WATER SUPPLIES DEPARTMENT

STANDARD SPECIFICATION E-51-01

LOW VOLTAGE SQUIRREL CAGE INDUCTION MOTORS OF 140 kW AND ABOVE

1 TECHNICAL REQUIREMENTS

1.1 General

This standard specification is for low voltage squirrel cage induction motors of rating 140 kW and above, particularly for driving water pumps.

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 / 1,500 rpm	6 poles / 1,000 rpm
140 kW	95.6%	95.4%
160 kW	95.8%	95.6%
200 kW or above	96.0%	95.8%

For motors with efficiency classification IE4

Rated output power	Minimum motor efficiency with the following number of poles / synchronous speed	
	4 poles / 1,500 rpm	6 poles / 1,000 rpm
140 kW	96.4%	96.0%
160 kW	96.6%	96.2%
200 kW	96.7%	96.3%
250kW or above	96.7%	96.5%

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

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

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

(e) Maximum speed : 1,500 rpm at 50 Hz (4 poles)
1,000 rpm at 50 Hz (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°C maximum continuous for 4 hours. 30°C average over any 24 hours. 5°C minimum.
(c)	Humidity	:	Up to 98% relative humidity.

1.3 Electrical Conditions

(a)	Electricity supply	:	380V three-phase, 50 Hz, four-wire system with solidly earthed neutral.
(b)	Voltage variation	:	-10% to +6%
(c)	Frequency variation	:	±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)	IEC 60751	Industrial platinum resistance thermometers and platinum temperature sensors
(f)	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 reduced voltage assisted 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.

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, under normal operating conditions.

1.6 Running

The motor shall be capable of operating continuously at any voltage in the range 90-106% of rated voltage and at any frequency between 49-51 Hz. The motor shall be capable of operation at full load with 75% rated voltage at 50 Hz for a period of 5 minutes without injurious heating.

1.7 Transient Recovery

The motor shall be capable of recovering normal operation in the event of a system disturbance causing temporary loss of supply voltage for periods of up to 0.2 seconds (fault clearance time) followed by a sudden restoration initially to 80% rated voltage. At this voltage, the motor shall be capable of accelerating to ultimate recovery under the most arduous load conditions, e.g. open fan vane, open pump discharge valve, speed controller at maximum speed position, etc.

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.

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 the motor shall comply with IEC 60072.

Motors for driving pumpsets of the same capacity and supplied under the same contract shall be interchangeable.

The motor shall have cast iron casing. Acoustic enclosures shall not be used.

The frame design of the motor shall facilitate easy removal of the rotor assembly and allow motor stator winding repair/cleaning to be carried out. Lifting lugs and other lifting gear shall be provided 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

The motor 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-driving 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°C above the ambient.

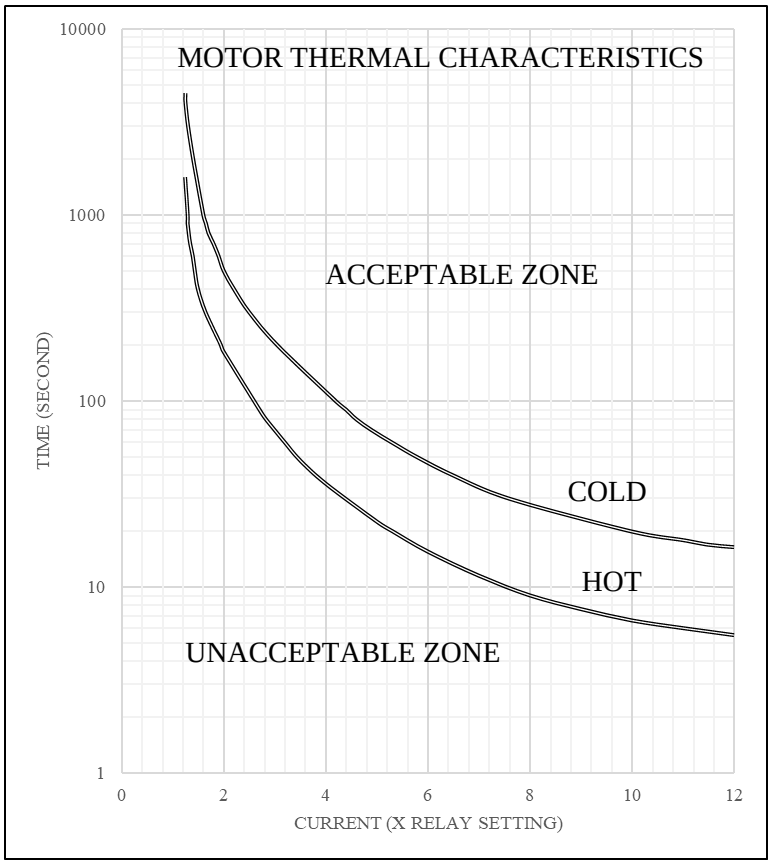
When used in conjunction with a variable speed drive (VSD) or inverter supply, IC416 cooling method shall be applied. Provisions of fixed speed fan with dedicated power supply mounted on the motor top as recommended by the motor manufacturer shall be required.

3.3 Class of Insulation and Thermal 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 motor short-time overload withstand characteristics shall be within the acceptable zone as shown in the graph below. If the maximum temperature rise is limited by the rotor, such condition shall be stated.



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.

The motor shall be designed to permit high voltage tests to be conducted after erection on site in accordance with IEC 60034-1.

Natural rubber insulated cables shall not be used for connection between the stator winding and motor terminals.

The stator winding shall be insulated by vacuum pressure impregnation (VPI) process. Alternatively, trickle impregnation process shall be acceptable provided that the motor insulation complies with the functional requirements of the latest IEC 60034-18-1.

3.5 Rotor

3.5.1 Vibration Level

The limits of vibration during works testing shall comply with Grade A of IEC 60034-14.

3.5.2 Dynamic Balancing

The rotor shall be dynamically balanced to ensure that vibration levels are within the specified limit.

3.6 Bearings

Bearings shall be of metric sizes. Ball or roller bearings to ISO 281 shall be used. Vertical shafts shall have thrust and guide bearings of the approved types.

Consideration shall be given to bearing service life, noise, losses and maintenance convenience in the selection of bearings. The life associated with 90% reliability (L10 life) of the bearings shall be not less than 50,000 hours under the most onerous conditions.

Bearings shall be easily accessible for inspection and shall be liberally rated to ensure cool even running. Bearings shall be suitable for reverse rotation at the normal running speed.

Bearings shall be adequately lubricated by grease and sealed against leakage of lubricant along the shaft. Their construction shall allow them to be dismantled and reassembled without any risk of damage.

The bearing assembly shall be designed to exclude the ingress of dust and water. It shall be provided with a grease relief device such that when the motor runs at its rated speed any surplus grease is ejected out of the motor casing.

Housing for ball/roller bearings shall be packed with suitable lithium-based grease at the time of delivery. The re-lubrication interval shall not be less than 4,000 hours.

Nipples for lubrication purposes shall be in accordance with ISO 6392 or other industrial standards.

Grease nipples shall be readily accessible without removal of guarding. Where necessary, they may be remotely mounted at a point as near as practicable to the lubrication point.

3.7 Motor Foundation

A motor bedplate/foundation block shall be provided unless the motor is to be mounted on the soleplate of the pump. Provision shall be made for fitting jacking screws to facilitate alignment of the coupling.

Vertical motors shall be designed for flange mounting on a detachable motor stool to be supplied with the motor.

3.8 Lifting

The complete motor shall be capable of being dismantled or reassembled by the use of one electric overhead crane.

Heavy parts of the motor shall be provided with a suitable arrangement for lifting and handling during erection and overhaul. Details of the arrangements shall be included in the instruction manual. Components weighing 1,000 kg or more to be removed during maintenance shall be marked with their respective weights.

3.9 Provision for Cabling

3.9.1 Cabling Provision at Bedplates

Where necessary, provision of a slot shall be made in the steel bedplate to facilitate vertical entry of cables to the bottom of the motor terminal box.

3.9.2 Cabling Provision at Cable Boxes

The termination box for a horizontally mounted motor shall be positioned at the top of the motor with the cable end box angled downwards to facilitate 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.

The orientation and position of the cable box shall be confirmed prior to manufacture.

An earthing terminal 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 outside the cable box. A tapped hole with screw external to the cable box would be acceptable.

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

3.9.3 Cabling Provision at Motor Casing

The terminal leads from the cable box to the winding shall be adequately braced to withstand the forces produced by maximum fault current.

3.9.4 Main Cable Termination

Motor cable terminations shall generally be suitable for use with the power supply cable sizes given in Table 1 below (based on installation in enclosed cable trenches). The correct size of cable to be used shall be confirmed prior to manufacture of the motor.

Table 1 - Power Supply Cable and Terminations

Stranded Copper Size mm^2	Type of Cable	Maximum Motor Full Load Current (A)		Compression Fitting Palm Width (max.) mm	Terminal Stud Centre Lines (min.) mm	Stud to Gland Plate Distance (min.) mm
		1 Cable	2 Cables			
70	XLPE/SWA/PVC 3 core	-	278*	30	44	225
95		-	342*	35	49	255
120		-	394*	40	57	280
150		-	459*	45	62	315
185		302	524*	50	67	355
240		358	619*	52	72	400
300		408	-	57	77	450
300	XLPE/AWA/PVC 3 x 1 core	455	788	57	77	450
400		499	863	65	85	450
500		553	958	70	90	500
630		608	1050	75	95	500

*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.

3.10 Cable Termination Box

3.10.1 General Construction

The cable termination box shall comprise an air insulated termination chamber and a cable end box. The degree of protection of the cable termination box shall be IP55 to IEC 60529.

The cable termination box shall be fabricated from mild steel plates of minimum 4 mm thickness. Cast iron boxes are not acceptable.

Joints shall be machined flat and fitted with neoprene rubber gaskets.

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

The cable termination box shall allow sufficient space for cable termination and be designed with clearance and mounting suitable for use with heat-shrinkable PVC cable termination for the incoming power supply cables.

3.10.2 Termination Chamber

Both ends of the three-phase winding shall be brought out and terminated on six insulated stud connectors in the termination chamber. Copper links shall be provided by the manufacturer and connected for DOL or VSD assisted starting. The terminal bases of the six-terminal cable box shall be in staggered, 2-tier, slanted or other suitable formation to facilitate easy cable termination.

Studs shall be so fixed as to prevent them from turning when the nuts are tightened down. Means shall be provided to prevent slackening of cable connections due to vibration.

The stud connector insulation shall be of epoxy resin, phenolic resin, glass-fibre polyester or other approved high-pressure moulding. Porcelain insulators are not acceptable.

Current carrying studs and sockets shall be of hard-drawn cadmium copper with the socket portion locally annealed for crimping.

Detachable polycarbonate plastic shrouds shall be fitted over each insulated connector. Polycarbonate plastic shrouds shall be of minimum wall thickness of 1.6 mm and minimum breakdown voltage of 1 kV.

The termination chamber shall be provided with a front access cover and shall be bolted to the motor frame with M10 high tensile steel studs and nuts. The minimum clearance from the stator casing shall be 130 mm to allow access to the rear fixing nuts.

3.10.3 Cable End Box

The cable end box shall be fixed to the termination chamber by means of M8 or M10 high tensile steel bolts or studs and nuts.

The cable end box shall be provided with a front access cover.

The cable end box shall be arranged for bottom entry of cables and with a detachable brass gland plate.

Cable tails at the junction between the cable gland plate and the insulated stud

connectors shall be held in place by a tufnol or laminated densified wood (permali) cable spacing block with bolts and nuts.

3.10.4 Clearance and Creepage Distances

Electrical clearance and creepage distances inside the cable termination box shall comply with the requirements listed in Table 2 below. These clearance and creepage distances shall also apply to the terminals or connectors which have to be insulated on site, and shall apply even if the terminals or connectors are fully insulated but are not intended to apply to the permanently insulated conductors.

Table 2 - Clearance & Creepage Distances

Motor rating (kW)	Minimum clearance between phases & to earth (mm)	Minimum creepage distance over bushings and surfaces resistant to tracking (mm)
up to 199	12.5	19.0
200 and above	19.0	25.0

3.10.5 Cable Lugs

Cable lugs specifically designed for the motor shall be supplied for the motor supply cables.

3.11 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.

3.12 Markings and Data Plates

An instruction plate and a data plate of stainless steel shall be provided. Lettering and numerals shall be either stamped or embossed. Data plates with lithographed or painted-on information are unacceptable.

The instruction plate shall give the connections and phase sequence for the required direction of rotation.

The data plate shall be stamped with all information required by IEC 60034-1. The minimum coolant (air) quantity shall also be marked.

The motor serial number shall be stamped with metal dies on the driving end shaft face of the motor in addition to being stamped on the stator.

4 PROTECTIVE EQUIPMENT

4.1 Embedded Temperature Detectors (ETDs)

A set of six ETDs complete with monitoring units shall be provided to afford protection against over-heating in accordance with IEC 60034-11.

3-wire Resistance Temperature Detectors (RTDs) shall be used. Each monitoring unit shall incorporate a winding temperature indicator in addition to the alarm and trip volt-free contacts.

The ETD monitoring units shall be supplied loose for mounting in the pumpset control panel as specified in WSD Standard Specification E-11-04. Sufficient length of appropriate signal cables interconnecting the RTDs and the monitoring units shall be provided.

4.2 Bearing Temperature Detectors and Indicators

A 3-wire RTD complying with IEC 60751 tolerance Class B shall be provided to monitor the temperature of each motor bearing. Thermometer pockets shall be provided on each bearing to enable insertion or removal of the temperature detector. Each RTD shall be supplied with a monitoring unit, which has alarm and trip volt-free contacts and a temperature indicator. The alarm and trip setting shall be adjustable. The monitoring units shall be supplied loose for installing in the pumpset control panel mentioned in Clause 4.1 above. Sufficient length of appropriate signal cables interconnecting the RTDs and the monitoring units shall be provided.

5. AUXILIARY EQUIPMENT

5.1 Spreader, Slings and Tools

General and special maintenance tools shall be supplied.

Special tools required for the dismantling, reassembly and maintenance of the motor together with the necessary slings and spreaders for the transport of the motor and its components shall be supplied. All lifting gear shall be tested, examined and certified by competent personnel in accordance with the statutory requirements prior to handing over to WSD.

5.2 Anti-condensation Heaters for Motor

Anti-condensation heaters suitable for operation on a 220V, single-phase, 50 Hz supply shall be fitted in the motor. Arrangements will be made in the switchgear for the heaters to be switched off when the motor is running.

The heaters shall be designed to permit replacement. The heater elements shall be rated and positioned such that the temperature measured at any point on the motor casing is within 2-15°C above the ambient temperature. They shall be designed to

provide even heating to the motor winding.

A separate termination box with a degree of protection IP55 to IEC 60529 shall be supplied for the anti-condensation heaters. The box shall be provided with terminals for 2.5 mm^2 2-core XLPE/SWA/PVC cable and a warning label of durable material on the lid with inscriptions "Separate Supply for Space Heater – Isolate Before Opening this Lid".

5.3 Marshalling Box for Protective Devices

Protective devices mounted on the motor shall be wired to a marshalling box mounted on the motor casing. The box shall have a degree of protection IP55 to IEC 60529. Screen cables or special temperature compensation cables, where required, for connection between the box and the pumpset control panel shall be supplied in sufficient length and terminated to the motor.

5.4 Small Wiring

Wiring shall be in accordance with WSD Standard Specification E-00-01 unless otherwise specified.

High temperature insulation shall be provided on all wiring where contact with heated parts of the motor is anticipated.

Wiring in conduits shall not be used. Wiring shall be run in a manner which enables checking without the removal of the cleats.

An allowance shall be made on the length of each wire at the point of connection to the terminal in order to permit the cutting off and re-making of the wire terminations without causing any disturbance to the main run of the wiring.

Ferrules shall be fitted for each wire core such that they would not be detached unintentionally when the wire is removed from the terminal.

5.5 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 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.

6. INSPECTION AND TESTING

6.1 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 calibration results of these instruments shall be provided to the Independent Inspection Body for inspection and included in the test report.

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 in Clause 6.2 below.

(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.

Type tests on equipment and standard calibration tests on instruments/equipment by manufacturers shall not form part of the normal inspection and hence they do not need to be witnessed by the Independent Inspection Body.

6.2 Motor Tests

6.2.1 General

Tests conducted at the manufacturer's works shall be in accordance with IEC 60034. No positive tolerance from the specified limits shall be allowed for noise level, temperature rise and starting (locked rotor) current.

The following basic tests shall be conducted by the manufacturer on one of the motors

of each rating and design supplied under the same contract. The motor shall also be used for the subsequent pump efficiency test:

	Test	Standard
(a)	Temperature rise	IEC 60034-1
(b)	Efficiency at rated load and at pump efficiency test duty points	IEC 60034-2-1
(c)	Power factor at rated load and at pump efficiency test duty points	
(d)	Locked rotor torque	
(e)	Starting (locked rotor) current (by transient recorder at rated voltage)	
(f)	Noise level	IEC 60034-9

The following routine tests shall be conducted on each motor supplied:

	Test	Standard
(a)	No load losses, current and power factor	IEC 60034-2-1
(b)	Withstand voltage	IEC 60034-1
(c)	Stator winding resistance measurement (cold) and direction of rotation	IEC 60034-1
(d)	Vibration	IEC 60034-14

6.2.2 Noise Level Test

The motor shall be tested at no load for noise level to IEC 60034-9. The measured sound power level shall not exceed the limits stated in Table 2 of the IEC Standard. Measurement details shall be provided in the test report.

6.2.3 Efficiency Test

The efficiency figures for the motor shall be established by summation of losses in accordance with IEC 60034-2-1. Curves of efficiency against the motor output shall be provided in the test report.

6.2.4 Power Factor Test and Temperature Rise Test

The power factor and temperature rise tests shall be conducted by direct loading at

rated supply voltage and frequency. Curves of power factor against the motor output shall be provided in the test report.

Temperature rise test shall be conducted in accordance with IEC 60034-1. The test shall be conducted for at least 4 hours and until the thermal equilibrium is reached, i.e. when the rise of temperature of the stator winding does not exceed 2°C over a period of one hour.

The stator winding temperature shall be measured by an instrument that has been calibrated to an accuracy of ±0.5°C.

The motor casing temperature shall be measured during the temperature rise test to verify that the actual rise in temperature throughout the test is within the specified figure.

6.3 Test on ETDs

Embedded temperature detectors shall be calibrated by suitable means before being fitted into the motor. 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.

7. INFORMATION FOR EQUIPMENT APPROVAL

7.1 Catalogues and Performance Data

Catalogues and performance data of the motor, motor cable box, instruments and protective equipment shall be submitted for assessment.

7.2 Pump and Motor Starting Characteristics

The pumpset starting characteristics shall be furnished for assessment and shall include the following:

(a) Pump torque characteristics at the most arduous load condition with closed valve.

(b) Pump torque characteristics at the most arduous conditions with delivery valve fully open.

(c) Motor torque characteristics at the lowest specified voltage across the motor terminals i.e. 49% nominal voltage.

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

7.3 Motor Thermal Characteristics

The short-time overload withstand characteristics of the motor (both hot state and cold state) shall be submitted by plotting on a semi-log graph paper given in Clause 3.3.

8. SOFTSTARTER (Optional)

8.1 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 for digital communication shall be provided for connecting the softstarter to a fieldbus 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%.

8.2 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.

8.3 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 -