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 of E-00-01 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) E-90-01 Drawings for Electrical and Instrumentation Equipment

(b) E-90-12 Drawings for Motors of 100 kW and Above and Generators of 150 kVA and Above

(c) E-90-02 Manuals for Electrical and Instrumentation Equipment

(d) E-90-22 Manuals for Motors of 100 kW and Above and Generators of 150 kVA and Above

1.3 Standards

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

(a) BS EN 60034 Rotating electrical machines

(b) BS EN 60751 Industrial platinum resistance thermometer sensors

(c) BS EN 60085 Electrical insulation, Thermal classification

(d) BS 4999 General requirements for rotating electrical machines

(e) BS 5512 Method of calculating dynamic load ratings and rating life of rolling bearings

(f) BS 6121 Mechanical cable glands, Armour glands, Requirements and test methods

Other equivalent standards issued by internationally recognized engineering institutions or organizations may also be accepted. Manufacturers offering equipment complying with other standards shall supply duplicate copies of such standards in English together with the tender.

1.4 Type Test Certification

Type tests shall have been performed on equipment which is essentially similar to that being supplied. Evidence to this effect shall be submitted at the time of tendering, or as soon as practicable thereafter.

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 British 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
(b) Standards	:	BS 4999 and BS EN 60034 except where modified herein
(c) Duty rating	:	Maximum continuous rating (MCR), S1 duty
(d) Insulation	:	Class F design for Class B operation with temperature rise not exceeding the limit applicable to BS EN 60034-1
(e) Speed	:	1500 r/min synchronous speed maximum

(f) Noise level	:	Limiting mean sound power level (L_W) in dB(A) for air-borne noise emitted by motor not to exceed 90 dB(A) to BS EN 60034-9 Method II
(g) Vibration level	:	BS 4999 Part 142 Table 1 Quality grade N or Table 2 as appropriate for both vertically or horizontally mounted motors
(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 1000 m
(b) Maximum ambient temperature	:	Average over 24 hours 35°C Peak over any 4 hours 40°C
(c) Minimum ambient temperature	:	0°C
(d) Average yearly temperature	:	30°C
(e) 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 110V ±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% nominal for direct-on-line started motor, and 50% nominal 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, 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 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, in solo or in parallel under the most arduous operating conditions specified.

No reduction in the 20% power margin for fresh water pump motor or 15% for salt water pump motor will be allowed for test tolerances on pump output efficiency etc.

3 DESIGN & CONSTRUCTION

3.1 Enclosure

The enclosure shall have the degree of protection of IP 22 (drip proof) or IP 54 (totally enclosed) to BS EN 60034-5. Dimensions and frame number of motors shall comply with BS 4999 Part 141.

Motors of the same capacity and speed shall be interchangeable.

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

Acoustic enclosure which covers the entire IP 22 motor shall not be used. Acoustic chambers where used shall be detachable and fitted with lifting bolts for easy removal. The position and the mounting of the chamber shall not cause undue vibration to the motor.

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 top bearing higher than 2,000 mm from the floor, access ladder with hand rail and other safety device shall be provided for access to the top of the motor. The access ladder shall be detachable and be firmly fixed to the floor or motor platform.

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

3.2 Ventilation & Cooling

Unless otherwise specified, motors of size 1000 kW or above shall be fitted with individual outlet air duct to BS EN 60034-6, method of cooling IC2A1. Smaller motors shall be designed for method of cooling IC0A1, with self-circulation air as coolant.

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

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 inlet and exhaust air grills shall be so placed to avoid recirculation of exhaust air on individual motors or between adjacent motors. The exhaust air grill shall be so positioned that it does not direct air straight onto the pump casing or its inlet and discharge pipes and onto walkway.

Where motors are specified for operation with inlet and/or outlet ducting, 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. 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.

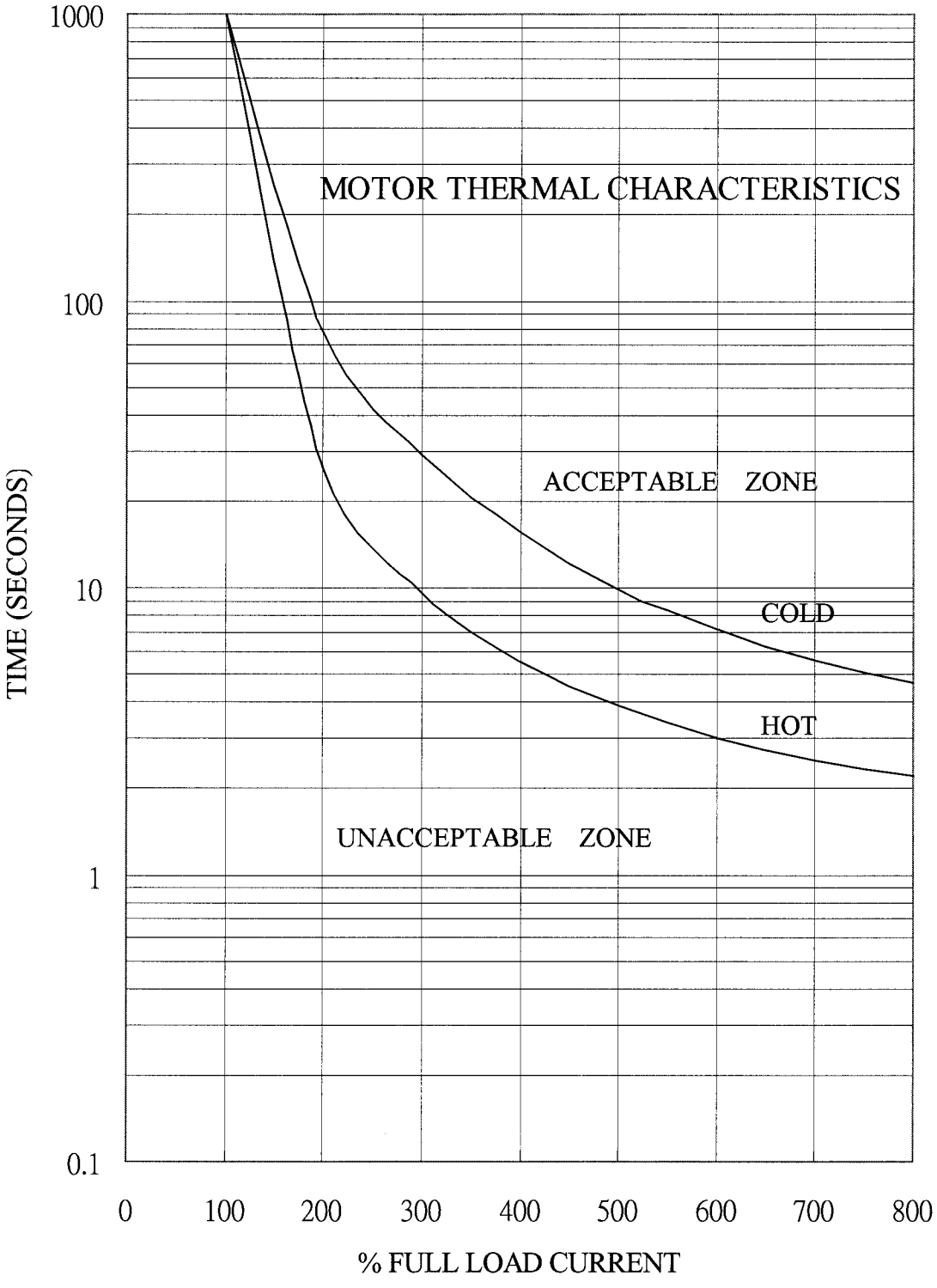
3.3 Thermal Insulation & Characteristic

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

The 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.

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



Motor Short-time Overload Withstand Characteristics

3.4 Motor Stators & Windings

The stator winding shall be designed for a minimum life of 25 years of service at rated load and voltage. Details of insulation system type tests and manufacturing quality assurance scheme shall be submitted for approval.

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.

If the motor has a graded insulation system such that different test voltages are recommended other than the standard voltage specified in BS 4999, this should be stated in the tender.

Motors shall be designed to permit high voltage tests in accordance with BS EN 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 insulation system of stator windings shall be of vacuum pressure impregnated type. Windings shall have a surface treatment to prevent deterioration due to adverse environmental conditions and for corona shield.

Windings 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 shall be better as compared with non-magnetic slot wedges.

Type test report for loss tangent and other high voltage tests to BS EN 50209 shall be provided to substantiate the winding insulation design. In addition, type test reports covering the following tests on two sample coils shall also be provided:

	Machine Rated Voltage	3.3 kV	6.6 kV	11 kV
(a)	Interturn insulation power frequency withstand voltage test (1 minute)	2.1 kV	3.2 kV	4.7 kV
(b)	Interturn insulation surge withstand voltage test (1.2/50 μs pulses)	4.5 kV peak	7.8 kV peak	12.3 kV peak

(c)	Earth insulation surge withstand test (1.2/50 μs pulses)	18 kV peak	31 kV peak	49 kV peak

3.5 Rotor

3.5.1 Type

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

3.5.2 Vibration Level

The limits of vibration shall comply with BS 4999, Part 142, Table 1 Quality Grade N or Table 2 as appropriate. The limits shall also be applicable to vertically mounted motors notwithstanding that the standard applies normally to horizontally mounted motors only.

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 above 1,000 kW, plain type thrust 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 preferred. Consideration shall also be given to bearing service life, noise, losses and maintenance convenience in the selection of bearings. Where rolling type bearing is selected 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 under this Contract 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 Contractor shall submit the design details to illustrate this requirement is met.

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 of 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 BS 5512 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 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 more than 4000 hours.

Grease nipples, oil cups and dip sticks shall be readily accessible without removal of guarding. Where necessary for accessibility, nipples may be remotely mounted at a point as near to the lubrication point as practicable.

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 to be supplied with the motor.

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 exceeds 1000 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 1000 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

A slot shall be provided in the steel bedplate where necessary to facilitate straight run of cable to the bottom of the motor cable terminal box. The Contractor shall advise within 6 weeks after the award of tender of any slots or openings in the pumpset foundation that may be required for the motor cables.

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. The Contractor shall seek approval of the required position of the cable box prior to manufacture.

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 BS EN 60034-8 shall be provided in the cable boxes.

3.10.3 Cabling Provision at Motor Casing

Terminal leads from cable box terminals or connectors to the windings 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 Cross Sectional Area of Terminal Leads (Copper Conductor)

Fault Level in MVA	3.3 kV	6.6 kV	11 kV
	mm^2	mm^2	mm^2
140	70	-	-
225	120	60	-
380	-	-	50

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 installation in enclosed cable trenches.

Table 4 - Motor Supply Cables

Cable Type Stranded Copper	Cable Size (mm^2)	Max. Motor Rating (kW)	Max. Motor Full Load Current (A)
PVC/SWA/PVC or	120	800	170
XLPE/SWA/PVC	185	1050	230
3 core	240	1350	300
3.3 kV	300	1500	335
	400	1700	380
PILC/SWA/PVC or	95	1450	160
XLPE/SWA/PVC	120	1650	180
3 core	150	1850	205
6.6 kV	185	2100	230
PILC/SWA/PVC or	95	2450	160
XLPE/SWA/PVC	120	2750	180
3 core	150	3100	205
11 kV	185	3500	230

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 a type fault-tested design as follows:

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

Type tested or BEAMA certified cable boxes shall be rated for 0.25 second of the following fault level:

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

The motor phase connections in the cable box shall each comprise a sealing chamber and an air insulated termination chamber bolted together and of degree of protection to BS EN 60529 IP 56. Sealing chamber is not required for stator winding star point termination box.

Termination boxes shall be fabricated from mild steel of minimum 6 mm thickness. Cast iron boxes shall not be acceptable.

The termination chamber shall be bolted to the motor casing such that its sides are vertical, with M10 high tensile steel studs and nuts. The cable sealing chamber shall be fixed to the bottom of the termination chamber by means of M10 high tensile steel bolts or studs and nuts.

The cable sealing chamber for PILC cables shall be designed with large orifices and adequate expansion space for complete compound filling. The compound filling level shall be clearly marked by indelible means on the outside of the box. A drain plug, a vent plug and a combined armour and earthing clamp shall be provided. The cable sealing chamber for PVC or XLPE cable shall be of dry type suitable for cable termination in Raychem heat shrinkable sleeving. Sealing chamber shall be fitted with a removable horizontal gland plate suitable for bottom cable entry.

The termination of motor supply cables shall be by bolts and nuts fixed onto stud terminal stems, and so designed that the motor can be removed to another location with the sealing chamber in-situ. No cable joint is permitted in the sealing chamber.

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 shall not be used. Cable-coupler type terminals shall not be acceptable.

Front access detachable cover plates shall be fixed by M10 studs and nuts. Separate plates shall be supplied for sealing and termination chamber.

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

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

Cable tails at the junction between cable terminations and sealing chambers shall be held in place by tufnol or laminated densified wood (permali) cable spacing block and bolts and nuts.

A polycarbonate plastic (PCP) shroud of minimum wall thickness 1.6 mm having a minimum breakdown voltage of 20 kV shall be fitted over each cable terminal.

3.11.2 Type Test Requirements

Unless BEAMA certified cable boxes are used, motor cable boxes shall be type tested by an approved Testing Authority as follows :

(a) Enclosure Test

Prototype cable boxes complete with cable sealing or end boxes shall be tested to demonstrate that an effective sealing/air tightness to BS EN 60529 IP 56.

(b) Short-circuit Tests

Prototype cable boxes shall be tested under the following specified system voltage and short-circuit conditions for 0.25 seconds:

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

Tests shall 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) shall result in no mechanical or electrical damage.

Test (ii) shall 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) shall 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 shall not result in spread or propagation of the fault to or between the other two phases, which are to be at rated potential for the test.

Test (b) may be waived for the stator star point termination box.

Type test on short circuit shall be undertaken by an independent Testing Authority such as ASTA, UK or other organization of similar standing.

3.11.3 Termination Box Auxiliaries

(a) Desiccator

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.

(b) Cable Gland

Brass cable glands shall be provided for motor supply cables. Where PILC cables are specified these glands shall be of the cone type for wiped joints and shall be complete with armour clamps. Where PVC or XLPE cables are specified, the glands shall comply with BS 6121 type E1W which has a seal on both the inner PVC sleeving and the outer PVC sheath of the cable. An earth tag and a PVC shroud shall be supplied with the E1W gland.

(c) Cable Lug

Cable lugs shall be supplied for the motor supply cable. Unless special lugs are used in the short circuit type test, cable lug shall be of compression type manufactured from tin-plated seamless copper tubing with single bolt palm terminal.

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, brass or other approved non-tarnishing metal shall be provided. The instruction plate shall give the connections and the phase rotation for the required direction of rotation. The required direction of rotation shall be marked on the motor.

The data plate shall be stamped with information required by BS EN 60034-1. The minimum coolant air quantity and the design letter for general characteristics to BS EN 60034-12 shall also be marked.

Data plates on which the above required information is only painted on will not be accepted. 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 Embedded Temperature Detectors (ETD)

A set of embedded temperature detectors of linear characteristics, e.g. thermocouple or resistance thermometer, and complete with monitoring unit shall be provided to afford protection against over-heating on load and stalling of the motor. Resistance temperature detector (RTD) shall comply with BS EN 60751 Class B.

At least six detectors 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 ETD may be isolated for testing.

The ETD 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 common digital temperature gauge and selection buttons for reading the winding temperatures of individual detecting elements.

4.2 Temperature Detectors

A 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. Digital indicators, with independently adjustable alarm and trip contacts, shall be provided at the pumpset instrument panel (Clause 4.6) to monitor the bearing and exhaust air temperatures. Contacts shall be arranged to close for alarm indication or tripping and shall be so arranged that the operation of the alarm or tripping can be checked manually.

4.3 Bearing Coolant Failure Detector

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

Suitable timers and relays shall be provided to obviate any false alarm during start up of the pumpset and on flow surges.

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 have an indicator to indicate vibration level in millimetres peak-to-peak. 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. In addition, to prevent inadvertent alarm during motor starting, the equipment shall be rendered inoperative for 15 seconds during starting.

The unit shall be fitted with an alarm reset push button and alarm indicating lights. The provision of an output connector for recording the signal by a portable instrument is preferred.

4.5 Circuitry

Power supply to the monitoring units and associated interposing relays shall be 110V d.c. If equipment operating at other voltages is used, switched type converter of high efficiency shall be supplied.

The alarm and trip contacts shall be volt free and rated at 110V, 0.5A 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. A voltage sensing relay shall be provided to initiate a remote alarm when the auxiliary supply to the protective devices fails.

A separate pair of fuse and link shall be provided for each protective equipment. The alarm and trip contacts of individual protective devices shall be wired to separate terminals.

4.6 Pumpset Instrument Panel

An individual instrumentation panel shall be provided for each pumpset. The panel shall be rectangular, fabricated with sheet steel of a minimum thickness of 2 mm, suitably braced to afford rigidity for floor mounting. The degree of protection shall be IP 55 to BS EN 60529.

The panel shall be mounted adjacent to the motor. The following equipment shall be mounted in this control panel:

(a) Pump motor running indication beacon

(b) Motor winding temperature indicator and monitoring unit

(c) Motor bearing temperature indicator and monitoring unit

(d) Pump bearing temperature indicator and monitoring unit

(e) Vibration monitor and display unit (for pumpsets of 750 kW or above)

(f) Motor exhaust air temperature indicator and monitoring unit

(g) No-flow switch monitoring unit (when specified)

(h) Emergency stop button

(i) Local controls for pumpset and ancillary equipment (when specified)

(j) Control relays and timers required for interfacing between pumpset alarms and pumpset control circuitry

(k) Sufficient terminals and cable glands for external cable connections

(l) Anti-condensation heater, isolator and associated thermostat

(m) Isolators, fuses in holders and other wiring ancillaries

All indicating instruments shall be mounted flush with the front panel. A rear hinged access door with chromium plated lockable handle shall be provided.

The control, wiring and layout drawings shall be submitted for approval prior to the manufacture of the panel.

Components shall be arranged such that access for routine maintenance tasks is not impeded.

Internal wiring shall be installed in plastic wiring channels and bundled neatly using insulated cleats. A maximum space factor of 50% shall be used in providing wiring channels.

Termination blocks for control wiring shall be located at least 300 mm from the base of the panel. Cable cores shall be identified with PVC ferrules visible without dismantling covers or disturbing adjacent terminations.

Provision of detachable gland plate and cable glands for one 37-core and two 2-core PVC/SWA/ PVC or XLPE/SWA/PVC 2.5 mm^2 600V grade cables at bottom entry shall be included among other control cables for interconnection with the pumpset.

One undercoat and two finishing coats of colour reference 18 B 21 (Light grey) to BS 4800 shall be applied to give a durable gloss finish. The internal finish shall preferably white to BS 4800 shade 00E51.

Auxiliary supply for panel heaters shall be 220V 50 Hz.

5. AUXILIARY EQUIPMENT

5.1 Power Factor Correction Capacitors

High voltage power factor correction capacitors equipment for high voltage pump motor shall comply with WSD Standard Specification E-60-07.

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 supplied by others for the heaters to be switched off 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 and a E1W gland for 2.5 mm^2 2-core PVC/SWA/PVC cable.

Heaters shall be designed to permit replacement of the unit. Heater elements shall be of a rating 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

Protective devices such as vibration and temperature detectors and equipment mounted on motor shall be cleated and wired by the contractor to a IP 55 marshalling box mounted on the motor casing and supplied under this Contract. Screened or

coaxial cables required for interconnection between equipment and the Pumpset Instrument Panel shall be supplied by the motor manufacturer.

The box shall be provided with detachable cable gland plates suitable for bottom entry of 600V grade PVC/SWA/PVC 1.5 mm^2, multi-core copper cables to BS 6346.

5.4 Small Wiring

Wiring shall be in accordance with Waterworks 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.

Ferrule numbering shall be in accordance with a system to be agreed with the Water Supplies Department.

6. SPARES AND TOOLS

6.1 Spare Winding

Stator winding details shall be supplied as detailed in Waterworks Standard Specification E-90-12 and E-90-22. Sufficient data and drawings shall be provided to enable stator coils to be ordered. Instructions for coil impregnation and curing, stator rewinding, impregnation and dry-out shall be supplied.

Where spare winding is specified, the following conditions should be complied with:

(a) Where four or more motors of the same rating and design are to be supplied in the contract, the tenderer shall submit a price and anticipated storage life (with a minimum of 25 years) for one complete set of spare stator windings along with all necessary insulating material and accessories required for rewinding and any special packing required for storage. The spare winding shall not require air conditioning or humidity control to achieve the declared storage span.

(b) Where the storage life of 25 years cannot be met, or where the stator construction will not permit rewinding to be carried out locally, a spare stator with fully cured winding shall be quoted instead. The overall dimension and weight shall be stated in the tender.

(c) The price of the spare winding/stator shall be based on the understanding that such item will be ordered prior to the manufacture of the motor windings for this contract so that the manufacturing cost would be kept to minimum.

6.2 Recommended Spares

Spares required for one-year operation of the motors and associated electrical equipment shall be separately priced in the tender. The following items shall be included as the recommended spares:

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

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

6.3 Recommended Tools

General and special maintenance tools shall be supplied. These shall include the following:

(a) Special tools required for the dismantling, reassembly and maintenance together with the necessary slings and spreaders for transport of motor and its components.

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

7. INSPECTION AND TESTING

7.1 General

The equipment supplied under the contract including spares and special tools shall be inspected and witness-tested by the Inspecting Engineer to be appointed by the Purchaser at the manufacturer's work prior to shipment.

The inspection work shall in general cover the following : -

(a) General inspection checks including physical dimensions, workmanship, quality, quantity, and standards.

(b) Functional checks of correct operation, interlocks and setting of equipment.

(c) Routine tests as specified herein or as required under the relevant British Standards and Clause 7.3 to 7.5.

(d) Packing and protection checks.

Inspection reports/certificates together with test arrangement drawings, circuits, calculations, and test results shall be submitted for approval immediately after the inspection prior to shipping of the plant.

Type tests on equipment and standard calibration tests on instruments/equipment by manufacturers shall not form part of the normal inspection and hence shall not be witnessed by the Inspecting Engineer. 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.

Indicating meters (ammeter, voltmeter, wattmeter etc.) and measuring devices (C.T., V.T. etc.) used during tests shall be Class 0.5.

Tolerance limits on motor tests shall only be permitted if specific figures are laid down in BS 4999 and BS EN 60034 and these have not been overwritten in the Specification issued by the Water Supplies Department. In the case of temperature rise, noise level, power factor, and starting current, no tolerance from the specified limits shall be permitted. Tolerance limits permitted by VDE, ISO or other Standards will not be accepted.

7.2 Quality Control Tests

7.2.1 Motor Winding

During production of coils, non-destructive electrical tests shall be carried out to confirm insulation integrity. A random sample test measurement of loss tangent and other dielectric tests shall be carried out to BS EN 50209. In addition, the following tests shall be conducted:

		Machine Rated Voltage		
		3.3 kV	6.6 kV	11 kV
(a)	Surge test voltage applied across each coil (60-100 kHz, 2 seconds)	10 kV peak	15 kV peak	25 kV peak
(b)	Earth insulation power frequency withstand voltage applied on assembled motor (1 minute)	7.6 kV	14.2kV	23 kV

Where impregnation of winding is to be carried out with the coils in stator slots, the above tests shall be conducted on at least two additional 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 Routine Tests on Assembled Motor

7.3.1 Scope of Tests

Tests conducted in Manufacturer's Work shall be in accordance with BS 4999, BS EN 60034 and BS EN 50209.

The following tests shall be conducted on at least one motor of each size and design supplied under this contract:

(a) Temperature rise

(b) Efficiency at rated load and at pump efficiency test duty point

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

(d) Locked rotor torque

(e) Starting current

(f) Noise level

The following witnessed test shall be conducted on each motor supplied:

(g) No load current losses and power factor tests

(h) Vibration tests

(i) Dielectric measurement and tangent delta test

(j) High voltage test

(k) Stator winding resistance measurement

7.3.2 Details of Test

(a) High Voltage and Dielectric Tests

High voltage tests shall be conducted in accordance with BS EN 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 (2500V for 3.3 kV, 5 kV for 6.6 kV and 10 kV for 11 kV motors) immediately before and after the high 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.

(b) Vibration Level Test

The motor shall be tested for vibration to BS 4999, Part 142. The amplitude of vibration of the motor shall not exceed the values specified.

(c) Noise Level Test

Each motor shall be tested for noise level to BS EN 60034-9 Method II. The calculated value at reference condition shall not exceed 90 dB(A) sound power level. Measurement and calculation details shall be submitted.

(d) Efficiency Test

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

(e) 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.

(f) Temperature Rise Test

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, acoustic enclosure, 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 tests 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.

(g) Hydraulic Pressure Test

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

(h) 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.

7.4 Pumpset Instrument Panel Tests

Functional test of the monitoring and control circuit shall be conducted for each panel.

7.5 Combined Pump and Motor Tests

Voltage, frequency, current and power input to motors shall be measured to determine the overall pump efficiency and uncorrected power factor at duty points.

During the test, the ambient temperature, air flow quantity, motor outlet exhaust temperature, motor winding temperature readings, vibration, bearing temperatures and readings of other instruments as installed shall be recorded at various operating points of the tests.

The settings of protective devices shall be recorded in the test report.

8. INFORMATION TO BE SUBMITTED

The following information shall be submitted with the tender and shall form part of the instruction manuals:

8.1 Catalogues

Catalogues of the main pumpset and auxiliary equipment, in particular the pumpset instrument panel, cable boxes and the various protective equipment, shall be submitted with the tender.

8.2 Pump and Motor Starting Characteristics

The following pumpset starting characteristics shall be furnished:

(a) Pumpset torque characteristic at the most arduous conditions with closed delivery valve.

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

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

The Y-axis shall be torque in N-m and the X-axis the motor speed in RPM.

8.3 Performance Data

The technical schedules issued with the specification shall be completed and submitted with the tender. Approval should be obtained from the Water Supplies Department for any changes in the technical details entered in the technical schedules after award of Contract.

8.4 Motor Thermal Characteristics

The short-time overload withstand characteristics of the motor (both hot state and cold state) plotted on a graph (ref. Clause 3.3) shall be submitted with the tender.

8.5 Type Test Certificate

Type test certificates specified in Clause 1.4 shall be submitted with the tender.

- End of this Specification -