Technical Specifications

1) Technical specification of 400kV TIE CT

1.1. Current transformers shall have single primary either ring type, or hair pin type and suitably designed for bringing out the secondary terminals in a weather proof (IP 55) terminal box at the bottom. PF Terminal for measurement of tan delta and capacitance of the unit shall be provided. These secondary terminals shall be terminated to stud type non disconnecting terminal blocks inside the terminal box. In case "Bar primary" inverted type current transformers are offered the manufacturer will meet following additional requirements:

a). The secondaries shall be totally encased in metallic shielding providing a uniform equipotential surface for even electric field distribution.

b). The lowest part of the insulation assembly shall be properly secured to avoid any risk of damage due to transportation stresses.

c). The upper part of insulation assembly resting on primary bar shall be properly secured to avoid any damage during transportation due to relative movement between insulation assembly & top dome.

d). Nitrogen if used for hermetic sealing (in case of live tank design) should not come in direct contact with oil.

e). Bidder/Manufacturer shall recommend whether any special storage facility is required for spare CT.

1.2. Different ratios specified shall be achieved by secondary taps only and primary reconnection shall not be accepted.

1.3. Core lamination shall be of cold rolled grain oriented silicon steel or other equivalent alloys. The cores used for protection shall produce undistorted secondary current under transient conditions at all ratios with specified CT parameters.

1.4. The expansion chamber at the top of the porcelain insulators should be suitable for expansion of oil.

1.5. Facilities shall be provided at terminal blocks in the marshalling box for star delta formation, short circuiting and grounding of CT secondary terminals.

1.6. Current transformer's guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.

1.7. For 420 kV class CTs, the rated extended primary current of the CTs shall be 200% of rated primary on all except 2000/1 tap ratio. On 2000/1 tap ratio the rated extended primary current shall be 120% However, at 2000/1, ratio the CT shall be thermally rated for 200% for 15 minutes and 120% continuous.

For 420 kV CTs rated for 3000A, the rated extended primary current shall be 120% for 3000/1 tap ratio and 180% for 2000/1 tap ratio and 200% for lower tap ratios. The secondary windings shall be rated for 1A continuously. Further, the intermediate tapping at 3000-1500 and 1500-1000 shall be suitable for using as 1000/1 and 1500/1 ratios. The Auxiliary reactor shall be suitable for connecting to the selected taps.

For 245/145/36 kV class CTs, the rated extended primary current shall be 120% on all cores of the CTs.

1.8. For 420/245/145/36 kV current transformers, characteristics shall be such as to provide satisfactory performance of burdens ranging from 25% to 100% of rated burden over a range of 5% to 120% (or specified rated extended current whichever is higher) of rated current in case of metering CTs and up to the accuracy limit factor/knee point voltage in case of relaying CTs.

1.9. The current transformer shall be suitable for horizontal transportation. It shall be ensured that the CT is able to withstand all the stresses imposed on it while transporting and there shall be no damage in transit. The Contractor shall submit the details of packing design to the Purchaser for review.

1.10. For 420/245/145/36 kV CTs the instrument security factor at all ratios shall be not more than 5 for metering core. If any auxiliary CTs/reactor are used in the current transformers then all parameters specified shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably be inbuilt construction of the CTs. In case these are to be mounted separately, these shall be mounted in the central marshalling box suitably wired upto the terminal blocks.

1.11. The wiring diagram plate for the interconnections of the three single phase CTs shall be provided inside the marshalling box.

1.12. The CT shall be so designed as to achieve the minimum risks of explosion in service. Bidder/Manufacturer shall bring out in his offer, the measures taken to achieve this.

1.13. Current transformers shall be suitable for high speed auto reclosing.

SL No.	Item	Ratings and Particulars
1.	Rated Primary Current, Amp	3000
2.	Rated short time thermal current for 1 sec., kA	40
3.	Rated dynamic current, kA (peak)	100
4.	Maximum temperature rise over design ambient temperature	As per IEC: 60044-1
5.	Type of insulation	Class A
6.	No. of Cores	5
7.	**Application**	
	(a) Core-I	Bus Diff. Check
	(b) Core-2	Bus Diff. Main
	(c) Core-3	Metering
	(d) Core-4	Trans. Backup/ Line Protection
	(e) Core-5	Trans. Diff./ Line Protection
8.	**Transformation ratio**	
	(a) Core-I	3000-2000-500/1
	(b) Core-2	3000-2000-500/1
	(c) Core-3	3000-2000-500/1
	(d) Core-4	3000-2000-500/1
	(e) Core-5	3000-2000-500/1
9.	**Rated out put**	

SL No.	Item	Ratings and Particulars
	(a) Core-1	-
	(b) Core-2	-
	(c) Core-3	0.2 (at all ratio)
	(d) Core-4	-
	(e) Core-5	-
10.	**Accuracy class (as per IS: 2705)**	
	(a) Core-1	PS
	(b) Core-2	PS
	(c) Core-3	0.2
	(d) Core-4	PS
	(e) Core-5	PS
11.	**Instrument security factor**	
	(a) Core-1	-
	(b) Core-2	-
	(c) Core-3	Less than 5
	(d) Core-4	
	(e) Core-5	-
12.	**Minimum Knee point voltage, Volts**	
	(a) Core-1	3000/2000/500
	(b) Core-2	3000/2000/500
	(c) Core-3	-
	(d) Core-4	3000/2000/500
	(e) Core-5	3000/2000/500
13.	**Maximum secondary resistance, ohm**	
	(a) Core-1	15
	(b) Core-2	15
	(c) Core-3	-
	(d) Core-4	15

SL No.	Item	Ratings and Particulars
	(e) Core-5	15
	Maximum exciting current, at Vk/4 mA	
	(f) Core-1	20/30/120
	(g) Core-2	20/30/120
	(h) Core-3	-
	(i) Core-4	20/30/120
	(j) Core-5	20/30/120

2) 400kV Line CVT

2.1 General Requirement

2.1.1. 420/245/145 kV voltage transformers shall be capacitor voltage divider type (CVT) with electromagnetic units and shall be suitable for carrier coupling. 36 kV voltage transformers shall be electromagnetic type.

2.1.2. Voltage transformer secondaries shall be protected by HRC cartridge type fuses for all the windings. In addition fuses shall be provided for the protection and metering windings for fuse monitoring scheme. The secondary terminals of the VTs shall be terminated to the stud type non - disconnecting terminal blocks in the individual phase secondary boxes via the fuse.

2.1.3. CVTs shall be suitable for high frequency (HF) coupling required for power line carrier communication. Carrier signal must be prevented from flowing into potential transformer (EMU) circuit by means of a RF choke/reactor suitable for effectively blocking the carrier signals over the entire carrier frequency range i.e. 40 to 500 KHz. Details of the arrangement shall be furnished along with the bid. H.F. terminal of the CVT shall be brought out through a suitable bushing and shall be easily accessible for connection to the coupling filters of the carrier communication equipment, when utilised. Further earthing link with fastener to be provided for HF terminal.

2.1.4. The electromagnetic unit of CVTs comprising compensating reactor, intermediate transformer and protective and damping devices should have separate terminal box with all the secondary terminals brought out.

2.1.5. The damping device which should be permanently connected to one of the secondary windings should be capable of suppressing the Ferro resonance oscillations.

2.1.6. The specified accuracy of metering winding for all voltage transformers should be maintained throughout the entire burden range upto 100 VA on all the windings without any adjustments during operation.

2.1.7. 420 & 220 kV CVTs shall be suitable for mounting on tubular GI pipes.

2.1.8. It should be ensured that access to secondary terminals is without any danger of access to high voltage circuit.

2.1.9. A protective surge arrester shall be provided if required, to prevent breakdown of insulation by incoming surges and to limit abnormal rise of terminal voltage of shunt capacitor/primary winding, tuning

reactor/RF choke etc. due to short circuit in transformer secondaries. In case of an alternate arrangement, bidder shall bring out the details in the bid.

2.1.10. The wiring diagram for the interconnection of the three single phase VTs shall be provided inside the marshalling box in such a manner that it does not deteriorate with time.

2.2. TERMINAL CONNECTORS

2.2.1. The terminal connectors shall meet the requirements as given in Section- 2.

2.3. TESTS

2.3.1. Routine/Acceptance Tests (all units)

In accordance with the requirements in Section-GTR, Current and Voltage Transformers should have been type tested and shall be subjected to routine tests in accordance with IEC:60044-1/IS:2705 and IEC: 60044-5/60044-2 respectively.

2.3.2. Type Tests: The bidder shall furnish type test certificates and results for the all tests as per relevant Standards along with the bid for current and potential transformers of identical design. Type test certificates so furnished shall not be older than 5 (five) years as on date of Bid opening.

2.4. PRE-COMMISSIONING TESTS

2.4.1. Contractor shall carry out following tests as pre-commissioning tests. Contractor shall also perform any additional test based on specialties of the items as per the field 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 along with calibration certificates and shall furnish the list of instruments to the Employer for approval.

(a) Voltage Transformers/Capacitive Voltage Transformers

(i) Insulation Resistance test for primary (if applicable) and secondary winding.
(ii) Polarity test.
(iii) Ratio test
(iv) Dielectric test of oil (wherever applicable).
(v) Tan delta and capacitance measurement of individual capacitor stacks.
(vi) Secondary winding resistance measurement.

SL No.	Item	Ratings and Particulars
1.	Rated Voltage, Amp	420
2.	System Fault Level for 1 sec., kA	40
3.	Type	Single Phase Capacitor VT (CVT)
4.	Rated Voltage Factor	1.2 (continuous) 1.5 (for 30 sec.)
5.	High frequency capacitance for entire carrier frequency range	80% to 150% of rated capacitance
6.	Standard reference range of frequencies for which the accuracies are valid	96% to 102% for protection and 99% to 101% for measurement

7.	Capacitance, pF	4400
8.	One minute power frequency withstand voltage :	
	(a) Between LV(HF) terminal and earth terminal	10 kV (rms) for exposed terminals and 4 KV (rms) for terminals enclosed in a weather proof box
	(b) For secondary winding	3 kV (rms)
9.	No. of Secondary Winding	3
10.	Voltage Ratio	
	a). Wdg.-1	400/0.110
	b). Wdg.-2	400/0.110
	c). Wdg.-3	400/0.110
11.	**Application**	
	a). Wdg.-1	Protection
	b). Wdg.-2	Protection
	c). Wdg.-3	Metering
12.	**Accuracy Class**	
	(a) Wdg-I	3P
	(b) Wdg-2	3P
	(c) Wdg-3	0.2
13.	**Rated output (min.), VA**	
	(a) Wdg-1	100
	(b) Wdg-2	100
	(c) Wdg-3	100
14.	**Phase angle error**	(+/-) 10 minutes (For metering core)

3) 400kV Line and Transformer CT

3.1. Current transformers shall have single primary either ring type, or hair pin type and suitably designed for bringing out the secondary terminals in a weather proof (IP 55) terminal box at the bottom. PF Terminal for measurement of tan delta and capacitance of the unit shall be provided. These secondary terminals shall be terminated to stud type non disconnecting terminal blocks inside the terminal box. In case "Bar primary" inverted type current transformers are offered the manufacturer will meet following additional requirements:

a) The secondaries shall be totally encased in metallic shielding providing a uniform equipotential surface for even electric field distribution.

b) The lowest part of the insulation assembly shall be properly secured to avoid any risk of damage due to transportation stresses.

c) The upper part of insulation assembly resting on primary bar shall be properly secured to avoid any damage during transportation due to relative movement between insulation assembly & top dome.

d) Nitrogen if used for hermetic sealing (in case of live tank design) should not come in direct contact with oil.

e) Bidder/Manufacturer shall recommend whether any special storage facility is required for spare CT.

3.2. Different ratios specified shall be achieved by secondary taps only and primary reconnection shall not be accepted.

3.3. Core lamination shall be of cold rolled grain oriented silicon steel or other equivalent alloys. The cores used for protection shall produce undistorted secondary current under transient conditions at all ratios with specified CT parameters.

3.4. The expansion chamber at the top of the porcelain insulators should be suitable for expansion of oil.

3.5. Facilities shall be provided at terminal blocks in the marshalling box for star delta formation, short circuiting and grounding of CT secondary terminals.

3.6. Current transformer's guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.

3.7. For 420 kV class CTs, the rated extended primary current of the CTs shall be 200% of rated primary on all except 2000/1 tap ratio. On 2000/1 tap ratio the rated extended primary current shall be 120% However, at 2000/1, ratio the CT shall be thermally rated for 200% for 15 minutes and 120% continuous.

For 420 kV CTs rated for 3000A, the rated extended primary current shall be 120% for 3000/1 tap ratio and 180% for 2000/1 tap ratio and 200% for lower tap ratios. The secondary windings shall be rated for 1A continuously. Further, the intermediate tapping at 3000-1500 and 1500-1000 shall be suitable for using as 1000/1 and 1500/1 ratios. The Auxiliary reactor shall be suitable for connecting to the selected taps.

For 245/145/36 kV class CTs, the rated extended primary current shall be 120% on all cores of the CTs.

3.8. For 420/245/145/36 kV current transformers, characteristics shall be such as to provide satisfactory performance of burdens ranging from 25% to 100% of rated burden over a range of 5% to 120% (or specified rated extended current whichever is higher) of rated current in case of metering CTs and up to the accuracy limit factor/knee point voltage in case of relaying CTs.

3.9. The current transformer shall be suitable for horizontal transportation. It shall be ensured that the CT is able to withstand all the stresses imposed on it while transporting and there shall be no damage in transit. The Contractor shall submit the details of packing design to the Purchaser for review.

3.10. For 420/245/145/36 kV CTs the instrument security factor at all ratios shall be not more than 5 for metering core. If any auxiliary CTs/reactor are used in the current transformers then all parameters specified shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably be inbuilt construction of the CTs. In case these are to be mounted separately, these shall be mounted in the central marshalling box suitably wired upto the terminal blocks.

3.11. The wiring diagram plate for the interconnections of the three single phase CTs shall be provided inside the marshalling box.

3.12. The CT shall be so designed as to achieve the minimum risks of explosion in service. Bidder/Manufacturer shall bring out in his offer, the measures taken to achieve this.

3.13. Current transformers shall be suitable for high speed auto reclosing.

SL No.	Item	Ratings and Particulars
14.	Rated Primary Current, Amp	2000
15.	Rated short time thermal current for 1 sec., kA	40
16.	Rated dynamic current, kA (peak)	100
17.	Maximum temperature rise over design ambient temperature	As per IEC: 60044-1
18.	Type of insulation	Class A
19.	No. of Cores	5
20.	**Application**	
	(f) Core-I	Bus Diff. Check
	(g) Core-2	Bus Diff. Main
	(h) Core-3	Metering
	(i) Core-4	Trans. Backup/ Line Protection
	(j) Core-5	Trans. Diff./ Line Protection
21.	**Transformation ratio**	
	(f) Core-I	2000-1000/1
	(g) Core-2	2000-1000/1
	(h) Core-3	2000-1000-500/1
	(i) Core-4	2000-1000-500/1
	(j) Core-5	2000-1000-500/1

SL No.	Item	Ratings and Particulars
22.	**Rated out put**	
	(f) Core-1	-
	(g) Core-2	-
	(h) Core-3	0.2 (at all ratio)
	(i) Core-4	-
	(j) Core-5	-
23.	**Accuracy class (as per IS: 2705)**	
	(f) Core-1	PS
	(g) Core-2	PS
	(h) Core-3	0.2
	(i) Core-4	PS
	(j) Core-5	PS
24.	**Instrument security factor**	
	(f) Core-1	-
	(g) Core-2	-
	(h) Core-3	Less than 5
	(i) Core-4	-
	(j) Core-5	-
25.	**Minimum Knee point voltage, Volts**	
	(f) Core-1	2000/1000
	(g) Core-2	2000/1000
	(h) Core-3	-
	(i) Core-4	4000/2000/1000
	(j) Core-5	4000/2000/1000
26.	**Maximum secondary resistance, ohm**	
	(k) Core-1	10/5
	(l) Core-2	10/5
	(m) Core-3	-

SL No.	Item	Ratings and Particulars
	(n) Core-4	10/5/2.5
	(o) Core-5	10/5/2.5
	Maximum exciting current, at Vk/4 mA	
	(p) Core-1	30/60
	(q) Core-2	30/60
	(r) Core-3	-
	(s) Core-4	30/60/120
	(t) Core-5	30/60/120

4) 400KV LA with counter

4.1 GENERAL REQUIREMENT

4.1.1. The surge arrestor shall draw negligible current at operating voltage and at the same time offer least resistance during the flow of surge current.

4.1.2. The surge arrestor shall consist of non-linear resistor elements placed in series and housed in electrical grade porcelain housing/silicon polymeric of specified creepage distance.

4.1.3. The assembly shall be hermetically sealed with suitable rubber gaskets with effective sealing system arrangement to prevent ingress of moisture.

4.1.4. The surge arrestor shall not operate under power frequency and temporary over voltage conditions but under surge conditions, the surge arrestor shall change over to the conducting mode.

4.1.5. The surge arrestor shall be suitable for circuit breaker performing 0-0.3sec.-CO-3min-CO- duty in the system.

4.1.6. Surge arrestors shall have a suitable pressure relief system to avoid damage to the porcelain/ silicon polymeric housing and providing path for flow of rated fault currents in the event of arrestor failure.

4.1.7. The reference current of the arrestor shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

4.1.8. The Surge Arrestor shall be thermally stable and the bidder shall furnish a copy of thermal stability test with the bid.

4.1.9. The arrestor shall be capable of handling terminal energy for high surges, external pollution and transient over voltage and have low losses at operating voltages.

4.2. ARRESTOR HOUSING

4.2.1. The arrestor housing shall be made up of porcelain/**silicon polymeric** housing and shall be homogenous, free from laminations, cavities and other flaws of imperfections that might affect the mechanical and dielectric quality. The housing shall be of uniform brown colour, free from blisters, burrs and other similar defects.

Arrestors shall be complete with insulating bases, fasteners for stacking units together, surge counters with leakage current meters and terminal connectors.

4.2.2. The **housing shall be so coordinated that external flashover shall not occur due to application of** any impulse or switching surge voltage up to the maximum design value for arrestor. The arrestors shall not fail due to contamination. The arrester housings shall be designed for pressure relief class as given in Technical Parameters of the specification.

4.2.3. Sealed housings shall exhibit no measurable leakage.

4.3. FITTINGS & ACCESSORIES

4.3.1. The surge arrestor shall be complete with insulating bases, fasteners for stacking units together, surge counters with leakage current meters and terminal connectors.

4.3.2. The terminals shall be non-magnetic, corrosion proof, robust and of adequate size and shall be so located that incoming and outgoing connections are made with minimum possible bends. The top metal cap and base of surge arrestor shall be galvanized. The line terminal shall have a built in clamping device which can be adjusted for both horizontal and vertical takeoff.

4.3.3. Grading corona control rings if necessary shall be provided on each complete arrestor pole for proper stress distribution.

4.4. SURGE MONITOR

4.4.1 A self-contained discharge counter suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation shall be provided for each single pole unit. Leakage current meter with suitable scale range to measure leakage current of surge arrestor shall also be supplied within the same enclosure. The number of operations performed by the arrestor shall be recorded by a suitable cyclometric counter and surge monitor shall be provided with an inspection window. There shall be a provision for putting ammeter to record the current/alarm contacts in the control room if the leakage current exceeds the permitted value. Similar provision shall be considered for surge counter also.

4.4.2. Surge monitor shall be mounted on the support structure at a suitable height so that the reading can be taken from ground level through the inspection window and length of connecting leads up to grounding point and bends are minimum.

4.5. TESTS

4.5.1. Test on Surge Arrestors

The Surge Arrestors offered shall be type tested and shall be subjected to routine and acceptance tests in accordance with IS: 3070 (Part-3). In addition, the suitability of the Surge Arrestors shall also be established for the following:

- Residual voltage test
- Reference voltage test
- Leakage current at M.C.O.V
- P.D. test
- Sealing test
- Thermal stability test
- Aging and Energy capability test
- Watt loss test

Each metal oxide block shall be tested for guaranteed specific energy capability in addition to routine/acceptance test as per IEC/IS.

4.5.2. The surge arrestor housing shall also be type tested and shall be subjected to routine and acceptance tests in accordance with IS: 2071.

4.5.3. Galvanization Test

All Ferrous parts exposed to atmospheric condition shall have passed the type tests and be subjected to routine and acceptance tests in accordance with IS: 2633 & IS 6745.

4.6. NAME PLATE

4.6.1. The name plate attached to the arrestor shall carry the following information:

Rated Voltage

Continuous Operation Voltage

Normal discharge current

Pressure relief rated current

Manufacturers Trade Mark

Name of Sub-station

Year of Manufacturer

Name of the manufacture

Purchase Order Number along with date

4.7. PRE-COMMISSIONING TESTS

4.7.1. Contractor shall carry out following tests as pre-commissioning tests. Contractor shall also perform any additional test based on specialties of the items as per the field 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 along with calibration certificates and shall furnish the list of instruments to the Employer for approval.

(a) Operation check of LA counters.
(b) Insulation resistance measurement.
(c) Capacitance and Tan delta measurement of individual stacks.
(d) Third harmonic resistive current measurement (to be conducted after energisation.)

Sl. No.	Particulars	420 kV
1	Rated voltage of arrester, kV	398
2	Continuous operating voltage, kV	267
2	Rated frequency, Hz	50
3	Nominal discharge current of arrester, kA	20

Sl. No.	Particulars	420 kV
4	(i) Min. switching surge residual voltage (2kA), kVp	670
	(i) Max. switching surge residual voltage (500 kA), kVp	650
5	Maximum residual voltage at,	
	(i) 5 kA nominal discharge current, kV (peak)	-
	(ii) 10 kA nominal discharge current, kV (peak)	800
	(iii) 20 kA nominal discharge current, kV (peak)	850
	(iv) Steep fronted wave residual voltage, kV (peak)	925 at 20 kA
6	One minute power frequency withstand voltage of arrester housing, kV (rms)	630
7	1.2 / 50 μ second impulse withstand voltage of arrester housing, kV (peak)	1425
8	Switching impulse withstand voltage (250/2500 micro second) of arrester housing dry and wet, kV (peak)	1050
9	Creepage distance of insulator housing (mm)	10500
10	Line discharge class	4
	Pressure Relief Class	40 kA

5) 400KV SF6 Circuit Breaker (with and without PIR)

5.1. GENERAL REQUIREMENTS

5.1.1. The circuit breakers and accessories shall conform to IEC: 62271-100, IEC: 62271-01 and other relevant IEC standards except to the extent explicitly modified in the specification

5.1.2. 420 kV, 245, 145 and 36 kV circuit breakers offered would be of sulphur hexafluoride (SF6) type only and of class C2-M2 as per IEC. The bidder may also offer circuit breakers of either live tank type or dead tank type of proven design.

5.1.3. The circuit breaker shall be complete with terminal connectors, operating mechanism, control cabinets, piping, interpole cable, cable accessories like glands, terminal blocks, marking ferrules, lugs, pressure gauges, density monitors (with graduated scale), galvanised support structure for CB and control cabinets, their foundation bolts and all other circuit breaker accessories required for carrying out all the functions the CB is required to perform.

All necessary parts to provide a complete and operable circuit breaker installation such as main equipment, terminals, control parts, connectors and other devices whether specifically called for herein or not shall be provided.

5.1.4. The support structure of circuit breaker as well as that of control cabinet shall be hot dip galvanized. All other parts shall be painted as per ANNEXURE (attached below). Exposed hardware items shall be hot dip galvanized or Electro-galvanized.

5.1.5. The SF6 breaker shall be designed to ensure that condensation of moisture is controlled by proper selection of organic insulating materials having low moisture absorbing characteristics.

5.1.6. The support structure of circuit breaker shall be hot dip galvanised. Sufficient galvanising thickness shall be achieved with 615 gm/m². All other parts shall be painted as per painting specification enclosed separately.

5.2. DUTY REQUIREMENTS

5.2.1. The circuit breakers shall be capable of performing their duties without opening resistors.

5.2.2. The circuit breaker shall meet the duty requirements for any type of fault or fault location also for line switching when used on a 420/245/145/36 kV effectively grounded system, and perform make and break operations as per the stipulated duty cycles satisfactorily.

5.2.3. 420 kV circuit breakers wherever specified shall be provided with single step pre-insertion closing resistors to limit the switching surges to a value of less than 2.3 p.u. for 420 kV. The value of the pre-insertion resistor and the duration of pre-insertion time shall be as given in Clause **Error! Reference source not found.** of this chapter. The resistor shall have thermal rating for the following duties:

(a) TERMINAL FAULT
Close - 1 Min - Open, Close, Open - 2 min – Close - 1 Min – Open, Close, Open.

(b) RECLOSING AGAINST TRAPPED CHARGES
Duty shall be 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.

(c) OUT OF PHASE CLOSING
One closing operation under phase opposition, that is with twice the voltage across the terminals.

(d) 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. Calculations and test reports of resistors proving thermal rating for duties specified above shall be furnished alongwith the bid. The calculations shall take care of adverse tolerances on resistance values and time settings.

5.2.4. The breakers shall be capable of interrupting the steady state and transient magnetising current corresponding of power transformers.

5.2.5. The circuit breaker shall also be capable of:

(a) Interrupting line/cable charging current as per IEC without use of opening resistors.
(b) Clearing short line fault (Kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current specified.
(c) Breaking 25% of the rated fault current at twice rated voltage under phase opposition condition.
(d) 420kV breakers shall be able to switch in and out the 400kV shunt reactor for any value from 50 MVAR up to 80 MVAR without giving rise to overvoltage more than 2.3 p.u.

Laboratory test and or field test reports in support of the same shall be furnished along with the bid.

5.2.6. The Breaker shall satisfactorily withstand the high stresses imposed on them during fault clearing, load rejection and re-energisation of lines with trapped charges. The breaker shall also withstand the voltages specified under Clause **Error! Reference source not found.** of this Chapter.

5.2.7. Controlled Switching Requirements (420 kV Breakers Only)

Controller shall be provided in Circuit breaker of switchable line reactor and in Main & Tie circuit breakers of Bus reactors.

The controlling relay 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.

The controlled switching device shall have following technical features:

a) The controller shall be designed to operate at the correctly and satisfactorily with the excursion of auxiliary A/C & DC voltages and frequency as specified elsewhere.

b) The controller shall meet the requirements of IEC-60255-4 Appendix 'E' class III regarding HF disturbance test, and fast transient test shall be as per IEC-61000 – 4 level III and insulation test as per 60255 – 5.

c) The controller shall have functions for switching ON & OFF the circuit breakers.

d) The controller shall get command to operate the breakers manually or through auto re-close relay at random. 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 controller 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 controller must consider all factors that may affect the operating time of the breaker such as, but not limited to, ambient temperature, hydraulic/pneumatic pressure of the operating mechanism, 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 controller should have display facility at the front for the settings and measured values.

g) The controller should 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 have self-monitoring facility.

i) The controller shall be suitable for current input of 1 amp from the secondary of the CTs. and 110 V (Ph to Ph) from the CVTs. The controller shall also take care of transient and dynamic state values of the current from the secondary of the CTs and CVTs.

j) The controller shall have time setting resolution of 0.1 ms or better.

k) The controller shall have two switching functions (ON & OFF)

l) The controller shall be able to give closing as well as tripping command to at least two breakers with intended discrimination.

m) The controller 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 the scheme.

5.3. TOTAL BREAK TIME

5.3.1. The total break time as specified under this Chapter shall not be exceeded under any of the following duties:

a) Test duties T10, T30, T60, T100a, T100s (TRV as per IEC: 62271-100)
b) Short line fault L75, L90 (TRV as per IEC: 62271-100)

5.3.2. The Bidder may please note that 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%), pneumatic/hydraulic pressure and arc extinguishing medium pressure etc. While furnishing the proof of the total break time of complete circuit breaker, the Bidders may specifically bring out the effect of non-simultaneity between contacts within a pole or between poles and show how it is covered in the guaranteed total break time.

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

5.4. CONSTRUCTIONAL FEATURES

5.4.1. Contacts:

5.4.2. The gap between the open contacts shall be such that it can withstand atleast 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).

5.4.3. If multibreak 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 of the grading elements shall be adequate for the service conditions and duty specified.

5.4.4. 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 gasketted 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 1 0.5% per year. In case the leakage under the specified conditions is found to be greater than 1 0.5% after one year of commissioning of circuit

breaker, the manufacturer will have to supply free of cost, the total gas requirement for subsequent ten (10) years, based on actual leakage observed during first year of operation after commissioning

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 420 kV CBs) and the SF6 density of each pole shall be monitored. 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. The density monitor shall have graduated scale and shall meet the following requirements:

i) 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). Each 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 installed. In addition, spare gas shall be supplied in separate unused cylinders if specified in BOQ.

5.4.5. 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 resisters if used, synchronisation of contacts in one pole.

5.5. SULPHUR HEXAFLUORIDE GAS (SF6 GAS)

5.5.1. The SF6 gas shall comply with IEC 60376, 60376A and 60376B and shall be suitable in all respects for use in the switchgear under the operating conditions.

5.5.2. 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.

5.5.3. Test: SF6 gas shall be tested for purity, dew point, air, hydrolysable fluorides and water content as per IEC 60376, 60376A and 60376B and test certificates shall be furnished to Employer indicating all the tests as per IEC 60376 for each lot of SF6 gas. Gas bottles should be tested for leakage during receipt at site.

5.6. INSULATORS

5.6.1. The mechanical characteristics of insulators shall match with the requirements specified under this Chapter.

5.6.2. All hollow insulators shall conform to IEC-62155. All routine and sample tests shall be conducted on the hollow column insulators as per these standards with requirements and procedures modified as under:

a) Pressure test as a routine test.

b) Bending load test as a routine test.

i) Bending load test as a sample test on each lot.

ii) Burst pressure test as a sample test on each lot.

5.6.3. In addition to above, ultrasonic test shall be carried out as additional routine test.

5.6.4. Hollow Porcelain for pressurized columns/chambers should be in one integral piece in green and fired stage.

5.7. OPERATING MECHANISM AND CONTROL

5.7.1. General Requirements

i) Circuit breaker shall be operated by pneumatic mechanism or spring charged mechanism or hydraulic mechanism or a combination of these. The mechanism shall be housed in a weather proof and dust proof control cabinet as stipulated in Section-GTR.

ii) The operating mechanism shall be strong, rigid, not subject to rebound and shall be readily accessible for maintenance for a man standing on ground or on a platform (with ladder) which to be supplied along with the circuit breaker.

iii) The mechanism shall be anti-pumping and trip free (as per IEC definition) under every method of closing.

iv) The mechanism shall be such that the failure of any auxiliary spring will not prevent tripping and will not cause trip or closing operation of the power operating devices.

v) 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 central control cabinet.

vi) Working parts of the mechanism shall be 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.

vii) The bidder 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, and erection, commissioning, troubleshooting, servicing and overhauling instructions.

5.7.2. Control

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

ii) Each breaker pole shall be provided with two (2) independent tripping circuits, pressure switches and coils each to be fed from separate DC sources and connected to a different set of protective relays.

iii) 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 central control cabinet.

iv) The trip coils shall be suitable for trip circuit supervision during both open and close position of breaker. The trip circuit supervision relay would be provided on relay panels.

v) 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 upto 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 in the additional information schedules.

vi) Density Meter contacts and pressure switch contact shall be suitable for direct use as permissive in closing and tripping circuits. 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.

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

5.7.3. Pneumatically Operated Mechanism

b) Each pneumatic operated breaker shall be equipped with compressed air system in accordance with Clause 0.

c) The breaker local air receivers shall comply with the requirements under Clause 0 and shall have sufficient capacity for atleast two CO operations of the breaker at the lowest pressure for auto reclosing duty without refilling.

d) Independently adjustable pressure switches with potential free, ungrounded contacts to actuate a lock out device shall be provided. This lockout device with provision of remote alarm indication shall be incorporated in the circuit breaker to prevent operation whenever the pressure of the operating mechanism is below that required for satisfactory operation of the circuit breaker. The scheme should permit operation of all blocking and alarm relays as soon as the pressure transient present during the rapid pressure drop has been damped and a reliable pressure measurement can be made. Such facilities shall be provided for following conditions:
   (i). Trip lockout pressure - 2 Nos.
   (ii). Close lockout pressure - 1 No.
   (iii). Auto-reclose lockout pressure - 1 No.
   (iv). Extreme low pressure - 1 No.

e) The compressed air mechanism shall be capable of operating the circuit breaker under all duty conditions with the air pressure immediately before operation between 85% and 110% of the rated supply pressure. The make/break time at this supply pressure shall not exceed the specified make/break time within any value of trip coil supply voltage as specified.

f) The compressed air piping shall comply to requirements under relevant clause.

5.7.4. Spring Operated Mechanism

a) Spring operated mechanism shall be complete with motor. 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.

5.7.5. Hydraulically operated mechanism

a) Hydraulically operated mechanism shall comprise of operating unit with power cylinder, control valves, high and low pressure reservoir and motor.

b) The hydraulic oil used shall be fully compatible for the specified temperature range.

c) The oil pressure switch controlling the oil pump and pressure in the high pressure reservoir shall have adequate number of spare contacts to be used for continuous monitoring of low pressure, high pressure etc.

d) The mechanism shall be suitable for atleast two close open operations after failure of AC supply to the motor starting at pressure equal to the lowest pressure of auto reclose duty plus pressure drop for one close open operation.

e) The mechanism shall be capable of operating the circuit breaker correctly and performing the duty cycle specified under all conditions with the pressure of hydraulic operated fluid in the operating mechanism at the lowest permissible pressure before make up. The opening time at the lowest pressure for a particular operation shall not exceed the guaranteed operating time within any value of trip coil supply voltage as specified.

f) Trip lockout shall be provided to prevent operations of the circuit breaker below the minimum specified hydraulic pressure. Alarm contacts for loss of Nitrogen shall be provided.

g) All hydraulic joints shall have no oil leakage under the site conditions and joints shall be tested at factory against oil leakage at a minimum of 1.5 times maximum working pressure.

5.8. UNIT COMPRESSED AIR SYSTEM FOR CIRCUIT BREAKERS

5.8.1. The unit compressed air system shall meet the following requirements:

i) The compressed air system shall be provided with necessary piping, piping accessories, control valves, safety valves, filters, reducing valves, isolating valves, drain ports, etc. The Unit compressed air system shall be provided with suitable antivibration pads wherever required.

ii) The compressors or pumps shall be of the air cooled type and mounted within the operating mechanism housing or a separate weather-proof and dust-proof housing.

iii) The air receiver shall have stored energy for 2 CO operations of the breaker at the blocking pressure for auto reclosing duty without refilling. The unit compressor shall be capable of building up required pressure for another 2 CO operations within 30 minutes.

iv) The size of the compressor shall be determined by the bidder. The compressor shall be of sufficient capacity for performing all the operations above mentioned.

5.8.2. Air Compressor

(i). The air compressor shall be of air cooled type complete with cylinder lubrication, drive motor etc. The compressor shall be rated for the following duty:

a) Total running time of not exceeding 80 minutes compressor to build up the rated pressure from atmospheric pressure

b) Normal running air not exceeding 15 minutes charging considering 10% leakage/day.

c) Air charging time not exceeding 15 minutes after one close-open operation from rated pressure.

(ii). Compressor shall be driven by automatically controlled motors.

(iii). The compressor shall be provided with automatic adjustable unloading device during starting.

(iv). The compressor shall be equipped with a Time totaliser and a Pressure gauge.

5.8.3. Intercooler and after cooler: (If applicable)

Intercooler between compressor stage and after cooler at discharge if any of H.P. cylinder shall be included in Contractor's scope. They shall be of air cooled type and shall be designed as per ASME Code of IEMA Standards.

The design pressure on the air side of cooler shall be 1.25 times the working pressure. A corrosion allowance of 3 mm shall be included for all steel parts.

5.8.4. Air Receivers

i) Air receiver shall be designed in accordance with the latest edition of the ASME Code for Pressure Vessel - Section VIII of BS: 5179. If the air receiver is not fully hot dip galvanised, it shall be coated on the inside face with antirust medium and a corrosion allowance of 3.0 mm shall be provided for shell and dished ends.

ii) Connections for air inlet and outlet, drain and relief valves shall be flanged type or screwed type. Pressure gauge and pressure switch connections shall be screwed type only.

iii) Accessories such as suitable sized safety valve to relieve full compressor discharge at a set pressure equal to 1.1 times the maximum operating pressure, blow off valve, auto drain tap with isolating and bypass valve, dial type pressure gauge with isolating and drain valve and test connection shall be provided.

iv) Air receiver shall be offered with atleast 50% spare capacity, calculated on the basis of total air requirement for 2 CO operations.

5.8.5. Quality of Air

Compressed air used shall be dry and free of dust particles and fully compatible with the materials used in the pneumatic operating mechanism. Arrangement for conditioning the compressed air if required shall be provided as an integral part of air compressor system.

If situation warrants, because of the severe ambient conditions, the supplier may offer centralised compressed air system.

5.8.6. Control and Control Equipment

i) The compressor control shall be of automatic start/stop type initiated by pressure switches.

ii) Duplicate incoming supply of 415 V, AC shall be provided by the Employer at switchyard bay marshaling box from where the Contractor shall take the feed to the operating mechanism.

iii) All the necessary compressor control equipment shall be housed in a totally enclosed sheet steel cabinet also conforming to requirements of Chapter-GTR. Pressure gauges and other indicating devices, control switches shall be mounted on the control cabinet.

iv) A glass window shall be provided for viewing the indicating instrument/gauges. The maximum height shall be 2000 mm.

5.8.7. Compressed Air Piping, Valves and Fittings

i) The flow capacity of all valves shall be at least 20% greater than the total compressor capacity.

ii) The high pressure pipe and air system shall be such that after one O-0.3 sec-CO-operation the breaker shall be capable of performing one CO operation within 3 minutes.

iii) All compressed air piping shall be bright annealed, seamless phosphorous Deoxidized Non-Arsenical Copper alloy as per BS: 2874 or stainless steel pipe (C - 106 of BS: 2871-1957).

iv) All joints and connections in the piping system shall be brazed or flared as necessary.

v) All compressed air piping shall be carried out in accordance with BS : 162.

vi) Compressed air piping system shall be complete with Saddle clamps to support the piping system at suitable intervals. Necessary bolts, nuts, pipe fixing clamps etc shall be included in the scope of Contractor.

5.8.8. Tests

The compressors and its accessories shall conform to the type tests and shall be subjected to routine tests as per applicable standards.

5.9. SUPPORT STRUCTURE

5.9.1. The structure design shall be such that during operation of circuit breaker vibrations are reduced to minimum.

5.9.2. If required, the Contractor shall provide suitable platform with steps on both sides for easy accessibility for monitoring the density/pressure of gas.

5.10. TERMINAL CONNECTOR PAD

5.10.1. 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 for rated current. The terminal pad shall have protective covers which shall be removed before interconnection

5.11. INTER POLE CABLING

5.11.1. All cables to be used by contractor shall be armoured and shall be as per IS – 1554 (1100 Volts Grade). All cables within & between circuit breaker poles shall be supplied by the CB manufacturer.

5.11.2. Only stranded conductor shall be used. Minimum size of the conductor for interpole control wiring shall be 1.5 sq.mm. (Copper).

5.11.3. The cables shall be with oxygen index Min-29 and temp. index as 250^0 C as per relevant standards.

5.12. FITTINGS AND ACCESSORIES

5.12.1. Following is a partial list of some of the major fittings and accessories to be furnished by Contractor in the Central Control cabinet. Number and exact location of these parts shall be indicated in the bid.

(i). Cable glands (Double compression type), Lugs, Ferrules etc.
(ii). Local/remote changeover switch.
(iii). Operation counter
(iv). Pneumatic/hydraulic pressure gauge, pump/compressor start counter (to be provided in case of pneumatic/Hydraulic operating mechanism).
(v). Control switches to cut off control power supply.
(vi). Fuses as required.
(vii). The number of terminals provided shall be adequate enough to wire out all contacts and control circuits plus 24 terminals spare for future use.
(viii). Antipumping relay.
(ix). Pole discrepancy relay.
(x). D.C. Supervision relays.
(xi). Rating and diagram plate in accordance with IEC incorporating year of manufacture.
(xii). Controlled switching equipment like sensors, timers, relays etc.(as applicable).

5.12.2. Additional fittings for pneumatically operated circuit breaker:

(i). Unit compressed air system in accordance with Clause 0.
(ii). Breaker air receivers.
(iii). Pressure gauge, spring loaded safety valve and pressure switch with adjustable contacts.
(iv). Pressure switch to initiate an alarm if the pressure in the auxiliary reservoir remains below a preset level for longer than it is normally necessary to refill the reservoir.
(v). Stop, non-return and other control valves, pipings and all accessories upto breaker mechanism housing.

5.13. TESTS

5.13.1. 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 analyser to determine the breaker contact movement during opening, closing, auto-reclosing and trip free operation under normal as well as limiting operating conditions (control voltage, pneumatic/hydraulic pressure etc.). 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 analyser alongwith necessary transducers, cables, console, etc. where included in scope of supply shall be furnished and utilised. In case of substations where operation analyser is existing the bidder shall utilise the same. However necessary adopter and transducers etc. if required shall have to be supplied by the bidder.

ii) Measurement of Dynamic Contact resistance measurement for arcing & main contacts. Signature of Dynamic contact resistance measurements shall be taken as reference for comparing the same during operation and maintenance in order to ascertain the healthiness of contacts.

iii) Controlled switching equipment validation tests.

5.13.2. The test reports of the type tests and the following additional type tests shall also be submitted for Employer's review:

a). Corona extinction voltage test.
b). Out of phase closing test as per IEC:62271-100.
c). Test to demonstrate the Power Frequency withstand capability of breaker in open condition at Zero Gauge pressure and at lockout pressure (Ref. Clause 0).
d). Seismic withstand test in unpressurised condition.
e). Verification of the degree of protection.
f). Low & high temperature test.(if applicable)
g). Humidity test.(if applicable)
h). Static Terminal Load test.
i). Critical Currents test (if applicable).
j). Switching of Shunt Reactors.
k). Controlled switching performance and validation tests(wherever applicable)

5.14. PRE-COMMISSIONING TESTS

5.14.1. Contractor shall carry out following tests as pre-commissioning tests. Contractor shall also perform any additional test based on specialties of the items as per the field 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 along with 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) Verification of pressure switches and gas density monitor.
(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)

5.15.

Sl. No.	Particulars	Data for 420 kV CB
1	Type	SF_6
2	Rated Voltage, kV(rms)	420
3	Rated Frequency, Hz	50
4	Design ambient temperature (°C)	50
5	No. of Poles	3
6	Reclosing	Single cum three phase reclosing
7	Service	Outdoor
8	Full wave impulse withstand voltage (1.2/50 micro sec.)	
	(i) Between line terminals and ground	±1425 kV peak
	(ii) Between terminals with circuit breaker open	± 1425 kVp impulse on one terminal and 240 kVp power frequency voltage of opposite polarity on other terminal
9	Switching impulse withstand voltage (250/2500 micro-second) dry and wet	
	(i) Between line terminals and ground	± 1050 kV peak
	(ii) Between terminals with circuit breaker open.	900 kVp impulse on one terminal and 345 kVp frequency voltage of opposite polarity on other terminal
10	Corona extinction voltage with Circuit Breaker in all positions	320 (min) (kV rms)
11	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz in all positions	1000 micro volts (at 266 kV rms)

12	One minute power frequency dry withstand voltage	
	(i) Between line terminals and ground	520 kV rms
	(ii) Between terminals with circuit breaker open	610 kV rms
13	Minimum Creepage distance	
	i) Phase to ground (mm)	10500
	ii) Between CB Terminals (mm)	10500
14	Phase to phase spacing, mm	6000/7000
15	Rated continuous current at design ambient temperature, Amp	2000
16	Rated short circuit current breaking capacity at rated voltage, kA	40
17	Symmetrical interrupting capability, kA rms	40
18	Rated short circuit making current, kAp	100
19	Short time current carrying capability for one second, kArms	40
20	Out of phase breaking current capacity, kArms	As per IEC
21	Rated operating duty	0-0.3 Sec - CO -3 Min -CO
22	First pole to clear factor	1.3
23	Rated line charging interrupting current at 90 deg. leading power factor	As per IEC
24	Temperature rise over the design ambient temperature	As per IEC: 62271-100
25	Total break time (max.), ms	45
26	Rated break time (max.), ms	40
27	Total closing time (max), ms	150
28	Operating mechanism	Pneumatic/spring/hydraulic or combination of these
29	Max. difference in the instants of closing/ opening of contacts	
	(i) Within a pole, ms	2.5
	(ii) Between poles (opening), ms	3.3
	(iii) Between poles (closing), ms	5.0
30	Trip coil and closing coil voltage, V, DC	220
31	Noise level at base and upto 50 m (distance from base of	140

	breaker), dB max)	
32	Rated terminal load	As per IEC
33	Auxiliary contacts	Besides requirement of specification, the bidder shall wire up 5 NO + 5 NC contacts as spares
34	Thermal Rating of Auxiliary Contacts	10 A at 220 V DC
35	Breaking Capacity of auxiliary contacts	2 A DC with circuit time constant not less than 20 ms.
36	No of Terminals in common Control cabinet	All contacts & control circuits to be wired out upto common control cabinet plus 24 terminals exclusively for Employer's use
37	Pre-insertion resistor Requirement	
	i) Rating (ohms)	400
	(ii) Minimum pre-insertion time (ms)	8
	Opening of PIR contacts	a) PIR Contacts should open immediately after closing of main circuits. OR b) Atleast 5 ms prior to opening of main contacts at rated air/gas pressure, where the PIR Contacts remain closed.
38	System neutral earthing	Effectively Earthed

6) Technical specification for Transformer Bushing

6.1. Bushings

6.1.1. The electrical and mechanical characteristics of bushings shall be in accordance with IS 2099/ IEC 60137.

6.1.2. Bushing for various voltage rating shall be as follows

52 kV and above: Hermetically sealed Oil filled condenser type/ RIP bushing with porcelain or composite insulator.

36 kV and below: Solid porcelain or oil communicating type. Dimensions of 36 kV bushing shall conform to IS: 3347 Part-V.

6.1.3. Oil Filled condenser type bushing shall be provided with at least the following fittings:

(a) Oil level gauge.

(b) Tap for capacitance and tan delta test. Test taps relying on pressure contacts against the outer earth layer of the bushing is not acceptable.

6.1.4. Where bushing current transformers are specified, the bushings shall be removable without disturbing the current transformers.

6.1.5. Bushings of identical rating shall be interchangeable.

6.1.6. Porcelain used in bushing manufacture shall be homogenous, free from lamination, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture

6.1.7. Clamps and fittings shall be of hot dip galvanised steel or stainless steel.

6.1.8. Bushing turrets shall be provided with vent pipes, to route any gas collection through the Buchholz relay.

6.1.9. No arcing horns shall be provided on the bushings.

6.1.10. Suitable insulating cap (preferably of porcelain) shall be provided on the terminal of Bushing of tertiary winding to avoid accidental external short circuit.

6.1.11. Installation procedures for the various voltage class bushings shall be clearly brought out in the Instruction manual.

6.1.12. Spare Bushing shall be specially packed suitable for long storage.

6.2. Bushing Current Transformer

6.2.1. Current transformers shall comply with IS 2705/ IEC-60185.

6.2.2. It shall be possible to remove the turret mounted current transformers from the tank without removing the tank cover. Necessary precautions shall be taken to minimize eddy currents and local heat generated in the turret.

6.2.3. Current transformer secondary leads shall be brought out to a weatherproof terminal box near each bushing. These terminals shall be wired out to cooler control cabinet/ marshalling box using separate cables for each core.

6.2.4. Bushing Current transformer parameters indicated in this specification are tentative and liable to change within reasonable limits. The Contractor shall obtain Employer's approval before proceeding with the design of bushing current transformers.

6.3. Terminal Marking

6.3.1. The terminal marking and their physical position shall be as per IS 2026/ IEC 60076.

6.4. Neutral Earthing Arrangement

The neutral terminal of auto transformer shall be brought to the ground level by a brass/tinned copper grounding bar, supported from the tank by using porcelain insulators. The end of the brass/tinned copper bar shall be brought to the bottom of the tank, at a convenient point, for making bolted connection to two (2) 75 x 12 mm galvanized steel flats connected to Employer's grounding mat.

HV Bushing

1	Type of Bushing	Lead type
2	Rated voltage	420KV
3	Rated current	1250A
4	Lightning voltage withstand voltage 1.2/50 micro second	1425 kVp
5	Phase to earth voltage	420/√3 kV rms
6	Rated frequency	50 Hz
7	Power frequency withstand voltage (Dry and wet)	630kV
8	Total creepage distance	10500mm
9	Angle of installation from vertical	30 degree max
10	Cantilever withstand load	2500N
11	Short time current rating	40kA for 1 second
12	Bushing performance conforms to	IS:2099-2003(RA) IEC:60137-2003
13	Switching impulse withstand	1050kVp

IV Bushing

1	Type of Bushing	Draw rod type
2	Rated voltage	245KV
3	Rated current	1250A
4	Lightning voltage withstand voltage 1.2/50 micro second	1050 kVp
5	Phase to earth voltage	142 kV
6	Rated frequency	50 Hz
7	Power frequency withstand voltage (Dry and wet)	460kV
8	Total creepage distance	6125mm
9	Angle of installation from vertical	30 degree max
10	Cantilever withstand load	1600N
11	Short time current rating	40kA for 1 second
12	Bushing performance conforms to	IS:2099-2003 SS(RA) IEC:60137-2003
13	P.D at 245kV IS<10 PC & corona extinction voltage	175kV

LV Bushing

1	Type of Bushing	Solid stem
2	Rated voltage	52KV
3	Rated current	3150A
4	Lightning impulse withstand voltage	250kVp
5	Phase to earth voltage	30kV
6	Rated frequency	50 Hz
7	Power frequency withstand voltage (Dry and wet)	105kV
8	Minimum creepage distance	1300mm
9	Angle of installation from vertical	30 degree max
10	Short time current rating	25kA for 1 second
11	Bushing performance conforms to	IS:2099-2003 IEC:60137-2003
12	Flush over length	475mm
13	P D Level	Max 10 PC upto 45kV

ANNEXURE

PAINTING OF EQUIPMENT

1) All surfaces of ferrous materials used for construction of outdoor equipment and enclosures such as instrument transformer main tanks and equipment, marshalling boxes, kiosk, operating boxes, metallic enclosures etc. shall be cleaned and painted as given below if not specified otherwise in respective Sections. The quality of paint such that its colour should not fade even if it is exposed to temperature up to 120^0 C.

Description	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	DFT	Colour Shade
CT & PT Main tanks of CT, PT and other oil filled equpment, etc. (**External surface**)	Shot Blast cleaning Sa 2½ (ISO 8501-1)	Epoxy base zinc primer (30-40µm)	Epoxy high build micaceous iron oxide (75 µm)	Aliphatic Polyurethane 2 coats (25 µm/coat)	Minimum 155 µm	Shade No. 631 of IS:5
-do- (**Internal surfaces**)	Shot Blast cleaning Sa 21/2 (ISO 8501-1)	Hot oil resistant, non-corrosive varnish or paint or epoxy	-	-	Minimum 30 µm	Glossy white for paint
Marshaling boxes, operating boxes etc (**External surface**)	Chemical/ Shot Blast cleaning Sa 21/2 (ISO 8501-1)	Epoxy base zinc primer (30-40µm)	Epoxy base zinc primer (30-40µm)	Polyurethane 2 coats (25 µm/coat)	Minimum 110 µm	Light Gray, Shade No. 697 of IS: 5
-do- (**Internal surfaces**)	Chemical/ Shot Blast cleaning Sa 21/2 (ISO 8501-1)	Epoxy base zinc primer (30-40µm)	-	-	Minimum 30 µm	Glossy white for paint
Smaller fasteners, Cable clips						Use non-ferrous material or Stainless steel

- All paints shall be carefully selected to withstand heat, rain and extremes of weather. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.
- In case finish paint chips off or crinkle during transit or installation, the contractor shall arrange for repainting transformer at site at his cost. The paint for repainting/touchup shall be supplied by the contractor.
- The paint used shall be ISI marked.
- The paint work done shall be guaranteed for a minimum period of 5 years from the date of receipt of the equipment.
- One coat of additional paint to the exposed exterior surfaces shall be given at site prior to commissioning in presence of the Employer's representative.