WATER SUPPLIES DEPARTMENT

STANDARD SPECIFICATION E-55-01

HIGH VOLTAGE MOTORS OF 3.3 kV AND ABOVE

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1 GENERAL

1.1 Scope

This specification covers the design, manufacture, testing and delivery of high voltage squirrel cage induction motors with rated voltages at 3.3 kV, 6.6 kV or 11 kV suitable for driving the water pumps specified in WSD Standard Specification M-01-01.

1.2 Waterworks Standard Specifications

The motor and auxiliary equipment shall comply with this Specification and WSD Standard Specification E-00-01 "Electrical Equipment - General". This Specification shall take precedence in case if there is any discrepancy between the two standard specifications.

The drawings and manuals supplied with the equipment shall comply with the following standard specifications issued by the Water Supplies Department:

(a) EM-90-01 Drawing for Mechanical, Electrical and Instrumentation Plant and Equipment

(b) EM-90-02 Instruction Manual for Mechanical, Electrical and Instrumentation Plant and Equipment

1.3 Standards

Equipment shall comply with the latest version of the relevant international Standards and Codes of Practice. The following Standards, in particular, shall apply where appropriate:

(a) IEC 60034 Rotating electrical machines

(b) IEC 60751 Industrial platinum resistance thermometer sensors

(c) IEC 60085 Evaluation and thermal classification of electrical insulation

(d) ISO 281 Rolling bearings - Dynamic load ratings and rating life

1.4 Type Test Certification

Type tests shall have been performed on equipment which is essentially similar to that being supplied.

Type test certificates of short circuit rating shall be issued by the Association of Short Circuit Testing Authorities UK (ASTA) or other equivalent internationally recognised

authority. Type tests shall be carried out in accordance with the requirements of the relevant Standards.

The type test requirements for equipment are listed as follows:

(a) Motor winding insulation level tests (Clause 3.4)

(b) Motor main cable box fault withstand type test (Clause 3.11.2)

Complete details of the type test reports containing the test arrangement and test results shall be submitted to supplement the test certificates when requested. The equipment supplied shall be strictly in accordance with the design of the approved type tested equipment.

2 PERFORMANCE REQUIREMENTS

2.1 Technical Particulars

(a) Type : High energy efficient squirrel cage induction motor with rated load efficiency as follows:

Rated Output	Minimum Efficiency
less than 500 kW	95.0 %
500 kW – 990 kW	95.5 %
1,000 kW and Above	96.0%

(b) Standards : IEC 60034, IEC 60072 and other relevant international standards

(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 50Hz

(f) Noise Level : Mean sound power level (Lw) in dB(A) for airborne noise emitted by motor not exceeding the limits given in IEC 60034-9.

(g) Vibration Level : Grade A of IEC 60034-14

(h) Uncorrected Power Factor : 0.83 minimum at duty point without negative tolerance

2.2 Site Operating Conditions

(a) Altitude of site above sea level	:	not greater than 1,000 m
(b) Ambient temperature	:	Peak over any 4 hours : 40°C Average over 24 hours : 35°C Minimum : 0°C
(c) Relative humidity	:	Up to 98%

2.3 Electricity Supply

(a) Mains supply	:	11 kV, 6.6 kV or 3.3 kV 3 phase, 50 Hz 3 wire solidly earthed neutral system
(b) Normal limits of voltage fluctuation	:	+10% -2½%
(c) Normal limits of frequency variation	:	±2%
(d) Auxiliary power supply	:	220V ±10% single phase 50 Hz and 24V ±15% d.c.

2.4 Starting Performance

Direct-on-line starting current at rated voltage shall not exceed 5 times the full load current for motors of 500 kW and above, and not exceed 6 times the full load current for motors below 500 kW.

The motor shall be designed to permit at least three starts per hour equally spaced during normal running conditions. The motor shall also be suitable for two starts in succession followed by a 30 minutes interval before attempting another starting sequence.

The minimum voltage at motor windings at starting shall be 80% of nominal value for direct-on-line started motor, and 50% for motor with auto-transformer starter.

The starting (run-up) torque characteristics of motor at minimum voltage shall be adequate for driving the load to full running speed under the most arduous conditions specified. 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.

Direct-on-line started motor with 80% rated voltage across its winding shall run to 90% of its synchronous speed within 4 seconds. Motor with assisted starting, at 50% rated voltage across its winding and without changing to its final connection, shall run to at least 90% of its synchronous speed within 10 seconds. During such starting intervals, the pump discharge valve shall open in its normal manner.

The pull-out torque of motors shall be not less than 200% of its full load torque unless otherwise approved.

2.5 Running

Notwithstanding the voltage fluctuation specified in Clause 2.3 above, motors shall be capable of operating continuously at any voltage in the range 90-110% of its rated voltage.

Motors shall be capable of continuous operation at 75% of its rated voltage at 50 Hz for a period of 5 minutes without excessive heating.

2.6 Transient Recovery

Motors shall be capable of recovering normal operation in the event of a system disturbance causing temporary loss of supply voltage for a period of up to 0.2 second (fault clearance time) followed by a sudden restoration to 80% of its rated voltage. At this voltage the motors shall then be capable of accelerating to ultimate recovery under the most arduous load conditions, e.g. open pump discharge valve, etc.

2.7 Power Rating

The rated motor power output shall be not less than 120% for fresh water pumpset and 115% for salt water pumpset of the maximum power absorbed by the pump over the entire pump operating range specified. The foregoing power margin shall not be reduced by any factors such as tolerances of pumpset performance or accuracy of test equipment.

3 DESIGN AND CONSTRUCTION

3.1 Enclosure

The enclosure shall have a degree of protection of IP 22 (drip proof) or IP 55 (totally enclosed) to IEC 60034-5. Dimensions and frame number of motors shall comply with IEC 60072. Motors of size less than 1,000kW shall be protected to IP 55.

Motors of the same capacity and speed shall be interchangeable.

Motors shall be provided with suitable means of breathing and draining to prevent accumulation of water from condensation.

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

The motor frame shall be designed to facilitate easy removal of rotor assembly and to permit access from both motor ends for cleaning and rewinding of the stator winding and replacement of the complete stator core assembly.

For motors to be installed at a location with the NDE bearing higher than 2,000 mm from the floor, a fixed motor platform complete with guardrails and ladder shall be provided for the safe access to the top of the motor. The platform shall be detachable to allow the safe and unimpeded removal and re-siting of the motor.

The finished colour of the motor shall be the same as the driven equipment.

3.2 Ventilation and Cooling

Unless otherwise specified, motors of size 1,000 kW or above shall be fitted with individual outlet air duct to IEC 60034-6, method of cooling IC2A1. Smaller motors shall be designed for method of cooling IC411, with self-circulation air as coolant.

The motor air inlet shall normally be arranged to draw ventilating air directly from the surrounding. The inlet shall be equipped with a removable and washable air filter.

The motor fan for outlet air shall be designed so that at the worst operating condition and rated output, the actual operating temperature of the stator winding will not exceed the value specified for Class B insulation and the external surface temperature of parts liable to be contacted with will not be more than 65°C at 40°C ambient.

The motor ventilating fan shall be directly driven by the motor itself viz. no auxiliary power supply required. The fan shall be designed to take into account the air resistance of the air ducting and the back pressure at the discharge outlet equivalent to a wind velocity of 10 m/sec. blowing directly against the exhaust air outlet grill. Design calculation of the air ducts shall be submitted for assessment.

Ducts shall be fabricated with hot dip galvanized steel sheet to BS EN 10143 Grade 22 and of thickness not less than 1.5 mm. The ducts shall be so constructed that the pressure losses due to eddies or vortices are minimized and no noise or vibration is created or transmitted. Face panels shall be stiffened and creased to prevent "drumming".

All ductwork shall be secured by hangers, brackets or other appropriate means of support. All mild steel components shall be hot dip galvanized.

Provisions shall be made in the design to prevent water or condensate getting into the winding through the ventilation ducts. An accessible drain cock shall be provided at the lowest point of the ducting for draining of condensate as and when necessary.

A flexible coupling shall be provided between the motor and the ducting. Access/maintenance openings shall be provided at suitable positions to facilitate inspection and cleansing of the interior.

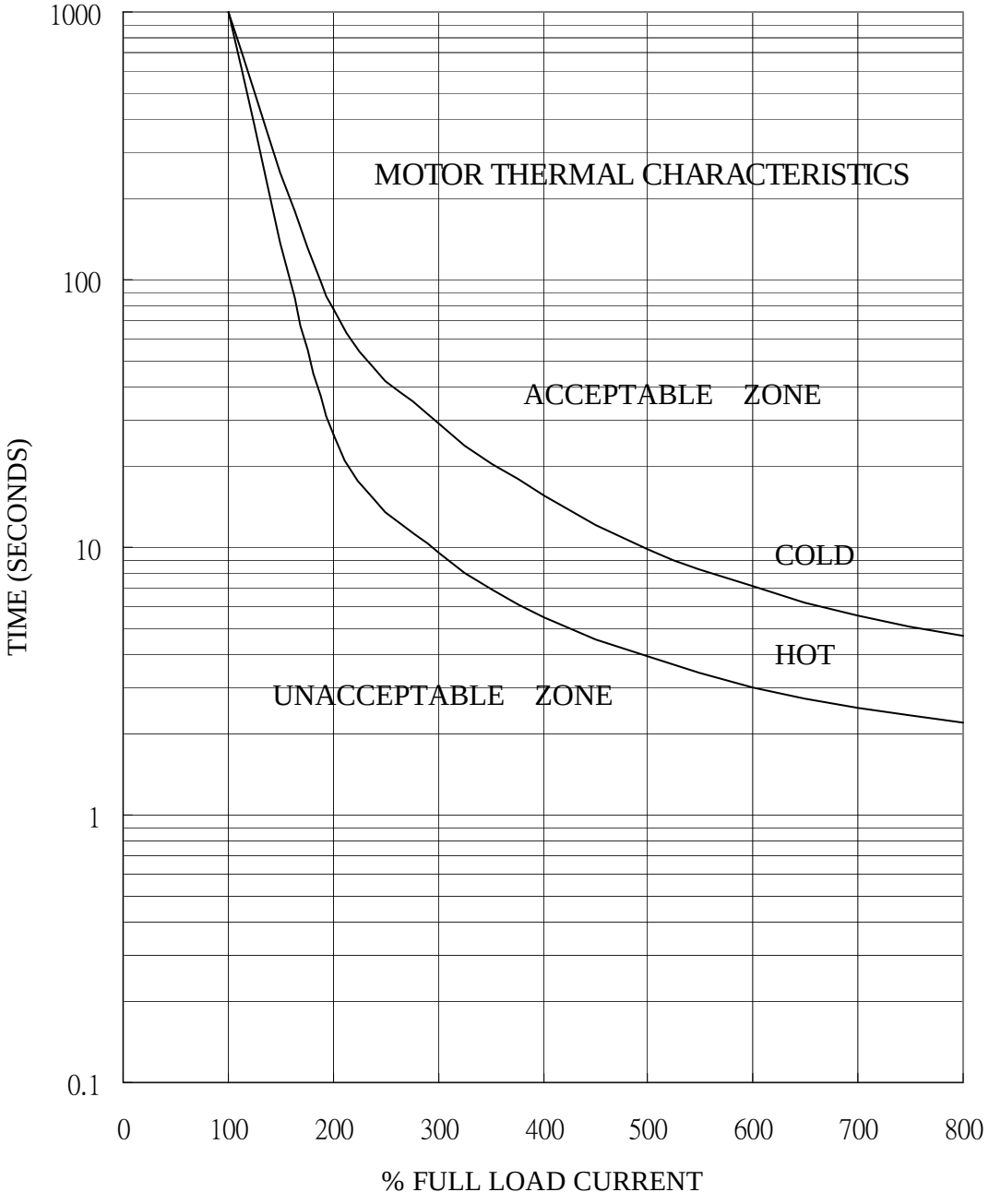
The air velocity in ducts shall not exceed 10 m/sec.

3.3 Thermal Insulation and Characteristic

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

The motor thermal characteristic shall be within the acceptable zone shown on the graph in the following page.

If the maximum temperature rise is limited by the rotor, this shall be stated with details.



Motor Short-time Overload Withstand Characteristics

3.4 Motor Stator and Winding

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

The motor winding insulation shall withstand the voltage stress caused by switching of an oil circuit-breaker, SF_6 circuit-breaker, vacuum circuit-breaker or vacuum contactor as motor starter. The vacuum interruptors will have a level of current chopping of 5A, a rate of rise of restriking voltage up to 0.2 kV/μs and a peak restriking voltage of 229% of its rated line voltage.

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

End windings shall be rigidly braced to prevent their movement at the specified service duty. Semi-resin mica tape and hyper-sealing tape shall be used for insulation of winding overhang and jumpers. Heat shrinkable insulating material shall not be used as Class F motor insulation. The winding overhang shall be accessible for cleaning.

The stator winding shall be insulated by vacuum pressure impregnation (VPI) process.
Windings shall have a surface treatment to prevent deterioration due to adverse environmental conditions and for corona shield.

Winding coils shall be of preformed type. Stator slots shall be of open type to facilitate easy insertion of replacement windings.

Laminated type magnetic slot wedges shall not be used. If the manufacturer proposes to use other type of magnetic wedges, the resulting change in performance as compared with non-magnetic slot wedges shall be submitted for acceptance.

Type test reports for loss tangent to BS EN 50209 and high voltage impulse test to IEC 60034-15 shall be provided to substantiate the winding insulation design.

Natural rubber insulated cables shall not be used between the stator windings and motor terminals.

Stator winding details including the embedded RTD shall be provided as detailed in WSD Standard Specification EM-90-01 and EM-90-02. Sufficient data and drawings shall be provided to enable stator coils to be ordered in future. Instructions for coil impregnation and curing, stator rewinding, impregnation and dry-out shall be supplied.

3.5 Rotor

3.5.1 Type

The rotor shall be of cage type with copper/copper alloy winding.

3.5.2 Vibration Level

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

3.5.3 Dynamic Balancing

The rotor shall be dynamically balanced at its rated speed or a speed not less than 600 rpm whichever is the greater to confirm that vibration levels are within the specified limit.

Means and access for fixing balancing weights in situ shall be provided at both ends of the rotor without the need to dismantle the motor for balancing on site.

3.5.4 Insulation Against Stray Current

For motors of 750 kW and above or where the induced shaft voltage exceeds 0.15V, an insulated bearing arrangement shall be provided. Where such provision is made, all motor bearings shall be insulated from the stator frame and a removable earth bonding link shall be provided at the driving end to facilitate insulation tests.

Oil and water pipes etc. where fitted shall be insulated to prevent a current return path through the bearings of the motor shaft. Care shall be taken to ensure that any insulation is not short-circuited by the application of electrically conducting paints or fixing clips. Laminated fibre-glass washers and sleeves shall be used for bearing insulation.

3.5.5 Rotor Removal

For vertically mounted motor, the rotor and the shaft shall be capable of being lifted vertically from the stator without the need of removing the half coupling.

When the motor shaft is not located axially by its own bearings, it shall be permanently marked to indicate its normal running position and the extent of float permissible in either direction.

3.5.6 Half Coupling

Coupling which do not require regular application of lubricant during operation shall be supplied.

3.6 Radial Air Gap

The nominal air gap between stator and rotor of motors shall take into consideration all causes of eccentric positioning of the rotor in the stator bore, (e.g. bearing clearance, clearances between bearing bracket spigots, deflection of shaft due to rotor weight and loading external to the shaft) and the deflection of the shaft due to unbalanced magnetic pull.

For motors with ball and/or roller bearings, the nominal air gap shall be not less than the appropriate value shown in Table 1 below.

For motors with plain (sleeve) type bearings, the nominal air gap shall be 1.5 times the appropriate value shown in Table 1.

Where the core length L of a motor is more than 1.75 times the rotor diameter D, the nominal air gap, shall be $\frac{L}{1.75D}$ times the appropriate value shown in Table 1.

Table 1 - Nominal Radial Air Gap

Number of Poles	Nominal Radial Air Gap (mm)	
	D = up to 750 mm	D = over 750 mm
4	$0.07 + \frac{D}{500}$	1.7
6 or more	$0.13 + \frac{D}{800}$	1.2

Note : D is the rotor diameter in mm.

Provision shall be made for checking the radial air gaps at each end of the motor having a plain (sleeve) type bearing.

3.7 Bearings

3.7.1 General

Bearings shall be exclusively of metric sizes.

Bearings for horizontal motors shall be provided in accordance with Table 2 below.

Table 2 - Type of Bearing (Horizontal Motor)

Number of Poles	Motor Rating	Type of Bearing for both DE and NDE
4	Above 500 kW	Plain
	Up to 500 kW	Rolling
6 or more	Above 750 kW	Plain
	Up to 750 kW	Rolling

For vertical motors of rating 1,000 kW or above, plain type thrust and guide bearings shall be provided at the non-drive end.

The motor manufacturer shall examine the external axial and radial load imposed from the shaft and the driven device in the selection of type of bearing to be used. Where damage is likely to occur to rolling bearings due to thrust load or stationary vibration, plain type bearings shall be used. Consideration shall also be given to bearing service life, noise, losses and maintenance convenience in the selection of bearings. Where rolling type bearing is to be used, the manufacturer shall provide calculation to verify that the life associated with 90% reliability (L10 life) of the bearing is not less than 50,000 hours at the most onerous operating 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 150% of the normal running speed.

Motor bearings supplied shall be suitably protected from damage by any stray currents as detailed in Clause 3.5.4.

Protective and auxiliary equipment applicable as per Clauses 4.2 and 4.3 shall be provided for the bearings.

3.7.2 Plain Type Bearings

Plain type bearings shall be self-lubricated and water-cooled. The cooler shall avoid any electrolytic action or corrosion and shall have a pressure rating exceeding the closed valve head of pumps. Bearings shall be designed to exclude the ingress of dust and water and adequately sealed to prevent leakage of oil.

The water pipes shall not run over or adjacent to the H.V. terminal boxes and shall not impede access to the bearing for inspection. The initial filling of bearing lubricating oil shall be supplied and delivered in an oil drum.

Bearings shall be provided with a filling hole, an air breather, an accessible drain plug and a clearly visible oil level indicator to show the oil levels during running and at standstill. Sight level indicators of the type fitted externally to the bearing shall be designed to prevent rotation about the gland connection.

The bearing design shall avoid oil being drawn into the winding through the shaft by centrifugal force or the effect of ventilation fan.

The bearing mounting bracket assembly shall be capable of completely detached from the stator, viz. no welding to the stator frame shall be permitted.

Bearing pads shall be self aligning in design, and shall not require any jacking screws for adjustment.

3.7.3 Rolling Type Bearings

Rolling type bearings shall comply with ISO 281 as appropriate. Special bearings shall not be acceptable. Bearings shall be adequately lubricated by grease and sealed

against leakage of lubricant along the shaft. Construction shall be such that bearings can be dismantled and reassembled without the risk of damage.

The bearing assembly shall be designed to prevent the entry of dust or water. It shall be provided with a separate grease nipple to serve each lubricating point and a grease relief device such that when the motor runs at its rated speed, any surplus grease is ejected out of the bearing casing to a separate container.

Housings for ball/roller bearings shall be packed with approved lithium-based grease at the time of assembly. The required re-lubrication interval shall be longer than 4,000 hours.

Grease nipples, oil cups and dip sticks shall be readily accessible without removal of guarding. Nipples shall be accessible on the plant floor or motor platform if provided.

3.8 Motor Foundation

A motor bedplate/foundation block shall be provided unless the motor is to be mounted on the soleplate of the pump. Jacking screws shall be fitted at perpendicular directions on the foundation block for alignment of the coupling.

Vertical motors shall be designed for flange mounting on a motor stool complete with removable mesh access panels such that the coupling can be accessed safely on the same floor of installation.

3.9 Lifting

The complete motor shall be capable of being dismantled or reassembled by use of an electric overhead crane. Spreader bars shall be supplied for lifting of motor when the motor diameter or length exceeds 1,000 mm.

Heavy parts of the motors shall be suitably arranged for lifting and handling during erection and overhaul. Details of the arrangements shall form part of the instruction manual. Components which weigh 1,000 kg or more and require to be removed during maintenance shall be marked with their respective weights.

3.10 Provision for Cabling and Termination

3.10.1 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.

3.10.2 Cabling Provision at Cable Boxes

The cable terminal box for the horizontally mounted motor shall be positioned at the side of the motor. Cable entry to vertical and horizontal motors will be from bottom of cable box.

An earthing terminal with the same current carrying capacity as the line terminals with a minimum size suitable for 25 x 6 mm copper strip shall be provided. A tapped hole with screw external to the cable box would be acceptable.

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

3.10.3 Cabling Provision at Motor Casing

Terminal leads from cable box to the winding for a distance of 150 mm or more from their point of entry into the motor frame shall be adequately braced to withstand the forces produced by maximum fault current. The minimum cross sectional area of terminal leads shall be as shown in Table 3:

Table 3 - Minimum CSA of Terminal Leads (Silicone Rubber Copper Conductor)

Fault Level in kA	3.3/6.6/11 kV
	mm^2
20	60
25	70
40	120

The phase windings shall be accessible for testing. For this purpose, neutral leads shall be brought out to a separate star-point terminal box and shorted with an insulated copper bar of cross-sectional area not less than the conductor of the terminal lead.

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

3.10.4 Motor Supply Cables

Motor terminations shall be suitable for connecting the power supply cable of sizes given in Table 4, based on the thermal rating of installation in enclosed cable trenches, subject to the minimum size to withstand the fault level as stated below:

20 kA - 95 mm^2
25 kA - 120 mm^2
40 kA - 185 mm^2

Table 4 - Motor Supply Cables

Cable Type Stranded Copper	Cable Size (mm^2)	Max. Motor Full Load Current (A)
XLPE/SWA/PVC 3 core	95	160
	120	180

3.3/6.6/11 kV	150	205
	185	230
	240	300
	300	335
	400	380

3.10.5 Clearances & Creepage Distances

Electrical clearance and creepage distance shall comply with the requirements in Table 5 below. These clearance and creepage distances shall also apply to terminals or connectors which have to be insulated on site. The requirements shall apply even though the terminals or connectors are fully insulated, but shall not apply to permanently insulated conductors.

Table 5 - Clearance and Creepage Distances for High Voltage Terminations

Rated Voltage	Minimum Clearance		Minimum Creepage Distances over Bushings and Surfaces Resistant to Tracking	
	To Earth	Between Phases	To Earth	Between Phases
kV	mm	mm	mm	mm
3.3	50	50	50	75
6.6	63	90	90	132
11	75	125	125	190

3.11 Motor Termination Boxes

3.11.1 Design and Construction

Cable boxes for motor power supply shall be of fault-rated phase-insulated or phase-segregated designs as follows:

3.3 kV - phase-insulated pressure relief type
6.6 kV, 11 kV - phase-segregated pressure relief type

Type tested cable boxes or cable boxes designed to ESI/BEAMA/CEGB standard or equivalent and rated for 0.25 second at the following fault level shall be provided:

3.3 kV - 25 kA (140 MVA) or 40 kA (225 MVA)
6.6 kV - 20 kA (225 MVA)
11 kV - 20 kA (380 MVA)

Technical documents including design drawings of the cable box shall be submitted

for information.

Cable boxes shall have the following major design features:

(a) The cable box shall comprise an end box and an air insulated termination chamber bolted together by means of high tensile steel bolts or studs and nuts and of degree of protection to IEC 60529 IP 56.

(b) Termination boxes shall be fabricated from mild steel of rigid welded construction. Cast iron boxes shall not be used.

(c) The termination chamber shall be bolted to the motor casing such that its sides are vertical, with high tensile steel studs and nuts.

(d) The cable end box shall be of dry type suitable for cable termination in Raychem heat shrinkable sleeving. It shall be fitted with a removable horizontal gland plate suitable for bottom cable entry. No cable joint is permitted in the end box.

(e) The termination chamber shall have an insulated assembly and be fitted with 3 stud terminals in insulating mouldings of epoxy resin, glass fibre, polyester or approved similar material. Porcelain insulators and/or cable-coupler type terminals shall not be used.

(f) Separate front access detachable cover plates shall be supplied for the end box and termination chamber.

(g) Pressure relief device shall be fitted to prevent build-up of pressure in an enclosed chamber.

(h) A plastic shroud or barrier having a minimum breakdown voltage of 20 kV shall be fitted for each cable terminal.

3.11.2 Type Test Requirements

Unless cable boxes to ESI/BEAMA/CEGB standard are used, motor cable boxes shall have been type tested as follows :

(a) Enclosure Test

Prototype cable boxes complete with cable end boxes should be tested to demonstrate that an effective sealing/air tightness to IEC 60529 IP 56.

(b) Short-circuit Tests

Prototype cable boxes should be tested under the specified system voltage and short-circuit conditions specified in Clause 3.11.1 by an independent Testing Authority such as ASTA, UK or other organization of similar standing.

Tests should include the following:

(i) A three-phase through-fault current test.
(ii) A three-phase internal short-circuit test.
(iii) A single line-to-earth internal short-circuit test.

Test (i) should result in no mechanical or electrical damage.

Test (ii) should result in no external damage to the terminal box structure other than rupturing of the pressure relief device. This test is not required for phase segregated containment type cable boxes.

Test (iii) should result in no external damage to the terminal box structure other than rupturing of the pressure relief device. For phase segregated containment type terminal boxes the test should not result in spread or propagation of the fault to or between the other two phases, which should be at rated potential for the test.

Short circuit tests are not required for the stator star point termination box.

3.11.3 Termination Box Auxiliaries

Each containment chamber of the termination box shall be fitted with a screw-in type desiccator with an indicator head. The desiccator shall be fitted such that the indicator is readily visible and removable from the cable box. When the desiccator is removed, access to live terminals shall be prevented by an internal metal barrier. This metal barrier shall not reduce the clearances required inside the box. The desiccator shall be fitted on a raised boss on a vertical box face to inhibit entry of contaminants when the desiccator is removed. The size of the desiccator shall be designed such that with a 95% relative humidity, replacement of the drying agent will not be necessary for a period of at least 3 months. The desiccant shall be silica gel crystals with humidity sensitive dye.

3.12 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.

3.13 Markings and Data Plates

An instruction and a data plate made of stainless steel shall be provided. The instruction plate shall give the connections and the phase sequence for the required direction of rotation. The required direction of rotation shall be marked on the motor casing.

The data plate shall be stamped with information required by IEC 60034-1. The minimum coolant air quantity and the design letter for general characteristics to IEC 60034-12 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 those being stamped on the stator.

4. PROTECTIVE EQUIPMENT & INSTRUMENTS

4.1 Winding Temperature Detectors

A set of embedded temperature detectors complying with IEC 60034-11, complete with monitoring units shall be provided to afford Class II Protection for the motor.

At least six 3-wire resistance temperature detectors (RTD) of the same characteristics suitably distributed around the stator shall be installed and positioned at points at which the highest temperatures are likely to occur. These positions are, e.g., two detectors between coil sides within the slots, two detectors under the coils at the bottom of the slots and two detectors between the coils and slot wedges and they shall be far apart from each other. Detector leads shall be brought out to an auxiliary cable box such that any RTD may be isolated for testing.

The RTD monitoring units for each motor shall have the following features:

(a) Alarm contacts to operate at 120°C and adjustable for individual detecting elements.

(b) Trip contacts to operate at 140°C and adjustable for individual detecting elements.

(c) A 4-20mA output signal corresponding to the measured temperature with adjustable span and zero.

4.2 Bearing and Exhaust Air Temperature Detectors

A 3-wire RTD temperature detector shall be installed for each bearing and for the motor exhaust air for high temperature alarm and trip operation.

Unless recommended otherwise by the motor manufacturer, alarms detectors shall operate at 10°C lower than the trip detectors.

Insulated thermometer pockets shall be provided to enable easy insertion or removal of temperature detector. The bearing/exhaust air temperature monitoring units for each motor shall have the following features:

(a) Alarm contacts and trip contacts adjustable for individual detecting elements.

(b) A 4-20mA output signal corresponding to the measured temperature with adjustable span and zero.

4.3 Bearing Coolant Failure Detector

Where water cooled bearings are used, a flow failure detector and associated strainer, if required, shall be provided.

The flow detector shall be fitted with a pair of change-over contacts for alarm initiation control.

4.4 Vibration Detector

At least two vibration detectors shall be installed for motors of 750 kW and above to initiate alarm and tripping of pumpset when a preset vibration level is exceeded. The detectors shall be located on different bearings and at perpendicular axes and of acceleration sensitive type.

The vibration monitor unit shall have a continuously adjustable alarm/trip setting from 50-300% of the normal vibration amplitude. The equipment shall output a 4-20mA signal corresponding to the measured vibration level in millimetres peak-to-peak with adjustable zero and span. The overall error of the equipment shall not exceed 5% of the full scale reading of the instrument range.

The detector shall be designed to prevent false alarm due to transient shocks by incorporating a time-delay device of two seconds.

The unit shall be fitted with an alarm reset push button and alarm indicating lights.

4.5 Circuitry

Power supply to the monitoring units above-mentioned shall be 24V d.c.

The alarm and trip contacts shall be volt free and rated at 24V, 5A d.c. or 220V, 50Hz 5A inductive. The output contacts shall be normally open and shall close on detection of an alarm condition such that tripping of motor shall not occur due to failure of the auxiliary supply.

4.6 Pumpset Control Panel

An individual control panel will be provided by others for each pumpset.

The panel will be mounted adjacent to the motor. The following motor related equipment to be mounted in the control panel shall be supplied loose with the motor:

(a) Motor winding temperature monitoring unit – 6 nos. (Clause 4.1)

(b) Motor bearing temperature monitoring unit – 2 nos. (Clause 4.2)

(c) Motor exhaust air temperature monitoring unit – 1 no. (Clause 4.2, for motor of 1,000 kW or above)

(d) Vibration monitor unit – 2 nos. (Clause 4.4, for pumpsets of 750 kW or above)

5. AUXILIARY EQUIPMENT

5.1 Power Factor Correction Capacitors

The motor will be connected and operated in parallel with a high voltage power factor correction capacitor equipment complying with WSD Standard Specification E-60-07. The motor manufacturer shall give all necessary technical information and advice for the correct sizing of the matching capacitor.

5.2 Anti-condensation Heaters

Anti-condensation heaters shall be fitted and shall be suitable for operation on a 220V, single phase, 50 hertz supply. Arrangements will be made in the switchgear to switch off the heaters when the motor is running and vice versa. A separate IP 55 terminal box shall be supplied for anti-condensation heater. The box shall be provided with detachable gland plate. The box shall be provided with terminals for 2.5 mm^2 2-core PVCSWAPVC cable and a warning label “Separate Supply for Space Heater – Isolate Before Opening this Lid”.

The heaters shall be replaceable strip type and complete with low watt density heating elements such that the temperature measured at the motor casing at any point shall be within 2° - 15° above the ambient temperature.

5.3 Marshalling Box for Protective Devices

Lead wires of protective devices such as vibration and temperature detectors and equipment mounted on motor shall be protected by flexible stainless steel tubing/braid sleeving, cleated and terminated to a IP 55 marshalling box mounted on the motor casing.

The box shall be provided with detachable cable gland plates suitable for bottom entry of steel wire armoured screened or coaxial instrumentation cables to BS5308 or equivalent standards.

5.4 Small Wiring

Wiring shall be in accordance with WSD Standard E-00-01 except where modified herein.

Wiring liable to come in contact with oil shall have suitable oil resisting insulation. The bared ends of stranded conductors shall be sweated together to prevent creepage of oil along the wire.

High temperature insulation shall be provided on all wiring when this comes into contact with the heated part of the motor.

Wiring in conduits shall not be used.

Wiring shall be run and fixed such that wiring can be checked against diagrams

without removing 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 at least twice without causing a disturbance to the main run of wiring.

Wires shall be coloured black for a.c. connections, grey for d.c. connections and yellow/green for earth connections.

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

6. SPARES AND TOOLS

6.1 Spares

The following spares shall be supplied loose for the motor:

(a) White metal pads for plain type thrust and guide bearings - one set for each type.

(b) Ball and roller bearings - one complete unit for each size.

(c) Anti-condensation space heater – one complete set for each motor.

Other spares required for one-year operation of the motors and associated electrical equipment shall be separately priced in the tender.

6.2 Tools

Special maintenance tools for the motor shall be supplied. These shall include the following:

(a) The necessary rotor locking device, slings and spreaders for transport of motor and its components.

(b) One set of special tools as necessary for dismantling, overhaul and reassembly of the motor e.g. rotor eye bolt.

(c) One no. of spare motor stool for each size of motors exceeding three in number.

7. INSPECTION AND TESTING

7.1 Inspection and Testing at the Manufacturer's Works

The motor shall be inspected and witness-tested by the Independent Inspection Body (IIB) at the manufacturer's work prior to shipment in accordance with WSD Standard Specification EM-00-01.

Indicating meters (ammeter, voltmeter, wattmeter etc.) and measuring devices (C.T., V.T. etc.) used during tests shall be Class 0.5. The calibration results of these instruments shall be provided to the IIB 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 and setting of equipment.

(d) Routine and basic tests as specified in Clause 7.3 below.

(e) Packing and protection checks.

Standard calibration tests on instruments/equipment by manufacturers shall not form part of the normal inspection and hence shall not be witnessed by the IIB. In addition, the quality assurance tests specified in Clause 7.2 need not be witnessed unless specifically called for. However the test reports shall be submitted for verification during inspection and the same shall be incorporated in the instruction manual.

7.2 Quality Control Tests

7.2.1 Motor Winding

During production of coils for the Contract, non-destructive electrical tests shall be carried out to confirm insulation integrity. A random sample test measurement of loss tangent to BS EN 50209 and the following high voltage impulse tests to two sample coils in accordance with IEC 60034-15 shall be conducted:

	Machine Rated Voltage		
	3.3 kV	6.6 kV	11 kV
Impulse voltage withstand test of interturn insulation			
(a) Surge test voltage applied across each coil (5 surges, front time of 0.2μs)	12 kV Peak	20 kV Peak	32 kV Peak
Power frequency voltage withstand test			
(b) Earth insulation power frequency withstand voltage applied between coil terminals and earth (1 minute) *	7.6 kV	14.2kV	23 kV

* After the 1 minute test, the applied voltage shall be increased at the rate of 1 kV/s up to 2 times the test voltage and then immediately reduced at a rate of at least 1 kV/s to zero.

Where impregnation of winding is to be carried out with the coils in stator slots, the above tests shall be conducted at reduced voltages on at least four sample coils manufactured under the same batch of equipment supplied.

7.2.2 Protective Devices

Embedded temperature detectors (ETD), bearing temperature detectors, coolant flow detectors or any other protective devices where fitted shall be calibrated by suitable means before being fitted into the motor.

7.3 Motor Tests

7.3.1 General

Tests conducted in Manufacturer's Work shall be in accordance with IEC 60034 and BS EN 50209. No positive tolerance from specified limits shall be allowed for noise level, temperature rise and starting (locked rotor) current.

The following basic tests shall be conducted on at least one motor of each size and design supplied under this Contract. This motor shall be used for the subsequent pump efficiency test:

(a) Temperature rise (IEC 60034-1)

(b) Efficiency at rated load and at pump efficiency test duty point (IEC 60034-2)

(c) Power Factor at rated load and at pump efficiency test duty point

(d) Locked rotor torque

(e) Starting current

(f) Noise level (IEC 60034-9)

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

(g) No load current, losses and power factor tests (IEC 60034-2)

(h) Vibration tests (IEC 60034-14)

(i) Dielectric measurement and tangent delta test (BS EN 50209)

(j) Withstand voltage test (IEC 60034-1)

(k) Stator winding resistance measurement (cold) and direction of rotation (IEC 60034-1)

(l) Hydraulic pressure test of water cooling circuit

(m) Insulation resistance test of auxiliary equipment

7.3.2 Withstand Voltage and Dielectric Tests

Withstand voltage tests shall be conducted in accordance with IEC 60034-1. The manufacturer shall provide test reports recording the leakage current obtained.

The insulation resistance of the winding shall be measured and recorded at one minute and 10 minute intervals with a megger (2,500V for 3.3 kV, 5 kV for 6.6 kV and 10 kV for 11 kV motors) immediately before and after the withstand voltage test. The polarization index shall be above 2.0.

The tangent delta of each phase winding shall be measured and the result shall not exceed the figures stipulated in BS EN 50209 unless otherwise agreed by the Water Supplies Department prior to the test.

7.3.3 Vibration Level Test

The motor shall be tested for vibration to IEC 60034-14. The vibration levels of the motor shall not exceed the “Grade A” limits given in the IEC standard.

7.3.4 Noise Level Test

Each motor shall be tested for noise level to IEC 60034-9. The calculated value at reference condition shall not exceed the limits given in the IEC Standard. Measurement and calculation details shall be submitted.

7.3.5 Efficiency Test

The efficiency figures for the motor shall be established by summation of losses in accordance with IEC 60034-2.

7.3.6 Power Factor Test

The power factor test shall be conducted by direct loading at rated supply voltage and frequency. Power factor at motor rated load based on results from indirect loading tests, figures of losses, etc. will not be accepted without the special approval of the Water Supplies Department.

The guaranteed figures for the power factor at motor rated load and at the pump efficiency test duty points shall be met.

7.3.7 Temperature Rise Test

The temperature of the motor winding shall be determined from the increase of winding resistance.

Temperature rise test shall be conducted by direct loading at rated supply voltage and frequency or by approved equivalent loading method with an auxiliary power of different frequency superimposed to the main power source.

The test shall be conducted until the thermal equilibrium has been reached for over 2 hours. The temperature equilibrium shall be deemed to have been reached when the rise of temperature of the stator winding does not exceed 2°C over an hour period.

At least for the last 4 hours of the temperature rise test, the stator winding temperature shall be measured by an instrument which has been calibrated to an accuracy equivalent to 0.5°C.

Where silencers, air ducting, filters etc. are required for the motors supplied, temperature rise test shall be conducted with these devices fitted, except for the case of long air ducts then an orifice plate shall be fitted during temperature rise test to simulate the pressure loss.

The ambient temperature, motor outlet temperature and air flow quantity shall be measured during temperature rise test to confirm that the actual rise in temperature throughout the test is within the specified figure for the design air flow.

The surface temperature of the motor shall be measured when thermal equilibrium has been reached. The temperature rise at any external parts which are liable to be touched shall not exceed 25°C.

7.3.8 Hydraulic Pressure Test

Bearing cooling coils where fitted shall be hydraulic pressure tested to 1.5 times maximum working pressure.

7.3.9 Insulation Resistance Test

Insulation resistance tests shall be carried out on all auxiliary circuits including motor heater and ETD's. For motors with insulated bearing arrangement, the bearing insulation and induced shaft voltages shall also be measured. The test method and results shall be recorded in the report.

8. INFORMATION FOR EQUIPMENT APPROVAL

8.1 Catalogues and Performance Data

Catalogues, type test certificates and performance data of the motor, motor cable box, motor winding coils, instruments and the various protective equipment shall be submitted for assessment.

8.2 Pump and Motor Starting Characteristics

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

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

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

(c) Motor torque characteristic at the lowest specified voltage across the motor terminals i.e. 50% nominal voltage for auto-transformer starting, 80% for DOL starting.

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.

8.3 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 graph paper against the motor thermal characteristics as given in Clause 3.3.

- End of this Specification -