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TECHNICAL SPECIFICATION

HIGH PRESSURE (HP) TRANSMISSION SYSTEMS

ELECTRIC MOTORS

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1. INTRODUCTION

2. SCOPE AND OBJECTIVES

This Specification covers the minimum requirements for the design, supply and installation for LV electric motors for the stations and pipelines of the natural gas transmission system.

3. REFERENCES

3.1 Reference Documents

3.2 Reference Codes and Standards

2014/34/EU	Equipment Explosive Atmospheres Directive
2014/35/EU	Low Voltage Directive
2014/30/EU	Electromagnetic Compatibility Directive
2006/42/EEC	Machinery
ELOT EN 1594 E3	Gas Supply Systems. Pipelines for Maximum Operating Pressure over 16 bar. Functional Requirements
ELOT EN 14161+A1	Petroleum and Natural Gas Industries. Pipeline Transportation Systems
ELOT EN IEC 60079-0 E5	Electrical Apparatus for Explosive Gas Atmospheres - Part 0: General Requirements
ELOT EN 60079-7 E3	Electrical Apparatus for Explosive Gas Atmospheres - Part 7: Increased safety e
ELOT EN 60079-10-1 E2	Electrical Apparatus for Explosive Gas Atmospheres – Part 10: Classification of Hazardous Areas
ELOT EN 60079-15	Electrical Apparatus for Explosive Gas Atmospheres – Part 15: Equipment Protection by Type of Protection "n"
ELOT EN 60529	Degrees of Protection provided by Enclosures (IP Code)
ELOT EN 60617	Graphical Symbols for Diagrams

ELOT EN ISO 9001 E4	Quality Management Systems
ELOT EN ISO 14001	Environmental Management Systems - Requirements with Guidance for Use
ELOT HD 384	Requirements for Electrical Installations
ELOT HD 60364	Electrical Installations of Buildings
EN 60034	Rotating Electrical Machines
EN 60034-1	Rotating Electrical Machines - Part 1: Rating and Performance
EN 60034-2-1	Rotating Electrical Machines - Part 2-1: Standard Methods for Determining Losses and Efficiency from Tests (excluding Machines for Traction Vehicles)
EN 60034-5	Rotating Electrical Machines - Part 5: Degrees of Protection Provided by the Integral Design of Rotating Electrical Machines (IP Code) – Classification
EN 60034-6	Rotating Electrical Machines - Part 6: Methods of Cooling (IC Code)
EN 60034-7	Rotating Electrical Machines - Part 7: Classification of Types of Construction, Mounting Arrangements and Terminal Box Position (IM Code)
EN 60034-8	Rotating Electrical Machines - Part 8: Terminal Markings and Direction of Rotation
EN 60034-9	Rotating Electrical Machines - Part 9: Noise Limits
EN 60034-12	Rotating Electrical Machines - Part 12: Starting Performance of Single-speed Three-phase Cage Induction Motors
EN 60034-30	Rotating Electrical Machines - Part 30: Efficiency Classes of Single-speed, Three-phase, Cage-induction Motors (IE-Code)
EN 60072	Dimensions and Output Series for Rotating Electrical Machines
EN 60085	Electrical Insulation - Thermal Evaluation and Designation
EN 60349	Railway Applications - Rotating Electrical Machines for Rail and Road Vehicles. Machines Other than Electronic Convertor-fed Alternating Current Motors

EN 60445	Basic and Safety Principles for Man-machine Interface, Marking and Identification. Identification of Equipment Terminals and of Terminations of Certain Designated Conductors, Including General Rules for an Alphanumeric System
IEC 60034-11-2	Rotating Electrical Machines - Part 11: Built-in Thermal Protection - Chapter 2: Thermal Detectors and Control Units Used in Thermal Protection Systems
IEC 60034-14	Rotating Electrical Machines - Part 14: Mechanical Vibration of Certain Machines with Shaft Heights 56 mm and Higher - Measurement, Evaluation and Limits of Vibration Severity
IEC 60279	Measurement of the Winding Resistance of an A.C. Machine During Operation at Alternating Voltage

4. ACRONYMS

AC	Alternating Current
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ATEX	ATmosphères EXplosibles (Explosive Atmospheres)
ATS	Automatic Transfer System
BMS	Building Management System
BVS	Block Valve Station
BCC	Back-up Control Centre at Nea Messimvria
CCTV	Closed Circuit Television System
CPR	Construction Products Regulation
CP	Cathodic Protection
CPU	Central Processor Unit
CS	Compressor Station
DB	Distribution Board
DC	Direct current
DCS	Distributed Control System

DEG	Detailed Engineering
DIN	Deutsches Institut für Normung (German Institute of Standardization)
DVA	Digital Voice Announcer
DVD	Digital Video Disc
EDG	Emergency Diesel Generator
ELOT	Hellenic Organization for Standardization
ELV	Extra Low Voltage (nominal voltage not exceeding 50 V AC or 120 V DC (ripple-free) between conductors or to earth, as defined by the Standard EN 61558)
EN	European Norms
EPC	Engineering, Procurement and Construction
EU	European Union
ESD	Emergency Shut Down
F&G	Fire and Gas
FACP	Fire Alarm Central Control Panel
FARP	Fire Alarm Repeater Control Panel
FAT	Factory Acceptance Test
FEG	Field Engineering
FC	Floe Computer
FOC	Fibre Optic Cable
GCC	Gas Control Centre at Patima
HEDNO	Hellenic Electricity Distribution Network Operator
HDPE	High Density Polyethylene
HMI	Human Machine Interface
HVAC	Heating Ventilation Air Conditioning
I/O	Input / Output
IEC	International Electrotechnical Commission
ISO	International Organization for Standarization
ITU	International Telecommunication Union
LAN	Local Area Network

LCS	Local Control System
LED	Light Emitting Diode
LFEP	Local Fire Detection & Fire Extinguishing Panel
LV	Low Voltage
LSP	Load Share Panel
MSC/MCS/SMC	Main Station Controller
MV	Medium Voltage
MPS	Master Project Schedule
MPR	Monthly Progress Report
NFPA	National Fire Protection Association
NNGTS	National Natural Gas Transmission System
NTSC	National Television System Committee
O&M	Operation and Maintenance
PID	Piping and Instrumentation Diagram
PA/GA	Public Address / General Alarm
PCS	Process Control System
PED	Pressure Equipment Directive
PEP	Project Execution Plan
PFD	Process Flow Diagram
PLC	Programmable Logic Controller
PMS	Power Management System
POC	Project Organization Chart
PAL	Phase Alternate Line
PPC	Public Power Corporation
PTZ	Pan, Tilt, Zoom
PVC	Poly Vinyl Chloride
QA	Quality Assurance
RCC	Remote Communications and Controls
RFI	Radio Frequency Interference
RTD	Resistance Temperature Detectors
RTU	Remote terminal Unit

S/S	Scraper Station
SAT	Site Acceptance Test
SCADA	Supervisory Control and Data Acquisition (including Telemetry)
SCS	Station Control System
SFP	Small Form-factor Pluggable
SPD	Surge Protection Device
SPL	Sound Pressure Level
UDP	User Datagram Protocol
UPS	Uninterruptible Power Supply
UV	Ultraviolet
VGA	Video Graphics Array
VMS	Video Management Software

5. ELECTRIC MOTORS DESIGN

5.1 Electric Motors Type

LV AC electric motors shall be of the squirrel cage, unless otherwise specified.

Squirrel cage type motors are the most common of motors that are used in industry today. They have the advantage of being relatively economical to make and can be used, in conjunction with the correct starters for most drive applications.

Manufacturer should be able to supply accurate figures for the rating and speed selected. Either higher starting torque or lower starting current can be obtained by different designs of the squirrel cage rotor. These advantages can only be obtained with increase in cost and/or decrease in power factor or efficiency. A high starting torque means a corresponding higher starting current. Similarly a lower starting current results in a reduced starting torque.

Two speed arrangements can be supplied with either tapped winding or double wound motors. The tapped wound motors are usually supplied where one speed is half of the other (e.g. 4/8 pole).

Double wound motors are usually supplied where the speeds are other than half of each other (e.g. 4/6 pole).

The tapped wound motor is cheaper than the double wound but requires more sophisticated control gear for operation.

As a general rule, two speed motors have lower starting torque than single speed motors and in most instances, the starting current is also lower. However, this shall depend on the speeds and motor used.

5.2 Rated Power Selection Criteria

The power rating of the motors shall be determined on the basis of the driven machinery absorbed power, under worst operating conditions (i.e. maximum power demand conditions), and a safety factor from 1.1 to 1.2 times the absorbed power of the driven equipment.

The method outlined below can be used to estimate the power absorbed by the driven machine:

$P = \eta \cdot \sqrt{3} \cdot V \cdot I \cdot \cos\phi$

Where:

P is absorbed power in watts

η is motor efficiency

V is applied voltage

I is absorbed current in amps

cosφ is the power factor

5.3 Electrical supply requirements

The electrical supply to the motors is defined as follows:

- Voltage:
  - 400 V ±10% for process motors and other motors with power 0,37KW,
  - 230 V ±10% for non-process motors with power <0,37KW.
- Frequency: 50Hz ± 5%

- Overload conditions that motors can be exposed according to EN 60034-1:

  - 1,5 x rated current (1,5 In) for up to 2min, for 400 V motors having rated outputs not exceeding 315 kW and rated voltages not exceeding 1 kV
  - 1,6 times the rated torque for 15 s (1,5 times for starting current of less than 4,5 times the rated current)

- Form and symmetry voltages and currents shall be according to EN 60034-1.
- Motors shall be able to operate continuously with, at least, a 4% voltage drop below rated value, under rated load.

Generally, tolerances and electrical parameters shall be according to EN 60034-1.

5.4 Starting and short circuit withstand

In general, direct on line starting shall be used for motors under 7.5 kW. Motors of 7.5 kW and above shall start with star/delta starting or auto transformer starter.

If a very high starting torque is required a larger motor can be used but this shall increase the starting current.

Solid state starters should only be considered if both current limitation and reasonable torque is required.

Where required, variable speed drives shall be used. Variable speed drives ensure high starting torque and low starting current.

The starting current of the LV motors and actuators may be up to 6 - 7 times their rated current (for direct on line starting) and about 2 – 2.3 their rated current (for star/delta starting).

The maximum torque furnished by the motor during starting (starting torque or breakdown torque) must not be higher than the maximum torque for which the driven equipment is calculated.

The stator winding, the rotor cage and the motor base shall be suitably braced and supported as to withstand the forces due to direct on-line starting and transfer conditions, as well as the maximum short circuit forces, with a terminal voltage equal to 110% of rated voltage.

The stator winding and the rotor cage shall have sufficient cross-sectional area to withstand the maximum prospective fault current for the period of time determined by the protective devices.

Cables shall be sized in accordance with the applicable codes and standards.

5.5 Documentation

During detail design, the following drawings and documents shall be developed and submitted to the Client for review, but not limited to:

- Calculations for Electric Motors
- One Line diagrams for Electric Motors
- Electric Motor Layout drawings
- Material Requisitions for Electric Motors

5.5.1 Calculations for Electric Motors

After selection of the appropriate Motor type and size for the specific application, the following calculations for such a Motor shall be provided, as a minimum:

- Protection and control devices sizing
- Cables sizing according to applicable codes and standards

5.5.2 One Line Diagrams for Electric Motors

The One Line Diagrams (Power and Control Circuit Diagrams) for Electric Motors shall include, as a minimum, information about:

- Rated power of each Motor
- Motor control systems
- Protection and control devices ratings and settings
- Types and cross-sections of Motors cables

5.5.3 Electric Motor Layout Drawings

Regarding Electric Motor layout drawings, the following information shall be provided, at least:

- Location of Motors
- Information about types and cross-sections of Motors power supply cables and their routing
- Earthing of Motors

5.5.4 Material Requisitions for Electric Motors

Material Requisitions for Electric Motors shall provide the whole information about technical characteristics, special requirements, quantity of Motors etc, is needed for the supply of Motors.

6. SUPPLY OF ELECTRIC MOTORS

6.1 General

Supply of motors shall include, but not limited to, procurement planning, purchasing, expediting, inspection and testing, spare parts procurement, packaging, shipment, transportation and delivery at site.

Motors shall be selected to comply with the latest editions of relevant EU Directives, Greek Legislation, European Standards and International Codes or Standards, as well as relevant project job specifications or requirements specified in other project documents or drawings. Therefore, all latest approval revisions of relevant project documents and drawings shall be forwarded to Supplier(s).

Apart from motors, Supplier(s) shall submit to the Client their documentation package consisting of necessary drawings and data to cover project requirements.

Procurement of motors shall be performed in accordance with specification for Supply of Electrical Equipment and Materials.

6.2 Shop Inspection and Testing

Electrical Examination and/or testing shall be as per applicable Codes and Specifications, including EN 60034 and IEC 60279.

Motors must have a CE conformity mark, according to all applicable EU Directives.

The manufacturer of motors should have a Quality Assurance System ELOT EN ISO 9001 and ELOT EN ISO 14001 for the motors construction and assembly.

During fabrication and testing, Manufacturer's Quality Department must perform all the required inspection activities.

After final inspection at Manufacturer's Workshops, the Manufacturer shall release copies of test certificates as imposed by the applicable codes or specifications to the Client and/or the Contractor.

Factory tests shall include routing tests and type tests.

7. ELECTRIC MOTORS CONSTRUCTION, INSTALLATION AND CONNECTIONS

7.1 Responsibility

Contractor shall provide labor, supervision, appropriate tools, equipment, consumables, services and all materials and accessories necessary for motors installation and connections. It is Contractor’s responsibility to execute motors installation and connections according to approved detail design drawings and documents, as have been described in paragraph 2.5 of this specification, as well as all relevant specifications and applicable codes and standards.

Contractor's engineers are responsible for:

- receipt and visual check for damages or omissions of motors.
- visual inspection of the execution of motors installation and connections with reference to the applicable Project’s Specifications.
- performing all works according to the safety requirements set by the Supplier and the Local Authorities.
- keeping the corresponding quality records for erection works and examination procedures.
- ensuring the quality of any remedial works that are essential to take place.

7.2 General Notes for Electric Motors Installation and Connections

Cables and cable routing material installation, as well as cable installation accessories and connections related to motors shall be in accordance with job specification for Cables and Cable Routing (Document Number 495-000-SP-ELE-05) and applicable codes and standards. Manufacturer's recommendation and applicable codes and standards for motors installation and connections shall be taken into consideration.

7.3 Construction

LV AC motors shall be constructed in accordance with applicable Codes and Specifications and the manufacturer's practice.

The construction shall be powerful and robust. The stator material shall be cast iron or extra corrosion resistant aluminium alloy or profile-pressed sheet steel. Any type of corrosion shall be avoided.

The stator winding of the motors shall be made of copper. Insulation class of the stator windings shall be at least F and temperature rise corresponding to insulation class shall be at least B, according to EN 60034-1, so as to provide a 25°C minimum safety margin. This can be used to increase the loading by up to 12 percent for limited periods, to operate at higher ambient temperatures or altitudes or with greater voltage and frequency tolerances. It can also be used to extend insulation life.

Rotor winding shall be made of aluminium.

The dimensions of the motors in relation to their power shall be fixed according to EN 60072. Mounting arrangements and the terminal box position of rotating electrical machines shall be in accordance with EN 60034-7.

Unless otherwise specified, the motors shall be provided with a free shaft extension of cylindrical shape with key and keyway. A coupling guard shall be provided.

The relationship between direction of rotation and terminal markings shall be in accordance to IEC 60034-8.

Motors for bridge cranes traveling (if any) shall follow IEC 60349.

Motors shall be in conformity to EN 60034-2-1, concerning the testing methods to be used for determining losses and efficiency, as well as EN 60034-30, which defines efficiency classes for single speed, three phase, cage induction motors.

Efficiency levels defined in EN 60034-30 are based on test methods specified in EN 60034-2-1. In particular, it is required motors to have IE3 efficiency class (or IE2 only for motors with frequency converter drives).

EN 60034-30 covers all motors with the following characteristics:

- Single speed, three phase, 50 Hz and 60Hz
- 2, 4 or 6 poles
- Rated output from 0.75 to 375KW
- Rated voltage up to 1000V
- Duty type S1 (continuous duty) or S3 (intermittent periodic duty) with a rated cyclic duration factor of 80 percent or higher
- Capable of operating direct online

Motors made solely for converter operation and motors completely integrated into a machine that cannot be tested separately from a machine are excluded from EN 60034-30.

The cooling system shall be designated in conformity to EN 60034-6. Motors shall be totally enclosed standard ones, frame surface cooled with fan (IC 411). Cooling type IC 416 (totally enclosed motors with auxiliary fan) should also be available (in case of motors with variable frequency drives, operating at low speeds, for a long time).

All motors shall be provided with ball or roller bearings. Bearings shall be chosen, so as to withstand stresses because of vibration, as well as all stresses involved by the installation mode of the motor according to EN 60034-7. Ball or roller bearings shall be delivered full of grease. They shall not produce increased noise during operation. It shall be easy to inspect them during operation.

All bearings shall be constructed, so that they exclude any ingression of dirt, or water, and they impede the ingression of grease to the interior of the motor.

In case that motors have no auto lubricated bearings, the manufacturer shall determine the frequency of completion or replacement of the amount of grease, as well as the kind of grease to be used.

Temperature detectors shall be located as close as possible to the points of expected maximum temperature. Temperature detectors and corresponding measuring and control equipment shall be in conformity to IEC 60034-11-2. Winding protection shall be 3 PTC thermistors, 150°C, as a minimum.

All motors installed outdoors or in areas with high humidity, as well as, all motors rated 50 kW or above, shall be provided with heating resistors, through separate fused contactor feeders, originated from the same distribution board that feeds the motor.

Heating resistors shall be chosen so as to keep the internal temperature of the motor higher than the dew point corresponding to the actual environmental conditions. When the motor is switched on, the electrical supply to the heating resistors shall be interrupted automatically, whereas when the motor is at standstill, the electrical supply to the heating resistors shall be automatically switched on.

All motors must withstand 20% overspeed for 2 min, according to EN 60034-1 (Table 6).

For motors ≥10 kW, the rotor must be separately balanced, without the coupling and the fan. The coupling and the fan must be separately balanced.

When the motor is uncoupled from any load or prime mover, horizontal and vertical vibrations of speed must be within the limits specified in IEC 60034 14, measured at the points specified by this same standard.

The noise level of motors, measured during no load operation, shall not exceed the limits specified in EN 60034-9 tables I (sound power level) or II/III (sound pressure level). Measurement of sound pressure level is carried out at 1m distance form the enclosure surface.

The enclosures of the motors which shall be installed indoors shall have a protection degree IP 55 (min), according to EN 60034-5 and the ones which shall be installed outdoors shall have a protection degree IP 65 (min).

All motors planned for installation in hazardous areas zone 1 or 2 (if any), shall have a protection method EExd or EExe and shall be suitable for gas group IIB, temperature class T3. In case that motors are intended to be used in hazardous areas zone 2, non-sparking (nA) protection type may be used, in accordance with ELOT EN 60079-15. EEx motors shall be certified in accordance with ELOT EN 60079, and shall be installed in accordance with respective directives, codes and standards.

7.4 Terminal boxes – terminals

Each motor shall be equipped with one main terminal box, including 6 separate terminals for the stator winding.

In general, motors equipped with temperature detectors or/and heating resistors, their terminals shall be located in separate terminal boxes, with the exception of some low power motors.

Terminal boxes shall be installed on accessible points of the enclosure. All terminals shall be designated and marked according to EN 60034 8. Degree of protection shall be identical to that of the motor.

The terminal leads, terminals, terminal boxes and associated equipment shall be suitable for terminating the respective type of cables.

The terminal boxes shall be of sufficient size to enable connections to be made in a satisfactory manner. Cable supports shall be provided with terminal boxes, if required.

The terminal boxes with the cables installed shall be suitable for connection to the supply systems, having an adequate short-circuit capability for the fault clearance time determined by the motor protective devices.

A permanently attached connection diagram shall be mounted inside the terminal box cover.

Terminal boxes shall be totally enclosed and designed to prevent the ingress of moisture and dust.

Depending on the size, the LV motors shall be fitted either with an approved cable sealing and dividing box, or with a gland plate installed in the terminal box and drilled, as required with suitable fittings for the cable entry, which shall be temporarily plugged or sealed during transport.

The insulation rating of the main (stator winding) terminal boxes shall be as follows:

- 400V motors insulation rating : 600 V
- The terminal boxes for the temperature detectors and the heating resistors shall have an insulation rating, at least equal to the insulation rating of the corresponding circuits.

The terminals shall be of adequate form and distances to each other, so that the feeding cables can be easily connected.

The inlet of cables into the terminal box shall be completely dustproof (and water proof for motors installed outdoors) with adequate glands.

All windings ends shall be brought out to terminal blocks or stud type insulators.

7.5 Earthing

Motors shall be provided with an earthing terminal or another device to permit the connection of a protective conductor or an earthing conductor.

The terminal for the earthing conductor shall be situated in the vicinity of the terminals for the line conductors, being placed in the terminal box, if one is provided. Motors having rated outputs in excess of 100 kW (or kVA) shall have in addition an earthing terminal fitted on the frame.

The earthing terminal shall be designed to ensure a good connection with the earthing conductor without any damage to the conductor or terminal. Accessible conducting parts, which are not part of the operating circuit, shall have good electrical contact with each other and with the earthing terminal. When all bearings and the rotor winding of the motor are insulated, the shaft shall be electrically connected to the earthing terminal.

When an earthing terminal is provided in the terminal box, it shall be assumed that the earthing conductor is made of the same metal, as the live conductors.

When an earthing terminal is provided on the frame, the earthing conductor may, by agreement, be made of another metal (for example, steel). In this case, in designing the terminal, proper consideration shall be given to the conductivity of the conductor.

According to EN 60034-1, for other cross-sectional areas of live conductors, the earthing or protective conductor shall have a cross-sectional area at least equivalent to:

– that of the live conductor for cross-sectional areas less than 25 mm^2;

– 25 mm2 for cross-sectional areas between 25 mm^2 and 50 mm^2;

– 50 % of that of the live conductor for cross-sectional areas exceeding 50 mm^2.

The earthing terminal shall be identified in accordance with EN 60445.

Specification for Earthing and Lightning Protection System and Electrical Std Details shall be taken into consideration.

7.6 Nameplate

Each motor shall have a name plate mounted in such a way that it may be easily read even when the driven machine is in operation. The nameplate shall be made of stainless steel and shall include the following information, but not limited to:

- Name of manufacturer
- Serial number
- Insulation class
- Ingress protection
- Motor weight
- Type of bearings

as well as,

- Nominal speed
- Nominal power
- Rated current
- Rated frequency
- Power factor

for various operation voltages.

The following information must also be shown on the motor rating plate, according to EN 60034-30, as a minimum:

– Lowest nominal efficiency at 100, 75 and 50 percent rated load

–Efficiency level (IE)

–Year of manufacture

In a separate plate, mounted as to be easily read during operation, lubricating instructions shall be included, in case that lubrication is required.

7.7 Inspection and Testing

Field and testing of motors shall be carried out by properly qualified and experienced personnel with calibrated test equipment provided by the Contractor.

Field inspection and testing shall also be witnessed by Client Representative.

Inspection and testing shall be according to project documentation or / and applicable codes and standards. Minimum test requirements are described below.

Check and confirmation of all nameplate information of the motor for compliance with the manufacturer's recommendation and this document shall be provided.

Insulation resistance tests shall also be provided.

Correct alignment of motor, as well as direction of rotation, bearing temperature, vibration and noise shall be checked.

Full and partial load tests on motor shall be provided.

Protection devices ratings and settings shall be checked.

A complete record of all tests that shall be carried out and their results shall be retained.

7.8 As-Built Documentation

At the completion of the works, a copy of all related project drawings, where all modifications and variations marked in red, shall be provided to Client Representative and as-built drawings shall be issued.