

TECHNICAL SPECIFICATION
SECTION: SWITCHGEAR-CB
REVISION-12

Summary of major changes made in this revision w.r.t earlier Technical Specification,Section: Switchgear, Chapter CB, Rev.11

<u>S.No</u>	<u>Clause</u>	<u>Reason for change.</u>
1	1.6	Provision for monitoring of CSD selector switch is added.
2	2.3 (i)(v), 16.0. 27(vi), 15.2 viii)	Text correction done
3	2.4	Scope of requirement of CSD for Circuit Breakers is updated along with IEC details for type testing.
4	2.4.1 b), g) & n)	IEC for Type testing of CSD are updated & The limit for inrush current for switching of Transformer by CSD shall be 1 P.U. of rated current of transformer
5	2.3 v) & 15.2 x)	Shunt Reactor type test requirement clarified as Transmission planning Criteria 2023 published by CEA.
6	8.2.4 & 8.2.9	Closing circuit supervision to be provided in 145 kV CB used for NGR Bypassing & AC supply monitoring added.
7	11.4	Minimum 10% spare cores in cables included
8	11.5 & 11.6	Plug-in connectors requirement for inter-pole cabling is deleted
9	15.2 v)	Seismic test requirement clarified in line with section GTR.
10	15.2 vii)	Low & High temperature type test requirement is updated in line with the Revised IEC/IS.
11	16	Few of the CB technical parameters have been updated.
12	17.1	Pre-commissioning document details updated as per the AM standard document.
13	18.0	Actions required to be taken by contractor in case of defects observed in AIS type Circuit Breakers have been updated.

Note: All Changes made in this document are shown with bold letters, further major changes are listed above; however, for complete details of changes, please refer the complete technical specification.

SECTION: SWITCHGEAR–CB (CIRCUIT BREAKER)

CONTENTS

Clause No.	Description	Page No.
1.0	General	4
2.0	Duty requirements	4
2.4	Controlled Switching Device (CSD)	7
3.0	Total Break Time	9
4.0	Constructional Features	9
5.0	Sulphur Hexafluoride Gas (SF6 Gas)	11
6.0	Insulators	11
7.0	Spare Parts and Maintenance Equipment	12
8.0	Operating Mechanism and Control	12
9.0	Support Structure	15
10.0	Terminal Connector Pad	16
11.0	Inter-pole Cabling	16
12.0	Fittings and Accessories	17
13.0	Additional Data to be Furnished	18
14.0	Dead Tank Type Circuit Breaker	19
15.0	Tests	19
16.0	Technical Parameters for Circuit Breaker	21
17.0	Pre-commissioning tests	24
18.0	Actions required for defects observed during defect Liability period	26
9.b) drg:	Indicative drawing for Platform details of 400kV & 765kV CB	28

SECTION: 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 Section-GTR.

1.2 800/420/245/145/72.5kV circuit breakers offered would be of sulphur hexafluoride (SF6) type and of class C2-M2 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), galvanized 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 Section – 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 Section-Project.

1.6 All 765kV & 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. **Further provision for status monitoring of this Selector switch is to be provided.**

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

800kV & 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 section. 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 support 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)
800kV	765/400kV	250 to 1500
420kV	765/400kV	250 to 1500
	400/220kV	250 to 630
	400/132kV	160 to 315
245kV	400/220kV	250 to 630
	220/132kV	50 to 200

	220/66kV	50 to 200
145kV	220/132kV	50 to 200
	132/33kV	10 to 50

- 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:

Voltage rating of CB	Reactor Rating (in MVAR)	Max. rise of over voltage (in p.u.)
800kV	240 to 330	1.9
420kV	50 to 250	2.3
245kV	25 to 50	2.3

145kV & above Voltage Class circuit breakers (except 145kV 1 - Phase CB used for NGR bypass) shall be able to switch out the shunt reactor as per requirement specified in IEC- 62271-110.

- a. Void.
- b. Void.
- c. Void
- d. Void

- vi) Circuit breakers shall also withstand the voltages specified under clause 16.0 of this section

2.4 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 765kV and 400kV side circuit breakers only)
- Switching of shunt Reactor

The CSD shall be provided in following circuit breakers (if specified in BPS):

- a) **765kV**
 - **Main and Tie bay for Auto Transformer**
 - **Main and Tie bay of Bus Reactor**
 - **Switchable Line Reactor Bay**
- b) **400kV**
 - **Main and Tie Bay for 765/400kV Auto Transformer**
 - **Main and Tie Bay for 400/220kV Auto Transformer**
 - **Main and Tie Bay of Bus Reactor**
 - **Switchable Line Reactor Bay**
- c) **220 & 132kV**
 - **Bay for operation of Shunt reactor**

The requirement of CSD shall be explicitly specified in price schedule.

2.4.1 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 section - GTR.
- b) The CSD shall meet the requirements of IEC-61000-4 16 class IV regarding HF disturbance test (for short & long durations both) and fast transient test shall be as per IEC-61000 – 4-4 level IV **or IEC 60255-26 zone A and insulation test as per 60255 – 27.**
- 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 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 downloading of the settings and measured values, date, time of switching etc. Window/**Web browser-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.
- n) **The limit for inrush current for switching of Transformer by CSD shall be 1.0 P.U. of rated current of transformer after fine tuning of CSD settings during pre-commissioning checks. For site acceptance of CSD during online CSD test after fine tuning, inrush current should be less than 1.0 P.U. of rated current in five consecutive operations.**

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

- a) 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.
- b) 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.
- c) 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.
- d) Each pole shall form an enclosure filled with SF6 gas independent of two other poles (for 800, 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.
- e) 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 gauge 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.

- f) Circuit Breaker shall be capable of withstanding a vacuum of minimum 8 millibars without distortion or failure of any part.
- g) 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 Section-GTR.
- b) The mechanical characteristics of insulators shall match with the requirements specified under this section.
- 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 alongwith 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 Space shall be available in 765kV CB common marshalling box to mount monitoring device, of about 300x300x150mm size and of approximately 7kg weight, by the owner in future.

- 8.1.10 Operating mechanism and Marshalling box should be provided with space heater with thermostat, CFL/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. **Further for 145 kV CB used for NGR Bypass, Closing circuit supervision shall also be provided.**
- 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 The 765kV, 3-Phase circuit breakers suitable for single phase switching shall be suitable for taking a spare pole into service in case of any operational requirement and their marshalling box shall be suitable for accommodating the additional relays etc. required for changeover arrangement of all contacts, alarms, signals, indications, interlocks, and lockouts.
- 8.2.7 In trip and closing circuits, relays/relay contacts shall preferably be used instead of contactors.
- 8.2.8 Controlled switching scheme/device wherever required shall be considered as integral part of CB and shall be commissioned along with CB.
- 8.2.9 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. AC & 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.

8.2.10 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 and 765kV 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 carry out 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. An indicative drawing of ladder and platform (Drg.Ref.: C-ENGG-IND.DWG-PLATFORM-CB, Rev.0) is added at page 28 of 28 with this specification for guidance which may be modified to suit the requirement of CB-by-CB manufacturer. However, the minimum size of the structural members shall be maintained as mentioned in the drawing.

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 of 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. **Each control cable shall include minimum 10% spare cores (subject to minimum 1 no. of spare core).**

11.5 **Void**

- 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 & 800kV circuit breakers.
- l) All duty requirements as applicable to 800 kV, 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 765kV and 400kV these secondaries shall be provided in sets of 3 cores, i.e., 2 cores of PX class and one core of metering class , 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 Section-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 Section-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 Section-GTR) in unpressurised condition **for 400kV & above CB only**.
- vi) Verification of the degree of protection.

- vii) **Low temperature test (applicable only for minimum ambient temperatures of less than (-) 5 deg.C application purpose and High temperature test. For Low & High temperature type test, Field performance report of CB's as per IEC 62271-100 revision 2008 (covering amendment-2 in 2017) is also acceptable as valid Type test report**
- viii) Static Terminal Load test/calculations.
- ix) Critical Currents test (if applicable).
- x) **Switching of Shunt Reactors: Test reports shall be submitted as per IEC 62271-110. In case, the breaker is tested at 100A for switching of shunt reactors, confirmation shall be provided by manufacturer regarding suitability of breaker for interrupting inductive current below 100A (if required as per the scope of specification) in line with requirements of clause 2.3(v).**
- 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 section-GTR)

Sl. no.	Parameter	765kV system	400kV system	220kV system	132 kV system	66 kV system
1.	Rated voltage (U _{max}) kV (rms)	800	420	245	145	72.5
2.	Rated frequency (Hz)	50	50	50	50	50
3.	No. of poles	3	3	3	3	3
4.	Type of circuit breaker	SF6 gas insulated	SF6 gas insulated	SF6 gas insulated	SF6 gas insulated	SF6 gas insulated
5.	Rated continuous current (A) at an ambient temperature of 50°C	3150/4000	2000/3150/4000 (as applicable)	1600/2500 (as applicable)	1250	1250
6.	Rated short circuit capacity with percentage of DC component as per IEC-62271-100 corresponding to minimum opening time under operating conditions specified.	50kA (As applicable)	40/50/63kA (As applicable)	40/50 kA (As applicable)	40/31.5kA (as applicable)	25kA
7.	Symmetrical interrupting capability kA (rms)	50	40/50/63 (As applicable)	40/50 (As applicable)	40/31.5kA (as applicable)	25
8.	Rated short circuit making current kAp	125	100/125/157.5 (As applicable)	100/125 (As applicable)	100/80(as applicable)	63
9.	Short time current carrying capability kA (rms)	50 for one second	40/50/63 As applicable for one second	40/50 As applicable for one second	40/31.5 (as applicable) for 1 Sec	25 for three second
10.	Out of phase breaking current carrying capability kA (rms)	12.5	10/12.5/15.75 (As applicable)	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	900	600	As per IEC	As per IEC	As per IEC

	current with test voltage immediately before 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	1.3	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
14.	Rated break time as per IEC (ms)	40	40	60	60	Less than 75
15.	Total break time (ms)	45	45	65	65	Less than 80
16.	Total closing time (ms)	Not more than 150	Not more than 150	Not more than 150	Not more than 150	Not more than 150
17.	Operating mechanism or a combination of these	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
19.	Reclosing	Single phase & Three phase auto 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.
20.	Pre-insertion resistor requirement	As per BPS	As per BPS	NA	NA	NA
i)	Rating (ohms)	Approx. 450 with tolerance as applicable	Approx. 400 with tolerance as applicable	NA	NA	NA
ii)	Minimum electrical (mechanical insertion time + pre-arcing time) pre-insertion time (ms)	9	8	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	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	NA	NA	NA

		pressure where the PIR contacts remain closed	pressure where the PIR contacts remain closed			
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)	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
22.	Maximum allowable switching over voltage under any switching condition	1.9 p.u.	2.3 p.u.	As per IEC	As per IEC	As per IEC
23.	Trip coil and closing coil voltage with variation as specified	220V DC	220V DC	220V 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	As per IEC	140dB (max.)	140dB (max.)	140dB (max.)	140dB (max.)
25.	Rating of Auxiliary contacts	10A at 220V DC	10A at 220V DC	10A at 220V DC	10A at 220V DC	10A at 220V 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
27.	Rated insulation levels					
i)	Full wave impulse withstand (1.2 /50 μ s) between line terminals and ground	\pm 2100kVp	\pm 1425 kVp	\pm 1050 kVp	\pm 650 kVp	\pm 325 kVp
ii)	Full wave impulse withstand (1.2 /50 μ s) between terminals with circuit breaker open	2100kVp impulse on one terminal & 455 kVp power frequency voltage of opposite polarity on the other terminal	1425 kVp impulse on one terminal & 240 kVp power frequency voltage of opposite polarity on the other terminal	\pm 1050 kVp	\pm 650kVp	\pm 325 kVp
iii)	Rated switching impulse withstand voltage (250/2500 μ s) Dry & wet between line terminals and ground	+ 1550kVp	+1050 kVp	NA	NA	NA
iv)	Rated switching impulse withstand voltage (250/2500 μ s) Dry & wet Between terminals with	1175kVp impulse on one terminal & 650 kVp	900 kVp impulse on one terminal & 345 kVp	NA	NA	NA

	circuit breaker open	power frequency voltage of opposite polarity on the other terminal	power frequency voltage of opposite polarity on the other terminal			
v)	One minute power frequency dry withstand voltage between line terminals and ground	830kV rms	520 kV rms.	460 kV rms.	275 kV rms	140 kV rms
vi)	One minute power frequency dry withstand voltage between terminals with circuit breaker open	1150kV rms	610 kV rms.	460 kV rms.	275 kV rms	140 kV rms
28.	Minimum corona extinction voltage with CB in all positions	508 kV rms	320kV rms	156 kV rms	92 kV rms	NA
29.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz (Micro volts)	2500 μ V (at 508kV rms)	1000 μ V (at 266kV rms)	1000 μ V (at 156kV rms)	500 μ V (at 92kV rms)	NA
30.	Minimum Creepage distance*					
i)	Phase to ground (25mm/kV)	20000mm	10500mm	6125mm	3625mm	1813mm
ii)	Between CB terminals	18000mm	10500mm	6125mm	3625mm	1813mm
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 for the site location under the Zone-V as per IS-1893 0.3g horizontal for the site location under other than the Zone-V as per IS-1893				

* The values indicated are for specific creepage of 25mm/kV. In case of specific creepage of 31mm/kV specified, 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. For Pre-commissioning tests, procedures and formats for circuit breakers, **POWERGRID document no.D-2-01-03-01-06 dated 07.05.2024 /Latest version will be the reference document.** This document will be available at respective sites and shall be referred by the contractor. 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.

18.0 ACTIONS REQUIRED FOR DEFECTS OBSERVED DURING DEFECT LIABILITY PERIOD

The actions required to be taken by contractor in case of defects observed in AIS type Circuit Breakers of ratings 132kV & above during the warranty period (defect liability period) shall be as per following. Further, the replaced/repaired/ refurbished equipment (or part of equipment) shall have warranty in line with the GCC clause 22 in SCC.

Sl.no.	Nature of problem	Corrective measures to be taken by contractor
1.	Blasting of interrupter, PIR, pole column,	Replacement of complete CB pole Including SF6 gas
	a. Abnormal DCRM and Travel Measurement b. Contact assembly and internal component damage, misalignment not leading to complete failure of interrupter/ PIR	Repair/replacement of affected assembly/ component based on repair procedure approved by QA
2.	Crack in insulator, cementing joint of interrupter , PIR , pole column, hotspots in interconnecting link for 765kV poles	Replacement of affected part
3.	SF6 gas leakage from sealing and bolted joints. SF6 gas leakage detectable by any Leakage Detection Method	Rectification by replacement of gasket, O-ring, sealing, Interrupter or affected part to be replaced etc(Within 15 days of leakage identification) If unable to arrest the leakage in 02 attempts, replacement of interrupter/ column
4.	SF6 gas low dew point: > (-)35 deg C at atmospheric pressure.	Re-conditioning of gas. If does not improve, complete evacuation of CB, replacement filter material and gas
5.	Oil leakage of grading capacitor Change in Capacitance value beyond +/- 5 % w.r.t. to value of Capacitance obtained at site during pre-commissioning test.	Replacement or Refurbishment of grading capacitor
6.	Pole/ break discrepancy (during O&M) Limits: Break to Break (Opening/Closing) : max. 2.5 ms Phase to Phase (Opening) : max. 3.33 ms Phase to Phase (Closing) : max 5 ms	Rectification/replacement of affected parts
7.	Static Contact Resistance: increase >50% from factory/ pre-commissioning value or >75 micro-ohm/ break whichever is lower	Rectification/Replacement of pole
8.	Drive mechanism assembly failure	Rectification/ Replacement of affected part If similar problem occurs two more-time, complete replacement of drive mechanism.
9.	Trip/ close coil, density monitor, relays and contactors and components of common MB	Replacement of affected part

Note: 1) Replaced/Repaired/Refurbished Equipment (or part of equipment) shall have 2 years warranty without prejudice to contractual warranty period.

2) The measurement at site shall be carried out as per POWERGRID standard Pre-commissioning procedures as indicated in Technical Specification.

3) In case spare is utilized for replacement/refurbishment of failed items (as per Table above) in view of emergency restoration, the replenishment of the utilized spare shall be done within 03 months of failure/violation.

