

**WATER SUPPLIES DEPARTMENT**  
**STANDARD SPECIFICATION E-51-05**  
**MOTORS OF 40-140 kW FOR SUBMERSIBLE PUMP**

1 **TECHNICAL REQUIREMENTS**

1.1 **General**

This standard specification is for submersible motors of rating between 40 kW and 140 kW, and used in clear water applications unless otherwise specified.

The motor shall comply with the following requirements:

- (a) Type : Energy efficient squirrel-cage type induction motor with the following minimum full load efficiency:

Rated Output Power	Minimum Motor Efficiency
40 – 75 kW	86%
76 – 140 kW	87%

- (b) Degree of protection : IP68 to IEC 60034-5 for continuous submersion in water.

- (c) Duty rating : Maximum continuous rating (MCR), S1 duty to IEC 60034-1.

- (d) Insulation : Dry-type Motors - Class F design with temperature rise not exceeding the limits applicable to Class B in IEC 60034-1.

Water-filled Motors - Class Y design with temperature not exceeding the limit specified in IEC 60085.

- (e) Max. speed : 1500 rpm other than borehole motors.

1.2 **Operating Conditions**

- (a) Ambient air temperature : 40°C maximum continuous for 4 hours.  
35°C average over 24 hours.  
5°C minimum.

- (b) Humidity : Up to 98% relative humidity.

- (c) Water temperature range : 5°C - 40°C

1.3 **Electrical Conditions**

- (a) Electricity supply : 380V three-phase, 50 Hz, four-wire system with solidly earthed neutral.

- (b) Voltage variations : -10% to +6%
- (c) Frequency variations :  $\pm 2\%$

#### 1.4 Standards

The equipment supplied shall comply with the latest version of the relevant international standards. In particular, the following standards are applicable:

IEC 60034	Rotating electrical machines.
IEC 60085	Electrical insulation – Thermal evaluation and designation
IEC 60529	Degrees of protection provided by enclosures (IP code)

## 2 STARTING PERFORMANCE AND RATING

The motor shall be suitable for both direct-on-line (DOL) and soft/auto-transformer starting. The DOL starting current at rated voltage shall not exceed seven times the full load current.

The starting time (time taken to attain 90% of the rated speed) under the most arduous conditions shall be as follows:

- 85% rated voltage at motor terminals - not more than 4 seconds.
- 49% rated voltage at motor terminals - not more than 10 seconds.

At the lowest specified voltage across the motor winding (i.e. 49% of motor rated voltage), the accelerating torque at any speed up to the peak torque point shall be not less than 10% of the motor rated full load torque.

The motor shall be suitable for two starts in succession followed by a cooling period of 30 minutes before attempting another starting sequence. The motor shall also be capable of at least three starts per hour, equally spaced, during normal operating conditions.

The uncorrected power factor of the motor shall be not less than 0.83 lagging at full load.

When used in conjunction with a variable speed drive (VSD) or inverter supply, the motor shall be designed with reference to IEC TS 60034-17 or other equivalent standards to withstand over-voltage, higher rate of rise of voltage, over-heating due to harmonics, flow of bearing current and other stressing effects arising from the pulse width modulated (PWM) waveform of the supply voltage.

## 3 DESIGN AND CONSTRUCTION

### 3.1 Enclosure and Cooling

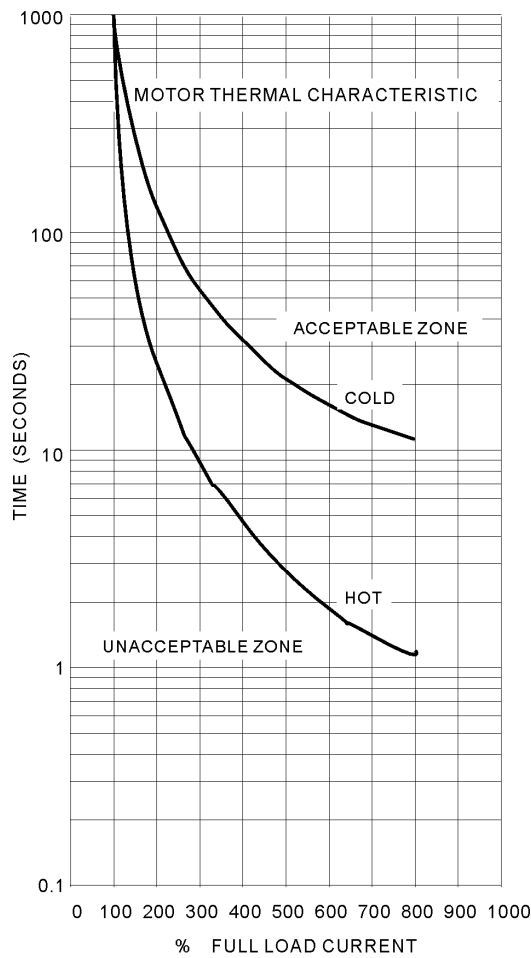
Motors filled with oil for cooling shall not be used.

The motor shall have a cast iron casing unless otherwise specified. It shall have lifting lugs for easy handling during erection or maintenance.

Water-filled type motor shall have self-circulation cooling to IEC 60034-6, characteristic code IC4W1W0 (viz. machine cooled by water in an internal closed circuit and immersed in water externally). Dry-type motor shall have self-circulation cooling to IEC 60034-6, characteristic code IC4A1W0 (viz. machine cooled by air in an internal closed circuit and immersed in water externally).

### 3.2 Short-time Characteristic

The short-time overload withstand characteristic of the motor shall be within the acceptable zone as shown in the graph below.



Motor Short-time Overload Withstand Characteristic

Alternatively, provision of a dedicated motor protection relay complete with current sensing devices for protecting the motor may be acceptable if the short-time overload withstand characteristic of the motor deviates from the above graph. Technical details of the protection relay shall be submitted for approval. The relay set supplied shall be housed in an enclosure suitable for external mounting and with a degree of protection IP55 to IEC 60529.

### 3.3 Motor Stator Winding

The stator winding shall be designed for a minimum life of 25 years of service at rated load and voltage.

3.4 Bearings

Motor bearings shall be of rolling type and metric sizes. Approved type thrust and guide bearings shall be provided for vertical-shaft motors. The life of bearing shall be not less than 50,000 hours under the most onerous conditions.

3.5 Cabling and Termination

Power supply and control cables shall be supplied integral with the motor. The length of the power supply and control cables shall be the duty pump head plus 10 metres unless otherwise specified.

The power supply cable shall be waterproof, flexible, resistant to abrasion and impact, of adequate current rating and complete with an integral earth continuity conductor. The earth continuity conductor shall have the same current carrying capacity as the line conductors and terminate at an earthing terminal inside the casing. Cable cores shall be identified by colour codes or lettering. The cable shall have insulation and an oversheath of synthetic rubber. The cable shall be of 450/750V grade to BS EN 50525 or other equivalent international standard with a maximum conductor temperature of 85°C.

The cable and termination at the motor end shall be suitable for continuous operation under water and shall have the same degree of protection as for the motor. The other end of the cable shall be suitably sealed to keep out of moisture.

Unless otherwise specified, the minimum size of the power supply cable shall be selected from Table 1 below. In addition, the voltage drop on the cable at full load shall not be greater than 2.5%.

Table 1 - Power Supply Cable Schedule

Stranded Copper Size (mm <sup>2</sup> )	Permissible Motor Rated Full Load Current for one cable (A)
25	76
35	94
50	114
70	145
95	176
120	203
150	234
185	266
240	313

3.6 Markings and Data Plates

An instruction plate and a data plate of stainless steel shall be provided. The

instruction plate shall give the connections and the phase sequence for the required direction of rotation while the data plate shall be stamped with the information specified in IEC 60034-1.

#### 4 EMBEDDED TEMPERATURE DETECTORS

Unless otherwise specified, motors of 70 kW or above shall be provided with a set of Embedded Temperature Detectors (ETDs) to monitor the temperature of the stator winding and to afford protection against over-heating in accordance with IEC 60034-11. An ETD monitoring unit in an enclosure with a degree of protection IP55 to IEC 60529 and suitable for external mounting, shall be supplied.

Thermistors of positive temperature coefficient (PTC) type, thermo-couples or resistance temperature detectors may be used as ETDs. Alarm and trip contacts at the monitoring unit shall be set to operate at 120°C and 140°C respectively. For water-filled motors, the alarm/trip settings shall be 60°C/70°C or other values as recommended by the manufacturer.

The monitoring unit shall operate at 220V a.c. 50 Hz unless otherwise specified. The contact rating shall be 5A, 220V 50 Hz inductive.

For motors of rating less than 70kW, winding embedded thermostat switches shall be used.

#### 5 INSPECTION AND TESTING

##### 5.1 Inspection and Testing at the Manufacturer's Works - General

The motors shall be inspected and tested together with the submerged pumps at the manufacturer's works prior to shipment under the witness of the Independent Inspection Body.

Measuring instruments (ammeter, voltmeter, wattmeter etc.) used during tests shall be of accuracy  $\pm 0.5\%$  or better.

The inspection work shall in general cover the following:

- (a) General inspection checks including physical dimensions, workmanship, quality, quantity, and standards.
- (b) Check on model and nameplate data.
- (c) Functional checks of correct operation, alarms, indications and setting of equipment.
- (d) Packing and protection checks.

Inspection reports/certificates with description on test arrangement, circuits, calculations, and test results shall be forwarded to WSD within one week from the

date of inspection.

5.2 Test Requirements for Motors

The following tests shall be conducted at the manufacturer’s works in accordance with the specified applicable standards:

<u>Tests</u>	<u>Standards</u>
(a) Resistance of windings (cold) and direction of rotation	IEC 60034-1
(b) Motor current and power factor at pump duty points	-
(c) Withstand voltage	IEC 60034-1
(d) Vibration	IEC 60034-14

5.3 Test on ETDs

Embedded temperature detectors shall be calibrated prior to fitting onto the winding in accordance with IEC 60034-11. The calibration needs not be witnessed by the Independent Inspection Body but the calibration report shall be submitted for verification during the motor works test.

6 INFORMATION FOR EQUIPMENT APPROVAL

6.1 Descriptive Literature and Performance Data

Descriptive literature and performance data relevant to the motor, ETDs and ETD monitoring units shall be submitted for assessment.

6.2 Motor Starting Torque Characteristics

The following torque-speed characteristics shall be furnished for assessment:

- (a) Torque characteristic at rated voltage.
- (b) Torque characteristic at the lowest specified voltage across the motor terminals.

The Y-axis shall be torque in N-m while the X-axis shall be the motor speed in rpm. Characteristic curves plotted on per-unit values are not acceptable.

6.3 Type Test Reports

The following type test reports to IEC 60034, conducted by the manufacturer on motor of the same design, frame size and construction shall be submitted for assessment.

<u>Tests</u>	<u>Standards</u>
(a) Temperature rise	IEC 60034-1

- |                                     |               |
|-------------------------------------|---------------|
| (b) Power factor at rated load      | -             |
| (c) Locked rotor torque             | -             |
| (d) Starting (locked rotor) current | -             |
| (e) Efficiency at rated load        | IEC 60034-2-1 |

- End of this Specification -