**Annexure- B**

**TECHNICAL SPECIFICATION 11 KV AUTOMATICALLY SWITCHED CAPACITOR BANKS AT 33/11KV SUB-STATIONS**

**FOREWORD:**

11 KV capacitor bank controlled by manually switched devices like Isolators/Load Break Switch or circuit breakers has the following disadvantages as compared to modern automatically switched Capacitor Bank:

* The ON/OFF operation of capacitor bank depends on one operator and it is difficult to regulate switching the capacitor bank as per varying load condition resulting in sub-optimal utilization of the investment made.
* Quantum of reactive compensation in circuit can not be controlled in small steps.
* This results in over compensation or under compensation of reactive power at varying load conditions.
* Difficult to keep a close watch on various parameters such as current in each phase of the capacitor bank, system voltage, unbalanced operating conditions etc., to provide adequate protection to the capacitor bank against abnormal operating conditions thereby increasing the chances of capacitor failures.
* The scheme eliminates conventional components like RVT, Electro-Magnetic Relays etc.
* A modern SF or Vacuum type circuit breaker is a costly equipment and designed for isolating faults rather than

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for reactive power switching duty. The breaker, there-fore is not ideal equipment for control of capacitor bank which may have to be operated a large number of times in a day.

To overcome above shortcomings use of 11 KV capacitor switches (instead of circuit breakers) for operation of capacitor bank divided into suitable steps for optimum utilization is being adopted.

The Circuit Breaker is replaced by two Capacitor Switches for utilizing the capacitor bank in two or three steps as required.

1. **SCOPE:**
   1. This specification covers design, engineering manufacture, testing at manufacturer’s works, supply and delivery, erection, testing and commissioning of 11 KV outdoor types 3 phase capacitor banks at site for out door installation along with necessary equipments in all respect.
   2. The specification covers 3 phase, 50 Hz, Out door type automatically switched shunt capacitor bank intended for installation at 11 KV side of 33/ 11 KV power transformers in various sub-stations. The equipment covered in this specification comprises Capacitor banks in steps, 0.2 % Series Reactors, Vacuum contactors, HT Fuses, RVT, CT, CRCA cubicle etc.
2. **Climatic Condition:**

|  |  |  |
| --- | --- | --- |
| 1. | Max. ambient air temperature | 0  60 C |
| 2. | Min. ambient air temperature | 0  (-)5 C |
| 3. | Average Daily Max. ambient temperature | 0  40 C |
| 4. | Max. yearly weighed average ambient temperature | 0  32 C |
| 5. | Max. altitude above mean sea level (Meters) | 1000 |
| 6. | Minimum Relative Humidity (%age) | 26 |
| 7. | Max. Relative Humidity (%age) | 95 |
| 8. | Avg. No. of Rainy days/year | 120 |
| 9. | Avg. annual rainfall | 900 mm |
| 10. | Maximum wind pressure | 195 Kg./m Sq. |

1. **Applicable Standard:**
   1. Unless otherwise modified in this specification, the capacitor shall comply with latest version of IS: 13925:1998. The other components such as Vacuum Circuit Breaker, Isolator, CT, PT, LA, Vacuum Contactors, HT fuses, Series Reactors, Auxiliary equipment shall comply with the latest version of relevant Indian Standards/International standards.
2. **Capacitor banks:** The capacitor banks are for use in a 3 phase 50 Hz 11 KV system. Capacitor bank shall consists series/parallel combination of small units of capacitor cells per phase, each with an out put rating of 100 or 200 or 400 KVAR, 7.3 KV single phase. Capacitor units should be connected in externally star with appropriate number of capacitors in parallel as per requirement. For Example 3 single units connected in star to obtain 300/600 KVAR at 12.65 KV 3 phase or 2 capacitors units in parallel per phase with 3 phase connection in star to obtain 600 or 1200 KVAR at 12.65 KV 3 phase. Necessary number of steps should be provided to meet requirement given in the schedule.

**Table 1.0: Capacitor Bank Rating:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sr. No** | **Transformer Rating** | **Capacitor Bank Rating at 12.65 KV** | **Step configuration**  **kVAr X No. of units** |
| I. | 4000 KVA | 1500 KVAR | 1200 X 1+300 X 1 |
| II | 5000 KVA | 1800 KVAR | 1200 X 1+300 X 2 |
| III | 6300 KVA | 2400 KVAR | 1200 X 1+600 X 2 |
| IV | 8000 KVA | 3000 KVAR | 1200 X 2+600 X 1 |
| V | 10000 KVA | 3600 KVAR | 600 X 6 |
| VI | 125000 KVA | 4800 KVAR | 1200 X 4 |
| VII | 16000 KVA | 6000 KVAR | 1200 X 5 |
| VIII | 20000 KVA | 7200 KVAR | 1200 X 6 |

Each capacitor unit shall be provided with external HT HRC fuse of 12 KV class with suitable current rating. Capacitor shall meet following specifications:

1. **Temperature Category:** The capacitor shall be suitable for operation with upper limit of ambient temperature 60

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C.

1. **Rated Voltage:**

The rated voltage of 3 phase capacitor banks shall be 11 KV (phase to phase) and maximum operational voltage shall be rated for 12.65 kV.

1. **Rated Output:** The Rated output of 3 phase capacitor banks shall be 600,1200,2400,3000,3600,4800,6000 or 7200 KVAR at the maximum operational voltage of 12.65 KV intended for use in suitable combination on power transformers rating of 4 MVA, 5 MVA, 6.3 MVA, 8 MVA, 10 MVA, 12.5 MVA, 16 MVA & 20 MVA. The standard basic unit rating of capacitors (single phase) shall be 100/200/400 KVAR. The unit shall be connected in externally star formation with floating neutral.
2. **Permissible Overloads:** For capacitor covered in this specification, the maximum permissible overloads with regard to voltage, current and reactive output shall not exceed the limits specified in IS:13925.
3. **Power Loss:**

The power loss in capacitors shall not exceed 0.2 watt / KVAR (Subject to tolerance of + 10 %).

1. **Discharge device:**

Suitable discharge device shall be connected across the capacitor unit in accordance with the provision of IS:13925. The discharge device shall reduce the residual voltage from the crest value of the rated voltage to 50 V or less within **10 Minutes** after the capacitor is disconnected from the source of the supply..

1. **Earthing Connections:**

The container of each capacitor unit shall be provided with suitable earthing terminal clearly marked with “Earth” symbol.

1. **Protective Fuses:**

The capacitor units shall be provided with either internal or external fuses, as per standard practice of the manufacturer shall supply the external HRC fuses together with fixing accessories; a set of six spare fuse links shall be supplied along with each capacitor bank.

1. **General Requirements:**

The capacitor shall be of non-PCB type, using polypropylene film as the dielectric. Complete mounting brackets supporting insulators and all other components for formation of capacitor banks racks shall be supplied along with the capacitor units. Necessary foundation bolts/nuts shall also be supplied. The outside of the capacitor container and other structures should have smooth and tidy look and should be coated with the weather proof, corrosion- resistant paint of white or light grey.

1. **Marking:** The capacitor unit shall be provided with a rating plate and terminal markings as stipulated in IS: 13925.
2. **TESTS:**

The bidder shall submit the type test report along with the bid.The switched capacitors shall be subjected to all the type, routine and acceptance test in accordance with IS: 13925.

1. **AUTOMATIC CONTROL UNIT**
2. **Switching Arrangement:**

The Automatic control unit shall be provided inside the control room to continuously monitor total KAVR requirment on secondary side of the transformer and shall automatically switch ON or switch OFF the capacitor banks through the operation of 12 KV Vacuum Contactor. Overriding provision shall be made for electrical switching ON or OFF of the capacitor switch by the operator from the ACU control box.

1. **Time Delay:**

The switching ON operation will take place for period of **10 minutes.** The switching OFF operation of relevant steps will be instantaneous.

1. **Controls:**

The Automatic control unit shall instantly switch OFF the incomer VCB of capacitor bank in the following contingencies occurring in any of the phases.

1. Voltage increased by 10% above the rated voltage of 11 KV.
2. Power transformer current impedance (due to single phasing and for any other reasons) between any of the two phases exceeding 20 % of the lowest.
3. Current increases in any capacitor unit by 30% above the rated current (only the relevant capacitor switch will open).

Current between any of the two phases of the capacitor bank differs more than 15% of the lowest current of the 3 phases (only the relevant capacitor switch will open).

1. **Monitoring Facility:** A suitable ammeter with selector switch to indicate the capacitor current in each phases of the capacitor bank shall be provided on the ACU panel inside the control room. Indicating lamps will also be provided to indicate ON & OFF status of each capacitor bank.
2. **Control Power:**

The DC control voltage for operation of the ACU shall be taken from sub-station battery. The standard DC control voltage at the 33/11 KV sub- station and 66/11 KV are 24 volts and 110 Volts respectively.

1. **Temperature Variation:**

The control equipment and associate circuitry shall be suitable for operation at an ambient temperature in the range

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of -5

o

C to (+) 60 C.

1. **Protection of ACU:**

Besides in-built protection against lines surges and transient over voltages, suitable fuses shall be provided for protection against over current. The ACU shall remain fully functional during and after line surges and transient over voltages.

1. **Control Unit Casing:**

Except for the terminals, the ACU shall be enclosed in a suitable casing so as to avoid ingress of dust.

1. **SCOPE**

This specification covers 11 KV, 50 Hz, out-door type automatic capacitor switches suitable for switching capacitor banks of 300 KVAR, 600 KVAR and 1200 KVAR ratings or any other higher rating specified.

1. **APPLICABLE STANDARDS**

Unless otherwise stipulated in this specification the capacitor switch shall comply with the latest version of IS:9920 (AC Switches for voltages above 1000 V).

1. **RATED VOTAGE** The rated voltage for the capacitor switch shall be 12 KV. This represents the highest system voltage corresponding to the nominal system voltage of 11 KV.
2. **RATED CURRENT**

The standard rated normal current shall be 200A.

1. **RATED CAPACITIVE SWITCHING CURRENT**

The rated capacitive switching current shall not be less than 100A. Note: The capability of the switch shall also take into account the parallel switching of capacitor bank steps.

1. **RATED SHORT TIME CURRENT**

The rated short time symmetrical current for 1 second shall be 10KA (rms A.C.component).

1. **RATED MAKING CURRENT**

The rated making current shall be 2.5 times the rms value of the a.c. component of rated short time capacity.

1. **BASIC IMPULSE LEVEL (BIL)**

The rated basic impulse level of switch to earth as also across the open terminals shall be 75 KV.

1. **CONTROL SUPPLY**

The control power for closing the switch shall be 230 V single phase AC supply. The closing mechanism shall be suitable for a voltage variation of (+) 10% to (-)20%.

1. **DESIGN & CONSTRUCTION REQUIREMENSTS**
   1. TYPE

The switches shall be of either vacuum or SF6 type.

* 1. The capacitor switches shall be of three phase construction and shall be suitable for remote operation.
  2. The capacitor switch shall be suitable for outdoor installation and shall have sealed weather proof type construction.
  3. The capacitor switch shall be provided with a mechanical indicator to show whether the contact is in open/closed position, locally, as also through indication on the ACU panel. Provision shall also be made for manual closing and opening.
  4. The metallic enclosure of the capacitor switch shall be provided with two earthing terminals marked with the earth symbol.
  5. The bushing provided on the switch shall have clamp type of terminals to directly receive aluminium conductors up to 10mm dia in both horizontal and vertical directions. The terminal arrangement shall be such as to avoid bimetallic corrosion.

1. **OPERATING MECHANSIM** The operating mechanism shall be either solenoid or motor charged spring for which the control supply shall be as per clause 30.
2. **MECHANICAL AND ELECTRICAL ENDURANCE**

The switch shall be capable of performing not less than 10,000 mechanical operations and 10,000 electrical operations at 100A capacitive current without getting damaged.

1. **MARKING**

The capacitor switch shall be provided with a legible and indelibly marked name plate with the following:

1. Name of the manufacturer.
2. Type, designation and serial number.
3. Rated voltage and current.
4. Rated frequency.
5. Number of poles.
6. Rated short time current (symmetrical).
7. Rated making current.
8. Rated capacitive switching current.
9. **TESTS** The switch shall be subjected to the following tests in accordance with the IS:9920 (Part-IV).
   1. Type Tests
10. Tests to verify the insulation level, including withstand tests at power frequency voltages on auxiliary equipment.
11. Tests to prove that the temperature rise of any part does not exceed the specified values.
12. Making and breaking tests including tests for the rated capacitive current.
13. Tests to prove the capability of the switch to carry the rated short time current.
14. Tests to prove satisfactory operation and mechanical/electrical endurance.
    1. Routine Tests
       1. Power frequency voltage dry tests.
       2. Voltage tests for auxiliary circuits.
       3. Measurement of the resistance of the main circuits.
       4. Tests to prove satisfactory operation.

**D. AUXILARY EQUIPMENTS**

1. **Isolator:**
   1. The Isolator shall be outdoor type, 11 KV, 400/630/800Amp, Single throw Double Break, off load type, triple pole, vertical gang operated switch and with earth switch.
   2. Tests: The Isolator shall be type tested and shall be subjected to routine and acceptance test in accordance with IS: 1818-1972.
   3. The bidder shall submit guaranteed technical particulars along with their bid.
2. **11 KV Indoor Vacuum Circuit Breaker with Panel: 1.0 Scope:** The specification covers supply and installation of 3 pole, 50Hz at 11KV, 250 MVA rupturing capacity, 400/630/800 Amp rated current. Vacuum circuit breaker having motor operated spring changing mechanism and electrical as well as manual closing facility for indoor installation matching / in conjunction with existing 11 KV panels including all necessary equipment such as CT(S) as per rating of capacitor bank, PT(S) and instruments such as Ammeter, Voltmeter and devices like relays as follows.
3. One No of Voltmeter (0-15 KV), 3 Nos. Ammeter of size (144 X144mm) of range 0-400/800Amp shall be fitted with each panel.
4. Relays:
5. Over Current = 2 Nos. + Earth Fault = 1 No combined one unit
6. Over Voltage Protection:
7. Unbalance Protection: (VDG-14)
8. No voltage / Under Voltage Protection.
9. Auxiliary relays to suit the purpose.
   1. **Rating:** The VCB shall comply with the following requirements:-
      1. Nominal System Voltage: 11 KV.
      2. Maximum System Voltage: 12 KV.
      3. Rated Current: 400A/630A/800A.
      4. Frequency: 50 Hz.
      5. Insulation level: 28 KV (rms) / 75 KV (peak). vi)Operating Mechanism: Spring Charged Motor.
10. Auxiliary Voltage: 110 V DC & 240 V AC.
11. Cree page Distance: 25 mm/KV
    1. **Tests:** The Vacuum Circuit Breaker shall be type tested and shall be subjected to routine and acceptance test in accordance with IS: 13118.
    2. **Guaranteed technical Particulars:** - The bidder shall submit guaranteed technical particulars along with their bid.
12. **Current Transformer:**
    1. The current transformers shall be dry type, suitable current ratio and burden for measuring the capacitor current shall form part of the equipment to be supplied. These CT’s shall be form an either an integral part of Indoor VCB or integral part of Capacitor bank enclosure or may be separate outdoor type on structure. The accuracy class for the purpose of measuring the current shall be1.0.
    2. **Tests:** The Current Transformer shall be type tested and shall be subjected to routine and acceptance test in accordance with IS: 2705.
13. **Lightning Arrestor:**
    1. The specification covers the supply, delivery, erection, testing & commissioning of 9 KV, 5 KA, static class heavy rating, gapless, metal (zinc) oxide surge arrestors complete along with clamps, complete fitting and accessories for installation on outdoor type 11 KV switchgear, transmission lines, transformers etc.
    2. **Tests:** The Lightning Arrestors shall be type tested and shall be subjected to routine and acceptance test in accordance with IS: 3070.
    3. The bidder shall submit guaranteed technical particulars along with their bid.
14. **Residual Voltage Transformer:**
    1. The Residual Voltage Transformer shall be dry type, 11 KV class, 5 Limb, with three windings i.e. Star/ Star – Open delta. The Primary winding-I in Star, Secondary-I in Star for metering and Secondary-II in Open delta for protection.
    2. **Tests**: The residual Voltage Transformer shall be type tested and shall be subjected to routine and acceptance test in accordance with IS: 3156.
    3. The bidder shall submit guaranteed technical particulars along with their bid.
15. **Vacuum Contactors:**
    1. The Vacuum contactor shall be 12 KV Class, 400 Amps, Three pole Vacuum contactors suitable for capacitor switching. It shall be electrically (solenoid) operated with operational voltage of 230 Volts AC or 110V DC and short time current rating of 9 KA for 1 Sec.
    2. **Tests**: The vacuum contactors shall be type tested and shall be subjected to routine and acceptance test in accordance with IS/IEC.
    3. The bidder shall submit guaranteed technical particulars along with their bid.
16. **HT HRC Fuses:**

**1.0** Suitable indoor type 11 KV HRC fuses along with the mounting insulators etc. to provide proper protection for the entire installation shall form part of the equipment to be supplied. The rupturing capacity of the fuses shall be

12.5 KA.

1. **Series Reactors:**

**1.0.** 0.2 % Series reactor per phase per step of capacitor rating for inrush current restriction to be connected on neutral end as per IS: 5553. The rated voltage shall be 12 KV. The reactor shall be dry type single phase reactors mounted on post insulators and designed to carry 130 % of rated current continuously without exceeding the temperature rise & shall be applicable for thermal class of insulation used. The reactor shall be mounted inside outside the capacitor cubicle on foundation.

**1.1 Tests:** The series reactor shall be type tested and shall be subjected to routine and acceptance test in accordance with IS: 5553.

1. **11 KV HT Cable (XLPE): A Power Cable:**
   1. 11 KV power cable shall be hot cured XLPE of following size conforming to IS: 7098 (P-II) amended latest. 11 KV Incoming: Three/Single core, 95/125/240/400 Sq. MM. 11KV (E). Jointing kit shall be heat shrink type as per latest relevant IS specification for indoor and out door utilization matching with the above cables.
   2. **Cable Jointing:** - Jointing should be heat shrink type. All materials required for such type of jointing of XLPE cable shall be supplied by the contractor.The work shall be carried out only by licensed / experienced cable jointer holding necessary license of cable jointing of appropriate grade. Sufficient surplus cable in the form of loop shall be left on both sides of the cable.

**B Control cable:**

The control cable shall conform to IS: 1554 (Part-I) 1976. All control cable shall be of copper and armored type. The bidder may furnish cable such schedule after finalization of sub-station layout, associated cable connection.

1. **Capacitor Cubicle:** It shall be free standing outdoor type sheet steel enclosure fabricated from 2 mm. thick CRCA sheets. Capacitor cubical shall be mounted on mild steel channel frame and base frame shall be provided with mounting holes for fixing on concrete foundation. All doors and covers shall be designed to avoid ingress of water, moisture, dust etc. and shall be provided with suitable gaskets to achieve IP-55 degree of protection. Covers and doors shall be provided with electrical interlocks to avoid access to live parts. In case some unauthorized person opens the door or covers, the main incomer breaker should be tripped. Viewing glasses shall be provided to view inside parts like fuses, contactors. CFL type internal panel lighting shall also be provided to have proper view in the night. Capacitor enclosure shall be duly painted with base coat of Epoxy based primer and final coat of polyurethane paint. FRP canopy shall be provided at the top and which projects about 200 mm beyond cubicle on all sides. All LT internal wiring shall be fire retardant cable of 2.5sq.mm. All cable entries shall be from bottom through cable glands of suitable size. HT XLPE cable entry shall be through a cable entry box mounted on cubicle or fixed separately on foundation and coupled to the cubicle. Necessary Danger plate & Name plate etc shall be provided at prominent places. All other necessary fittings and accessories should be provided by manufacturer to ensure safe and smooth operation of the equipment.
2. **SUBMISSION AND APPROVAL OF DRAWINGS:**

Following drawings and technical documents shall be submitted along with the bid.

* Technical data sheet
* GA drawings.
* Bill of Material.
* General Technical Particulars.

1. **INSTALLATION OPERATION AND MAINTAINANCE:** The supplier shall provide:
2. Necessary manual on installation, operation and maintain ace as also the schedule for the routine testing or check ups of all the equipments covered by the installation.
3. List of recommended spares indicating prices and specialized test equipments required for the routine testing of the system.
4. **GUIDANCE FOR PROCUREMENT:**

The entire equipment covered under this specification shall be covered as a single package to avoid the problem of mismatching for maintenance etc.

1. **WARRANTY:**

The suppler shall guarantee satisfactory performance of the complete capacitor bank installation for a period of 16 months from the date of commissioning. During the warranty period all repairs/replacements shall be carried out free of cost.

1. **INSPECTION:**

All tests and inspection shall be made at the place of the manufacturer 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 being supplied is in accordance with the specification.

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

The manufacturer shall be responsible to pay penalty of Rs 20,000/- for each occasion at which the fake inspection call has been made or the material is rejected during testing/inspection by the authorized agency/representative of the Nigam. This penalty would be in addition to the expenses incurred by the Nigam in deputing the Inspecting Officer, carrying out such inspection

1. **Challenge Clause:-** The material offered/received after the inspection by the authorized inspecting officer may again be subjected to the test for or any parameter from any testing house/in-house technique of the Nigam & the results if found deviating un-acceptable or not complying to approved GTP’s the bidder shall arrange to supply the replacement within thirty (30) days of such detection at his cost including to & fro transportation. In addition, penalty @10% of cost of the inspected lot of material shall be imposed.