

|             |                        |          |
|-------------|------------------------|----------|
| <b>15</b>   | <b>ELECTRIC MOTORS</b> | <b>2</b> |
| <b>15.1</b> | <b>GENERAL</b>         | <b>2</b> |
| 15.1.1      | Submittals             | 2        |
| 15.1.2      | References             | 2        |
| <b>15.2</b> | <b>PRODUCTS</b>        | <b>3</b> |
| 15.2.1      | Motor Enclosures       | 3        |
| 15.2.2      | DUTY                   | 4        |
| 15.2.3      | Induction Motors       | 4        |
| <b>15.3</b> | <b>INSTALLATION</b>    | <b>9</b> |
| 15.3.1      | General                | 9        |
| 15.3.2      | Factory Tests          | 9        |
| 15.3.3      | Field Checks           | 9        |

## 15 ELECTRIC MOTORS

### 15.1 GENERAL

#### 15.1.1 Submittals

- 1 Submit for QGEWC/Engineer approval, shop drawings, factory test reports, manufacturer's certified reports and technical data for motors supplied with driven equipment to the extent required in this Section and the Specification Sections for mechanical equipment.
- 2 Shop Drawings. In addition to information to be included in the shop drawings as specified in Part 1, shop drawings shall include the following:
  - (a) motor locked rotor and full load currents
  - (b) power factors and efficiencies at full load, three quarters load and half load
  - (c) motor housing material, winding material, ambient temperatures and maximum elevations in which motor is designed to operate continuously, service factor, insulation Class, temperature rise, type of enclosure, voltage, bearing life and dynamic balance; all of which shall comply to the requirements of the specifications.
  - (d) nameplate data
  - (e) dimensions, weights and mounting details of motors.
  - (f) motor construction details
  - (g) speed torque/current at 100 % volts
  - (h) wiring diagrams, internal and typical external connections.
- 3 Current Data. Submit eight copies to the Engineer of field recorded current data. The data shall indicate the full load current for each motor, and current rating for the overload relay in each motor starter and controller.

#### 15.1.2 References

- 1 The following standards or revised/updated versions are referred to in this Part:
  - BS 2048.....Dimensions for fractional horse-power motors (BS-5000-11)
  - BS 4999.....Winding terminations
  - BS 5000.....Rotating electrical machines of particular types or for particular applications
  - EN 60034-5 .....Rotating electrical machines - Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) – Classification; (IEC 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); (IEC 60034-6 Rotating electrical machines - Part 6: Methods of cooling (IC Code))
  - EN 60034-9 .....Rotating electrical machines - Part 9: Noise limits; (IEC 60034-9 Rotating electrical machines - Part 9: Noise limits)
  - BS 2757.....Method for Determining the Thermal Classification of Electrical Insulation (EN 60085: Electrical insulation. Thermal evaluation and designation; IEC 60085 Electrical insulation - Thermal evaluation and designation)

## 15.2 PRODUCTS

### 15.2.1 Motor Enclosures

- 1 Motor enclosures shall be selected from EN 60034-5 as follows: -
  - (a) for submersible applications the enclosure shall be IP68 and be capable of being continuously submersed to a depth of at least 2 metres greater than the maximum immersion depth of the application. Where such motors are to be installed in an area designated as potentially explosive then it shall have the appropriate BASEEFA/CENELEC or other similar National Testing Organisation Certification. Copies of the Certificates shall be submitted. Motors to be used in sewage wet wells shall be certified for use in a Zone 2 area and Certificates shall show that the motors were tested at an ambient temperature of 55°C. They shall be certified in accordance with BS 4683 Parts 1 and 2 classification Ex d IIA T3.
  - (b) motors shall be of the submersible squirrel cage rotor induction type suitable for operating in the specified medium (sewage, effluent etc.).
  - (c) motors shall be suitable for continuous operation when immersed in the specified medium and when the motor is above the specified medium in an ambient temperature of 50°C.
  - (d) the motors shall be entirely waterproof and provided with adequate cooling facilities which shall be achieved either by the surrounding liquid in the sump or by providing a motor jacket cooling system supplied with liquid from the pump volute.
  - (e) terminal boxes shall be watertight and the motor shall be supplied with an adequate length of multi-core heavy duty flexible cable with tough rubber outer sheath.
  - (f) the cable shall pass through a watertight gland on entry into the motor body.
  - (g) the rotor and impeller assembly shall be dynamically balanced at the duty speed.
  - (h) for indoor applications the enclosure shall be to IP54 of EN 60034-5. Submersible motors that are to be installed in dry wells shall be to IP 68 of EN 60034-5. The cooling method shall be exactly the same as if the motor was installed in a submerged condition. Under no circumstances will an external cooling fan be permitted on dry installed submersible motors.
  - (i) for outdoor application the enclosure shall be to IPW55 of EN 60034-5. A certificate shall be issued by the manufacturer certifying the motor suitability for the outdoor application, in the service conditions as described under the general section of this specification.
  - (j) for high voltage motors the enclosure shall be protected to IP55 of BS 4999 Part 105
- 2 Unless stated otherwise, stator frames shall be of cast iron, foot and flange mounted as required by the Contract. Aluminium frames are permitted for 2.2 kW motors and smaller only. Ductile stainless steel frames shall be used, when specified in the particular specification, for aggressive sewage conditions, and shall be of grade 316L minimum.
  - (a) lifting facilities shall be provided on all motors
  - (b) submersible motors shall be protected by a tandem mechanical seal arrangement. Lip seals are not permitted. The Contractor shall provide complete data on the seal materials, seats, faces etc., and ensure suitability for the medium being sealed i.e. oil chamber, oil and supernatant.
  - (c) on pumps greater than 2.2 kW the mechanical seal performance shall be monitored by monitoring equipment to detect the following:- (alarm indication shall be transmitted on Motor starter panel.)

- (i) moisture within the oil chamber.
- (ii) moisture/water or oil within the motor casing.
- (iii) temperature rise of the hydraulic driven end bearing.
- (iv) loss of oil from the oil chamber.
- (d) motors installed outdoors shall be protected from direct sunlight. Fan covers and cooling fans shall be metallic. Plastic fan covers and/or fans shall not be permitted on motors installed outdoors. Sunshades on motors/machinery should be sized such that cable entry points and the ends of cable trays are protected from sunlight. Sun/weather protection shades shall be manufactured from welded mild steel, hot dip galvanised after manufacture, or stainless steel. There shall be no sharp edges or dangerous protrusions on any sun/weather protection shades.

### 15.2.2 DUTY

- (a) Motors shall be selected to satisfy the performance requirements of the particular application and with any relevant QGEWC starting current restrictions.
- (b) Motors shall be capable of continuous operation under all duty conditions at:
  - i. Maximum brake power absorbed by the driven load not less than that stated in Table.
  - ii. Maximum rated torque without adverse affect or overheating.
- (c) Where flywheels are fitted to the main pump set, the motors shall be capable of starting and driving the pumps under these conditions.
- (d) Motor characteristics shall allow starting of the motor by employing variable frequency drive and/or electronic soft starters, ensuring compatibility at all points in the operating range and derated accordingly with particular attention being given to the following:
  - i. Heating carried by harmonics in the non-sinusoidal waveform produced by the inverter or soft starter.
  - ii. Reduced cooling at low motor speeds due to the reduced effectiveness of the cooling fan.
- (e) Rating plate information, as detailed in BS 4999 Part 101 or equivalent, shall be embossed on a metallic, corrosion-resistant rating plate fixed to the motor casing.
- (f) The motor and all components shall be rated and braced to withstand the maximum prospective fault level at the point of installation as detailed by the Contract.
- (g) Unless required by the Contract, motors shall have a maximum speed corresponding to 4-pole construction at 50Hz. Where super synchronous operation is required, full details of the motor capability at maximum speed shall be advised.

### 15.2.3 Induction Motors

#### 1 General:

- (a) motors shall be supplied by the manufacturer of the driven equipment as specified in this section, and specifically outlined in the driven equipment specifications

- (b) all motors shall be suitable for operation on a 415V or 690V, 50 Hz 3 phase supply. Different voltage levels may be used as indicated in particular specifications or drawings
- (c) All motors shall be capable of starting 10 times per hour. The stalled motor current shall not exceed 6 times full load current
- (d) All motors shall be commercially silent in operation and run free from vibration and the rotors shall be perfectly balanced both statically and dynamically and shall be tested and adjusted for dynamic balance in an approved manner
- (e) All motors shall be fitted with anti-condensation heaters of a size to maintain the temperature of the windings 5 °C above ambient. Each heater shall be provided with a switch and automatic control to disconnect it when its motor is in operation
- (f) Terminal Boxes
  - (i) Terminal boxes shall be cast iron and shall be designed to accept XLPE or PVC armoured cable as detailed in the Contract. On non-submersible motors, terminal boxes shall be mounted on the right hand side when viewed from the driving end of the motor, unless otherwise required by the Contract.
  - (ii) The motor stool base where appropriate shall be drilled at works vertically below the terminal box gland for the passage of the cables and the edges of the hole slightly countersunk or the hole bushed.
  - (iii) Motor terminals shall be stud-type, substantially designed, anchored to a carrier terminal block and insulated from the motor frame. Terminals shall be identified in accordance with BS 4999 Part 108 or equivalent. A separate earth stud shall be included on each terminal box. Heater terminals shall be shrouded and prominently labelled.
  - (iv) Adequate space and glanding arrangements shall be provided, particularly on smaller motors requiring glanding and terminating of steel wire armoured cable for star/delta starting, anti-condensation heating and thermistor winding protection devices.
  - (v) Where a common terminal box is used for main, heater and thermistor cable terminations, a permanent warning label shall be fixed to the terminal box cover. In addition, heater and thermistor cable terminations shall be clearly marked to identify their separate functions and operating voltages.
  - (vi) Terminal box covers shall be gasketed to provide a degree of protection equivalent to or better than that of the motor.
  - (vii) For Ex 'd' flameproof motors, terminal boxes may employ Type 'e' increased safety protection, utilising indirect cable entry to the flameproof enclosure. However, this must be of the same type used to obtain the potentially explosive hazardous area motor certification.
  - (viii) 3.3kV motor cable termination boxes shall be high fault level type, with segregated phases, pressure relief diaphragm and sealing chamber.
- (g) arrangements shall be made with the manufacturer so that the Engineer shall witness motor tests for motors with power larger than 75 kW as specified in the FAT testing paragraph.
- (h) the motors shall run in ball and/or roller bearings and the weight of the motor shall be carried by thrust bearings incorporated in the motor body
- (i) bearings shall be grease lubricated using hydraulic type nipples which are freely accessible without any dismantling, or otherwise piped out to a readily accessible location

- (j) "Sealed for Life" bearings shall not normally be used. However, for small motors the Engineer may allow the use of sealed for life bearings.

2 Motor Ratings:

- (a) The efficiency and power factor of the motors shall be high over a wide range of load conditions. The motors shall be designed, manufactured and tested in accordance with BS 4999 and BS 5000 (or BS 2048 and BS 5000 in the case of small horsepower motors) for continuously rated industrial electric motors and Class "H" insulation but limited to Class 'B' temperature rise. This shall be in addition to any adjustments necessary for high ambient temperatures at site. The maximum continuous rating (MCR) of each motor shall be as set out in Table 15.1 and shall be rated and designed to suit the climatic conditions at site. This reserve power requirement shall be added to the calculated power prior to any other adjustments e.g. high ambient temperatures at site

Table 15.1  
MCR Ratings

| Application  | Up to 75 kW drive   | Above 75 kW drive  |
|--|---|--|
| All pump motors (excluding positive displacement type) | 10% above that required under all conditions of operation | 5% above that required under all conditions of operation |
| Positive displacement pumps and compressors            | 25% above maximum duty requirements                       | 12.5% above maximum duty requirements                    |

- (b) motor starters shall be selected from the following to satisfy the stipulated performance requirements and comply with QGEWC starting current restrictions:-
- motors up to 11 kW (15 hp) shall be squirrel cage suitable for DOL starting having a starting current not greater than 6 x full load current (FLC)
  - motors between 11 kW (15 hp) and 37.5 kW shall have their starting current restricted to 4 x FLC and shall use one of the following starting methods; as indicated in the Project Drawings or the Project Documentation:-
    - Solid State Reduced Voltage (Soft) Start with torque characteristics suitable for the application
    - Star - Delta
  - motor over 37.5 kW shall have their starting current restricted to 2.5 FLC and shall use one of the following starting methods:
    - Solid State Reduced Voltage (Soft) Start with torque characteristics suitable for the application
    - VFD
  - submersible pump motors because of inherent design are to generally comply with the foregoing. The starting method is to be restricted to DOL, Star-delta, soft start or VFD according to rating. In case of VFD starter, the pump manufacturer shall confirm the motor is suitable designed for VFD operation.
- (c) motors shall be suitable and certified for the zone of hazard in which they are to be installed
- (d) where flywheels are fitted to the main pump set, the motors shall be capable of starting and driving the pumps under these conditions.

3 Motor Cooling

- (a) non-submersible motors shall be air cooled to IC 41 of EN 60034-6.
- (b) cooling of submersible motors shall be an efficient system to the manufacturer's design.

4 Motor Windings

- (a) motor windings shall be copper and treated to render them impervious to moisture, saline atmospheres, acid/alkaline fumes, oil and grease. They shall be adequately braced to prevent movement of coils during all conditions of service and be insulated throughout to Class H of BS 2757 or equivalent with a temperature rise limit of Class B. This provision shall be in addition to any adjustments necessary for ambient temperatures at site of 55°C
- (b) motor operating voltage and connection type shall be clearly stated on the motor nameplate.
- (c) for high voltage motors, the stator windings shall use a modern synthetic resin insulation system based on mica glass tape continuously wound on the coils to give a void-free homogeneous structure. The end windings shall be securely braced to prevent harmful movement arising from electro-magnetic and mechanical forces. The rotor bars shall be securely keyed into the rotor. The rotor shall be shrunk and keyed onto the shaft.

5 Thermal Protection

- (a) all motors rated at 11 kW and above shall be equipped with thermostatic contact elements in accordance with QGEWC Regulation 801. Six thermostats shall be provided (3 in use, 3 spare) to BS 4999 Part 111 to give Class 1 protection. Thermostats shall be of the normally closed (break on temperature rise) type. They shall operate at 140°C on rising temperature and shall be complete with leads and terminals.
- (b) when thermistors are specified six shall be provided (3 in use, 3 spare) to BS 4999 Part 111 to give Class 1 protection. Thermistors shall be PTC type P140 and shall be complete with control units for motor tripping.
- (c) when embedded resistance thermometers are specified six shall be provided (3 in use, 3 spare) either in the stator slots or end windings. They shall be of the platinum wire type compensated for 0°C at 100 ohms (Pt. 100). They shall be complete with evaluating unit and remote temperature indicators with set points for over temperature alarms.
- (d) when motor winding thermocouples are specified six shall be provided (3 in use, 3 spare) either in the stator slots or end windings. They shall be complete with remote temperature indicator with set points for over-temperature alarm.
- (e) When motor winding RTD's (Resistance Temperature Detectors) are specified six shall be provided (3 in use, 3 spare) either in the stator slots or end windings.
- (f) when bearing temperature indicators are specified the sensors shall be Pt. 100 resistance thermometers installed as close as possible to the bearing and complete with remote temperature indications with set points for alarm.
- (g) when cooling air temperature indicators are specified two shall be provided to monitor both the warmed air and the fresh air. The sensors shall be Pt. 100 resistance thermometers installed in the air passage and complete with remote temperature indications with set points for alarms.



- (h) where thermostats or thermistors are used in explosion proof designs, the devices must be of the same type used to obtain the potentially explosive hazardous area motor certification.

6 Submersible motor cables

- (a) submersible motors shall be complete with lengths of black PTFE covered flexible cable for Power, Signalling and Protection purposes.
- (b) each cable shall be a minimum of 20 metres long or as otherwise required by the Contract, and shall be rated in accordance with the cable routing details. As a minimum cables shall be continuously rated to carry the motor full load current when laid in a classified area to the approval of QGEWC. The cable shall be factory fitted according to the connection of the motor winding.
- (c) flexible cables for use in potentially explosive atmospheres shall be identical to those types used to obtain the potentially explosive hazardous area combined motor/cable certification. Where protection cables are part of an intrinsically safe circuit the outer sheath shall be coloured blue.
- (d) jointing of cables is not acceptable.
- (e) cables shall be laid such that there is no fouling of the submersible pump whilst lifting or lowering. The extra length of cable shall be relaxed and not coiled.

7 Bearings

- (a) the motors shall run in ball and/or roller bearings and the weight of the motor shall be carried by thrust bearings incorporated in the motor body.
- (b) maximum life bearings with oil seals shall be fitted to both drive end and non-drive end bearing housings to prevent ingress of solid particles and liquids. Bearings shall be in accordance with BS 292 or equivalent.
- (c) bearings that are not sealed for life shall be grease lubricated and shall be fitted with a means for replenishing the grease and a relief device for disposal of excess grease. Hydraulic button head grease nipples in accordance with BS 1486 Part 2 or equivalent shall be provided and shall be extended, where necessary, such that they are located at the top of the frame. Re-greasing points shall be located for ease of access.
- (d) bearing temperature monitoring facilities shall be provided on submersible motors over 75 kW and on non-submersible motors over 100kW.
- (e) All VFD controlled motors shall be provided with insulated bearings to prevent bearing failure due to circulating rotor currents. Confirmation from Motor manufacturer shall be provided that the motors are suitable for VFD (Variable speed Drive) continuous operation.

8 Noise Levels

- (a) unless otherwise required by the Contract, the noise levels (Sound Power Levels dB(A)) of the motors shall be in accordance with EN 60034-9.

9 Paint finish

- (a) the paint finish shall be entirely compatible with the environment to which the motors will be subjected. This shall consist of an anti-corrosion primer/undercoat with a 2 part heavy duty epoxy resin paint or such other paint finish determined by the application, and as detailed in the specification for Corrosion Protection.



### 15.3 INSTALLATION

#### 15.3.1 General

- 1 Provide all the equipment installations and wiring installations, including connections as indicated, specified and required. Assure proper fits for all equipment and materials in the spaces as shown on the Drawings.
- 2 Motor:
  - (a) provide power, control, alarm and earthing installations for all motors as indicated and required
  - (b) check the connections to provide correct rotation for all motors
  - (c) record the full load current to each motor, and the overload relay rating in each motor starter for the certified data submittal
  - (d) provide the wiring for heaters in the motor frames and the required controls to de-energise the heater when the motor operates (if applicable)
  - (e) provide the required wiring for all equipment that shall be furnished and installed according to other relevant Sections of the Specifications
  - (f) install the control stations and/or emergency stop units on steel stanchions or building structures near motors, if specified and as shown on the Drawings. Control stations, where required in accordance with the particular specification, shall incorporate a "Local/Remote" switch, "On/Off" switch and the emergency stop unit
  - (g) field damaged factory finish on equipment shall be touched-up with paint that is equal in quality and colour to the original factory finish.

#### 15.3.2 Factory Tests

- 1 Factory tests shall be carried out as follows
  - (a) All motors:
    - No load current
    - High voltage on windings and auxiliary
    - Windings resistance
    - Vibration
  - (b) One motor:
    - Full load heat run and temperature rise
    - Efficiency at 100 %, 75 %, 50 % and 25 % load
    - Power factor at 100%, 75%, 50% and 25% load
    - Noise
    - Momentary overload
  - (c) Type test certificate shall be provided for all motors to cover as a minimum the following:
    - Locked rotor current
    - Locked rotor torque
    - Saturation curves
    - Percent slip
- 2 The Contractor shall provide calculations to demonstrate motor power rating and bearing life with derating factors taken into account.

#### 15.3.3 Field Checks

- 1 Motor Installations shall be complete and correct.
- 2 Operation tests shall be performed to observe that motors start, run and stop satisfactorily under design load.

END OF PART