WATER SUPPLIES DEPARTMENT

STANDARD SPECIFICATION E-51-03

SQUIRREL CAGE INDUCTION MOTORS OF 40-140 kW RATING

1 TECHNICAL REQUIREMENTS

1.1 General

This standard specification is for low voltage squirrel cage induction motors of rating between 40 kW and 140 kW.

The motor shall comply with the following requirements:

(a) Type : Energy efficient squirrel-cage induction motor to Class IE3 or higher of IEC 60034-30-1. The motor shall demonstrate minimum full load efficiency values as specified in IEC 60034-2-1:

For motors with efficiency classification IE3

Rated output power	Minimum motor efficiency with the following number of poles / synchronous speed	
	4 poles / 1500 rpm	6 poles / 1000 rpm
45 kW	94.2%	93.7%
55 kW	94.6%	94.1%
75 kW	95.0%	94.6%
90 kW	95.2%	94.9%
110 kW	95.4%	95.1%
132 kW	95.6%	95.4%

For motors with efficiency classification IE4

Rated output power	Minimum motor efficiency with the following number of poles / synchronous speed	
	4 poles / 1500 rpm	6 poles / 1000 rpm
45 kW	95.4%	94.8%
55 kW	95.7%	95.1%
75 kW	96.0%	95.4%
90 kW	96.1%	95.6%
110 kW	96.3%	95.8%
132 kW	96.4%	96.0%

(b) Degree of protection : Totally enclosed IP55 to IEC 60034-5.

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

(d)	Insulation	:	Class F design with temperature rise not exceeding the limits applicable to Class B in IEC 60034-1.
(e)	Maximum speed	:	1,500 rpm at 50Hz (4 poles) 1,000 rpm at 50Hz (6 poles)
(f)	Noise level	:	Mean sound power level (Lw) in dB(A) for airborne noise emitted by motor not to exceed the limits in Table 2 of IEC 60034-9.
(g)	Vibration level	:	Grade A of IEC 60034-14

1.2 Operating Conditions

(a)	Altitude	:	Not greater than 1,000 m.
(b)	Ambient temperature	:	40℃ maximum continuous for 4 hours. 35℃ average over 24 hours. 5℃ minimum.
(c)	Humidity	:	Up to 98% relative humidity.

1.3 Electrical Conditions

(a)	Electricity supply	:	380V three-phase, 50Hz, four-wire system with solidly earthed neutral.
(b)	Voltage variations	:	+6% to -10%
(c)	Frequency variations	:	±2%

1.4 Standards

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

(a)	IEC 60034	Rotating electrical machines
(b)	IEC 60072	Dimensions and output series for rotating electrical machines
(c)	IEC 60085	Electrical insulation – Thermal evaluation and designation
(d)	IEC 60529	Degrees of protection provided by enclosures (IP code)
(e)	ISO 281	Rolling bearings - Dynamic load ratings and rating life

1.5 Starting Performance

The motor shall be suitable for both direct-on-line (DOL) and star/delta starting. For motor with efficiency class IE3 or IE4, the DOL starting current at rated voltage shall not exceed 7.5 times and 8.6 times respectively.

For pump and fan applications, 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.

When the voltage across the motor terminals is 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.

2 RATING

For the procurement of motors supplied together with pumps, the rated motor power output shall be not less than 110% of the maximum power absorbed by the pump over the entire pump operating range specified for the pumpset.

For the procurement of motors intended to replace existing aged units, the rated motor power output shall be not less than 120% and 115% of the maximum power absorbed by the pump over the entire pump operating range specified for (1) fresh water or raw water pumpset; and (2) salt water or recycled water pumpset respectively.

For other applications, the motor power margin shall be not less than 10% unless otherwise specified.

The foregoing power margin shall not be reduced by any factors such as tolerances of pumpset or accuracy of test equipment.

The uncorrected power factor of the motor shall be not less than 0.85 and 0.83 lagging at full load for 4-pole and 6-pole motors respectively.

The motor shall be designed with reference to IEC TS 60034-25 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

Dimensions and frame number of motor shall comply with IEC 60072. Motors of the same rating shall be interchangeable.

The motors shall have cast iron casings. Acoustic enclosures shall not be used.

Motors shall be provided with lifting lugs for easy handling during erection or maintenance.

The colour of final coat of the motor shall be same as the pump.

3.2 Ventilation and Cooling

Motors shall be designed for method of cooling IC416 or IC411 to IEC 60034-6.

The motor air inlet shall normally be arranged to draw ventilating air directly from the surroundings.

For IC411 cooling method, the motor ventilating fan at non-drive end (NDE) shall be directly driven by the motor, i.e., with no auxiliary power supply required and complete with a detachable steel fan cover. The motor shall be designed such that at the worst operating condition and rated output, the maximum casing temperature is less than 35^{o}C above the ambient.

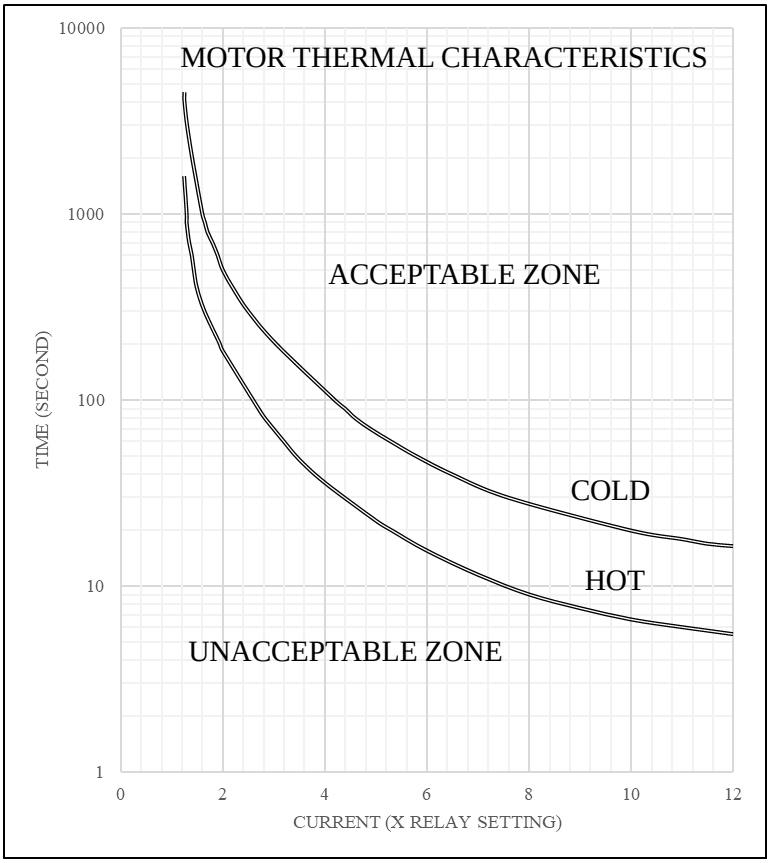
When used in conjunction with a variable speed drive (VSD) or inverter supply, IC416 cooling method shall be applied. Provisions of fixed speed fan with dedicated power supply mounted on the motor top as recommended by the motor manufacturer shall be required.

3.3 Thermal Insulation and Short-time Characteristics

The motor windings and accessories shall be designed for Class F insulation with Class B maximum temperature rise limit to IEC 60034-1.

The minimum safe locked rotor time of motor at rated voltage and hot condition shall be 5 seconds more than the start time of the specified driven load at 85% rated voltage or 10 seconds, whichever is longer.

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



Motor Short-time Overload Withstand Characteristics
(Is / In = 7.5)

3.4 Stator Winding

The stator winding shall be designed for a minimum life of 25 years of service at rated load and voltage. All winding coils shall be adequately supported, braced and blocked to provide sufficient rigidity during all conditions of service.

3.5 Bearings

Motor bearings shall be of rolling type to ISO 281 and metric sizes. Approved type thrust and guide bearings shall be provided for vertical-shaft motors. The life associated with 90% reliability (L10 life) of the bearing shall be not less than 50,000 hours under the most onerous conditions.

3.6 Provision for Cabling and Termination

3.6.1 Cabling provision at cable boxes

The cable terminal box for the motor power supply cable(s) shall be adequately sized and suitable for cable entry from below. The terminal box shall be diagonally split to enable quick and easy installation and maintenance. Where necessary, a cable adaptor termination box shall be provided to facilitate secure and efficient cable

termination, ensuring compatibility with the incoming cable size, type, and insulation class.

Both ends of the three-phase winding shall be brought out and terminated on stud connectors in the termination chamber. Copper links shall be provided and connected for DOL starting.

An earthing terminal, outside the cable box, with the same current carrying capacity as the line terminals but not smaller than that suitable for the termination of a 50 x 6.3 mm copper strip shall be provided. A tapped hole with screw external to the cable box would be acceptable.

The cable box shall be fabricated from mild steel plate of minimum 3mm thick with degree of protection IP55 to IEC 60529. The cable box shall be provided with a detachable brass gland plate and an external earthing stud.

The insulation of terminals, connectors, cables and conductors shall be of moisture-resistant material, e.g. butyl rubber, PVC, PVC heat-shrinkable tubing or similar homogeneous material.

Permanent terminal markings and direction of rotation in accordance with IEC 60034-8 shall be provided in the cable box.

3.6.2 Motor Supply Cables

Motor terminations shall generally be suitable for use with the size of motor supply cable selected from Table 1 below. The actual cable size will be confirmed subsequent to the award of contract.

Table 1 - Power Supply Cable and Terminations

Stranded Copper Size mm^2	Motor Full Load Current (A) XLPE/SWA/PVC 3-core Cable		Compression Fitting Palm (max.) mm	Terminal Stud Centre (min.) mm	Stud to Gland Plate (min.) mm
	1 Cable (Direct-on-line)	2 Cables* (Star-delta)			
16	-	113	22	33	140
25	86	150	22	33	155
35	104	180	25	36	180
50	127	220	27	41	205
70	161	278	30	44	225
95	198	342	35	49	255
120	228	-	40	57	280
150	265	-	45	62	315
185	302	-	50	67	355

* Note : This is applicable to star-delta starting motor for which each of the supply cables will share 0.577 of the motor rated full load current.

3.7 Anti-condensation Heaters

An anti-condensation heater suitable for operation on a separate 220V, single-phase, 50Hz supply shall be fitted. Arrangements will be made in the switchgear for the heater to be switched off when the motor is running. A separate terminal box with degree of protection IP55 to IEC 60529 shall be provided for the anti-condensation heater. A label of durable material shall be fixed on the lid of the heater terminal box with inscriptions “Separate Supply for Space Heater – Isolate Before Opening this Lid” for warning purpose.

Heater elements shall be rated and positioned such that the temperature measured at any point on the motor casing is within 2-15℃ above the ambient temperature.

3.8 Rotor Locking Device

A rotor locking device shall be fitted in the motor prior to shipment for protecting the bearings against damage during transport. The device shall be of robust design and be reusable for future maintenance.

3.9 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 AUXILIARY EQUIPMENT

4.1 Embedded Temperature Detectors

Unless otherwise specified, motors 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 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 shall be at the monitoring unit and set to operate at 120℃ and 140℃ respectively.

The monitoring unit shall operate at 220V a.c. 50 Hz, or 24V d.c. if it will be installed in the pumpset control panel as specified in WSD Standard Specification E-11-04. The contact rating shall be 5A, 220V 50 Hz inductive.

4.2 Motor Protection

The motor directly connected to the main power supply shall be protected by microprocessor based motor protection relay. The functions of motor protection shall include, but not be limited to thermal overload, instantaneous overcurrent, earth fault and phase unbalance. Unless other specified, the motor protection relay should be 24V D.C. operated and also equipped with multiple operating communication ports and common network protocol such as fieldbus via RS485/Ethernet communication link by means of plugging in communication module and without further modification of the basic unit. Trip on Fault Relay and stabilizing resistor should also be provided for the motor protection. Communication cable between computer notebook and the motor protection relay should also be provided.

Overvoltage protection shall be designed for inhibit starting of idle pumps. Undervoltage protection shall be designed for tripping of running pumps and inhibit starting of idle pumps. Auxiliary relays should be provided for both functions. They should be auto-reset in motor control circuit when the power system returns normal, which allows operator to switch on the equipment without manual reset of the relays.

5 INSPECTION AND TESTING

5.1 Inspection and Testing at the Manufacturer’s Works - General

The motors shall be inspected and tested 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 ±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) Routine and basic tests as specified.

(e) 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 works in accordance with the specified applicable standards:

	Tests	Standards
(a)	Resistance of windings (cold) and direction of rotation (routine test on each motor)	IEC 60034-1
(b)	No load losses, current and power factor (routine test on each motor)	IEC 60034-2-1
(c)	Withstand voltage (routine test on each motor)	IEC 60034-1
(d)	Vibration (routine test on each motor)	IEC 60034-14
(e)	Efficiency at rated motor output and at pump duty points (basic test on one motor of each rating and design only)	IEC 60034-2-1

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 characteristics at rated voltage.

(b) Torque characteristics 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 r/min. characteristics 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.

	Tests	Standards
(a)	Temperature rise	IEC 60034-1
(b)	Power factor at rated load	-
(c)	Locked rotor torque	-
(d)	Starting (locked rotor) current	-
(e)	Noise level	IEC 60034-9

7. SOFTSTARTER (Optional)

7.1 General Requirements

(a) The softstarter shall be of the power electronic type motor starting device. It shall control the voltage applied to the motor smoothly by varying the conduction angle of the solid stage AC switches which can be triacs, reverse parallel connected SCR-diode circuit or reverse parallel connected SCR-SCR circuit, etc. or using other similar technique. Provision shall be made for digital communication to enable the the softstarter to connect to the digital network for monitoring and control purposes.

(b) Softstarter shall be manufactured to conform to the following relevant standards or other similar recognised international standards:

IEC 60068-2-6	: for vibration resistance where softstarter is affected by vibration;
IEC 60068-2-27	: for shock resistance where softstarter is affected by shock;
IEC 61000-4-2	: for electrostatic discharge immunity test;
IEC 61000-4-3	: for radiated, radio-frequency, electromagnetic field immunity test;
IEC 61000-4-4	: for electrical fast transient/burst immunity test;
IEC 61000-4-5	: for surge immunity test.

(c) The softstarter shall be manufactured by a reputable manufacturer which has continuously manufactured softstarter for at least 5 years and their manufacturing facility shall have a local agent to provide full technical support, including adequate spares holding and technical expertise in testing, commissioning and troubleshooting. Training shall be provided by the manufacturer's representatives for government staff on operational and maintenance aspects including essential trouble-shooting techniques.

(d) Full technical details of the softstarter provided by the manufacturer shall be submitted and shall cover at least the following:

(i) technical guide on its applications;
(ii) schematic and wiring drawings down to circuit board level;
(iii) shop drawings and as-fitted drawings;
(iv) operation manuals with commissioning guide;
(v) maintenance manuals with trouble-shooting guide; and
(vi) parts list and recommended spare parts with price.

(e) Degree of Protection of Enclosure
The softstarter shall be protected to at least IP44 for indoor and IP55 for outdoor application by a single front-access enclosure and shall be suitable for operation without derating under ambient temperature of up to 40℃ and relative humidity of up to 99%.

7.2 Performance Requirements

(a) Mode of Operation

Softstarter shall provide the following modes of operation and shall be transitionless without causing any current inrush and torque surges during operation: -

(i) Voltage ramp - The motor voltage shall begin initially at a preset 'start

voltage' and increase to line voltage at a preset 'ramp rate'. The acceleration ramp time shall be adjustable up to 30 seconds;

(ii) Current limitation - It shall be capable of limiting the maximum starting current which shall be adjustable to at least 4 times of rated current;

(iii) Soft stop - A deceleration voltage ramp shall be applied to the motor for applications which require an extended coast to rest. The voltage ramp down time shall be adjustable to 30 seconds or above;

(iv) Kickstart - A current pulse shall be provided in the softstarter to develop additional torque when started for loads which may need a boost to get started.

(b) Protection

Softstarter shall have internal protection to the motor and softstarter and LED diagnostics to aid in set-up and troubleshooting. The protection shall include: -

(i) thermal overload protection of the motor and softstarter;

(ii) mains supply protection for phase failure and phase unbalance;

(iii) internal fault protection; and

(iv) stalled motor protection.

(c) Auxiliary Contact

The softstarter shall provide auxiliary contacts for end of starting (by-pass) and fault condition. The output relay contact shall be suitable for 220 V A.C. operation in category AC11 and D.C. operation in category DC11.

7.3 Selection of Softstarter and Operating Precautions

(a) The starting current-speed transition curve of the selected softstarter shall closely match with the starting torque-speed characteristics of the motor and loading. The ratings of the softstarter shall base on 'hot start' operation i.e. the motor is restarted immediately after operating at maximum rating for a period of time.

(b) The motor associated with the softstarter shall be capable of starting the driven load when is supplied at reduced voltage and current. In case of severe duty, checking with the motor manufacturer shall be carried out that its derating is compatible with the operating cycle and the starting times.

(c) The heat sink of the softstarter shall be of good quality aluminium construction and shall provide sufficient thermal inertia to permit successful starting of the motor without exceeding the permitted junction temperature of the solid state AC switches.

(d) When using a by-pass contactor, the order to close and open the contactor shall be controlled by the built-in signal of the softstarter.

(e) The softstarter shall have the possibility to accept D.C. input from external device such as Programmable Logic Controller (PLC) for controlling the start and stop of the unit.

(f) Semiconductor fuses shall be available as an option and have the characteristics suitable to protect the softstarter.

(g) The solid stage AC switches shall have a blocking voltage of at least 1,400 V for 415 V system with a rate of rise of reapplied voltage tolerance of at least 1,000 V per microsecond. However, an isolation contactor or isolator shall be available as an option to isolate the supply in the 'Off' stage to the softstarter for the safety of the operator.

(h) Under no circumstances shall the power factor correction equipment be connected between the softstarter and the motor. If power factor correction equipment is employed, it shall be connected to the supply side of the softstarter.

- End of this Specification -