

# **TECHNICAL** **SPECIFICATIONS**

## **CHAPTER 3A- SWITCHGEAR–CB (CIRCUIT BREAKER)**

*for*

### **PACKAGE KC-6**

*of*

## **KOSHI CORRIDOR 220kV TRANSMISSION LINE PROJECT**

**IFB No.: KOSHI/NEA/KC-6**

**Procurement of Design, Supply, Installation, Testing  
and Commissioning of 220kV(GIS)/132kV  
Substation Expansion at Dhungesanghu Substation**



**नेपाल विद्युत प्राधिकरण**  
(नेपाल सरकारको स्वामित्व)  
**Nepal Electricity Authority**  
(A Government of Nepal Undertaking)

**CHAPTER 3A: SWITCHGEAR–CB (CIRCUIT BREAKER)****1.0 GENERAL**

- 1.1 The circuit breakers and accessories shall conform to IEC: 62271-100, IEC: 62271-1 and other relevant IEC standards except to the extent explicitly modified in the specification and shall also be in accordance with requirements specified in Chapter-GTR.
- 1.2 420/245/145/**72.5kV** circuit breakers offered would be of sulphur hexafluoride (SF6) type and of class C2-M2 as per IEC. 36/12kV circuit breakers offered would be of Vacuum type and of class C2-M2-E2 as per IEC. The bidder may offer circuit breakers of either live tank type or dead tank type of proven design.
- 1.3 The circuit breaker shall be complete with operating mechanism, **common marshalling box**, piping, inter-pole cables, cable accessories like glands, terminal blocks, marking ferrules, lugs, pressure gauges, density monitors (with graduated scale), galvanised support structure, **platform with ladder** for CB, their foundation bolts and all other accessories required for carrying out all the functions of the CB.
- All necessary parts to provide a complete and operable circuit breaker installation such as terminal pads, control parts and other devices shall be provided.
- 1.4 Painting shall be done in line with Chapter 2– GTR. **Paint shade RAL-7032** or similar shades can be used for painting. The support structure, **platform & ladder** of circuit breaker shall be hot dip galvanised. Exposed hardware items shall be hot dip galvanised or Electro-galvanised.
- 1.5 The circuit breakers shall be designed for use in the geographic and meteorological conditions as given in Chapter 1-PSR.
- 1.6 **All 400kV Circuit Breaker control schematics shall be finalized in such a way, that it may operate with or without CSD by using a suitable selector switch irrespective of whether circuit breakers to be supplied are envisaged along with CSD or not as per bid price schedules.**

**2.0 DUTY REQUIREMENTS**

- 2.1 The circuit breakers shall be capable of performing their duties without opening resistors.
- 2.2 The circuit breaker shall meet the duty requirements for any type of fault or fault location **and** also for line switching when used on effectively grounded system and perform make and break operations as per the stipulated duty cycles satisfactorily.

**2.2.1 PRE-INSERTION RESISTER**

**420kV** circuit breakers shall be provided with single step pre- insertion closing resistors (**wherever the requirement of PIR is explicitly specified in bid price schedules**) to limit the switching surges. The resistance value of pre-insertion resistor and the duration of pre-insertion time **is** given in clause **16.0** of this chapter. The resistor shall have thermal rating for the following duties:

i) **TERMINAL FAULT**

Close .... 1 Min .... Open Close Open.....2 min..... Close ..... 1 Min .....  
Open Close Open.

ii) **RECLOSING AGAINST TRAPPED CHARGES**

Duty shall be the same as under (i) above. The first, third and fourth closures are to be on de - energised line while second closing is to be made with lines against trapped charge of 1.2 p.u. of opposite polarity.

iii) **OUT OF PHASE CLOSING**

One closing operation under phase opposition, that is with twice the voltage across the terminals.

iv) No allowance shall be made for heat dissipation of resistor during time interval between successive closing operations. The resistors and resistor supports shall perform all these duties without deterioration. Test reports of resistors proving thermal rating for duties specified above shall be furnished during detailed engineering. The calculations shall be provided to take care of the effect of tolerances on resistance values and insertion time.

2.3 The breaker shall be capable of:

i) Interrupting the steady and transient magnetizing current corresponding to Power transformers as follows:

Voltage rating of CB	Type of Transformer	Rating (in MVA)
<b>420kV</b>	<b>400/220kV</b>	<b>250 to 630</b>
	<b>400/132kV</b>	<b>160 to 315</b>
<b>245kV</b>	<b>400/220kV</b>	<b>200 to 630</b>
	<b>220/132kV</b>	<b>50 to 200</b>
	<b>220/66kV</b>	<b>50 to 200</b>
<b>145kV</b>	<b>220/132kV</b>	<b>50 to 200</b>
	<b>132/33kV</b>	<b>10 to 50</b>

ii) Interrupting line/cable charging current as per IEC without use of opening resistors. **The breaker shall be able to interrupt the rated line charging current as per IEC-62271-100 with test voltage immediately before opening equal to the product of  $U/\sqrt{3}$  and 1.4**



- iii) Clearing short line fault (kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current specified.
- iii) Breaking 25% of the rated fault current at twice rated voltage under phase opposition condition.
- iv) **Withstanding all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e. shall be designed for 2 p.u. across the breaker continuously, for validation of which a power frequency withstand test conducted for a duration of at least 15 minutes is acceptable).**
- v) **Circuit breakers shall be able to switch in and out the shunt reactor as detailed below:**

<b>Voltage rating of CB</b>	<b>Reactor Rating (in MVAR)</b>	<b>Max. rise of over voltage (in p.u.)</b>
<b>420kV</b>	<b>50 to 150</b>	<b>2.3</b>
<b>245kV</b>	<b>25 to 50</b>	<b>2.3</b>

- a. **Capability of 400 kV circuit breakers to interrupt inductive current below 100 A without giving rise to overvoltage more than 2.3 p.u. (As specified in IEC-62271-110) shall be validated by carrying out the simulation study/analysis (EMTP/PSCAD) by modeling an equivalent circuit comprising all circuit component i.e. Inductance of Shunt Reactor, Stray capacitance of Shunt Reactor, Circuit Breaker, Stray capacitance of Bus Connection, Capacitance of grading Capacitor, inductance of neutral grounding reactor, Network Thevenin's equivalent, any other series/parallel inductance/capacitance connected to simulate the actual inductive load switching.**
- b. **Current chopping capability (chopping number) of circuit breaker as per IEC-62271-306 to be figured out from actual Laboratory test and / or field test report and same Current chopping capability (chopping number) shall be used in above said simulation study/analysis.**
- c. **To validate the results of above said simulation study/analysis report, the same study shall be carried out for capability of tested circuit breaker and the study/analysis results shall be comparable with actual Laboratory test and / or field test reports.**
- d. **Laboratory test/ field test reports shall be submitted for 400 kV CBs in case there is change in design including change in following:**
  - i. **Different short circuit current capability**
  - ii. **Different model/type**



- vi) The breakers shall also withstand the voltages specified under clause **16.0** of this chapter.

## 2.6 CONTROLLED SWITCHING DEVICE (CSD):

Circuit Breakers shall be equipped with controlled switching **device** with consequent optimization of switching behavior, when used in:

- Switching of transformer (**from 400kV side circuit breakers only**)
- Switching of shunt Reactor (From 132, 220, 400 kV side of CB)

The CSD shall be provided in Circuit breaker of switchable line reactor **bay** and in Main & Tie **Bay** circuit breakers of Transformers, line with non- switchable line reactors and Bus reactors. **The CSD shall be supplied as per requirement given in the chapter PSR.**

### 2.6.1 Technical Requirement for controlled switching device:

- a) The CSD shall be designed to operate correctly and satisfactorily with the excursion of auxiliary A/C & DC voltages and frequency as specified in Chapter 2- GTR.
- b) The CSD shall meet the requirements **of IEC-61000-4-16 class IV** for HF disturbance test (**for short and long durations both**) and fast transient test shall be as per **IEC-61000-4-4 level IV** and insulation test as per IEC 60255-5.
- c) The CSD shall have functions for switching ON & OFF the circuit breakers.
- d) The CSD shall get command to operate the breakers manually. The controller shall be able to analyze the current and voltage waves available through the signals from secondaries of CTs & CVTs for the purpose of calculation of optimum moment of the switching the circuit breaker and issue command to circuit breaker to operate.
- e) The CSD shall also have an adaptive control feature to consider the next operating time of the breaker in calculation of optimum time of issuing the switching command. In calculation of next operating time of the breaker, the CSD must consider all factors that may affect the operating time of the breaker such as, but not limited to, ambient temperature, control voltage variation, SF6 gas density variations etc. Schematic drawing for this purpose shall be provided by the contractor. The accuracy of the operating time estimation by the controller shall be better than **± 0.5 ms**.
- f) The CSD should have display facility at the front for the display of settings and measured values.



- g) The CSD shall be PC compatible for the setting of various parameters and down loading of the settings and measured values, date, time of switching etc. Window based software for this purpose shall be supplied by the contractor to be used on the owner's PC.
- h) The controller shall be suitable for current input of 1 ampere from the secondary of the CTs. and 110 V (Ph to Ph) from the CVTs. The CSD shall **withstand** transient and dynamic state values of the current from the secondary of the CTs and CVTs.
- i) The CSD shall have time setting resolution of 0.1 ms or better.
- j) The CSD shall have sufficient number of output/input potential free contacts for connecting the monitoring equipment and annunciation system available in the control room. Necessary details shall be worked out during engineering of the scheme.
- k) **The CSD shall also record and monitor the switching operations and make adjustments to the switching instants to optimize the switching behavior as necessary. It shall provide self-diagnostic facilities, signaling of alarms and enable downloading of data captured from the switching events.**
- l) The provision for bypassing the Controlled switching device shall be provided through BCU and SCADA both **so that whenever, the CSD is not healthy due to any reason (including auxiliary supply failure), uncontrolled trip/close command can be extended to the circuit Breaker. Alternatively,** in case of any non-operation of the CSD after receiving a close/trip command after a pre-determined time delay, the CSD should automatically be bypassed so as to ensure that the trip and close commands are extended to the Trip/Close coils **through subsequent command.**
- m) **The CSD shall be provided with a communication port to facilitate online communication of the CSD with Substation automation system directly on IEC 61850 protocols. If the CSD does not meet the protocols of IEC 61850, suitable gateway shall be provided to enable the communication of CSD as per IEC 61850.**

### 3.0 TOTAL BREAK TIME

3.1 The total break time as specified under this section shall not be exceeded under any of the following duties:

- i) Test duties T10, T30, T60, T100a, and T100s (with TRV as per IEC: 62271-100)
- ii) Short line fault L75, L90 (with TRV as per IEC: 62271-100)

3.2 The total break time of the breaker shall not be exceeded under any duty



conditions specified such as with the combined variation of the trip coil voltage (70-110%), arc extinguishing medium pressure etc. While furnishing the proof of the total break time of complete circuit breaker, the effect of non- simultaneity between contacts within a pole or between poles **shall be brought out to establish** guaranteed total break time.

- 3.3 The values guaranteed shall be supported with the type test reports.

#### **4.0 CONSTRUCTIONAL FEATURES**

The features and constructional details of circuit breakers shall be in accordance with requirements stated hereunder:

##### **4.1 Contacts**

- 4.1.1 The gap between the open contacts shall be such that it can withstand at least the rated phase to ground voltage for 8 hours at zero gauge pressure of SF6 gas due to the leakage. For vacuum type, the gap between contacts of the Circuit Breaker inside interrupter should be capable of withstanding 1.5 time voltage to neutral at one atmospheric pressure at normal ambient condition within Breaker in the event of vacuum pressure drop due to leakage. The breaker should be able to withstand all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e. 2 p.u. across the breaker continuously, for validation of which a power frequency dielectric with stand test conducted for a duration of at least 15 minutes is acceptable).

- 4.2 If multi-break interrupters are used, these shall be so designed and augmented that a uniform voltage distribution is developed across them. Calculations/ test reports in support of the same shall be furnished. The thermal and voltage withstand rating of the grading elements shall be adequate for the service conditions and duty specified.

##### **4.3 Additional requirements**

- 4.3.1 For Vacuum Circuit Breaker shall meet the following additional requirements:

- a) In vacuum interrupter the contact configuration, contact area, contact pressure will be sufficient for carrying rated current and short time rates current, without any abnormal phenomena.
- b) The design life of vacuum bottle should be at least 100 nos. operation at rated short circuit level.
- c) Complete details of main contacts shall be furnished. The material of contacts and coating of the contacts shall be suitable for vacuum Breaker technology. Evaporation of metal during arcing and deposition of the same in the inner surface of vacuum interrupter should be restricted by adopting suitable material. Contractor shall furnish the justification of using the materials for contacts.
- d) Complete details of main contacts and arc quenching device, if any with sectional drawings shall be furnished at the time of offer.





Measures taken to free the contacts from vibration during closing shall be clearly explained in the drawing, support by tests results.

- e) The contact erosion should be limited upto 3 mm for useful life.
- f) The vacuum pressure within interrupter shall be adequate to interrupt the fault current. Precaution shall be taken so that there will be no flush over on outside of the vacuum interrupter inside the porcelain insulator.
- g) Design of the vacuum bottle and its insulator encasing should be suitable for outdoor use, taking care of required creepage distance considering possibility of moisture condensation if any, in the annular space between the vacuum bottle and insulator enclosure.
- h) Vacuum bottle with its insulator encasing chamber shall be hermetically sealed. Free passage of air in the chamber with or without provision of circulation of hot air is not accepted.

4.3.2 The SF6 Circuit Breaker shall meet the following additional requirements:

- i) The circuit breaker shall be single pressure type. The design and construction of the circuit breaker shall be such that there is a minimum possibility of gas leakage and entry of moisture. There should not be any condensation of SF6 gas on the internal insulating surfaces of the circuit breaker.
- j) All gasketed surfaces shall be smooth, straight and reinforced, if necessary, to minimise distortion and to make a tight seal, the operating rod connecting the operating mechanism to the arc chamber (SF6 media) shall have adequate seals. The SF6 gas leakage should not exceed 0.5% per year and the leakage rate shall be guaranteed **during the warrantee period**. In case the leakage under the specified conditions is found to be greater than 0.5% **per year after** commissioning of circuit breaker **during the warrantee period**, the manufacturer will have to supply free of cost, the total gas requirement for subsequent ten (10) years, based on actual leakage observed during **the warrantee period**.
- k) In the interrupter assembly there shall be an absorbing product box to minimise the effect of SF6 decomposition products and moisture. The material used in the construction of the circuit breakers shall be fully compatible with SF6 gas decomposition products.
- l) Each pole shall form an enclosure filled with SF6 gas independent of two other poles (for 420 & 245 kV CBs) and the SF6 density of each pole shall be monitored individually. For CBs of voltage class of 145 kV or less, a common SF6 scheme/density monitor shall be acceptable.
- m) The dial type SF6 density monitor shall be adequately temperature





compensated to model the pressure changes due to variations in ambient temperature within the body of circuit breaker as a whole. **Separate density monitor and dial type temperature compensated pressure guage is also acceptable.** The density monitor shall have graduated scale and it shall be possible to dismantle the density monitor for checking/replacement without draining the SF6 gas by providing suitable interlocked non return valve coupling.

- n) Circuit Breaker shall be capable of withstanding a vacuum of minimum 8 millibars without distortion or failure of any part.
- o) Sufficient SF6 gas **(including that will be required for gas analysis during filling)** shall be provided to fill all the circuit breakers **being supplied**. Spare gas shall be supplied in separate unused cylinders as per requirement specified in **BPS**.

4.4 Provisions shall be made for attaching an operational analyser to record contact travel, speed and making measurement of operating timings, pre insertion timings of closing resistors if used, synchronisation of contacts in one pole.

4.5 **The CO (Close-open) operation and its timing shall be such as to ensure complete travel/insertion of the contact during closing operation and then follow the opening operation.**

## 5.0 SULPHUR HEXAFLUORIDE GAS (SF6 GAS)

- a) The SF6 gas shall comply with IEC 60376 and shall be suitable in all respects for use in the switchgear under the operating conditions.
- b) The high pressure cylinders in which the SF6 gas is shipped and stored at site shall comply with requirements of the relevant standards and regulations. **SF6 gas shall be supplied (in returnable cylinders) for all circuit breakers. However, SF6 gas for spare circuit breakers and mandatory spare quantity of SF6 gas shall be supplied in non- returnable cylinders.**
- c) Test: SF6 gas shall be tested for purity, dew point, air, **hydro-soluble** fluorides and water content as per IEC 60376 and test certificates shall be furnished to Employer indicating all the tests as per IEC 60376 for each lot of SF6 gas and Material safety datasheet shall be provided. Gas bottles should be checked for leakage during receipt at site.

## 6.0 INSULATORS

- a) The porcelain/**polymer** of the insulators shall conform to the requirements stipulated under Chapter 2-GTR.
- b) The mechanical characteristics of insulators shall match with the



requirements specified under this chapter.

- c) All **porcelain & polymer** hollow **column** insulators shall conform to IEC-62155 & **IEC-61462 respectively**.
- d) Hollow Porcelain/**polymer** for pressurised columns/chambers should be in one integral piece in green and fired stage.

## **7.0 SPARE PARTS AND MAINTENANCE EQUIPMENT**

The bidder shall include in his proposal, spare parts and maintenance equipment in accordance with BPS. Calibration certificates of each maintenance equipment shall be supplied along with the equipment.

## **8.0 OPERATING MECHANISM AND CONTROL**

### **8.1 General Requirements**

#### **8.1.1 Circuit breaker shall be operated by spring charged mechanism. The mechanism box shall meet the requirements of IP-55.**

#### **8.1.2 The operating mechanism box shall be strong, rigid, rebound free and shall be readily accessible for maintenance.**

#### **8.1.3 The mechanism shall be anti-pumping and trip free under every method of closing.**

#### **8.1.4 The mechanism shall be such that the failure of any auxiliary spring will not prevent tripping and will not cause **unwanted** trip or closing operation of the Circuit Breaker**

#### **8.1.5 A mechanical indicator shall be provided to show open and close position of the breaker. It shall be located in a position where it will be visible to a man standing on the ground level with the mechanism housing closed. An operation counter shall also be provided in the **common marshalling box**.**

#### **8.1.6 Working parts of the mechanism shall be of corrosion resisting material, bearings which require grease shall be equipped with pressure type grease fittings. Bearing pin, bolts, nuts and other parts shall be adequately pinned or locked to prevent loosening or changing adjustment with repeated operation of the breaker.**

#### **8.1.7 The **contractor** shall furnish detailed operation and maintenance manual of the mechanism along with the operation manual for the circuit breaker. The instruction manuals shall contain exploded diagrams with complete storage, handling, erection, commissioning, troubleshooting, servicing and overhauling instructions.**

#### **8.1.8 Size of common marshalling Box shall be such that adequate space is available for working in the panel and all wiring shall be routed through non-inflammable wire troughs with covers.**



**8.1.9 Operating mechanism and Marshalling box should be provided with space heater with thermostat, LED lamp and AC point /Socket.**

**8.2 Control:**

8.2.1 The close and trip circuits shall be designed to permit use of momentary contact switches and push buttons.

8.2.2 Each breaker shall be provided with two (2) independent tripping circuits, pressure switches and coils each to be fed from separate DC sources.

8.2.3 The breaker shall normally be operated by remote electrical control. Electrical tripping shall be performed by shunt trip coils. However, provisions shall be made for local electrical control. For this purpose a local/remote selector switch and close and trip control switch/push buttons shall be provided in the Breaker **common marshalling box**.

8.2.4 The trip coils shall be suitable for trip circuit supervision during both open and close position of breaker.

8.2.5 Closing coil and associated circuits shall operate correctly at all values of voltage between 85% and 110% of the rated voltage. Shunt trip coil and associated circuits shall operate correctly under all operating conditions of the circuit breaker up to the rated breaking capacity of the circuit breaker and at all values of supply voltage between 70% and 110% of rated voltage. However, even at 50% of rated voltage the breaker shall be able to open. If additional elements are introduced in the trip coil circuit their successful operation and reliability for similar applications on outdoor circuit breakers shall be clearly brought out during detailed engineering.

**8.2.6 In trip and closing circuits, relays/relay contacts shall preferably be used instead of contactors.**

**8.2.7 Controlled switching scheme/device, wherever required shall be considered as integral part of CB and shall be commissioned along with CB.**

8.2.8 Density Monitor contacts and pressure switch contacts shall be **preferably** suitable for direct use as permissive in closing and tripping circuits. **The devices shall provide continuous & automatic monitoring of the state of the gas as follows:**

**a) 'Gas Refill' level**

**This contact will be used for remote indication/ to annunciate the need for gas refilling.**

**b) 'SF6 gas density Low' Alarm level - 1**

**This contact will be used for remote indication/ to annunciate the need for the urgent gas refilling.**



c) 'SF6 gas density Low' Alarm level - 2

This contact will be used to annunciate the need for gas refilling under emergency or trip the Circuit Breaker.

d) 'Breaker Block' level

This is the minimum gas density at which the manufacturer will guarantee the rated fault interrupting capability of the breaker. At this level the breaker block contact shall operate & the tripping & closing circuit shall be blocked.

It shall be possible to test all gas monitoring relays/devices without de-energizing the primary equipment & without reducing pressure in the main section. Plugs & sockets shall be used for test purposes. It shall also damp the pressure pulsation while filling the gas in service, so that flickering of the pressure switch contacts does not take place.

The density monitor shall be placed suitably inclined in such a way so that the readings are visible from ground level with or without using binoculars. Separate contacts have to be used for each of tripping and closing circuits. If contacts are not suitably rated and multiplying relays are used then fail safe logic/schemes are to be employed. DC supplies for all auxiliary circuits shall be monitored and provision shall be made for remote annunciations and operation lockout in case of D.C. failures. Density monitors are to be so mounted that the contacts do not change on vibration during operation of circuit Breaker.

8.2.9 The auxiliary switch of the breaker shall be positively driven by the breaker operating rod.

8.3 **Spring operated mechanism:**

- a) Spring operated mechanism shall be complete with motor **as per manufacturer practice**. Opening spring and closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit shall also be provided.
- b) As long as power is available to the motor, a continuous sequence of the closing and opening operations shall be possible. The motor shall have adequate thermal rating for this duty.
- c) After failure of power supply to the motor one close open operation shall be possible with the energy contained in the operating mechanism.
- d) Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring. Facility for manual charging of the closing spring shall also be provided. The motor rating shall be such that it requires not more than 30 seconds for full charging of the closing spring.
- e) Closing action of circuit breaker shall compress the opening spring



ready for tripping.

- f) When closing springs are discharged after closing a breaker, closing springs shall be automatically charged for the next operation and an indication of this shall be provided in the local and remote control cabinet.
- g) Provisions shall be made to prevent a closing operation of the breaker when the spring is in the partial charged condition. Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is already in the closed position.
- h) The spring operating mechanism shall have adequate energy stored in the operating spring to close and latch the circuit breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is derived from the operating mechanism.
- i) **The spring charging failure alarm shall be provided with a time delay relay having setting range from 0-1minute.**
- j) **Separate MCBs shall be provided for each spring charging motor and the rating of MCBs shall be suitably selected to match the starting, running and stalling time.**
- k) **An overload relay shall be provided for protection of the spring charging motor.**

## 9.0 SUPPORT STRUCTURE

- a) The structure design shall be such that during operation of circuit breaker vibrations are reduced to minimum.
- b) **Ladder and Maintenance platform for 400kV Circuit breaker:**  
A suitable ladder with the safety cage and a free standing maintenance platform with railing for each pole of the circuit breaker shall be supplied along with the equipment and its support structure. The platform shall be suitable for maintenance personnel to stand and carryout the activities along with the tools and plant. The ladder cum maintenance platform shall be designed as a free standing structure without taking any support from the main circuit breaker structure. The ladder having height more than 3.0m shall have at least 15 degree slope and is to be provided with safety guard above 2.0m level. All structural steel for the platform shall be as per IS: 2062 and to be galvanized.
- c) **For 220kV, 132kV & 66kV circuit breakers a suitable platform cum ladder shall be provided as per manufacturer design.**

## 10.0 TERMINAL CONNECTOR PAD



The circuit breaker terminal pads shall be made up of high-quality electrolytic copper or aluminium and shall be conforming to Australian Standard AS- 2935 **or equivalent standard** for rated current. The terminal pad shall have protective covers which shall be removed before interconnections.

## **11.0 INTER-POLE CABLING**

- 11.1 All cables to be used by contractor shall be armoured and shall be as per IS – 1554/ IEC-60502 (1100 Volts Grade). All cables within & between circuit breaker poles and its marshaling box and up to the controlled switching device is included in the scope of work. Special cables like screened cable if required for Circuit Breaker, **temperature Transducer/CB Status Signals for CSD** and its associated C&R panel shall be laid in 50mm diameter PVC pipe. Suitable supports for PVC pipe shall be included in the scope of Supply.
- 11.2 Only stranded conductor shall be used. Minimum size of the conductor for inter-pole control wiring shall be 1.5 sq.mm. Copper.
- 11.3 The cables shall be with oxygen index Minimum 29 and temperature index as 250°C as per relevant standards.
- 11.4 **Separate cables shall be used for AC, DC-I, DC-II and selected DC.**
- 11.5 **All inter-pole cabling of Circuit breakers and up to common marshalling box shall be done by plug-in type arrangement. Suitable removable type encasing cover shall be provided in case plug-in type connection arrangement is provided exterior side of LCC/MB. The plug-in type cable termination shall be conforming to IP-67 as per IEC60529. Cable sealing arrangement shall be provided (as per requirement) to avoid entry of moisture etc.**
- 11.6 **Vertical run of cables to the operating mechanism box shall be properly supported by providing the perforated closed type galvanized cable tray (Cable tray also to be supplied along with the Circuit Breaker) to be fixed as an integral part of the structures. The load of the cable shall not be transferred to the mechanism box/plug-in type terminal arrangement in any circumstances. Hanging or loose run of cable is not permitted. The drawing of cable tray including fixing arrangement shall be incorporated in the GA drawing of CB also.**
- 11.7 **Wiring** shall be done with stud type terminals and ring type lugs. More than two wires shall not be connected on each side of terminal.

## **12.0 FITTINGS AND ACCESSORIES**

- 12.1 Following is **list of** some of the major fittings and accessories to be furnished by Contractor in the **common marshalling box**. Number and

exact location of these parts shall be indicated **in the drawing**.

- i) Cable glands (Double compression type), Lugs, Ferrules etc.
- ii) Local/remote changeover switch.
- iii) Operation counter
- iv) Control switches to cut off control power supply.
- v) Fuses/**MCBs** as required.
- vi) The number of terminals provided shall be adequate enough to wire out all contacts and control circuits plus 24 terminals spare for future use.
- vii) Anti-pumping relay.
- viii) Pole discrepancy relay (for electrically ganged CBs).
- ix) D.C. Supervision relays.
- x) Rating plate description in accordance with IEC incorporating year of manufacture.
- xi) Controlled switching **accessories** like sensors, timers, relays etc.(as applicable)
- xii) **Transducers/Fixtures required for travel measurement shall be supplied by CB manufacturer. The complete set of Transducers/Fixtures for measurement of complete 3-phase CB shall be supplied for each station. Further, one set of gas filling adopter (Including coupling, regulator, connecting hose pipe up to ground level) shall be supplied as per BPS.**

### 13.0 ADDITIONAL DATA TO BE FURNISHED

- a) Drawing, showing contacts in close, arc initiation, full arcing, arc extinction and open position.
- b) The temperature v/s pressure curves for each setting of density monitor along with details of density monitor.
- c) Method of checking the healthiness of voltage distribution devices (condensers) provided across the breaks at site.
- d) Data on capabilities of circuit breakers in terms of time and number of operations at duties ranging from 100% fault currents to load currents of the lowest possible value without requiring any maintenance or checks.
- e) **Maximum** non-simultaneity between contacts, between poles and **effect of the same on the** guaranteed total break time.





- f) Sectional view of non-return couplings used for SF6 pipes.
- g) Details & type of filters used in interrupter assembly and also the operating experience with such filters.
- h) Details of SF6 gas:
  - i) The test methods used in controlling the quality of gas used in the circuit breakers particularly purity and moisture content.
  - ii) Proposed tests to assess the conditions of the SF6 within a circuit breaker after a period of service particularly with regard to moisture contents of the gas.
- j) Shall furnish curves supported by test data indicating the opening time under close open operation with combined variation of trip coil voltage.
- k) Detailed literature and schematic diagrams of switching mechanism for closing resistor showing the duration of insertion shall also be furnished alongwith the calculations in respect of thermal rating of resistors for the duties specified under clause **2.2.1** of this section in case of 420 kV circuit breakers.
- l) All duty requirements as applicable to 420 kV, 245 kV, 145 kV & 72.5kV CBs specified under Clause **2.0** of this section shall be provided with the support of adequate test reports.

#### **14.0 DEAD TANK TYPE CIRCUIT BREAKER**

14.1 In case dead tank type circuit breaker is offered, the Bidder shall offer bushing type CTs (whose secondary parameters are given in under **Section: Switchgear-Instrument Transformer** and in case of 400kV these secondaries shall be provided in sets of 3 cores, i.e., 2 cores of PX class and one core of metering, on both sides of dead tank circuit breaker instead of conventional outdoor CTs.

14.2 The enclosure shall be made of either Al/Al Alloy or mild steel (suitably hot dip galvanized). The enclosure shall be designed for the mechanical and thermal loads to which it is subjected in service. The enclosure shall be manufactured and tested according to the pressure vessel codes {i.e., latest edition of the ASME code for pressure vessel - Section VIII of BS-5179, IS4379, IS-7311 (as applicable) and also shall meet Indian Boiler Regulations}.

The maximum temperature of enclosure with CB breaker carrying full load current shall not exceed the ambient by more than 20 deg C.

14.3 The enclosure has to be tested as a routine test at 1.5 times the design pressure for one minute. A bursting pressure test shall be carried out at 5 times the design pressure as type test on the enclosure.

#### **15.0 TESTS**



- 15.1 In accordance with the requirements stipulated under Chapter 2-GTR the circuit breaker alongwith its operating mechanism shall conform to **the type tests as per IEC: 62271-100.**
- 15.2 The type test reports **as per IEC** and the following additional type test reports shall also be submitted for purchaser's/**employer's** review:
- i) Corona extinction voltage test (**procedure** as per Annexure-A of Chapter 2-GTR).
  - ii) Out of phase closing test as per IEC: 62271-100.
  - iii) Line charging interrupting current for proving parameters as per clause no. **16.0** of this section.
  - iv) Test to demonstrate the Power Frequency withstand capability of breaker in open condition at Zero Gauge pressure and at lockout pressure (Ref. Clause 4.1.1).
  - v) Seismic withstand test (**procedure** as per Annexure-B of Chapter 2-GTR) in unpressurised condition.
  - vi) Verification of the degree of protection.
  - vii) **Low temperature test (applicable only for minimum ambient temperatures of less than (-) 10 deg.C application purpose) and High temperature test. Contractor can also submit the field performance report in line with IEC stipulations.**
  - viii) Static Terminal Load test.
  - ix) Critical Currents test (if applicable).
  - x) Switching of Shunt Reactors. **Test reports shall be submitted as per IEC. Calculations shall be submitted for meeting the requirements of clause 2.3(v) of this section.**
  - xi) **Circuit breakers meant for controlled switching shall conform to requirements of IEC/TR-62271 – 302. The contractor shall submit test reports to demonstrate that the offered CB conforms to the requirements of performance verification tests and parameter definition tests as per IEC/TR 62271-302. The contractor shall also furnish the report for the re-ignition free arcing window for switching 3-phase shunt reactor as demonstrated in the shunt reactor switching test.**

15.3 **Routine Tests**

Routine tests as per IEC:62271-100 shall be performed on all circuit breakers.

In addition to the mechanical and electrical tests specified by IEC, the following tests shall also be performed.



- i) Speed curves for each breaker shall be obtained with the help of a suitable operation analyzer to determine the breaker contact movement during opening, closing, auto reclosing and trip free operation under normal as well as limiting operating **control voltage conditions**. The tests shall show the speed of contacts directly at various stages of operation, travel of contacts, opening time, closing time, shortest time between separation and meeting of contacts at break make operation etc. This test shall also be performed at site for which the necessary operation analyzer along with necessary transducers, cables, console etc. shall be **arranged by the contractor at his own cost**.
- ii) **During testing of CB, dynamic contact resistance measurement (DCRM) shall be carried out for close-open (CO) operations with delay of 300ms between close and trip operations. Minimum 100A current shall be injected for DCRM test. Travel characteristics, injected current, trip/close coil current shall also be recorded along with DCRM test.**
- iii) **Routine tests on Circuit breakers with Controlled switching device as per IEC/TR 62271-302.**
- iv) **Tan delta and Capacitance measurement for grading capacitors at rated voltage and also at 10kV (for reference).**

## 16.0 TECHNICAL PARAMETERS FOR CIRCUIT BREAKER

(In addition to those indicated in Chapter 2-GTR)

Sl. no.	Parameter	400kV system	220kV system	132 kV system	66 kV system	33 kV system	11 kV system
1.	Rated voltage (U <sub>max</sub> ) kV (rms)	420	245	145	72.5	36	12
2.	Rated frequency (Hz)	50	50	50	50	50	50
3.	No. of poles	3	3	3	3	3	3
4.	Type of circuit breaker	SF6 gas insulated	SF6 gas insulated	SF6 gas insulated	SF6 gas insulated	Vacuum insulated	Vacuum insulated
5.	Rated continuous current (A) at an ambient temperature of 50°C	As per BPS	As per BPS	As per BPS	As per BPS	As per BPS	As per BPS
6.	Rated short circuit capacity with percentage of DC component as per IEC-62271-100 corresponding to minimum opening time under operating conditions specified.	63kA	50 kA	40kA	40kA	31.5kA	25kA
7.	Symmetrical interrupting capability kA (rms)	63kA	50 kA	40kA	40kA	31.5kA	25kA
8.	Rated short circuit making current kAp	157.5	125	100	100	80	63



9.	Short time current carrying capability kA (rms)	63 one second	50 for one second	40 for one second	40 for one second	31.5 for one second	25 for three second
10.	Out of phase breaking current carrying capability kA (rms)	15.75	As per IEC	As per IEC	As per IEC	As per IEC	As per IEC
11.	Rated line charging interrupting current at 90 deg. Leading power factor angle (A rms) (The breaker shall be able to interrupt the rated line charging current with test voltage immediately before	600	As per IEC	As per IEC	As per IEC	As per IEC	As per IEC
	opening equal to the product of $U/\sqrt{3}$ and 1.4 as per IEC-62271-100						
12.	First pole to clear factor	1.3	1.3	1.3	1.5	1.5	1.5
13.	Temperature rise over an ambient temperature of 50°C	As per IEC: 62271-100	As per IEC: 62271-100	As per IEC: 62271-100	As per IEC: 62271-100	As per IEC: 62271-100	As per IEC: 62271-100
14.	Rated break time as IEC (ms)	40	60	60	Less than 75	Less than 75	Less than 75
15.	Total break time (ms)	45	65	65	Less than 80	Less than 80	Less than 80
16.	Total closing time (ms)	Not more than 150	Not more than <b>150</b>	Not more than <b>150</b>	Not more than <b>150</b>	Not more than <b>150</b>	Not more than <b>150</b>
17.	Operating mechanism or a combination of these	Spring	Spring	Spring	Spring	Spring	Spring
18.	Rated operating duty cycle	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO
19.	Reclosing	Single phase & Three phase auto reclosing.	Single phase & Three phase auto reclosing.	Three phase auto reclosing. (Single phase auto reclosing if specified in section-project)	Three phase auto reclosing.	Three phase auto reclosing.	Three phase auto reclosing.
20.	Pre-insertion resistor requirement	As per BPS	NA	NA	NA	NA	NA
i)	Rating (ohms)	400(max.) with tolerance as applicable	NA	NA	NA	NA	NA
ii)	Minimum electrical (mechanical insertion time + pre-arcing time) pre-insertion time (ms)	8	NA	NA	NA	NA	NA



iii)	Opening of PIR contacts	PIR contacts should open immediately after closing of main contacts OR At least 5 ms prior to opening of main contacts at rated air/gas pressure where the PIR contacts remain closed	NA	NA	NA	NA	NA
21.	Max. difference in the instants of closing/opening of contacts (ms) between poles at rated control voltage and rated operating & quenching media pressures	2.5(within a pole) 3.3(opening) 5.0(closing)	3.3(opening) 5.0(closing)	3.3(opening) 3.3(closing)	As per IEC	As per IEC	As per IEC
22.	Maximum allowable switching over voltage under any switching condition	2.3 p.u.	As per IEC	As per IEC	As per IEC	As per IEC	As per IEC
23.	Trip coil and closing coil voltage with variation as specified	220V DC or 110V DC	220V DC or 110V DC	220V DC or 110V DC	220V DC or 110V DC	220V DC or 110V DC	220V DC or 110V DC
24.	Noise level at base and up to 50 m distance from base of circuit breaker	140dB (max.)	140dB (max.)	140dB (max.)	140dB (max.)	140dB (max.)	140dB (max.)
25.	Rating of Auxiliary contacts	10A at 220/110V DC	10A at 220/110V DC	10A at 220/110V DC	10A at 220/110V DC	10A at 220/110V DC	10A at 220/110V DC
26.	Breaking capacity of Aux. Contacts	2A DC with circuit time constant not less than 20ms	2A DC with circuit time constant not less than 20ms	2A DC with circuit time constant not less than 20ms	2A DC with circuit time constant not less than 20ms	2A DC with circuit time constant not less than 20ms	2A DC with circuit time constant not less than 20ms
27.	<b>Rated insulation levels</b>						
i)	Full wave impulse withstand (1.2 /50 $\mu$ s) between line terminals and ground	$\pm 1425$ kVp	$\pm 1050$ kVp	$\pm 650$ kVp	$\pm 325$ kVp	$\pm 170$ kVp	$\pm 75$ kVp



ii)	Full wave impulse withstand (1.2 /50 $\mu$ s) between terminals with circuit breaker open	1425 kVp impulse on one terminal & 240 kVp power frequency voltage of opposite polarity on the other terminal	$\pm 1050$ kVp	+ 650kVp	$\pm 325$ kVp	$\pm 195$ kVp	$\pm 85$ kVp
iii)	Rated switching impulse withstand voltage (250/2500 $\mu$ s) Dry & wet between line terminals and ground	+1050 kVp	NA	NA	NA	NA	NA
iv)	Rated switching impulse withstand voltage (250/2500 $\mu$ s) Dry & wet Between terminals with circuit breaker open	900 kVp impulse on one terminal & 345 kVp power frequency voltage of opposite polarity on the other terminal	NA	NA	NA	NA	NA
v)	One minute power frequency dry withstand voltage between line terminals and ground	520 kV rms.	460 kV rms.	275 kV rms	140 kV rms	70 kV rms	28 kV rms
vi)	One minute power frequency dry withstand voltage between terminals with circuit breaker open	610 kV rms.	460 kV rms.	275 kV rms	160 kV rms	80 kV rms	32 kV rms
28.	Minimum corona extinction voltage with CB in all positions	320kV rms	156 kV rms	92 kV rms	NA	NA	NA
29.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz (Micro volts)	1000 $\mu$ V (at 266kV rms)	1000 $\mu$ V (at 156kV rms)	500 $\mu$ V (at 92kV rms)	NA	NA	NA
30.	Minimum Creepage distance*						
i)	Phase to ground (25mm/kV)	10500mm	6125mm	3625mm	1813mm	900 mm	300 mm
ii)	Between CB terminals	10500mm	6125mm	3625mm	1813mm	900 mm	300 mm
31.	System neutral earthing	Effectively earthed					
32.	Rated terminal load	As per IEC or as per the value calculated based on specific switchyard layout requirement, whichever is higher.					
33.	Auxiliary contacts	Besides requirement of technical specification, the manufacturer/contractor shall wire up 10 NO + 10 NC contacts exclusively for purchaser's use and wired up to common marshalling box.					
34.	No. of terminals in common marshalling box	All contacts & control circuits to be wired out up to common marshalling box + minimum 24 terminals exclusively for purchaser's future use					
35.	Seismic level	0.5g horizontal					

**\* The values indicated are for specific creepage of 25mm/kV. In case of specific creepage of 31mm/kV specified in PSR, the Minimum Creepage distance values**



**shall be considered proportionately.**

## **17.0 PRE-COMMISSIONING TESTS**

17.1 An indicative list of tests is given below. All routine tests except power frequency voltage dry withstand test on main circuit breaker shall be repeated on the completely assembled breaker at site. Contractor shall perform any additional test based on specialties of the items as per the field Q.P./instructions of the equipment Supplier or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests alongwith calibration certificates and shall furnish the list of instruments to the Employer for approval.

- (a) Insulation resistance of each pole.
- (b) Check adjustments, if any suggested by manufacturer.
- (c) Breaker closing and opening time.
- (d) Slow and Power closing operation and opening.
- (e) Trip free and anti pumping operation.
- (f) Minimum pick-up voltage of coils.
- (g) Dynamic Contact resistance measurement.
- (h) Functional checking of control circuits interlocks, tripping through protective relays and auto reclose operation.
- (i) Insulation resistance of control circuits, motor etc.
- (j) Resistance of closing and tripping coils.
- (k) SF6 gas leakage check.
- (l) Dew Point Measurement
- (m) Operation check of pressure switches and gas density monitor during gas filling.
- (n) Checking of mechanical 'CLOSE' interlock, wherever applicable.
- (o) Testing of grading capacitor.
- (p) Resistance measurement of main circuit.
- (q) Checking of operating mechanisms
- (r) Check for annunciations in control room.
- (s) Point of wave switching test (wherever applicable)

17.2 The contractor shall ensure that erection, testing and commissioning of circuit





breaker shall be carried out under the supervision of the circuit breaker manufacturer's representative. The commissioning report shall be signed by the manufacturer's representative.

