

**KARNATAKA POWER TRANSMISSION CORPORATION**  
**LIMITED**

**TECHNICAL SPECIFICATION**

**SECTION -11KV CAPACITOR  
BANKS**

## **TECHNICAL SPECIFICATION FOR 11 KV CAPACITOR BANKS, 12.1kV, 2904 KVAR**

### **1.0 SCOPE:**

The specification covers 3 Phase, 50 Hz, naturally cooled 11 KV shunt Capacitor Banks.

### **2.0 APPLICABLE STANDARDS:**

Unless otherwise stipulated in this specification, the 11 KV Capacitors shall comply with the latest version of IS-13925 (Shunt Capacitors for Power Systems) and series reactor to IS:5553 and NCT to IS:2705.

### **3.0 TEMPRATURE CATEGORY**

Unless otherwise specified, the Capacitors shall be suitable for temperature category of 50°C as per IS:13925.

### **4.0 BRIEF DESCRIPTION**

The Capacitor Banks shall be suitable for outdoor use complete with all protection and control equipment and a *Single Tier Steel Rack* assembly suitable to accommodate all the units on one bank with all interconnections of the units, fuses and bus bars.

The Capacitor units shall be manufactured by adopting latest technology using good quality polypropylene dielectric of adequate thickness and high purity Aluminium/copper foil. The paper dielectric is not acceptable in view of its high watt loss / KVAR, inferior quality, less life and more volume. The impregnant used shall be most suitable for high temperature. The impregnation shall be carried out under high vacuum for increasing dielectric strength. Type of impregnant shall be non-PCB capacitor liquid.

The capacitor units shall be hermetically sealed.

Each 11 KV, 3 phase Capacitor Banks shall have a net output of 2400 KVAR as specified after allowing for the reactors and the units may be conveniently arranged according to the

standard practice of the manufacturer and type of protection offered. The switching in and out, of the bank shall be by means of vacuum circuit breakers.

#### 4.1 Principle Parameters

- |   |  |  |
|---|--|--|
| a | Nominal system voltage                                 | : 11 KV  |
| b | KVAR capacity required at nominal system               | : 2400 KVAR (min)  |
| c | Rated voltage of the Capacitor Banks kV                | : 12.1 KV  |
| d | Rated output of Capacitor Banks at rated voltage       | : 2904 KVAR  |
| e | Rating of capacitor unit with internal Fuses at 12.1kV | : 484 KVAR   |
| f | Connection of Capacitor Banks                          | : Double star with internal fuses with floating neutral.   |
| g | No. of units / Bank                                    | : 6Nos. - 1Unit for each Phase with double star arrangement.   |
| h | Power loss   | : Not to exceed 0.2 watt / KVAR including losses in fuses subject to tolerance as per IS:13925.                    |
| i | Permissible overload                                   | : Maximum permissible over loads with reference to voltage, current and reactive output shall confirm to IS:13925. |
| j | Type of Grounding                                      | : Ungrounded   |
| k | Capacitor Impregnant                                   | : Non Poly Chloro Bi-Phenyl (NPCB)   |
| l | Type of protection                                     | : Internal fuse  |
| m | Type of Discharge                                      | : Internally through resistor provided within the capacitor unit.  |

- |                                       |   |
|---------------------------------------|---|
| n Capacity to receive in rush current | : Not less than 100 times<br>rated current. |
| o Normal Frequency                    | : 50 Hz $\pm$ 3%                            |
| p System Grounding                    | : Solidly Grounded.                         |

#### **4.2 Arrangement of Bank:**

The shunt Capacitor Banks shall comprise of capacitor units and protective fuses suitably connected in series and parallel and mounted on suitable galvanized mounting frames 2.5 meters above the ground level with heavy duty post insulator between capacitor section and to ground as required.

#### **4.3 (a) The protective scheme shall be by a two step relay arranged as follows:**

If the failure of one or more units causes an over voltage of less than 10% tolerable, on the remaining healthy units then the unbalance current shall cause in the first step to sound an alarm. But if more than the above number of units fail causing a voltage rise of more than 10% on the remaining healthy units then the unbalance current shall cause to trip and isolate the Capacitor Banks instantaneously in the second step.

- (b) Calculation for the rise in percentage voltage at the time of failure of one and also more numbers of capacitor elements should be submitted for number of series groups chosen. The internal series group for each unit shall not exceed six.

#### **4.4 (a) The temperature rise at any point on the container when the capacitor is delivering the rated output with specified ambient temperature shall not exceed 25°C.**

(b) The capacitor units shall be designed to give reactive capacity of not less than 95% at rated voltage and frequency and not more than 115% measured at 25°C.

#### **4.5 The capacitor units shall be suitable for continuous operation of 130% of rated current. The maximum MVAR shall include**

- a** MVAR due to excess voltage at normal frequency but within permissible limits of the rated voltage.

- b MVAR due to other frequency of harmonic voltage super imposed on the fundamental frequency.

#### **4.6 Permissible over voltage and line unbalance current:**

The capacitor units shall be capable of continuous operation at maximum permissible voltage shall be as per IS: 13925. The unbalance current shall not exceed 3% of the normal line current.

#### **4.7 Material and Workmanship:**

This shall be of highest order and shall conform to modern practice. Various components shall be interchangeable. The machining tolerance shall be clearly indicated so that replacement made as per drawing can be readily installed. All galvanizing shall be done after fabrication by hot dip methods. Threads of nuts shall have a neat fit, so that they can be turned throughout the length of the threads of the bolts and shall be capable of withstanding full strength of bolts. All materials galvanized shall satisfactorily withstand the tests as per the relevant standards. Individual capacitor units shall be so mounted so that they are easily accessible and replaceable without disturbing the other units.

#### **4.8 Discharge Device:**

Suitable discharge resistor shall be provided in the capacitor in accordance with IS: 13925.

The discharge device shall reduce the residual voltage from the crest value of the rated voltage to 50 volts or less within 10 minutes after the capacitor is disconnected from the source of supply.

#### **4.9 General Requirements of capacitor:**

- a. The capacitor shall be of non-PCB type.
- b. The container shall be made from CRCA sheet steel of thickness not less than 1.6 mm.
- c. Complete mounting brackets, supporting insulators and all other components for elements for formation of Capacitor Banks racks shall be supplied along with the capacitor units.

- d. The container shall be hermetically sealed by controlled arc welding process. The metal flanges of the bushing should be soldered / welded to the container and covered with epoxy compound, providing a strong hermetical seal to the container.
- e. The outside of the capacitor units and other structures should have smooth and tidy look and should be coated with weatherproof, corrosion resistant paint of light Grey shade, shade No. 631 of IS: 5
- f. The capacitor units shall be provided with a rating plate and terminal marking as stipulated in IS:13925.

#### **4.10 Capacitor Banks with Double Star Formation:**

- a. For Capacitor Banks connected in double star formation with a floating neutral, one neutral Current Transformer shall be supplied. The neutrals of the two portions of the Capacitor Banks (connected in double star formation) shall be connected through the neutral Current Transformer. The NCT secondary will be connected to a circulating current relay with a timer in the 11 KV Switchgear panel so that the neutral displacement and unbalanced neutral currents due to failure of capacitor units / unbalanced capacity of capacitor units in each phase is detected and associated breaker is tripped.
- b. The ratio of neutral current transformers shall be selected such that the failure of one unit of any group is detected by an instantaneous current operated relay with setting of 20%. The main technical particulars of the neutral current transformer shall be :
  - a. Rated Voltage : 12 KV
  - b. Reference Standard : IS 2705
  - c. Ratio : To be specified by  
Tenderer (Secondary  
should be 1 Amps for  
full rated current)  
Calculation of neutral current for  
failure of element of capacitor unit  
at alarm and trip condition.

d. Ratio Burden	Core I	: 15 VA
	Core II	: 15 VA
e. Accuracy Class	Core I	: 5 P
	Core II	: 1
f. Accuracy limit factor		
	Core I	: 20
	Core II	: -
g. Instrument Security factor		
	Core I	: -
	Core II	: not more than 5
h. Short time rating		: 100 times the primary rated current.
i. Minimum total Creepage distance		: 300 mm
j. Basic insulation level impulse withstand Voltage		: 78 KV – Peak
k. Power Frequency withstand voltage.		: 28kV rms
l. Test requirements		: All routine tests shall be carried out as per IS:2705.

#### **4.11 Protection Arrangement:**

The capacitor shall be provided with necessary protection devices as detailed below:

##### **Fuses:**

- a. Each element of the capacitor unit shall be protected by internal element fuses conforming to IS: 12672 / IEC : 593 which shall be properly designed to cut off the element that may fail due to electrical or mechanical failure. Fuse failure shall be easily detectable.
- b. Internal fuses for individual elements within the unit shall be as per the manufacturer's design and shall be ensured to withstand normal switching inrush transient currents, discharge currents when the bank is switched off. Fuses shall be capable of disconnecting a faulty unit or elements over wide range of unit normal voltage from 70 to 200% of normal voltage. In case all the elements in the same row are fused out in cascade inside a unit, then the fuse element blown shall be capable of successful disconnection, with an voltage of not less than 150% of the rated voltage appearing across its terminals. After the fuse blows the fuse assembly and the gap shall withstand this voltage i.e. 150% of rated voltage successfully and continuously. The capacitor unit shall also withstand this voltage successfully and continuously. An internal element / elements fuse blowing out shall not cause, case rupture of the containers of the unit.
- c. The fuses shall not melt or deteriorate when subject to inrush currents, which occur during the life of the Capacitor Banks. It is anticipated that up to 10000 number of times current inrush will occur during the life of the bank with minimum interval of five minutes between successive inrush currents with capacitor charged to peak voltage. The fuses associated with healthy units or elements shall not melt when carrying the discharge current resulting from breakdown of a unit or element or from an external short circuit.
- d. Fuses shall be capable of carrying continuously a current of at least 165% the rated rms current of the associated unit element.
- e. Fuses shall preferably be of the current limiting type, but the fuse system shall in any event be designed to ensure that the energy released into a faulty capacitor unit is less than the value that will cause rupture or bursting of the container. Evidence shall be submitted to show that the probability of case rupture following internal fuse failure is very small. In case of internal fuse, the cost for supply of Capacitance Bridge should be quoted.
- f. All capacitor units shall be provided with suitable discharge resistor to meet requirements under relevant standards.



- g. The firm shall give details in their offer about the method of detecting the internal fuse failure and one portable instrument shall be supplied as a part of contract for testing capacitor unit fuse failure.
- h. The rates of 10% spares shall be quoted in the offer separately.

#### **4.12 Details of Mounting:**

The complete assembly of the Capacitor Banks, NCT and series reactor shall be on a mild steel galvanized steel structure are in the scope of supply. The details of mounting structures connections with relevant drawings shall be furnished. The bottom most portion of the lowest post insulator shall be at absolute height of 2500 mm from the ground level.

#### **4.13 Reactors**

The reactor should be air-cooled dry type and non-magnetically shielded. The series reactor of 0.2% rating shall be connected on neutral end of the star connection. The reactor shall be suitable to carry 130% of the rated current of the Capacitor Bank. The rated current shall be 120.72 Amps.

#### **4.14 Under Voltage**

In case of failure in the incoming supply, it has to be ensured that the capacitors are not switched on again until the capacitors are discharged to a safe value to prevent high transient switching currents. In order to ensure this, under voltage release coil should be provided for opening the breaker automatically in the event of failure or drop in the incoming supply.

#### **4.15 Timer Relay:**

One timer relay to prevent high transient switching current shall be provided with control switch to allow sufficient timing for the Capacitor Banks to discharge to a safe value before the bank is switched in again. The time limit for the units to discharge to a safe level shall not be more than 5 minutes. This timer should also ensure that if once the controlling breaker is tripped, the breaker can't be closed against unless a minimum period of 5 minutes is lapsed.



#### 4.16 Switchgear and protection of capacitors

The protection scheme of Capacitor Banks shall be unbalanced current protection via split neutral CT. The rating of 11 KV switch gear of porcelain clad / metal clad type for protection of Capacitor Banks shall be same as that of the bank i.e. incoming feeder. The detailed specification of the 11 KV switchgear of porcelain clad / metal clad type is included elsewhere in the Technical Specification of the bidding documents.

Following relays will be provided in the 11 KV switchgear meant for Capacitor Bank and are covered in the scope of supply of 11 KV switchgear included in the bidding documents.

- a. Circulating current relay with timer (mentioned in Cl. No. 4.10 (a) )
- b. Under voltage relay ( mentioned in Cl. No.4.14)
- c. Timer relay (mentioned in Cl. No.4.15)

#### 4.17 Rating Plate

- a. Manufacturer's name and / or trade mark:
- b. Manufacturer's identification number and manufacturing year:
- c. Rated output in KVAR;  $Q_N$ :
- d. Rated Current;  $I_N$ :
- e. Nominal capacitance;  $C_N$  :
- f. Rated voltage in V or KV;  $U_N$
- g. Rated frequency in Hz;  $F_N$ :
- h. Temperature category: -5/C
- i. Number of phases:
- j. Connection symbol (only for poly-phase units):
- k. Basic Insulation level:
- l. Discharge device;  / Internal/.....  $\Omega$
- m. Reference to self-healing design, for example NSH:
- n. Total weight;
- o. Type of di-electric-P / PP / MPP / M:
- p. Type of impregnant – NPCB:
- q. A warning instruction that “Discharge Capacitors before Handling” should be permanently marked in red.
- r. P.O. reference.
- s. Internal Fuses;  :

#### 4.18 Instruction name plate

Detailed instructions on an instruction name plate located at a suitable place shall be provided duly including the mode of disposal of leaking and unusable capacitors. And the

warning instruction that “Discharge Capacitor before handling” shall be permanently marked in red. The instruction name plate should be located at a conspicuous place such that it is easily readable.

#### **4.19 Rating Plate:**

Technical parameters shall be given on the rating plate of the Capacitor Bank, series reactor, and NCT as per relevant IS.

#### **4.20 Tests:**

Each capacitor units will be subjected to following routine/acceptance tests at the manufacturers works as per IS 13925 (Part I with its latest version/amendments).

##### **(a) Type Tests:**

Type test reports of offered capacitor units shall be furnished. The type test reports shall not be older than **Five (5)** years as on the **last date of submission of bid**.

##### **a) For Capacitor Units manufactured in India:**

- i. The type tests on indigenous equipment for which testing facility is available in India, should have been conducted in any independent laboratories approved by the Government or the laboratories accredited by the National accreditation body of the country like Central Power Research Institute (CPRI), Electrical Research and Development Association (ERDA), etc.
- ii. The type tests on indigenous equipment, for which testing facility is not available in India, should have been conducted in a laboratory of foreign country accredited by National accreditation body of that country.
- iii. The type tests conducted in-house by a manufacturer shall also be acceptable provided the laboratory is accredited by National accreditation body of the country and the tests has been conducted in the presence of a representative of NABL accredited laboratory or any of the purchasing utilities or CEA in that order. Such type test reports shall record the details of such witness including the signature/authentication in the type test report.

##### **b) For Capacitor Units manufactured Abroad:**

- i. Type tests on imported equipment should have been conducted in an Indian Laboratory or foreign laboratory accredited by National accreditation body of the country where the Type test has been conducted.
- ii. The type tests conducted in-house by a manufacturer shall also be acceptable provided the laboratory is accredited by National accreditation body of the country and the tests has been conducted in the presence of a representative of accredited laboratory or any of the purchasing utilities or CEA in that order. Such type test reports shall record the details of such witness including the signature/authentication in the type test report.  
In case of in-house type tested imported equipment of foreign OEM, the term “Purchasing Utility” covers the foreign Utility who has purchased that equipment

The bidder shall furnish following type test reports of offered capacitor units as per IS: 13925 (Part-I), 13925 (Part-II), IEC 60871-2 with its latest version/amendments, if any or to any equivalent International Standard.

- i. Thermal stability test.
- ii. Measurement of the tangent of the loss angle ( $\tan \delta$ ) of the capacitor at elevated temperature.
- iii. AC voltage test between terminals and container.
- iv. Lightning impulse voltage test between terminals and container (see Clause 16).
- v. Short circuit discharge test (see Clause 17).
- vi. Disconnecting test on internal fuses (see 5.3 of IEC 60871-4)
- vi. Endurance Test as per IS 13925 (Part-II) or to any equivalent International Standard.

Note: Two units are to be tested & no break down shall occur

**(b) Routine/Acceptance Test:**

- i. Visual examination.
- ii. Capacitance measurement
- iii. Measurement of the tangent of the loss angle ( $\tan \delta$ ) of the capacitor
- iv. Voltage test between terminals
- v. A.C. Voltage test between terminals and container
- vi. Test of internal discharge device
- vii. Sealing test

viii. Discharge test on internal fuses

#### **4.21 Inspection:**

All tests and inspection shall be made at the place of manufacture unless otherwise especially agreed upon by the manufacturer and the purchaser at the time of purchase. The manufacturer shall afford the inspector representing the purchaser all reasonable facilities, without charge, to satisfy him that the material is being supplied in accordance with the specification.

The purchaser has the right to get the tests carried out at his own cost by an independent agency, wherever there is a dispute regarding the quality of supply.

#### **4.22 Note:**

A visible indication to indicate the failure of internal fuse shall be provided for each unit.

\* \* \* \* \*

## SCHEDULE OF GUARANTEED TECHNICAL PARTICULARS FOR CAPACITOR BANK WITH SERIES REACTORS AND NEUTRAL CURRENT TRANSFORMERS

### I. CAPACITOR UNITS:

1. Standards applicable
2. Name of the make
3. Rated voltage of individual unit
  - a) Max.
  - b) Min
4. Rated KVAR of each unit
5. 50C/S test voltage and duration between terminals
6. Impulse test voltage b/w terminals
7. Power frequency withstand voltage – 10 secs.
8. Capacitance of each unit
9. Continuous KVA output plus and minus
10. Temperature rise of container at rated output and at ambient of 45 deg. C
11. Tolerance for KVA output plus and minus
12. Maximum unbalance in phase current %
13. Details of voltage rise caused by the blow fuses (for Internal fuse type)
14. Type of insulating liquid and quantity in each unit
15. Type of containers and thickness
16.
  - a) Type of fuse
  - b) Make of fuse
17. Whether provided with internal over pressure disconnecter :Yes/No.
18. Whether instruments to detect internal fuse failure is provided
19. Dimensions and weight.
20.
  - a) Material and dielectric
  - b) Dielectric loss per unit (watts)
  - c) Dielectric loss for the entire Capacitor Bank.

## II. CAPACITOR BANK

1. KVAR rating of Capacitor Bank at
  - a) Nominal system rating of 11KV
  - b) Rated voltage 12.1KV
2. Number of units in series and parallel in each phase of individual groups (Schematic diagram of (Connection to be enclosed).
3. No. of banks offered
4. Details of voltage rise due to failure of Capacitor Units in the bank
5. Area required for the installation.

## III. TECHNICAL PARTICULARS FOR SERIES REACTOR (DRY TYPE)

1. Type and make
2. Reference standard
3. Rated voltage
4. Rated current
5. No. of Phases 3 phases/1phase : type of connection  
neutral side/line side.
6. Rated capacity/inductance.
7. Continuous rating in % of rated current  
Of capacitor bank.
8. Rated frequency
9. Compensation % of series reactor.
10. Rated short time current and duration
11. Basic insulation level
  - a) Impulse withstand voltage KV rms
  - b) Power frequency withstand voltage KV rms
  - c) Switching surge withstand voltage KV rms.
12. Reactance at rated output rated MVAR
13. Description of wdg. Insulation
14. Winding resistance.
15. Materials of winding Cu/Al.
16. Maximum current density A/Sq.mm
17. Load losses
18. Maximum temp. rise
19. Terminal arrangement
20. Maximum system voltage for which reactor is designed.
21. Type of shielding adopted in the reactor
22. fitting and accessories
23. Dimensions
24. Noise level and ref. Standard db
25. Vibration level

26. Harmonic content in any
27. Approximate weight.

#### IV. NEUTRAL CURRENT TRANSFORMER:

1. Type
  2. Manufacturer Type designation
  3. Rated voltage
  4. Rated primary current
  5. Rated secondary current
  6. Secondary terminal voltage at normal current
  7. Secondary terminal voltage at 10 times normal voltage
  8. Core details Knee point      VA Class of
- |            |                |          |       |
|------------|----------------|----------|-------|
| Accuracy   |                |          |       |
|            | Voltage factor | Accuracy | limit |
| a) Core-I  |                |          |       |
| b) Core II |                |          |       |
9. Rated current dynamic (peak value)
  10. One minute Power frequency dry withstand voltage KV/RMS.
  11. One minute Power frequency dry withstand test voltage KV/RMS
  12. One minute Power frequency dry withstand test voltage on secondaries KV/RMS
  13. 1.2/50 Micro Second impulse withstand voltage v/Peak
  14. Weight
  15. Mounting details
  16. Overall dimensions

#### IV. Fuses

1. Rated voltage of the fuse
2. Current rating of the fuse link or refill unit
3. Maximum continuous current capability
4. Current rating of the fuse base of fuse carrier contacts
5. Time current Characteristic for an ambient air  
Temp of 27 deg. C      :      furnished  
not furnished



6. Rated capacitive breaking current
7. Maximum it values which the fuse can withstand  
For 5 and 100 discharges.
8. Maximum available capacitor energy which the fuse can withstand at the  
specified voltage without bursting
9. Minimum pre arcing it and maximum total clearing it at inductive and capacitive  
power frequency current.
10. Cold resistance of fuse link and percentage tolerance of resistance value.

## DETAILS OF EXPERINECE

1. Name of Manufacturer
2. Standing of the Firm as Manufacturer of equipment quoted
3. Description of equipment similar to that quoted, supplied and installed during last 3 years with name of party to whom supply was made
4. Details as to where installed etc.
5. Testing facilities at Manufacturers works
6. If the manufacturer is having collaboration with another firm, details regarding the same.

# **TECHNICAL SPECIFICATION FOR 11 KV CAPACITOR BANKS: 12.1kV, 5808KVAR**

## **1.0 SCOPE:**

The specification covers 3 Phase, 50 Hz, naturally cooled 11 KV shunt Capacitor Banks.

## **2.0 APPLICABLE STANDARDS:**

Unless otherwise stipulated in this specification, the 11 KV Capacitors shall comply with the latest version of IS-13925(Shunt Capacitors for Power Systems) and series reactor to IS:5553 and NCT to IS:2705.

## **3.0 TEMPERATURE CATEGORY**

Unless otherwise specified, the Capacitors shall be suitable for temperature category of 50°C as per IS:13925.

## **4.0 BRIEF DESCRIPTION**

The Capacitor Banks shall be suitable for outdoor use complete with all protection and control equipment and a *Single Tier Steel Rack* assembly suitable to accommodate all the units on one bank with all interconnections of the units, fuses and bus bars.

The Capacitor units shall be manufactured by adopting latest technology using good quality polypropylene dielectric of adequate thickness and high purity Aluminium foil. The paper dielectric is not acceptable in view of its high watt loss / KVAR, inferior quality, less life and more volume. The impregnant used shall be most suitable for high temperature. The impregnation shall be carried out under high vacuum for increasing dielectric strength. Type of impregnant shall be non-PCB capacitor liquid.

The capacitor units shall be hermetically sealed.

Each 11 KV, 3 phase Capacitor Banks shall have a net output of 4800 KVAR as specified after allowing for the reactors and the units may be conveniently arranged according to the standard practice of the manufacturer and type of protection offered. The switching in and out, of the bank shall be by means of vacuum circuit breakers.

## 4.1 Principle Parameters

- a Nominal system voltage : 11 KV
- b KVAR capacity required at nominal system : 4800 KVAR (min)
- c Rated voltage of the Capacitor Banks kV : 12.1 KV
- d Rated output of Capacitor Banks at rated voltage : 5808KVAR
- e Rating of capacitor unit with internal Fuses : 400KVAR at 6.35kV
- f Connection of Capacitor Banks : Double star with internal fuses with floating neutral.
- g No. of units / Bank : 12Nos. - 2Units for each Phase with parallel arrangement.
- h Power loss : Not to exceed 0.25 watt / KVAR including losses in fuses subject to tolerance as per IS:13925.
- i Permissible overload : Maximum permissible over loads with reference to voltage, current and reactive output shall confirm to IS:13925 and shall be capable of operating at 10% overvoltage continuously.
- j Type of Grounding : Ungrounded
- k Capacitor Impregnant : Non Poly Chloro Bi-Phenyl (NPCB)
- l Type of protection for capacitor units : Internal fuse
- m Type of Discharge : Internally through resistor provided within the capacitor unit.

- n Capacity to receive in rush current : Not less than 100 times rated current.
- o Normal Frequency : 50 Hz  $\pm$  3%
- p System Grounding : Solidly Grounded.

#### **4.2 Arrangement of Bank:**

The shunt Capacitor Banks shall comprise of capacitor units and protective fuses suitably connected in series and parallel and mounted on suitable galvanized mounting frames 2.5 meters above the ground level with heavy duty post insulator between capacitor section and to ground as required.

#### **4.3 (a) The protective scheme shall be by a two step relay arranged as follows:**

If the failure of one or more units causes an over voltage of less than 10% tolerable, on the remaining healthy units then the unbalance current shall cause in the first step to sound an alarm. But if more than the above number of units fail causing a voltage rise of more than 10% on the remaining healthy units then the unbalance current shall cause to trip and isolate the Capacitor Banks instantaneously in the second step.

- (b) Calculation for the rise in percentage voltage at the time of failure of one and also more numbers of capacitor elements should be submitted for number of series groups chosen. The internal series group for each unit shall not exceed six.

#### **4.4 (a) The temperature rise at any point on the container when the capacitor is delivering the rated output with specified ambient temperature shall not exceed 25°C.**

**(b)** The capacitor units shall be designed to give reactive capacity of not less than 95% at rated voltage and frequency and not more than 115% measured at 25°C.

#### **4.5 The capacitor units shall be suitable for continuous operation of 130% of rated current. The maximum MVAR shall include**

- a** MVAR due to excess voltage at normal frequency but within permissible limits of the rated voltage.

- b MVAR due to other frequency of harmonic voltage super imposed on the fundamental frequency.

#### **4.6 Permissible over voltage and line unbalance current:**

The capacitor units shall be capable of continuous operation at maximum permissible voltage as per IS: 13925. The unbalance current shall not exceed 3% of the normal line current.

#### **4.7 Material and Workmanship:**

This shall be of highest order and shall conform to modern practice. Various components shall be interchangeable. The machining tolerance shall be clearly indicated so that replacement made as per drawing can be readily installed. All galvanizing shall be done after fabrication by hot dip methods. Threads of nuts shall have a neat fit, so that they can be turned throughout the length of the threads of the bolts and shall be capable of withstanding full strength of bolts. All materials galvanized shall satisfactorily withstand the tests as per the relevant standards. Individual capacitor units shall be so mounted so that they are easily accessible and replaceable without disturbing the other units.

#### **4.8 Discharge Device:**

Suitable internal discharge resistor shall be provided in the capacitor unit in accordance with IS:13925.

The discharge device shall reduce the residual voltage from initial peak voltage of  $\sqrt{2}$  times rated voltage upto 75 volts or less within 10 minutes after the capacitor is disconnected from the source of supply.

#### **4.9 General Requirements of capacitor:**

- a. The capacitor shall be of non-PCB type.
- b. The container shall be made from CRCA sheet steel of thickness not less than 1.6 mm.
- c. Complete mounting brackets, supporting insulators and all other components for elements for formation of Capacitor Banks racks shall be supplied along with the capacitor units.

- d. The container shall be hermetically sealed by controlled arc welding process. The metal flanges of the bushing should be welded to the container (weldable type of bushings) and covered with epoxy compound, providing a strong hermetical seal to the container.
- e. The outside of the capacitor units and other structures should have smooth and tidy look and should be coated with weatherproof, corrosion resistant paint of light Grey shade, shade No. 631 of IS: 5
- f. The capacitor units shall be provided with a rating plate and terminal marking as stipulated in IS:13925.

#### 4.10 Capacitor Banks with Double Star Formation:

- a. For Capacitor Banks connected in double star formation with a floating neutral, one neutral Current Transformer shall be supplied. The neutrals of the two portions of the Capacitor Banks (connected in double star formation) shall be connected through the neutral Current Transformer. The NCT secondary will be connected to a circulating current relay with a timer in the 11 KV Switchgear panel so that the neutral displacement and unbalanced neutral currents due to failure of capacitor units / unbalanced capacity of capacitor units in each phase is detected and associated breaker is tripped.
- b. The ratio of neutral current transformers shall be selected such that the failure of one unit of any group is detected by an instantaneous current operated relay with setting of 20%. The main technical particulars of the neutral current transformer shall be :
  - a. Rated Voltage : 12 KV
  - b. Reference Standard : IS 2705
  - c. Ratio : To be specified by  
Tenderer (Secondary  
should be 1 Amps for  
full rated current)  
Calculation of neutral current for  
failure of element of capacitor unit

at alarm and trip condition to be furnished.

- |   |         |  |
|---|---------|--|
| d. Ratio Burden                                     | Core I  | : 15 VA  |
|   | Core II | : 15 VA  |
| e. Accuracy Class                                   | Core I  | : 5 P  |
|   | Core II | : 1  |
| f. Accuracy limit factor                            |         |  |
|   | Core I  | : 20   |
|   | Core II | : -  |
| g. Instrument Security factor                       |         |  |
|   | Core I  | : -  |
|   | Core II | : not more than 5  |
| h. Short time rating                                |         | : 100 times the primary rated current.                   |
| i. Minimum total Creepage distance                  |         | : 300 mm   |
| j. Basic insulation level impulse withstand Voltage |         | : 78 KV – Peak   |
| k. Power Frequency withstand voltage.               |         | : 28kV rms   |
| l. Test requirements                                |         | : All routine tests shall be carried out as per IS:2705. |

#### 4.11 Protection Arrangement:

The capacitor shall be provided with necessary protection devices as detailed below:

##### Fuses:

- a. Each element of the capacitor unit shall be protected by internal element fuses conforming to IS: 12672 / IEC: 60871-4 which shall be properly designed to cut off the element that may fail due to electrical or mechanical failure.



- b. Internal fuses for individual elements within the unit shall be as per the manufacturer's design and shall be ensured to withstand normal switching inrush transient currents, discharge currents when the bank is switched off. Fuses shall be capable of disconnecting a faulty unit or elements over wide range of unit normal voltage from 70 to 200% of normal voltage. In case all the elements in the same row are fused out in cascade inside a unit, then the fuse element blown shall be capable of successful disconnection, with an voltage of not less than 150% of the rated voltage appearing across its terminals. After the fuse blows the fuse assembly and the gap shall withstand this voltage i.e. 150% of rated voltage successfully and continuously. The capacitor unit shall also withstand this voltage successfully and continuously. An internal element / elements fuse blowing out shall not cause, case rupture of the containers of the unit.
- c. The fuses shall not melt or deteriorate when subject to inrush currents, which occur during the life of the Capacitor Banks. It is anticipated that up to 10000 number of times current inrush will occur during the life of the bank with minimum interval of five minutes between successive inrush currents with capacitor charged to peak voltage. The fuses associated with healthy units or elements shall not melt when carrying the discharge current resulting from breakdown of a unit or element or from an external short circuit.
- d. Fuses shall be capable of carrying continuously a current of at least 165% the rated rms current of the associated unit element.
- e. Fuses shall preferably be of the current limiting type, but the fuse system shall in any event be designed to ensure that the energy released into a faulty capacitor unit is less than the value that will cause rupture or bursting of the container. Evidence shall be submitted to show that the probability of case rupture following internal fuse failure is very small.
- f. All capacitor units shall be provided with suitable discharge resistor to meet requirements under relevant standards.
- g. The firm shall give details in their offer about the method of detecting the internal fuse failure and one portable instrument shall be supplied for each station as a part of contract for testing capacitor unit fuse failure.

#### **4.12 Details of Mounting:**

The complete assembly of the Capacitor Banks, NCT and series reactor shall be on a mild steel galvanized steel structure are in the scope of supply. The details of mounting structures connections with relevant drawings shall be furnished. The bottom most portion of the lowest post insulator shall be at absolute height of 2500 mm from the ground level.

#### **4.13 Reactors**

The reactor should be air-cooled dry type and non-magnetically shielded. The series reactor of 0.2% rating shall be connected on neutral end of the star connection. The reactor shall be suitable to carry 130% of the rated current of the Capacitor Bank. The rated current of capacitor bank shall be 251.94Amps.

#### **4.14 Under Voltage**

In case of failure in the incoming supply, it has to be ensured that the capacitors are not switched on again until the capacitors are discharged to a safe value to prevent high transient switching currents. In order to ensure this, under voltage release coil should be provided for opening the breaker automatically in the event of failure or drop in the incoming supply.

#### **4.15 Timer Relay:**

One timer relay to prevent high transient switching current shall be provided with control switch to allow sufficient timing for the Capacitor Banks to discharge to a safe value before the bank is switched in again. The time limit for the units to discharge to a safe level shall not be more than 10 minutes. This timer should also ensure that if once the controlling breaker is tripped, the breaker can't be closed against unless a minimum period of 10 minutes is lapsed.

#### **4.16 Switchgear and protection of capacitors**

The protection scheme of Capacitor Banks shall be unbalanced current protection via split neutral CT. The rating of 11 KV switch gear of porcelain clad / metal clad type for protection

of Capacitor Banks shall be same as that of the bank i.e. incoming feeder. The detailed specification of the 11 KV switchgear of porcelain clad / metal clad type is included elsewhere in the Technical Specification of the bidding documents.

Following relays will be provided in the 11 KV switchgear meant for Capacitor Bank and are covered in the scope of supply of 11 KV switchgear included in the bidding documents.

- a. Circulating current relay with timer (mentioned in Cl. No. 4.10 (a) )
- b. Under voltage relay ( mentioned in Cl. No.4.14)
- c. Timer relay (mentioned in Cl. No.4.15)

#### 4.17 Rating Plate

- a. Manufacturer's name and / or trade mark:
- b. Manufacturer's identification number and manufacturing year:
- c. Rated output in KVAR;  $Q_N$ :
- d. Rated Current;  $I_N$ :
- e. Nominal capacitance;  $C_N$ :
- f. Rated voltage in V or KV;  $U_N$
- g. Rated frequency in Hz;  $F_N$ :
- h. Temperature category: -5/C
- i. Number of phases:
- j. Connection symbol (only for poly-phase units):
- k. Basic Insulation level:
- l. Discharge device;  $H \dots \Omega$
- m. Total weight;
- n. Type of di-electric- PP:
- o. Type of impregnant – NPCB:
- p. Internal Fuses;  $\dots$  :
- q. A warning instruction that “Discharge Capacitors before Handling” should be permanently marked in red.
- r. P.O. reference.

#### 4.18 Instruction name plate

Detailed instructions on an instruction name plate located at a suitable place shall be provided duly including the mode of disposal of leaking and unusable capacitors. And the warning instruction that “Discharge Capacitor before handling” shall be permanently marked in red. The instruction name plate should be located at a conspicuous place such that it is easily readable.

#### 4.19 Rating Plate:

Technical parameters shall be given on the rating plate of the Capacitor unit, Capacitor Bank, series reactor, and NCT as per relevant IS.

#### 4.20 Tests:

##### (a) Type Tests:

Type test reports of offered capacitor units shall be furnished. The type test reports shall not be older than Five (5) years as on the last date of submission of bid.

##### **a) For capacitor units manufactured in India:**

- iv. Type tests on indigenous equipment for which testing facility is available in India, should have been conducted in any independent laboratories approved by Government or accredited by National accreditation body of the country like Central Power Research Institute (CPRI), Electrical Research and Development Association (ERDA), etc.
- v. Type tests on indigenous equipment, for which testing facility is not available in India, should have been conducted in a laboratory of foreign country accredited by National accreditation body of that country.
- iii. The type tests conducted in-house by manufacturers shall also be acceptable provided the lab (manufacturer's) is accredited by National accreditation body of the country and the tests have been witnessed by a representative of NABL accredited Independent laboratory/Power utility.

##### **b) For capacitor units manufactured Abroad:**

- ii. Type tests on imported equipment should have been conducted in an Indian Laboratory or foreign laboratory accredited by National accreditation body of respective country.
- ii. Type tests conducted in-house by manufacturers shall also be acceptable provided the laboratory is accredited by National accreditation body of the country and the tests have been witnessed by a representative of accreditation body/Power utility.

The bidder shall furnish following type test reports of offered capacitor units as per IS: 13925 (Part-I), 13925 (Part-II), IEC 60871-2 with its latest version/amendments, if any or to any equivalent International Standard.

- i. Thermal stability test.
- ii. Measurement of the tangent of the loss angle ( $\tan \delta$ ) of the capacitor at elevated temperature.
- iii. AC voltage test between terminals and container.
- iv. Lightning impulse voltage test between terminals and container (see Clause 16).
- v. Short circuit discharge test (see Clause 17).
- vi. Disconnecting test on internal fuses (see 5.3 of IEC 60871-4)
- vi. Endurance Test as per IS 13925 (Part-II) or to any equivalent International Standard.

Note: Two units are to be tested & no break down shall occur

(b) Routine/Acceptance Test:

Each capacitor units will be subjected to following routine/acceptance tests at the manufacturers works as per IS 13925 (Part I with its latest version/amendments).

- i. Visual examination.
- ii. Capacitance measurement
- iii. Measurement of the tangent of the loss angle ( $\tan \delta$ ) of the capacitor
- iv. Voltage test between terminals
- v. A.C. Voltage test between terminals and container
- vi. Test of internal discharge device
- vii. Sealing test
- viii. Discharge test on internal fuses

#### 4.20 Inspection:

All tests and inspection shall be made at the place of manufacture unless otherwise especially agreed upon by the manufacturer and the purchaser at the time of purchase. The manufacturer shall provide all reasonable facilities to the inspector representing the purchaser, without charge, to enable him to witness all the tests as per the relevant standards for the materials that are being supplied in accordance with the specification.

The purchaser has the right to get the tests carried out at his own cost by an independent agency, wherever there is a dispute regarding the quality of supply.

\* \* \* \* \*



**GUARANTEED TECHNICAL PARTICULARS FOR CAPACITOR BANK WITH SERIES  
REACTORS AND NEUTRAL CURRENT TRANSFORMERS:**

**(Bidder should indicate the guaranteed technical data of all equipment/materials for each type of  
rating separately)**

<b>I</b>	<b>CAPACITOR UNITS</b>			
1	Standards applicable			
2	Name of the make			
3	Rated voltage of individual unit			
	a)Max.			
	b)Min.			
4	Rated KVAR of each unit			
5	50 C/S test voltage and duration between terminals			
6	Impulse test voltage between terminals			
7	Power frequency withstand volage- 10secs			
8	Capacitance of each unit			
9	Continuous KVA for which the unit is designed			
10	Temperature rise of container at rated output and at ambient of 45 degC			
11	Tolerance for KVA output plus and minus			
12	Maximum unbalance in phase current%			
13	Details of voltage rise caused by the blow fuses (for internal fuse type)			

14	Type of insulating liquid and quantity in each unit			
15	Type of containers and thickness			
16(i)	a)Shape of basic element			
	b)Type of dielectric			
	c)Thickness of dielectric(by weight)			
	d)Thickness of dielectric layers between Aluminium foils			
	e)Voltage rating of each Capacitor (element)			
	f)Voltage stress			
	g)Is each element provided with fuse			
(ii)	Type of fuse			
(iii)	Make of fuse			
17	Whether provided with internal over pressure dis-connector (yes/no)			
18	Whether instruments to detect internal fuse failure is provided			
19	Dimensions and weight			
20	a)Material of dielectric			
	b)Dielectric loss per unit(watts)			
	c)Dielectric loss for the entire capacitor bank			
21	Whether CRCA containers of unit capacitor provided with earthing terminals			



22	Whether the unit capacitors and capacitor banks are of outdoor type requiring no protection from the direct rays of the sun and rain.			
23	Upper limit and lower limit of temperature for which capacitors are designed			
<b>II</b>	<b>CAPACITOR BANK</b>			
1	Rated voltage of capacitor bank			
2	KVAR rating of capacitor bank at			
	a)Nominal system voltage			
	b)Rated voltage			
3	Rated current at rated voltage			
4	Rated frequency			
5	Number of units in series and parallel in each phase of individual groups(schematic diagram of connections to be enclosed)			
6	No. of banks offered			
7	Over voltage to which the remaining units in series groups of phase leg are subjected when elements of unit capacitors be come defective(calculations to be enclosed)			
8	Area required for the <b>Installation &amp; clearance</b>			
<b>III</b>	<b>TECHNICAL PARTICULARS FOR REACTOR</b>			
1	Type and make			
2	Reference standard			
3	Rated voltage			
4	Rated current			

5	a)No. of phases     3 phase / 1 phase			
	b)Type of connection neutral side / line side			
6	Rated capacity/inductance			
7	Continuous rating in % of rated current of capacitor bank			
8	Rated frequency			
9	Compensation % of series reactor			
10	Rated short time current and duration			
11	Basic insulation level			
	a)Impulse withstand voltage KV peak			
	b)Power frequency withstand voltage KV rms			
	c)Switching surge withstand voltage KV peak			
12	Reactance at rated output, rated MVAR			
13	Description of wdg. Insulation			
14	Winding resistance			
15	Material of winding Cu/Al			
16	Maximum current density A/Sq.mm			
17	Load losses			
18	Maximum temp.rise			
19	Terminal arrangement			
20	Maximum system voltage for which reactor is designed			
21	Type of shielding adopted in the reactor			
22	Fitting and accessories			
23	Dimensions			
24	Noise level and ref. standard db			

25	Vibration level			
26	harmonic content if any			
27	Approximate weight			
<b>IV</b>	<b>NEUTRAL CURRENT TRANSFORMER</b>			
1	Type			
2	Manufacturers type designation			
3	Rated voltage			
4	Rated primary current			
5	Rated secondary current			
6	Secondary terminal voltage at normal current			
7	Secondary terminal voltage at 10 times normal voltage			
8	Core details:	knee point voltage	VA	Class of accuracy
	a)Core-I			
	b)Core-II			
9	Rated current dynamic (peak value)			
10	One minute power frequency dry withstand voltage KV/RMS			
11	One minute power frequency wet withstand test voltage on secondaries KV/RMS			
12	One min power frequency withstand test voltage on secondarieskv/RMS			
13	1.2/50 Micro second impulse withstand voltage (KV/peak)			
14	Weight			
15	Mounting details			
16	Overall dimensions			
<b>V</b>	<b>FUSES:</b>			
1	Rated voltage of the fuse			

2	Current rating of the fuse link or refill unit			
3	Maximum continuous current capability			
4	Current rating of the fuse base of fuse carrier contacts			
5	Time current characteristics for an ambient Air temp of 27 deg C Furnished/ Not furnished			
6	Rated capacitive breaking current			
7	Maximum values which the fuse can withstand for 5 and 100 discharges			
8	Maximum available capacitor energy which the fuse can withstand at the specified voltage without bursting			
9	Minimum pre arcing <b>time</b> and maximum total clearing <b>time</b> at inductive and capacitive power frequency current			
10	Cold resistance of fuse link and percentage tolerance of resistance value.			

**Date**

**Place**

**Name**

**Designation**

**Name of the Company**