WATER SUPPLIES DEPARTMENT

STANDARD SPECIFICATION E-60-07

HIGH-VOLTAGE POWER FACTOR CORRECTION CAPACITOR

1. GENERAL

1.1 Scope

This Specification covers the design, construction, manufacture, testing and delivery of high-voltage power factor correction capacitor equipment for high-voltage pump-motors. The equipment shall include all sub-units and component items to form a complete working system.

1.2 Operating Conditions

Capacitors supplied shall be capable of operating satisfactorily without mechanical or electrical damage, or degradation of operating characteristics under the following conditions:

(a) Climate Conditions

Ambient temperature	:	40°C maximum continuous for 4 hours 35°C average over any 24 hours 30°C average over one year 0°C minimum.
Humidity	:	Up to 98% relative humidity
Altitude	:	Not greater than 1000 metres

(b) Electrical Conditions

Electricity supply	:	11kV, 6.6kV or 3.3kV as specified in the Particular Specification, 3-phase, 50 Hz, 3-wire system
Normal limits of voltage variation	:	+10%, -2½%
Normal limits of frequency variation	:	±2%
Maximum prospective symmetrical fault level	:	System Voltage 3.3kV 225 MVA 6.6kV 225 MVA 11kV 380 MVA

1.3 Standard

Capacitors supplied shall comply with the latest editions and amendments of the following standards:

IEC 60871	Shunt capacitors for a.c. power systems having a rated voltage above 1000V
IEC 60282	High-voltage fuses

Other equivalent standards issued by internationally recognized engineering institutions or organizations may also be accepted. Manufacturers offering equipment to other standards shall supply duplicate copies of such standards in English together with full details of any deviations from the standards referred to in this Specification with the tender.

2. DESIGN AND CONSTRUCTION

2.1 Design

The capacitor shall be designed for heavy-duty operation. It shall be composed of capacitor units which are connected in delta by bolted and rigidly insulated copper bar connections. The copper bars shall be silver-plated and PVC sleeve insulated. The three line connections shall be provided with high breaking capacity (HBC) fuses with striker pin to IEC 60282. The striker pins shall be arranged to operate a set of volt-free normally open contacts rated at 110V 0.5A d.c..

In order to prevent flashover due to accumulation of dust and salty particles, all support insulators for the busbars, cables and high-voltage HBC fuses shall be of epoxy resin type suitable for outdoor applications.

The capacitor unit shall be of low-loss dielectric type. The loss shall be not more than 0.15 watt per kVAr. The capacitor unit shall be made up of by a number of elements each fitted with an internal fuse. Internal discharge resistors shall be permanently fitted across the terminals of each capacitor unit to reduce the residual voltage from the crest value of the rated voltage to a value not greater than 75 volts within 10 minutes after the capacitor is disconnected from the supply.

The impregnant in the capacitor unit shall be a biodegradable fluid with high insulation strength and free from toxic element. Impregnant materials which may pollute the environment such as polychlorobiphenyl etc. or may be hazardous in any other way (for example, the material is flammable or gives off toxic gas when burning) will not be accepted unless otherwise approved. Oil or compound filled capacitors shall not be accepted.

Reactors connected in series with the capacitor units shall be provided within the enclosure to limit the inrush current during energization of the capacitor.

2.2 Construction

All the sub-units and component items of the capacitor shall be housed in an air-insulated, floor-mounted and vermin-proof sheet steel cubicle to IEC 60529 IP44 of minimum thickness 2 mm and equipped with a full-height hinged lockable door.

A heavy-duty door limit switch with a pair of changeover contacts shall be provided for each leaf of door to trip the supply circuit-breaker upon opening of the door of the capacitor cubicle is opened and when the supply circuit-breaker is in service position.

A 220V a.c. anti-condensation heater complete with humidity sensor, double-pole isolation switch and protection fuse/neutral link shall be provided in the capacitor cubicle. Arrangement shall be made in the supply circuit-breaker to switch off the heater when the capacitor is energized or vice versa.

An auxiliary termination box for terminating the external cables for the striker pin of the capacitor fuses, anti-condensation heater and door limit switch shall be provided.

The capacitor cubicle shall be painted to BS 4800 shade 18B21 light grey. An earth stud terminal of M10 size minimum shall be provided on the cubicle at low level. A sight glass window shall be provided for viewing the striker pins of the fuses.

Suitable lifting lugs shall be fitted for the transport of capacitor equipment. A stainless steel rating plate engraved with the data of the capacitor supplied shall be provided and fixed by screws on the capacitor cubicle.

2.3 Mechanical Interlock

A mechanical interlock system shall be provided to prevent access to the interior of the capacitor cubicle when the capacitor is energized.

The interlock system shall be achieved by using key interlocks with the locks and keys coded with the symbols “C1”, “C2”, “C3” etc. such that the key for the capacitor cubicle door will only be available when the corresponding supply circuit-breaker is in the circuit earth position. The Contractor shall advise the type and coding symbols of the locks and keys to the Engineer for approval prior to manufacture.

2.4 Type Tests

The following type tests to IEC 60871 shall be carried out on capacitors of a design identical to the capacitor supplied:

(a) Thermal stability test
(b) Measurement of the tangent of the loss angle (tan δ) of the capacitor at elevated temperature
(c) AC voltage test between terminals and container
(d) Lightning impulse test between terminals and container
(e) Overvoltage test
(f) Short-circuit discharge test

3. POWER CABLE TERMINATION BOX

3.1 Design

The cable box shall be one of the following types:

(a) cable box type tested to Clause 3.4 by an internationally recognized testing authority such as Association of Short Circuit Testing Authorities UK (ASTA)

(b) cable box certified by BEAMA or other equivalent internationally recognized authority for 0.25 second at the following fault level:

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

(c) for prototype cable box other than Clause 3.1(a) and 3.1 (b) above, type testing can be waived provided that the following conditions are met:

(i) termination area is open to the capacitor cubicle so that there will be no build-up of pressure within the cable box;

(ii) copper busbars are used between the fuse and the external termination point; each copper bar shall have a cross-sectional area equivalent to that of the external cable; and

(iii) cable box is fabricated in accordance with the requirements in Clause 3.3.

3.2 Cable Termination

Termination for capacitor up to and including 750kVAr shall be suitable and have sufficient space for termination with the following external cables:

Supply	Cable Type	Cable Size (Copper)
6.6kV/11kV	XLPE/SWA/LSZH 3-core	95 mm^2
3.3kV	XLPE/SWA/LSZH 3-core	185 mm^2

Cable lugs and cable glands shall be supplied to match the above cables. Cable lugs shall be of the compression type manufactured from tin-plated seamless copper tubing with single bolt palm terminal. Cable glands shall fully comply with BS 6121:Part 1:1989 type E1W. Suitable shrouds, slip-on earth tags and backnuts shall be supplied.

3.3 Construction

The cable termination box shall be fabricated from mild steel of minimum thickness 6mm. Cast iron box will not be accepted. The box shall be arranged for bottom entry of cable and with a detachable horizontal gland plate.

The cable termination box shall be bolted to the capacitor cubicle frame with M10 high-tensile steel studs and nuts. Front access detachable cover plates shall be fixed by M10 studs and nuts.

The cable termination box shall be of the dry type suitable for cable termination with XLPE/SWA/LSZH cable. The termination of the supply cable shall be by bolts and nuts on to stud terminal stems. The termination box shall be an insulated assembly fitted with 3 stud terminals in epoxy resin mouldings.

The terminal box cover plates shall have deep return flanges formed into channel sections for rigidity and to accommodate close-fitting rubber or neoprene sealing gaskets of minimum cross-section, 6 x 6 mm to prevent ingress of dust and entry of vermin.

3.4 Type Test Requirements

(a) Enclosure Test

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

(b) Short-circuit Tests

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

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

Other tests shall include the following:

(i) A three-phase through-fault current test
(ii) A three-phase internal short-circuit test. This test is not required for phase segregated containment type box
(iii) A single line-to-earth internal short-circuit test

Test (i) shall result in no mechanical or electrical damage to the cable boxes.

Test (ii) shall result in no external damage to the terminal box structure other than the rupturing of any pressure relief device.

Test (iii) shall result in no external damage to the terminal box structure other than the rupturing of any pressure relief device. For phase segregated containment type terminal box 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.

4. INSPECTION AND TESTING AT MANUFACTURER'S WORKS

4.1 General

The capacitor supplied including spares shall be inspected by an Independent Inspection Body (IIB) at the manufacturer's works prior to shipment. Routine tests carried out on the capacitor supplied shall be witnessed by the IIB. Inspection and test reports /certificates together with test arrangement drawings, circuits, calculations and test results shall be submitted to the Engineer for acceptance in accordance with WSD Standard Specification EM-00-01.

4.2 Inspection

The scope of inspection shall cover the following:

(a) General inspection checks including physical dimensions, workmanship, quality, quantity and standards
(b) Verification of type test reports as specified in Clause 2.4
(c) Verification of calibration reports of testing instruments for routine tests
(d) Packing and protection checks

4.3 Routine Tests

The following routine tests to IEC 60871 shall be carried out by the manufacturer on every capacitor supplied before delivery:

(a) Capacitance measurement
(b) Measurement of the tangent of the loss angle (tan δ) of the capacitor
(c) Voltage test between terminals
(d) AC voltage test between terminals and container
(e) Test of internal discharge device
(f) Sealing test
(g) Discharge test on internal fuses

5. INFORMATION TO BE SUBMITTED

The following information shall be submitted for assessment prior to manufacture:

(a) Catalogues of the capacitor supplied showing the technical specifications, constructional details, materials used etc.

(b) Typical arrangement drawings for the capacitor and reactor equipment and the power cable termination box

(c) Test certificates/reports as specified in Clauses 2.4 and 3.4

- End of this Specification -