Full-load heat run | | (2) | |
| 6. Determination of power factor: at locked – rotor at ½, ¾, and 4/4 of rated output | | √ √ | |
| 7. Determination of efficiency at ½, ¾ and 4/4 of rated output | | √(3) | |
| 8. Determination of slip: at no-load at rated output load | | √ | |
| 9. Measurement of breakway torque | | √(1) | |
| 10. Determination of torque versus speed curve | | (2) | |
| 11. Check of direction of rotation and phase sequence | √ | √ | |
| 12. Overspeed test | | (2) | |
| 13. Sight control of bearings and vibrations at no load | √ | | |
| 14. Measurement of vibrations at no-load | √ | | |
| 15. Measurement of vibrations at rated output | | √(2) (4) | |
| 16. Air-flow pressure –drop measurement on forced ventilated motors | | (2) | |
| 17. Sight complete dimensional and mechanical check including terminal box location and mechanical protection degree | √ | √ | |
| 18. Test of mechanical protection degree | | (2) | |
| 19. Check of nameplate data | √ | √ | |
| 20. Short circuit test on the terminal boxes | | (2) | |
| 21. Measurement of axial float and thrust for horizontal sleeve bearing motors | | √(5) | |
| 22. Measurement of no-load losses | | √ | |
| 23. Measurement of copper losses | | √ | |
| 24. Measurement of shaft voltage | | √ | |
| 25. Noise measurement | | √ | |
| 26. Measurement of current and torque during acceleration | | √ | |
| 27. Reactance measurement | | √ | |
| (1) Test may be carried out at reduced voltage, if agreed with Contractor. | | | |
| (2) Test to be quoted separately and to be carried out only if requested in MR. | | | |
| (3) Method of test to be agreed between Manufacturer/Vendor and Contractor. | | | |
| (4) Motor and bearings shall be at rated temperature. | | | |
| (5) If applicable. | | | |

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| TABLE 4 | | INFORMATION AND DATA TO BE FURNISHED BY MANUFACTURER/VENDOR | | |
|---|---|---|---|--|
| DESCRIPTION | A | B | C | |
| Applied Standard | √ | | | |
| Rated output (at 40°C) | √ | | | |
| Output at different design temperature (if requested) | | | | |
| Rated current | √ | | | |
| No load current (p.u.) | | | √ | |
| No load power factor | | | √ | |
| Efficiency and power factor at 4/4 rated output | √ | | | |
| Efficiency and power factor at 1/4, 2/4 and 3/4 of rated output | | | √ | |
| Rated temperature rise and class of insulation | √ | | | |
| Rated torque | | √ | | |
| Breakaway torque (p.u.) | √ | | | |
| Pull up torque (p.u.) | | √ | | |
| Pull out torque (p.u.) | | √ | | |
| Slip at pull - out torque | | | √ | |
| Rotor inertia | | √ | | |
| Thermal time constant at rated output | | | √ | |
| Locked rotor allowable time (starting from cold and starting from hot) t _E (s) | | | √ | |
| Frame size (IEC 60072) | √ | | | |
| Bearing and lubrication type | √ | | | |
| Noise spectrum | | √ | | |
| Winding connection | √ | | | |
| Weights | √ | | | |
| Space heater data | | √ | | |
| Dimensional drawings | √ | √ | | |
| Information and deviation from Specification and MR | √ | | | |
| Additional information suggested by Manufacturer/Vendor | √ | | | |

A. Denotes information and data to be furnished with the bid.
 B. Denotes information and data to be furnished after order placement.
 C. Denotes information and data to be furnished only if requested in MR.

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| TABLE 4.1 INFORMATION AND DATA TO BE FURNISHED BY MANUFACTURER/VENDOR FOR MOTORS OVER 10000 KW | | | |
|---|---|---|--|
| DESCRIPTION | A | B | |
| Applied Standard | √ | | |
| Rated output in KW at 40°C | √ | | |
| Rated speed | √ | | |
| Rated current | √ | | |
| No load current | √ | √ | |
| No load power factor | | √ | |
| Efficiency and power factor at 1/4, 2/4 and 3/4 and 4/4 of rated output | √ | | |
| Rated temperature rise and class of insulation | √ | | |
| Breakaway starting current | √ | | |
| Breakaway starting current of the system (where applicable) | √ | | |
| Breakaway torque (p.u.) | √ | | |
| Rated torque | √ | | |
| Pull -out torque (p.u.) | √ | | |
| Pull -up torque (p.u.) | √ | | |
| Slip at pull - out torque | | √ | |
| Rotor inertia at motor shaft | √ | | |
| Speed vs torque curve based on motor saturation at rated voltage | √ | | |
| Speed vs power factor and speed vs current curves based on motor saturation at rated voltage | | √ | |
| Speed vs torque curves based on motor saturation at 90%, 85%, 80% and 75% of rated voltage | √ | | |
| Thermal time constant at rated output | | √ | |
| Max permissible locked rotor time at 40°C and at rated voltage starting from cold and starting from hot (s) | | √ | |
| For rotor bar (or ring if governing) max permissible temperature rise accelerating load | √ | | |

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| TABLE 4.1 | | INFORMATION AND DATA TO BE FURNISHED BY MANUFACTURER/VENDOR FOR MOTORS OVER 10000 KW | |
|---|---|--|--|
| DESCRIPTION | A | B | |
| AC/DC resistance ratio | | √ | |
| Open circuit time constant (s) | | √ | |
| Symmetrical contribution to 3 phase terminal fault: | | | |
| a) at ½ cycle | | √ | |
| b) at 5 cycles | | √ | |
| Mounting | √ | | |
| Bearings and lubrication type | √ | | |
| Noise spectrum | | √ | |
| Winding connection | √ | | |
| Weights | √ | | |
| Space heaters data | | √ | |
| Dimensional drawings | √ | √ | |
| System calculation proving the proposed starting method | √ | √ | |
| Calculation of starting time | √ | √ | |
| List of individual deviation from specification and MR if any | √ | | |
| Other data and information Vendor deem to suggest | √ | | |
| | | | |
| A. Denotes information and data to be furnished with the bid. B. Denotes information and data to be furnished after order placement. | | | |

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| TABLE 5 DESCRIPTION | LIST OF ADDITIONAL TESTS | | | | | | | |
|--|--------------------------|------|--------------|------|---------------|------|--------------|------|
| | Short test | | | | Complete test | | | |
| | TYPE OF MOTOR | | | | | | | |
| | Ex-d | Ex-e | Non-sparking | Ex-p | Ex-d | Ex-e | Non-sparking | Ex-p |
| 1. Full-load heat run | | √ | | | | √ | √ | |
| 2. Determination of cooling medium pressure drop at rated flow | | | | √ | | | | √ |
| 3. Determination of explosion pressure of the Enclosures (s) | | | | | √ | √a) | | √a) |
| 4. Determination whether the enclosure is flameproof | | | | | √ | √a) | | √a) |
| 5. Pressure test | | | | | | √a) | | √a) |
| 6. Routine pressure test | √b) | | | | | | | |
| 7. Check that Manufacturer shall certify that each individual apparatus is identical with the prototype submitted to testing authority | √ | √ | | | | | | |
| 8. Check of absence of arcing at locked rotor squirrel cage rotor | | | | | | √ | √ | |
| 9. Measurement of the time t_E with rotor locked | | | | | | √ | | |
| 10. Check of the temperature with regard of the time t_k of protective device | | | | | | √ | | |

NOTES: a) These tests shall be carried out on the terminal boxes and/or auxiliaries of Ex-p and Ex-e motors whenever their protection method is Ex-d.
 b) Except for enclosures of welded construction, no routine test is required if the volume of the enclosure does not exceed 10 cm³ or the prototype has been successfully tested under a static pressure equal to four times the reference pressure.