

CHAPTER -CB
CIRCUIT BREAKERS

1.0 GENERAL

- 1.1 The circuit breakers and accessories shall conform to IEC: 62271-100, IEC: 60694 and other relevant IEC standards except to the extent explicitly modified in the specification.
- 1.2 420 kV circuit breakers offered would be of sulphur hexafluoride (SF6) type only and of class C1-M1 as per IEC. The bidder may also offer circuit breakers of either live tank type or dead tank type of proven design.
- 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.
- 1.4 The support structure of circuit breaker as well as that of control cabinet shall be hot dip galvanised. All other parts shall be painted as per shade 697 of IS
- 1.5 The circuit breakers shall be designed for use in the geographic and meteorological conditions.

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 also for line switching when used on a 420 kV effectively grounded system, and perform make and break operations as per the stipulated duty cycles satisfactorily.

2.2.1 PRE INSERTION RESISTER

420 kV circuit breakers wherever specified shall be provided with single step preinsertion closing resistors to limit the switching surges to a value of less than 2.3 p.u. The value of the pre-insertion resistor and the duration of preinsertion time shall be as given in clause 17.0 of this chapter. the resistor shall have thermal rating for the following duties:

i) TERMINAL FAULT

Close 1 Min Open Close open 2 min close 1 Min
..... open close open.

ii) RECLOSING AGAINST TRAPPED CHARGES

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

iii) OUT OF PHASE CLOSING

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

iv) No allowance shall be made for heat dissipation of resistor during time interval between successive closing operations. The resistors and resistor supports shall perform all these duties without deterioration. 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.

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

2.4 The circuit breaker shall also be capable of:

- i) Interrupting line/cable charging current as per IEC without use of opening resistors.
- ii) 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) 400kV breakers shall be able to switch in and out the 400kV shunt reactor for any value from 50MVAR upto 80MVAR 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 alongwith the bid.

2.5 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 17 of this Chapter.

3.0 TOTAL BREAK TIME:

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

- i) Test duties 1,2,3,4,5 (TRV as per IEC: 62271-100)
- ii) Short line fault L75, L90 (-do -)

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.

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 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).

4.2 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.

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 1% per year. In case the leakage under the specified conditions is found to be greater than 1% 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 such as 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. Typical scheme for SF6 gas density monitoring is enclosed with the bid documents.
- 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 as per requirement.

Provisions shall be made for attaching an operational analyser after installation of circuit breakers at site to record contact travel, speed and making measurement of operating timings, preinsertion timings of closing resistors if used, synchronisation of contacts in one pole. In case operation analyser is already available at a particular site, the contractor shall have to supply a suitable adaptor/transducer so that the offered circuit breaker can be used with the operational analyser.

5.0 SULPHUR HEXAFLUORIDE GAS (SF6 GAS):

- a) The SF6 gas shall comply with IEC 376, 376A and 376B 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.
- c) Test: SF6 gas shall be tested for purity, dew point, air, hydrolysable fluorides and water content as per IEC 376, 376A and 376B and test certificates shall be furnished to Employer indicating all the tests as per IEC 376 for each lot of SF6 gas. Gas bottles should be tested for leakage during receipt at site.

6.0 INSULATORS:

- a) The porcelain of the insulators shall conform to the requirements stipulated IS/IEC
- b) The mechanical characteristics of insulators shall match with the requirements specified under this Chapter.
- c) All insulators shall conform to IEC-61264 (for pressurised hollow column insulators) and IEC-233 (for others). All routine and sample tests shall be conducted on the hollow column insulators as per these standards with requirements and procedures modified as under:
 - i) Pressure test as a routine test.
 - ii) Bending load test as a routine test.
 - iii) Bending load test as a sample test on each lot.
 - iv) Burst pressure test as a sample test on each lot.
 - v) In addition to above, ultrasonic test shall be carried out as additional routine test.
- d) Hollow Porcelain for pressurised columns/chambers should be in one integral piece in green and fired stage.

7.0 SPARE PARTS AND MANDATORY MAINTENANCE EQUIPMENT:

The bidder shall include in his proposal spare parts and maintenance equipment in accordance with Section-Project. Calibration certificates of each maintenance equipment shall be supplied alongwith the equipment.

8.0 OPERATING MECHANISM AND CONTROL

8.1 General Requirements

- 8.1.1 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
- 8.1.2 The operating mechanism shall be strong, rigid, not subject to rebound and shall be readily accessible for maintenance for a man standing on ground.
- 8.1.3 The mechanism shall be antipumping and trip free (as per IEC definition) 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 trip or closing operation of the power operating devices.
- 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 central control cabinet.
- 8.1.6 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.
- 8.1.7 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, erection, commissioning, troubleshooting, servicing And overhauling instructions.
- ### **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 pole shall be provided with two (2) independent tripping circuits, pressures switches and coils each connected to a different set of protective relays.
- 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 central control cabinet.

- 8.2.4 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.
- 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 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.
- 8.2.6 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.
- 8.2.7 The auxiliary switch of the breaker shall be positively driven by the breaker operating rod.
- 8.2.8 The preferred basic control schematic of the Circuit breaker is enclosed with the bid documents and it is expected to be followed by the bidder. This, however, does not absolve the bidder from the responsibility for safe and reliable operation of the breaker in its lifetime.

8.3 **Pneumatically operated mechanism:**

- a) Each pneumatic operated breaker shall be equipped with compressed air system in accordance with Clause 16.0.
- b) The breaker local air receivers shall comply with the requirements under Clause 16.4 and shall have sufficient capacity for atleast two CO operations of the breaker at the lowest pressure for auto reclosing duty without refilling.
- c) 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.

- d) 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.
- e) The compressed air piping shall comply to requirements under Clause 16.0.

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.

Hydraulically operated mechanism(if applicable):

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

9.0 SUPPORT STRUCTURE:

- a) The structure design shall be such that during operation of circuit breaker vibrations are reduced to minimum.
- b) If required, the Contractor shall provide suitable platform with steps on both sides of the circuit breaker for easy accessibility for monitoring the density/pressure of gas.

10.0 TERMINAL CONNECTOR PAD:

The circuit breaker terminal pads shall be made up of high quality electrolytic copper or aluminium. The terminal pad shall have protective covers which shall be removed before interconnections.

11.0 INTERPOLE CABLING:

- 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.
- 11.2 Only stranded conductor shall be used. Minimum size of the conductor shall be 2.5 sq.mm. (Copper).
- 11.3 The cables shall be with oxygen index Min-29 and temp. index as 250°C as per relevant standards.

12.0 FITTINGS AND ACCESSORIES

- 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 gauges.
 - 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.

12.2 Additional fittings for pneumatically operated circuit breaker a) Unit compressed air system in accordance with Clause 16.0. b) Breaker air receivers. c) Pressure gauge, spring loaded safety valve and pressure switch with adjustable contacts. d) 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. e) Stop, non-return and other control valves, pipings and all accessories upto breaker mechanism housing.

13.0 ADDITIONAL DATA TO BE FURNISHED ALONGWITH THE OFFER:

- 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 alongwith 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) The effect of non-simultaneity between contacts between poles and also show how it is covered in the guaranteed total break time.
- f) Sectional view of non-return couplings if 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.
- i) A complete catalogue on operation analyser satisfying all the requirements of this Chapter.
- j) The bidders shall furnish along with the bid, curves supported by test data indicating the opening time under close open operation with combined variation of trip coil voltage and pneumatic/hydraulic pressure.

- 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 of this chapter in case of 420 kV circuit breaker.
- l) All duty requirements as applicable to 420 kV & 245 kV CBs specified under Clause 2.0 of this Chapter shall be provided with the support of adequate test reports to be furnished alongwith the bid failing which the bid is likely to be rejected.
- m) Field test report or laboratory test report in case of CB meant for reactor switching duty.

14.0 TESTS:

14.1 The circuit breaker alongwith its operating mechanism shall conform to IEC:62271-100.

14.2 The test reports of the type tests and the following additional type tests shall also be submitted for Purchaser's review:

- i) Corona extinction voltage test .
- ii) Out of phase closing test as per IEC:62271-100.
- iii) Line charging breaking current for proving parameters as per clause no. 17.9 of this Chapter.
- iv) Test to demonstrate the Power Frequency withstand capability of breaker in open condition at Zero Gauge pressure (Ref. Clause 4.1.1) and at lockout pressure.
- v) Seismic withstand test in unpressurised condition.
- vi) Verification of the degree of protection.
- vii) Low & high temperature test.(if applicable)
- viii) Humidity test.(if applicable)
- ix) Static Terminal Load test.
- x) Critical Currents test (if applicable).
- xi) Switching of Shunt Reactors.

14.3 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.

- 1) 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.
- 2) 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.

14.4 Site Tests:

1 routine tests except power frequency voltage dry withstand test on main circuit breaker shall be repeated on the completely assembled breaker at site.

15.0 DEAD TANK TYPE CIRCUIT BREAKER

15.1 In case dead tank type circuit breaker is offered, the Bidder shall offer bushing type CTs (whose secondary parameters are given in either Chapter-INST) on either side of dead tank circuit breaker instead of conventional outdoor CTs.

15.2 The enclosure shall be made of either Al/Al Alloy or mild steel (suitably hot dip galvanised).

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.

15.3 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.

16.0 UNIT COMPRESSED AIR SYSTEM FOR CIRCUIT BREAKERS:

16.1 The unit compressed air system shall meet the following requirements:

- a) The compressed air system shall be provided with necessary piping, piping accessories, control valves, safety valves, filters, reducing valves, isolating valves, drain ports, etc. Also the Unit compressed air system shall be provided with suitable antivibration pads.
- b) 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.
- c) 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.
- d) 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.

16.2 Air Compressor:

- a) 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:
 - i) Total running time of Not exceeding 80 minutes compressor to build up the rated pressure from atmospheric pressure
 - ii) Normal running air Not exceeding 15 minutes charging considering 10% leakage/day.
 - iii) Air charging time Not exceeding 15 minutes. after one close-open operation from rated pressure.
- b) Compressor shall be driven by automatically controlled motors
- c) The compressor shall be provided with automatic adjustable unloading device during starting.
- d) The compressor shall be equipped with a Time totaliser and a Pressure gauge.

16.3 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.

16.4 Air Receivers:

- a) Air receiver shall be designed in accordance with the latest edition of the ASME Code for Pressure Vessel -Section VIII of BS: 5179. A corrosion allowance of 3.0 mm shall be provided for shell and dished ends.

Receivers shall be coated on the inside face with antirust medium if it is not hot dip galvanised.

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

16.5 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.

16.6 Control and Control Equipment:

- a) The compressor control shall be of automatic start/stop type initiated by pressure switches.
- b) 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.
- c) All the necessary compressor control equipment shall be housed in a totally enclosed sheet steel cabinet . Pressure gauges and other indicating devices, control switches shall be mounted on the control cabinet.
- d) A glass window shall be provided for viewing the indicating instrument/gauges. The maximum height shall be 2000 mm.

16.7 Compressed Air Piping, Valves and Fittings:

- a) The flow capacity of all valves shall be at least 20% greater than the total compressor capacity.
- b) 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.
- c) 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).
- d) All joints and connections in the piping system shall be brazed or flared as necessary.
- e) All compressed air piping shall be carried out in accordance with BS: 162.
- f) 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.

16.8 Tests:

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

17.0 TECHNICAL PARAMETERS:

A. 420 kV CIRCUIT BREAKER:

A17.1	Rated continuous current	2000 A at design ambient temperature.
A17.2	Rated short circuit	40
A17.3	Symmetrical interrupting	40 capability (kA rms)
A17.4	Rated short circuit making current (kAp)	100
A17.5	i) Short time current capability for one second (kArms)	40 carrying
	ii) Out of phase breaking current capacity (kArms)	10

A17.6	Rated operating duty	O-0.3sec-CO-3min-CO cycle
A17.7	Reclosing Single phase & three phase autoreclosing	
A17.8	First pole to clear factor	1.3
A17.9	Rated line charging interrupting current at 90 deg. leading power factor angle (A. rms)	600 A
A17.10	Temperature rise over the design ambient temperature	As per IEC: 62271-100
A17.11	i) Total break time as per IEC (ms)	45
A17.11	ii) Rated break time as per IEC (ms)	40
A17.12	Total closing time (ms)	Not more than 150
A17.13	Operating mechanism or a combination of these	Pneumatic/spring/hydraulic
A17.14	Max. difference in the instants of closing/ opening of contacts (ms)	
	i) Within a pole	2.5
	ii) Between poles(opening)	3.3
	iii) Between poles (closing)	5.0
A17.15	Trip coil and closing coil voltage	220 V DC with variation as specified
A17.16	Noise level at base and upto 50 m (distance from base of breaker)	140 dB (Max.)
sA17.17	Rated terminal load whichever is higher.	As per IEC or as per the value calculated
A17.18	Auxiliary contacts	Besides requirement of specification, the bidder shall wire up 5 NO + 5 NC contacts for future use of purchaser.
A17.19	No of Terminals in common Control cabinet	All contacts & control circuits to be wired out upto common control cabinet plus 24 terminals exclusively for Purchaser's use.

A17.20	Maximum allowable switching overvoltage under any switching condition	2.3 p.u.
A17.21	Pre-insertion resistor requirement	
	i) Rating (ohms)	400
	ii) Minimum pre-insertion time (ms)	8
	iii) Opening of PIR contacts	a) PIR Contacts should open immediately after closing of main circuits. b) Atleast 5 ms prior to opening of main contacts at rated air/gas pressure, where the PIR Contacts remain closed.

18.0 TESTING AND COMMISSIONING

18.1 An indicative list of tests is given below. 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 compressed air plant and all accessories.
- (i) Functional checking of control circuits interlocks, tripping through protective relays and auto reclose operation.
- (j) Insulation resistance of control circuits, motor etc.
- (k) Resistance of closing and tripping coils.
- (l) SF6 gas leakage check.
- (m) Dew Point Measurement
- (n) Calibration of pressure switches and gas density monitor.
Checking of mechanical 'CLOSE' interlock, wherever applicable.
- (q)