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PRINTING HISTORY

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SPECIFICATION P-165:89
11,000 VOLT CAPACITOR BANKS
AND CONTROL EQUIPMENT

- 0 FOREWORD
- 0.1 This specification has been prepared by the Standard and Research Directorate of Design Department, Power Wing, WAPDA.
- 0.2 This specification is intended for the procurement of material and does not include all the necessary provisions of a contract.
- 0.3 The specification for 11,000 Volt Capacitor Banks and Contact Switchgear was first issued in 1982. Later in 12/82 its amendment No.1 was issued. The Specification of Switchgear was mainly based upon P-44:79 Specification for 11,000 Volt Metalclad Switchgear. P-44 has since been revised twice and at present its 1987 edition is in force. Thus the changes in P-44 are required to be incorporated in P-165. Recently Capacitor Switch conforming to Specification P-185:89 has been introduced to control each 2.4 MVAR Section of the Capacitor Bank. Necessary changes in bus bar sizes and configuration have been made to accommodate the Capacitor Switch. The revised edition, incorporates besides other addition/alteration, the Amendment No.1 dated December, 1982.
- 0.4 This specification is subject to revision as and when required.
- 1 SCOPE
- 1.1 This specification covers materials, ratings, characteristics, construction details and tests for capacitor banks and control switchgear to be installed in substations.
- 1.2 A Capacitor Bank shall comprise of the following:
- i) Capacitors of 100 or 200 kVAR rating
 - ii) Racks for mounting of capacitors
 - iii) Expulsion type fuses for protection of individual capacitors
 - iv) Bus work, insulation and mounting arrangement
 - v) Other accessories.

The size of standard rack shall be 2400 kVAR. Racks shall be capable of being assembled together to form larger single banks.

The specification for Power Capacitors are covered separately under WAPDA Specification P-78:82.

- 1.3 The Control and Switching Equipment shall comprise of 11kV indoor switchgear alongwith necessary relays and accessories for switching and protection of capacitor banks. Cables for connection with the out-door capacitor banks are not included.

2 SERVICE CONDITIONS

2.1 Climatic Conditions

2.1.1 Atmospheric Conditions

It may be assumed that the air is not normally heavily polluted by dust, smoke, corrosive or flammable gases, vapours or salt. However at certain times of the year, severe dust storms may be experienced. Fine dust particles are present in the air and these are deposited on exposed surfaces.

2.1.2 Ambient Temperature

Maximum	50°C
Maximum mean over any 24 hours	45°C
Mean in any year	30°C
Minimum	-10°C

2.1.3 Relative humidity may range upto 100%.

The maximum value of the ambient temperature and humidity however do not occur simultaneously. During the monsoons high humidity may persist for many days at a time.

2.1.4 Altitude

Installation upto 1000m above sea level.

2.2 Supply System

- 2.2.1 The capacitor banks shall be suitable for installation in A.C. supply system of the following characteristics:

Nominal System Voltage	11kV
Nominal Voltage at Grid Stations	11.5kV
Rated Voltage	12kV
Frequency	50 Hz

3 GENERAL REQUIREMENTS

3.1 The capacitor banks shall be supplied as complete units in factory assembled form or in knock down condition which shall be assembled at site of erection. The unit block rating shall be 2400 kVAR and shall be supplied with properly sized bus bars, necessary insulators, unit earthing switch or separate earthing kit and other equipment as detailed in Clause 1.1.

3.2 The capacitor banks shall be erected outdoor in the switchyard. The capacitors shall be connected through metalclad switchgear panel to 11kV bus bar of the installed sub station for automatic switching of the capacitor banks. This switchgear panel shall be erected next to the incoming panel and busbars of both jointed together such that to each incoming transformer, one capacitor bank feeder is available.

General layout of the banks is given in drawing No. PDW/DF-383 Standard Switched Bank Capacitors are 2400, 3600, 4200, 6000 & 7200 kVAR.

3.3 Racks capacitor banks shall be switched on for improving 132/66kV side voltage so that the specified voltage level be maintained. The capacitor banks shall be switched off beyond certain voltage level. For this purpose voltage and time sensitive automatic switching controls shall be used. The equipment details are given in clause 4.3.4.

3.6 Capacitor banks shall be designed for the following insulation level:

- i) Rated lightning impulse withstand voltage .. 95kV
- ii) Rated one minute power frequency voltage (rms) .. 34kV

The minimum clearances shall be as under:-

- Phase to phase .. 160mm
- Phase to ground .. 125mm

3.7 The capacitor banks shall be supplied with built in earthing switch or a separate earthing kit to assure maintenance personnel safety while working on or around capacitor banks. The built in switch shall be mounted on capacitor mounting frame and operatable with a hook stick. The design of the separate earthing kit or built in earthing switch shall be provided by the manufacturer with the tender documents.

4 SWITCHGEAR PANEL

4.1 The switchgear shall be of the indoor type meant for automatic switching of the capacitor banks. It shall generally conform to Wapda Specification P-44:87 except as mentioned herein.

4.2 Panel Components

4.2.1 Each panel shall comprises the following equipment:

1. One Circuit Breaker
2. Three current transformers for over current protection and metering
3. Instruments
4. Relays
5. Hooter
6. Cable Termination Pad
7. Signalling Lamps ON/OFF Indications

4.3 Circuit Breaker

4.3.1 General

4.3.1.1 Circuit Breaker shall be of 25 KA breaking capacity. It shall be triple pole and all the three poles shall be coupled so as to operate simultaneously. The breakers shall be vacuum or SF6 types. The breaker shall be draw out type suitable for indoor installation.

4.3.1.2 The breaker shall be capable of interrupting the required range of capacitor currents without restriking and allow capacitor currents to persist without making serious attempts at interruption until sufficient contact separation is reached which is able to withstand the recovery voltage twice as high as system voltage at half cycle after the first current pause.

4.3.1.3 The breakers shall be suitable for Electrical and Mechanical Switching operations as under:

1. Electrical: Switching operations at rated load : 10,000.
2. Mechanical: Switching operations : 10,000.

4.3.1.4 The closing springs of breakers shall be charged by an AC motor rated at 240V AC.

4.3.2 Characteristics and Ratings

The breaker shall have the following characteristics:

1. Current rating 630 Amps

2.	Rated Voltage	12 kV
3.	Frequency	50 Hz
4.	Capacitor Switching Current	500 A
5.	Breaking Current Symmetrical	25 kA
6.	Making Current	63 kA
7.	Rated one minute power frequency withstand voltage	36 kV
8.	Rated lightning impulse withstand voltage	95 kV
9.	Operation Duty	0-3mh-CO-3mr-CO
10.	Total maximum break time	6 Cycles

4.3.3 Busbars

4.3.3.1 The busbars shall conform in general to clause 13 of wapda Specification P-44:87. The size of busbars shall be 2x100x10 so that they can be jointed to the incoming busbars standardised vide Dwg: No.PDW/TS-1630 of P-44:87. The busbar connections and joints shall be as detailed in Dwg: No. PDW/DF-297 of P-44:87.

4.3.4 Voltage and Time Sensitive Control

4.3.4.1 The voltage and time sensitive automatic capacitor switching control shall be of single pole type, flush mounted and suitable for installation in the switch-gear instrument compartment on the front door. The scale and range of operations shall be suitable for switching a 7200 kVAR capacitor bank. The accuracy shall be 2% of the full scale. Selector switches shall be provided for manual or automatic operation through "Automatic-Manual" and open-Neutral-Close switches.

4.3.4.2 The voltage sensitive control shall measure 132 & 66kV line voltage and as function of that quantity control the relay which in turn shall operate the switchgear. The relay shall be electronically controlled with an adjustable time delay. The instrument shall also be provided with adjustable band width range for setting switching IN and OUT voltages so that little variation in voltage shall not cause hunting.

4.3.5 Protection

5.3.5.1 110 Volts AC and a current of 5 Amps shall be available from the secondary voltage of the PT & CT respectively.

4.3.5.2 All the panels shall have overcurrent and earth fault protection which shall be provided by means of inverse induction type relays with two overcurrent elements and one earth fault element. The relay shall have three instantaneous elements. The relays shall conform to clause 14 of Wapda Specification P-44:87.

4.3.5.3 The capacitor unbalance detection relays shall be suitable for operation from a 5 Amps secondary of the bank neutral current transformers. The relays shall be of 2 steps type, the first step to give alarm on the failure of one capacitor unit and the second step to trip the breaker on the failure of the second capacitor unit.

4.3.5.4 The neutral unbalance protection scheme for the capacitor bank shall consist of double star with neutral connected to the current transformer as shown in Fig.2 CT's shall be mounted at a suitable place on the structure and shall operate the relay described in Clause 4.3.5.3.

4.3.6 Current Transformers

4.3.6.1 The current transformers shall conform in general to clause 15 of P-44.

4.3.6.2 For overcurrent protection and metering the current transformers shall have 400/200/5-5 transformers ratios.

4.3.6.3 The outdoor capacitor bank neutral current transformers shall be totally epoxy-resin covered or porcelain insulator type and completely weather proof. The primary current rating shall be 50A whereas the secondary current shall be 5A. The accuracy class shall be 5P20. The characteristics of insulator shall be as follows:

Min creepage distance	= 300mm
Dry arcing distance	= 150mm
Dry one minute Power Frequency withstand voltage	= 36kV
Lighting impulse withstand voltage	= 95kV

4.3.7 Voltage Transformers

The voltage transformer shall not be supplied. The secondary voltage of 110 Volts AC from the existing voltage transformer in the substation shall be used to operate the instruments and relays on the switchgear panels of the capacitor banks.

4.3.8 Instruments

The switchgear panel shall be provided with the follow-

ing instruments:

1. One voltmeter 0-15kV with selector switch
2. Three ammeters 0-250-500 Amps, one in each phase.

4.3.9 Control Wiring and Termination

The control cable and switchboard wiring cable shall conform to Wapda Specification P-100. The minimum size for voltage and current circuits shall be 2.5 sq. mm and 4 sq. mm respectively. The wire colour code and termination method shall be as per clause 18 of P-44:87.

4.3.10 Circuit Connection

Each panel shall have position for connection to outdoor capacitor bank through two 240mm² cables per phase. Space shall be provided for above cable connection with dry termination.

4.3.11 Tests

The switchgear panels shall be subjected to type and routine tests as listed in clause 22 of P-44:87. Certified type test reports may be accepted in lieu of the actual test.

5 STRUCTURE FOR CAPACITOR BANKS

5.1 General

The mounting structure shall be of extendable unit construction, each unit being suitable for 2400 kVAR capacitor bank with provision for mounting of fuses, cable terminations, insulators and rigid buses. The layout of the capacitor bank shall generally be in accordance with Drawing No. PDW/DF-383. The manufacturer shall offer alternate suitable design subject to approval of Wapda.

5.2 Material

All parts of the bank structure shall be made of hot dip galvanised steel sections having the following characteristics:

Tensile strength	41-56 kg/mm ²
Min. Yield point	23 kg/mm ²
Min. elongation	20% on 200mm gauge length

5.3 Construction Requirements

- 5.3.1 The steel structures shall be of bolted type construction and designed with sufficient stiffening and cross

bracing to adequately perform their functions under maximum conditions of loading and wind pressure of 150 kgs/sqm without any vibrations.

5.3.2 All steel parts including nuts and bolts shall be hot dip galvanised in accordance with Wapda Specification P-82:. The average and minimum weight of zinc coating shall be 610 and 550 gm/sq meter respectively.

5.3.3 The capacitor bank shall generally be constructed in accordance with drawing No. PdW/DF-383 and shall meet the following requirements:

- i) Centre to centre distance of the capacitor unit 250mm
- ii) Minimum mounting height of the capacitor unit (bushing top) 2500mm
- iii) Minimum height of the busbar 3000mm

5.4 Tests

The steel structures shall be subjected to the following tests:

- i) Visual Examination
- ii) Verification of Dimensions as per approved manufacturer's drawings.
- iii) Galvanising tests as per Wapda Specification P-82.
- iv) Tensile Tests as per ISO/R-82.

6 BUS BARS

6.1 A set of three round or rectangular bus bars of 98% IACS electrical conductivity copper for connection to capacitors shall be provided. The size of bus bar shall be as per dwg. No. PDW/DF-383 (revised).

6.2 The manufacturer shall design the bus bars and joints so that temperature rise at joints and connections shall not be more than 40°C and shall submit all such design details with the bid.

6.3 The bus bars shall be of sufficient mechanical strength and rigidly supported over insulators as to withstand mechanical forces resulted from the short circuits.

6.4 All bus bars shall be insulated to prevent flashovers due to lizards and small birds etc; preferably with heat shrinkable tubing of polyolefine. Snap on PVC or equivalent material covers shall be provided at all joints and connectors. The thickness of insulation

	<u>50 K</u>	<u>25 K</u>
Dry one minute power frequency withstand voltage to ground	35kV	35kV
Wet one minute power frequency withstand voltage to ground	30kV	30kV
Temperature rise at rated current	40°C	40°C
Fuse link rating	50 K	25 K

7.4 Tests

- 7.4.1 All tests shall be carried out in accordance with IEC Publication IEC 549.
- 7.4.2 Certified type test reports may be accepted in lieu of the actual tests.
- 7.4.3 All fuses shall be subjected to routine tests by Wapda at the manufacturers works.

8 TECHNICAL DATA AND DRAWINGS

- 8.1 The manufacturer shall include in his offer complete engineering and test data with complete dimensional drawings, showing front, side and plan views of the complete capacitor bank and of individual parts. All leading dimensions and clearances in millimeters shall also be indicated.

Encls: Drawing No. PDW/DF-383(revised)

YK

shall be such as to withstand at least twice the rated voltage continuously. The manufacturer shall supply mechanical and electrical characteristics of the insulating materials.

- 5 All bus bars joints and connectors shall be tin or silver plated.
- 6 The bus bars shall be capable of being extended without difficulty on either side and provision shall be made for withstanding expansion and contraction of the bus bars and connections due to variations in temperature over a range of 80°C.

EXPULSION FUSE

- 7.1 The expulsion fuse for protection of the capacitors shall be outdoor type and shall be manufactured and tested in accordance with IEC Publication 549 and 282 and the requirements listed herein.

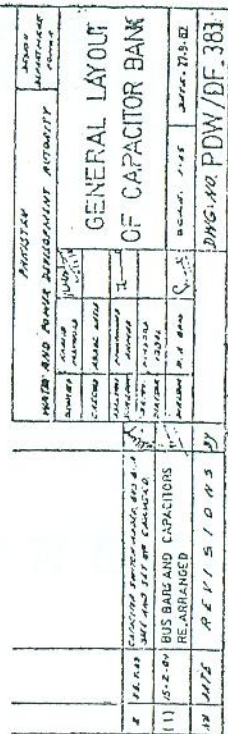
7.2 Constructional Requirements

- 7.2.1 The fuse shall generally be constructed for installation on switched capacitor banks as shown in general arrangement Drawing No. PDW/DF-383 (revised).
- 7.2.2 The design of the fuse shall be such that blown fuse is indicated and shall be detectable from the ground. Also there shall be no possibility of tracking and flashovers during its life time. The fuse length shall be replaceable type.
- 7.2.3 The contact design shall assure positive contact engagement and shall be tin or silver coated. The minimum thickness of silver coating shall be 20 microns.
- 7.2.4 The terminals shall be made of copper or brass materials and tin plated.
- 7.2.5 The standard fuse link for protection of 200 kVAR capacitor shall be 50K and for 100 kVAR capacitor shall be 25K. The time current characteristics of the fuse links shall be supplied.

7.3 Ratings

The fuse shall have the following ratings:

	50 K	25 K
Nominal voltage	11.5 kV	11.5 kV
Rated continuous current	50 Amps	25 Amps
Rated interruption current	5000 Amps	5000 Amps
Impulse withstand voltage to ground	95 kV	95 kV



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