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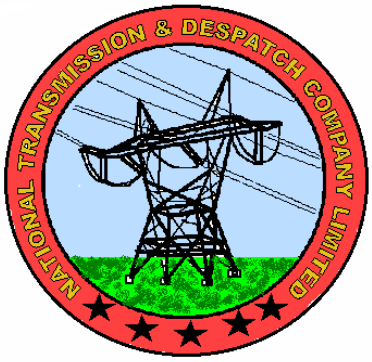

SF6 CIRCUIT BREAKERS 145kV, 72.5kV AND 36kV

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0.0 FOREWORD

0.1 This specification has been prepared by Standards & Research Directorate of the Design Department NTDC. This third edition cancels and replaces the editions published in 1983 & 1995 and its amendments.

0.2 This specification is intended for the procurement of material but does not include all the necessary provisions of the contract.

0.3 This specification is subject to revision as and when required by S&R directorate of Design NTDC only. No other department is authorized to make/issue amendment in the said specification.

1.0 SCOPE

1.1 This specification is applicable to alternating current live tank 3-pole SF6 circuit breaker alongwith steel supporting structures, grounding bolts, terminal heads and connector for 600mm^2 aluminium conductor for outdoor installations and for operation on 3-phase system having voltages of 145 kV, 72.5 kV and 36 kV.

2.0 REFERENCE STANDARDS

2.1 The circuit breakers shall generally be designed, constructed and tested in accordance with the International Electro-technical commission publication 62271-100 "High Voltage Alternating Current Circuit Breakers" amended to-date.

2.2 The definitions given in the IEC Publication 62271-100 shall apply herein.

2.3 In case the requirements laid down herein differ from those given in the IEC Publication in any particular aspect, the requirements listed herein shall prevail.

3.0 DEFINITIONS

For the purpose of this International Standard, the definitions of IEC 62271-100 shall apply. Some of them are recalled here for ease of reference.

3.1 Out-of-Phase Conditions

Abnormal circuit conditions of loss or lack of synchronism between the parts of an electrical system on either side of a circuit-breaker in which, at the instant of operation of the circuit breaker, the phase angle between rotating vectors, representing the generated voltages on either side, exceeds the normal value and may be as much as 180° (phase opposition).

3.2 **Short-Line Fault (SLF)**

Short-circuit on an overhead line at a short, but significant, distance from the terminals of the circuit-breaker.

3.3 **External Insulation**

Distance in air and the surfaces in contact with open air of solid insulation of the equipment, which are subject to dielectric stresses and to the effects of atmospheric and other external conditions such as pollution, humidity, vermin, etc.

3.4 **Internal Insulation**

Internal solid, liquid or gaseous parts of the insulation of equipment which are protected from the effects of atmospheric and other external conditions.

3.5 **Self-Restoring Insulation**

Insulation which completely recovers its insulating properties after a disruptive discharge.

3.6 **Non-Self Restoring Insulation**

Insulation which loses its insulating properties, or does not recover them completely, after a disruptive discharge.

3.7 **Disruptive Discharge**

Phenomenon associated with the failure of insulation under electric stress, in which the discharge completely bridges the insulation under test, reducing the voltage between the electrodes to zero or nearly to zero.

3.8 **Restrike Performance**

Expected probability of restrike during capacitive current interruption as demonstrated by specified type tests.

3.9 **Circuit-Breaker Class E1**

Circuit-breaker designed so as not to require maintenance of the interrupting parts of the main circuit during its expected operating life, and only minimal maintenance of its other parts.

3.10 **Circuit-Breaker Class C2**

Circuit-breaker with very low probability of restrike during capacitive current breaking as demonstrated by specific type tests.

3.11 **Circuit-Breaker Class M2**

Frequently operated circuit-breaker for special service requirements and designed so as to require only limited maintenance as demonstrated by specific type tests (circuit-breaker with extended mechanical endurance, mechanically type tested for 10 000 operations).

3.12 **Circuit-Breaker Class S2**

Circuit breaker intended to be used in a line system or in a cable system with direct connection (without cable) to overhead lines.

3.13 **Terminal Head**

Component provided for the connection of a device to external connectors.

3.14 **Connector**

Component provided for the connection of terminal head to the external conductor.

3.15 **Making (or Breaking) Unit**

Part of a circuit-breaker which in itself acts as a circuit-breaker and which, in series with one or more identical and simultaneously operated making or breaking units, forms the complete circuit-breaker.

3.16 **MODULE**

Assembly which generally comprises making or breaking units, post-insulators and mechanical parts and which is mechanically and electrically connected to other identical assemblies to form a pole of a circuit breaker.

3.17 **Stored Energy Operation**

Operation by means of energy stored in the mechanism itself prior to the switching operation and sufficient to complete the specified operating sequence under predetermined conditions.

3.18 **Making-Current Release**

Release which permits a circuit-breaker to open, without any intentional time delay, during a closing operation, if the making current exceeds a predetermined value, and which is rendered inoperative when the circuit-breaker is in the closed position.

3.19 **Prospective Peak Current**

Peak value of the first major loop of the prospective current during the transient period following initiation.

3.20 **Peak Current**

Peak value of the first major loop of current during the transient period following initiation.

3.21 **(Peak) Making Current**

Peak value of the first major loop of the current in a pole of a circuit-breaker during the transient period following the initiation of current during a making operation.

3.22 **Critical (Breaking) Current**

Value of breaking current, less than rated short-circuit breaking current, at which the arcing time is a maximum and is significantly longer than at the rated short-circuit breaking current. It will be assumed that this is the case if the minimum arcing times in any of the test-duties T10, T30 or T60 is one half-cycle or more longer than the minimum arcing times in the adjacent test-duties.

3.23 **No-Load Line-Charging Breaking Capacity**

Breaking capacity for which the specified conditions of use and behaviour include the opening of an overhead line operating at no-load.

3.24 **No-Load Cable-Charging Breaking Capacity**

Breaking capacity for which the specified conditions of use and behaviour include the opening of an insulated cable operating at no-load.

3.25 **Capacitor Bank Breaking Capacity**

Breaking capacity for which the specified conditions of use and behaviour include the opening of a capacitor bank.

3.26 **Capacitor Bank Inrush Making Capacity**

Making capacity for which the specified conditions of use and behaviour include the closing onto a capacitor bank.

3.27 **Out-of-Phase (making or breaking) Capacity**

Making or breaking capacity for which the specified conditions of use and behaviour include the loss or the lack of synchronism between the parts of an electrical system on either side of the circuit-breaker.

3.28 **Opening Time**

a) For a circuit-breaker tripped by any form of auxiliary power, the opening time is the interval of time between the instant of energizing the opening release, the circuit-breaker being in the closed position, and the instant when the arcing contacts have separated in all poles;

b) For a self-tripping circuit-breaker, the opening time is the interval of time between the instant at which, the circuit-breaker being in the closed position, the current in the main circuit reaches the operating value of the over-current release and the instant when the arcing contacts have separated in all poles.

3.29 **Arcing Time (of a multi pole switching device)**

Interval of time between the instant of the first initiation of an arc and the instant of final arc extinction in all poles.

3.30 **Break Time**

Interval of time between the beginning of the opening time of a mechanical switching device and the end of the arcing time.

3.31 **Closing Time**

Interval of time between energizing the closing circuit, the circuit-breaker being in the open position, and the instant when the contacts touch in all poles.

3.32 **Make Time**

Interval of time between energizing the closing circuit, the circuit-breaker being in the open position, and the instant when the current begins to flow in the first pole.

3.33 **Pre-Arcing Time**

Interval of time between the initiation of current flow in the first pole during a closing operation and the instant when the contacts touch in all poles for three-phase conditions and the instant when the contacts touch in the arcing pole for single-phase conditions.

3.34 **Open-Close Time (during auto-reclosing)**

Interval of time between the instant when the arcing contacts have separated in all poles and the instant when the contacts touch in the first pole during a reclosing cycle.

3.35 **Dead Time (during auto-reclosing)**

Interval of time between final arc extinction in all poles in the opening operation and the first re-establishment of current in any pole in the subsequent closing operation.

3.36 **Re-closing Time**

Interval of time between the beginning of the opening time and the instant when the contacts touch in all poles during a reclosing cycle.

3.37 **Re-Make Time (during reclosing)**

Interval of time between the beginning of the opening time and the first re-establishment of current in any pole in the subsequent closing operation.

3.38 **Close-Open Time**

Interval of time between the instant when the contacts touch in the first pole during a closing operation and the instant when the arcing contacts have separated in all poles during the subsequent opening operation.

3.39 **Make-Break Time**

Interval of time between the initiation of current flow in the first pole during a closing operation and the end of the arcing time during the subsequent opening operation.

3.40 **Pre-Insertion Time**

Interval of time during a closing operation in any one pole between the instant of contact touch in the closing resistor element and the instant of contact touch in the main breaking unit of that pole.

3.41 **Minimum Trip Duration**

Minimum time the auxiliary power is applied to the opening release to ensure complete opening of the circuit-breaker.

3.42 **Minimum Close Duration**

Minimum time the auxiliary power is applied to the closing device to ensure complete closing of the circuit-breaker.

3.43 **Normal Current**

Current which the main circuit of a circuit-breaker is capable of carrying continuously under specified conditions of use and behaviour.

3.44 **Peak Factor (of the line transient voltage)**

Ratio between the maximum excursion and the initial value of the line transient voltage to earth of a phase of an overhead line after the breaking of a short-line fault current.

3.45 **First-Pole-to-Clear Factor (in a three-phase system)**

When interrupting any symmetrical three-phase current the first-pole-to-clear factor is the ratio of the power frequency voltage across the interrupting pole before current interruption in the other poles, to the power frequency voltage occurring across the pole or the poles after interruption in all three poles.

3.46 **Amplitude Factor**

Ratio between the maximum excursion of the transient recovery voltage to the crest value of the power frequency recovery voltage.

3.47 **Minimum Functional Pressure for Operation**

Pressure, referred to the standard atmospheric air conditions of +20 °C and 101.3 kPa, which may be expressed in relative or absolute terms, at which and above which rated characteristics of a circuit-breaker are maintained and at which a replenishment of the operating device becomes necessary. This pressure is often designated as interlocking pressure.

3.48 **Minimum Clearing Time**

Sum of the minimum operating time, minimum relay time (0.5 cycle) and the minimum arcing time at current interruption after the minor loop of the first pole to clear, during test duty T-100a, as declared by the manufacturer.

4.0 SERVICE CONDITIONS

The circuit breakers and all accessories shall be suitable for satisfactory operation under the following service conditions:-

4.1 Climatic Conditions

4.1.1 Ambient Temperature

Maximum	50°C.
Maximum mean over any 24 hours	45 °C.
Mean in any year	30 °C
Minimum	-10 °C

4.1.2 Relative Humidity

The relative humidity may range from 0 to 100 percent. The maximum value of the ambient temperature and humidity, however, do not occur simultaneously. During the monsoons, high humidity may persist for many days at a time along with temperatures ranging from 30°C to 40°C.

4.2 Altitude

The circuit breakers shall be suitable for installation upto 1000 m above sea level.

4.3 Atmospheric Conditions

It may be assumed that the air is not normally heavily polluted by dust, smoke, aggressive gases, vapours or salt spray. However, at certain times of the year severe dust storms may be experienced.

4.4 Wind Load

The maximum wind load shall be taken as 122 kg/sq. m. (corresponding to wind speed of 44.2 m/s).

4.5 Supply System

The circuit breakers shall be suitable for installation in 132 kV, 66 kV and 33 kV 3-phase A.C. supply system of the following characteristics:

Rated Voltage	145 kV	72.5 kV	36 kV
Nominal Voltage	132 kV	66 kV	33 kV
Frequency	50 Hz	50 Hz	50 Hz

4.6 **Control and Auxiliary Voltage.**

The nominal control and auxiliary supply voltages shall have the following values:

D.C. Voltage	110 V or 220 V as applicable
A.C. Voltage	240 V single phase and 415 V three-phase, 50 Hz

5.0 **RATINGS AND CHARACTERISTICS**

5.1 The circuit breakers and their accessories shall be so designed as to comply with the following ratings, characteristics and to meet all test requirements laid down herein with respect to insulation strength, current carrying capacity, making and breaking currents and mechanical & electrical operations etc.

	Description			
i.	Nominal Voltage (kV)	132	66	33
ii.	Rated Voltage, U_r (kV)	145	72.5	36
iii.	Class w.r.t. Mechanical Operation	M2	M2	M2
iv.	Class w.r.t. Electrical Endurance	E1	E1	E2
v.	Class w.r.t. Capacitive Current Breaking	C2	C2	C2
vi.	Class w.r.t. Connection to overhead line	S2	S2	S2
vii.	Rated insulation level:			
	a. Lightning impulse Withstand voltage (kV)			
	i) Phase to Phase	650	325	170
	ii) Phase to Earth	650	325	170
	b. One minute power frequency withstand voltage (kV)			
	i) Phase to Phase	275	140	70
	ii) Phase to Earth	275	140	70
viii.	Rated frequency (Hz)	50	50	50
ix.	Rated normal current at 50°C Ambient Temperature (A)	2000	1250	630
x.	Rated short circuit breaking current (kA)	40	25	25
xi.	Rated short circuit making current (kA)	100	63	63
xii.	Rated duration of short-circuit (Sec.)	3	3	3
xiii.	First pole to clear factor	1.5	1.5	1.5
xiv.	Initial transient recovery voltage (kV)	As Per IEC 62271-100		

xv.	Rated transient recovery voltage (TRV) for Terminal faults. (kV)	As Per IEC 62271-100		
xvi.	Rated TRV of the supply circuit for short-line faults(kV)	As Per IEC 62271-100		
xvii.	Rated TRV for out of phase breaking (kV)	As Per IEC 62271-100		
xviii.	Single Capacitor Bank breaking current (A)	As Per IEC 62271-100		
xix.	Rated back to back capacitor bank breaking Current (A)	As Per IEC 62271-100		
xx.	Rated line charging breaking current (A)	As Per IEC 62271-100		
xxi.	Rated out of phase breaking current (kA)	As Per IEC 62271-100		
xxii.	Rated cable charging breaking current (A)	As Per IEC 62271-100		
xxiii.	Rated operating sequence	0-0.3 Sec-CO-3min-CO		
xxiv.	Rated capacitor bank inrush making current (kA)	As Per IEC 62271-100		
xxv.	Rated Short time withstand current (kA)	40	25	25
xxvi.	Rated peak withstand current (kA)	100	63	63
xxvii.	Rated D.C. voltage (V)	110	110	110
xxviii.	Rated D.C. time constant (ms)	45	45	45
xxvix.	Total max. break time for 0 to 100 percent of the rated breaking current (ms)	60	100	100
xxx.	Rated dead time (ms Max.)	300	300	300
xxxi.	Rated opening time (ms Max..)	30	30	30
xxxii.	Max. Radio Interference Level $1.1U_r/\sqrt{3}$ (RIV) (µV)	≤2500	-	-
xxxiii	No. of Mechanical switching operations		10000	
xxxiv.	No. of switching operations at:			
	i) 100% short circuit breaking current		20	
	ii) 60% short circuit breaking current		50	
	iii) 30% short circuit breaking current		200	
	iv) 10% short circuit breaking current		4000	
	v) Max. continuous current carrying capacity		6000	

6.0 GENERAL PERFORMANCE REQUIREMENTS

6.1 The circuit breakers shall be single pressure sulphur hexafluoride (SF6) three pole outdoor type with self contained power operated spring charged operating mechanism. The performance requirements include high breaking capacity, low switching over-voltages, re-strike free capacitive switching, high operational reliability and low maintenance and suitable to withstand the seismic stress/magnitude according to Richer-scale $\geq$ 7 (horizontal acceleration up to 5m/s² (0.5g) for safety of equipment under heavy earth quake conditions.

6.2 The circuit breakers shall suitable for automatic tripping and automatic reclosing and complete with safety interlocks and all necessary accessories to make a complete operating unit. The circuit breakers shall be suitable for single shot, 3-pole rapid auto re-closing. For three pole operation, the poles of the breaker shall be electrically as well as mechanically coupled. The quality of SF6 gas shall conform to relevant IEC standard.

6.3 The circuit breakers shall be capable of breaking any current from zero to its rated breaking current at any voltage upto the rated voltage in a predominantly resistive, inductive and capacitive circuit. The total break time at all currents less than the rated current shall not exceed the maximum breaking time. No restrikes at the main contacts shall be permitted under any operating duty.

6.4 The circuit breakers shall be capable of switching covered by transients over or under voltage and/or over-currents in the system i.e. switching the no load currents of power transformer, switching of shunt capacitor banks and the charging current of overhead lines/ cables up to values indicated in IEC 62271-100. The switching unit enables synchronisation of the switching in both closing & opening conditions. The switching over voltage to earth, measured at the breaker terminals, shall not exceed 2.5 times the maximum rated voltage to earth. No re-strikes at the main contacts shall be permitted under these conditions.

6.5 The circuit breakers shall be capable of breaking the rated out of phase interruption of current upto 25% of the rated short circuit breaking current and rated out of phase making current shall be the crest value of the rated out of phase breaking current. The power frequency recovery voltage shall be $2\sqrt{3}$ times the rated voltage for effectively earth neutral system. The control scheme of pole discrepancy is a part of circuit breaker.

6.6 The maximum noise level of the breaker when operated to close or open the three poles simultaneously shall be less than 140 dB at 1 m horizontal distance at the perimeter of circuit breaker with cabinet closed.

6.7 The circuit breaker shall be designed and constructed to operate mechanically without replacement of parts due to breakage or excessive wear or adjustments for 10000 operations each consisting of a complete opening and closing of the circuit breaker.

6.8 The power carrying circuits shall be capable of carrying its rated current at rated frequency continuously without excessive maintenance. The terminals and the connections between parts shall be designed to ensure permanently low resistance contacts.

i. The temperature-rise if carried out at 40^{o}C ambient temperature of contacts, connections, terminals and all other material used as an insulation and metal parts of the circuit breaker shall be in accordance with the values given in Table-3 of **IEC 62271-1** with a reduction of 10^{o}C(K). For carrying the temperature-rise at other ambient conditions, the normal current may be increased by multiplying the necessary correction factor as per temperature versus current curve of the circuit breaker to ascertain whether the offered current rating comply with the requirements of said specification or not when actually work at 40^{o}C ambient condition.

ii. The quality of contacts shall be such that a continuous layer of coating material remains in the contact area after making & breaking test, short time withstand test and mechanical endurance test, otherwise the contacts may be considered " bare" for consideration in temperature-rise test.

iii. The maximum temperature of the auxiliary circuits and devices, when the circuit breaker is carrying rated currents and voltages and when tested in accordance with the relevant clauses of IEC 62271-1 shall not exceed the values given in Table-3 of IEC 62271-1 with the exception that the reference ambient temperature shall be taken as 50 deg. C.

7.0 GENERAL CONSTRUCTIONAL REQUIREMENTS

7.1 The design shall be such that installation, replacement and general maintenance may be undertaken with a minimum of time and all parts are easily assemble and protected from rusting or corrosion.

7.2 The pole column shall rest on a common circuit breaker base. The pole columns shall be filled with SF6 for arc quenching and insulating purposes. The arc interrupting mechanism shall be designed with ample mechanical and electrical factors of safety in all of its parts.

7.3 It shall be possible to make independent adjustment to each pole of the circuit breaker. In the event of any phase failing to complete a closing operation, provisions shall be made for automatic tripping of the circuit breaker.

7.4 Circuit breakers shall be so constructed that the interval between the instants when the contacts of the individual poles touch or separate shall not exceed 10 ms during a closing or opening operation.

7.5 To facilitate transport, lifting lugs, jacking pads or other handling devices, capable of supporting each unit when fully erected and ready for service, shall be provided.

7.6 Each circuit breaker shall be equipped with two earthing terminals capable of accommodating bare stranded copper earthing conductors of 95 sq.mm cross-section. The earthing terminals shall be capable of carrying the rated short time current of the breaker and shall be distinctly marked.

7.7 Provision shall be made in the design of breakers to ensure that the proper operation of circuit breakers and accessories is not impaired by vermin, insects, small animals and birds etc.

7.8 All exposed surfaces of frames, tanks, operating mechanism etc., which would normally be painted when in service, shall be given one rust-protective coat of paint and at least one coat of a synthetic resin having excellent weather resistant properties. The total paint thickness shall not be less then 0.08mm (80 microns). All exposed parts of circuit breakers shall be weather-proof.

7.9 No leakage for gas shall occur under specified conditions of operation and there shall be no entrance of moisture or other gases. The maximum annual leakage of SF6 gas shall be 0.5% of the total volume of SF6 in a pole of circuit breaker. The quantity of SF6 gas shall comply with the acceptance level of relevant IEC standard.

7.10 All moving parts shall be suitably covered and expulsion vents shall be oriented to prevent any hazards to personnel or adjacent equipment.

7.11 No current transformers shall be built into the circuit breakers.

7.12 **External Insulation / Insulators**

7.12.1 External insulation shall be provided by means of glazed, non-hygroscopic porcelain insulators and shall conform to relevant IEC Standard. All porcelain insulators shall be wet process, homogeneous and free from cavities and other defects.

7.12.2 Circuit breaker porcelain unit & support column, shall be designed to withstand internal pressure of three times the maximum operating pressure and shall have the same Insulation Level as the breaker. These shall be airtight under pressure and shall have adequate mechanical strength to withstand the wind loads, seismic stress, static and dynamic forces from conductor.

7.12.3 Circuit breaker porcelain insulators shall have following minimum creepage distance from live to earthed parts for operation under the prevailing atmospheric conditions:

Circuit Breaker Rated Voltage (kV)	Minimum Creepage Distance (mm)
145	3900
72.5	1960
36	970

7.12.4 The colour of insulators shall be chocolate brown and tested in accordance with IEC-60273. Manufacturer's type & routine Test reports shall be submitted at the time of pre-delivery inspection.

8.0 LOCAL & REMOTE CONTROLS AND INDICATIONS

8.1 Circuit breakers shall be suitable for operation by electrical means either from the local operating cubicle or remotely from the control room. The operation selector switch (Remote-Neutral-Local) shall be a key operated switch provided in each operating cubicle for operation of the circuit breaker. Provision shall also be made to lock the cubical doors with padlocks.

8.2 A multiple, hand operated lockable change-over switch labelled 'Remote' and 'Local' shall be provided in each operating cubicle for establishing the point of control.

8.3 A reliable, easily readable, mechanically operated indicator shall be provided on each circuit breaker to show the position of the circuit breaker. The marking of indicator plates shall be "ON" and "OFF".

9.0 ELECTRICAL CONTROL FEATURES

9.1 Functional Requirements

The circuit breaker control scheme shall comply with the following essential control requirements.

9.1.1 The circuit breaker shall be mechanically and electrically trip-free.

9.1.2 The circuit breaker mechanism shall make one complete closing operation including automatic cut off of the closing power after an initiating control device has operated and the first device in the control scheme has responded, even though the contacts of the initiating control device are opened before the circuit breaker closing operation is completed.

9.1.3 The circuit breaker shall incorporate anti-pumping feature. Anti pumping relay shall be integral part of the circuit breaker to ensure that the circuit breaker shall

not repeatedly opened & closed in the event of simultaneous ON & OFF commands and also to avoid continuously energizing of circuit breaker closing coil, once the circuit breaker has already closed. Only one closing operation of the circuit breaker mechanism shall result from each closing operation of a manually operated initiating control device, even though the circuit breaker trips while the initiating control device is being held in the closed position. The control scheme needs not provide against re-closure in the event that control power is removed by casual and entirely random occurrences, such as the opening of a control circuit to check for grounds, while the initiating control device remains closed.

9.1.4 When power is removed from the closing control circuit after or during an incomplete closing operation, all electrically operated devices in the control circuit shall reset to the normal circuit breaker open position, except for those devices which require a supply of control power in order to assume their normal circuit breaker open position.

9.1.5 When the circuit breaker is in the closed position, a closing operation of an initiating control device shall not result in an operation of the circuit breaker closing mechanism.

9.1.6 When a closing operation of a circuit breaker cannot be completed successfully because of the absence of an adequate supply of stored energy, all actuating devices in the control circuit shall remain in the normal circuit breaker open position when the initiating control device is operated.

9.1.7 Electrical tripping facilities for the operating mechanism of each pole of circuit breaker shall be duplicated. These shall include atleast the following:-

i. Two electrically independent and identical trip coils for each pole of the circuit breaker shall be provided and so arranged that failure of one trip coil shall not affect the operation of second trip coil. Both the coils shall be physically separated and magnetically complied. In the event of three pole operation, control system shall include circuitry to trip the circuit breaker by energizing both sets of trip coils if pole – disagreement occurs.

ii. Two electrically independent and identical sets of wiring, terminals and protecting equipment shall be provided for connection to independent control of closing and tripping circuits.

9.1.8 Low and high SF6 gas pressure interlocking devices shall be fitted. Temperature compensated SF6 Gas density monitor shall be provided with two level alarms. First stage alarm shall be actuated when SF6 gas pressure drops below the normal operating pressure as specified by the manufacturer and second stage alarm shall cause opening/closing lockout in the event of gas pressure falling below the minimum value prescribed for the successful interruption of the current. It shall also give annunciation on control panel.

9.1.9 Provision shall be made by placing all the shut valves in the control mechanism to measure the SF6 gas pressure of each pole by closing the valves of other two poles in the operating mechanism.

9.1.10 Interlocking features both electrical & mechanical and related equipment alongwith their signalling and annunciation as required for reasons of safety and convenience of operation shall be provided. Electrical interlocking shall also be provided in the control & protection circuits of individual pole and the complete circuit breaker. Interlocking design shall also prevent closing operation when the circuit breaker is already in closed position and closing operation during an opening operation.

9.2 **Auxiliary Circuits**

The auxiliaries provided as part of each circuit breaker assembly, shall be as described herein.

9.2.1 Extra auxiliary switches, four normally open and four normally closed, in addition to those normally provided as part of the circuit breaker operation and indication functions, shall be provided.

9.2.3 All auxiliary equipment including wiring shall be adequately protected against rain and humidity. A thermostatically controlled anti condensation heaters/heating resistors shall be provided in each control cubical and shall be protected through a two-pole miniature circuit breaker to protect sensitive components from condensed water during rapid temperature changes.

9.2.4 When individual compressor motors are used, a two-pole miniature circuit breaker shall be connected in the supply to the compressor motor.

9.2.5 The auxiliary switch and circuits shall be able to carry 10A current continuously and rated short time withstand current of 100A for 50m sec.

10.0 **OPERATING MECHANISM**

The operating mechanism unit contains all components required for operation, monitoring and control of circuit breaker. The operating mechanism shall be motor operated spring charged and meet the following requirements.

10.1 The mechanism shall be designed such that the failure of spring will not prevent tripping and will not cause tripping or closing.

10.2 The circuit breaker operating mechanism and all accessories shall operate satisfactorily at 50^{o}C ambient temperature within the following range of voltages:

Rated Voltage	**Control Voltage**	**Operating Mechanism Voltage**	**Tripping Voltage**
110 V DC	90 – 130	90 – 130	77 - 130
220 V DC	180 – 260	180 – 260	154 – 260
240 V AC		200 – 260	
415 V AC		345 – 450	

10.3 The closing mechanism shall not prevent or delay the opening of the circuit breaker beyond the standard interrupting time and the energy shall be removed automatically from the closing mechanism when the closing operation is completed.

10.4 A conveniently located purely mechanical manual tripping device shall be provided. Latches shall be so designed as not to require delicate or frequent adjustments.

10.5 The mechanism shall be designed and constructed to operate mechanically without replacement of parts due to breakage or excessive wear or adjustments for 10000 operations each consisting of a complete opening and closing of the circuit breaker. The mechanically operation counter without resetting facility provided inside the cubicle shall be visible and readable from outside and shall count one full count on the closing cycle of circuit breaker.

10.6 The closing mechanism shall be recharged automatically for further operation as soon as the circuit breaker has completed a closing operation. If the closing mechanism is not fully recharged within a pre-determined time, the mechanism shall be locked out and an alarm initiated.

10.7 Each part of the mechanism shall be of substantial construction, utilizing such materials as stainless steel, brass or gunmetal, where necessary, to prevent sticking due to rust or corrosion. The overall design shall be such as to reduce mechanical shock to a minimum and shall prevent inadvertent operation due to fault current stresses, vibrations or other causes. A convenient means for applying lubricant shall be provided where required.

10.8 All permanently fixed bolts, nuts and studs shall be securely locked in place to prevent loosening during operation. Blind tapped holes shall be avoided where practicable.

10.9 The auxiliary switch shall be mechanically coupled with circuit breaker mechanical operating arrangement.

10.10 The energy required for switching the circuit breaker shall be stored in closing spring common to all tree poles and opening spring. In closed position of the circuit breaker, the energy stored in motor compressed spring shall be sufficient for an Open-Close-Open operation at rated short circuit current.

10.11 The charging motor shall be 110V DC motor. No diode/bridge circuit is allowed for converting AC to DC. The motor shall not require more than 15 seconds to re-charge the closing springs after a close-open operation. If the closing mechanism is not fully recharged, the mechanism shall be locked out and an alarm initiated.

10.12 Means shall be provided to prevent operation of the mechanism when maintenance work is being done.

10.13 The mechanism shall be so designed that emergency manual spring charging shall be made by using hand crank and release of the springs is possible without electrical operation.

10.14 Operating mechanism shall be provided with the indictor to show the charged/discharged state of spring.

11.0 OUTDOOR CONTROL CUBICLE

11.1 Circuit breaker operating mechanism, auxiliary switches and associated relays, control switches, control cable terminations and other ancillary equipment shall be accommodated in vermin-proof, dust-proof and weather proof cubicles. The cubicles shall be preferably free standing with front and rear access. The degree of protection shall be IP55 in accordance with IEC-62271-1.

11.2 Cubicles shall be made of galvanized steel sheet of 2.0 mm minimum thickness or corrosion free painted aluminium alloy sheet of 3.0 mm minimum thickness and shall be of rigid construction and shall include any supporting steel work necessary for mounting on the circuit breaker or on concrete foundations. Access to all compartments shall be provided by either removable panels or doors with lift off hinges. Bolts or carriage keys shall not be used to secure the panels or doors. All fastenings shall be integral with the panel or door and provision shall be made for pad locking.

11.3 Cubicles shall be well ventilated through vermin-proof louvers comprising a brass/aluminium gauze screen attached to a frame and secured to the inside of the cubicle. Divisions between compartments within the cubicle shall be perforated to assist air circulation.

11.4 Arrangement of equipment within the cubicle shall be such that access for maintenance or removal of any item shall be possible with the minimum disturbance. Suitable door gaskets made of neoprene rubber shall be provided to prevent ingress of moisture etc.

11.5 Circuit breaker cubicles shall be provided with a 240 V, 5A single phase three pin socket outlet protected by MCB shall be mounted within the cubicle. Means for interior lighting shall be provided within each cubicle assembly. Lamps shall be 240 V.A.C. and shall be automatically switched on when the door is opened.

11.6 An approved schematic diagram, of installations, identifying the various components within the cubicle and on the circuit breaker instructions shall be affixed to the inside of the cubicle access door. The diagram shall be marked on durable non-fading material suitable for the specified climatic conditions.

11.7 All incoming auxiliary supply cables shall be terminated directly into switch fuse isolators without intermediate terminals and provision shall be made for looping these supplies into similar cubicles in the switchyard. The entrance of cables in the cubicles shall be accomplished having brass glands with neoprene gaskets.

11.8 In case, the cubicles are mounted separately on concrete foundations, the same shall be equipped with one earthing terminal for earth conductor of 95 sq. mm.

11.9 **Wiring**

11.9.1 The wiring shall be such that individual components of the applicable control circuits of closing power devices, closing control devices and tripping devices shall be electrically grouped and terminated in physically separate groups.

11.9.2 The terminals of the control circuit components as stated above and the heater circuits and the individual compressor or spring charge motor circuits shall be readily accessible, closely grouped, and conveniently arranged for making connections between control circuits grouped and for external wiring.

11.9.3 Wiring between devices and terminal blocks shall be carried in troughs or in neatly formed packs which shall be tied or otherwise secured at appropriate intervals to prevent undue stress on equipment or connections. Connections across portions which are hinged or otherwise movable shall be made with flexible wire, formed to distribute the bending motion. No connections shall be made with wire smaller than 2.5mm^2. The cable used in wiring shall conform to relevant IEC standard.

11.9.4 Both ends of each wire shall be identified by a closed ring type ferrule of plastic label having weather resistant properties securely attached to the wire with no possibility of detachment under normal handling. The ferrules for closing circuits shall be of a colour preferably green and marked "close". The ferrules on all wiring directly connected to circuit breaker trip coils, tripping switches etc. shall be of a colour, preferably red, different from that of the remainder and marked "Trip".

Alternatively both ends of each wire shall be identified by machine lettered permanent fiber printed at least 50mm from the end of wire. Ground wire has no number and identified by cable colour. Following colour identification shall be applied:

3 PHASE AC	**1 PHASE AC**	**DC**	**COLOUR**
Phase 1	Phase	Positive	Red
Phase 2	-	-	Yellow
Phase 3	-	-	Blue
Neutral	Neutral	Negative	Black
Ground	-	-	Green

11.9.5 No. wires shall be tied or jointed between terminal points. Electrical wiring and instruments shall be so located that leakage of oil or water cannot affect them. Bus wiring between control panels etc. shall be fully insulated and completely segregated from the main panel wiring. Stacking of more than two wires on a terminal will not be permitted.

11.9.6 All metallic cases of instruments, control switches, relays etc. mounted on control panels or in cubicles, shall be provided with an accessible copper tail to facilitate connection by means of bare copper conductors of not less than 2.5mm^2 section to the nearest earth bar.

11.9.7 All the auxiliary relays, gauges and terminals blocks shall conform to relevant IEC/International standards and shall be so located as to permit easy access and ample room for repair/replacement of the components and every component shall have its location No. properly labelled as per schematic diagram.

11.10 **Terminal Blocks.**

11.10.1 Terminal blocks shall be mounted at an easily accessible position and shall be equipped with barriers, terminal strips and colour coded strips. The AC, DC, and current and potential transformer circuits shall be physically segregated in groups. The AC 415/240 volt circuit terminals will be fitted with non inflammable transparent plastic covers to prevent accidental contact with live parts.

11.10.2 Each incoming and outgoing cable shall be connected to an individual terminal. Each terminal block shall have an individual marking strip which shall be machine lettered or engraved with the circuit designations of the terminals which shall also be shown on the wiring diagram. One spare marking strip shall be provided for each terminal block. Approximately 10 percent extra terminals shall be provided on each block for terminating spare conductors and for future changes. In case of hinged panels matching terminal blocks shall be provided on both sides of the hinged section.

12.0 ELECTROMAGNETIC COMPATIBILITY (EMC)

The control & auxiliary circuit including components used in control cubical mounted on or adjacent to circuit breaker shall be able to withstand electromagnetic disturbances without damage and malfunctioning both under normal operation, switching conditions and interruption under fault conditions.

13.0 CIRCUIT BREAKER SUPPORTING STRUCTURE

13.1 Each circuit breaker shall be supplied alongwith two leg steel supporting structures by the circuit breaker manufacturer, its foundations/grouting bolts etc. on which the type tests of circuit breaker were performed. Supply of steel supporting structure from other sources/local representative will not be accepted.

All structural material shall be hot dip galvanized. Drawings and data such as dynamic forces, static forces, impact loading and terminal load of circuit breaker shall be provided. The foundation drawings shall be designed using the soil bearing capacity of 1 kg/cm² and suitable to withstand the seismic stress/magnitude according to Richer-scale ≥ 7 (horizontal acceleration up to 5m/s² (0.5g) for safety of equipment under heavy earth quake conditions unless otherwise specified in the tender. Design calculations and guidelines shall also be supplied.

13.2 The dimensions indicated in drawing No.PDW/TS-3217 are minimum values and for guidance only. The manufacturer shall submit their own drawings without affecting the interchangeability requirement of the foundation bolts as indicated in detail B of the drawing. The circuit breaker manufacturer may design the steel supporting structure according to their requirements and fulfilling the wind load, wind speed and other forces involved at the time of opening/closing of the circuit breaker under fault condition. The change in dimensions of foundation arrangement is not allowed.

13.3 The steels shall conform to the requirements as to tensile properties prescribed below:

	Mild Steel	High Tensile Steel
Tensile strength kg/mm^2		
Minimum	40	50
Maximum	56	80
Yield points kg/mm^2		
Minimum	26	35
Elongation in 200mm guage Length percent, minimum		
Upto 8mm Thickness	16	15
Over 8mm Thickness	20	18

13.4 All bolts and nuts shall be hexagonal type made from mild steel. The bolts shall be provided with one flat washer under each nut.

13.5 All grouting bolts for fixing the structures to the foundation shall be from High Tensile Steel. Washers shall not be less than 5 mm thickness and only one thickness of washer shall be used. The diameter of the washer and bolt holes shall be 1.5mm larger than the bolt diameter and the outside diameter of washer shall not be less than 1.5mm larger than the diagonal of the nut.

13.6 All connection bolts nuts, lock nuts and washers shall be furnished in excess of actual number required in quantity at least 5% greater than actual requirements sufficient to compensate for normal field losses.

13.7 All main legs/ structural material shall be coupled with foundation arrangement & top plate with nuts & bolts only. No connection with welding at the base and top is allowed.

13.8 All members with its identification marks shall be coupled with main structural members/legs through nuts & bolts only. Welding of members with legs is not allowed.

13.9 Prior to galvanizing, material shall be drilled, punched, cut or otherwise fabricated as required, free from burrs, cleaned so that zinc coating shall be adherent, dense, smooth, continuous and uniform. It shall also be completely free from lumps, blisters, uncoated or porous spots, black spots, dross, flux or any other imperfection.

13.10 The weight of zinc coating and thickness of zinc coating on angles shall not be less than 600gm/mm^2 and 0.010 mm respectively.

13.11 The weight of zinc coating and thickness of zinc coating on nuts & bolts shall not be less than 380gm/mm^2 and 0.035 mm respectively. The brinell hardness of bolts & nuts shall be between 120 to 200 HB. The ultimate strength and other properties of the nuts & bolts not listed above shall conform to relevant International standard viz British/ASTM/IEC etc.

13.12 Acceptance Tests:

The following acceptance tests shall be carried out on one complete structure out of lot offered for inspection.

For Section and Plates

1. Visual examination
2. Verification of dimensions and weights
3. Assembly tests
4. Tensile tests
5. Bend Tests
6. Impact tests
7. Galvanizing tests
   - Weight of zinc coating
   - Uniformity of zinc coating
   - Adherence of zinc coating
   - Embitterment test

For Nuts and Bolts

1. Verification of dimensions
2. Visual inspection
3. Proof load test
4. Ultimate tensile strength test
5. Hardness test

6. Galvanizing tests
   - Weight of zinc coating
   - Uniformity of zinc coating
   - Adherence of zinc coating
   - Embitterment test

Test reports shall be furnished by the manufacturer as per relevant international standard and conforming to above requirements.

14.0 TERMINAL HEAD AND TERMINAL CONNECTOR

14.1 Provision for four Nos., suitable size, two way terminal head shall be provided so that the breaker can be connected in any configuration to other allied equipment viz: disconnectors, current transformers etc.

14.2 Mono-metallic or Bimetallic terminal connector as per requirement of terminal head alongwith stainless steel nuts and bolts suitable for connection between terminal heads and 600mm^2 Aluminium conductor shall be provided with each pole of the circuit breaker. The connectors shall be bolted type having nuts & washers. The connectors with single bolt technology are not acceptable.

14.3 The material and composition of the Aluminium alloy used on monometallic connectors and the Aluminium portion of the bimetallic connectors shall be properly heat treated. Keepers and components which are subjected to high forces during services, will be obtained by gravity die casting with following characteristics:

Ultimate tensile strength, min	=	24 kg/ mm^2
Yield strength, 0.2% off set, min	=	15.5 kg/mm^2
Elongation, min	=	3% on 50 mm scale
Electrical conductivity, min	=	38% IACS
Brinell hardness, min	=	100 HB

14.4 The copper alloy shall be from the Copper/Nickel base family of alloys with a minimum of 96.4% of copper in order to guarantee high conductivity properties as well as high strengths characteristics. Copper alloy shall be heat treated. Bronze or Brass alloys are not acceptable.

The copper alloy shall have the following characteristics:

Ultimate tensile strength Rm, min	= 20 kg/ mm^2, (196.2) N/mm^2, (196.2) MPa
Yield strength Re 0.2% ,min	= 10 kg/mm^2, (98.1) N/mm^2, (98.1) MPa
Elongation (min)	= 18% on 50 mm scale
Electrical conductivity at 20^{0}C	= 32% IACS (min)

14.5 The bolts, nuts and washers shall be of stainless steel having following properties:

Breaking strength, min	=	65 kg/ mm^2
Yield strength, min	=	40 kg/mm^2
Brinell hardness, min	=	140 HB

14.6 **Type Tests**

The type test reports for the following tests from on connector bodies, keepers shall be furnished by the connector manufacturer as per relevant international standard and conforming to above requirements.

a. Material composition test
b. Tensile strength test
c. Elongation test
d. Brinell hardness test
e. Heat cycle test
f. Conductivity test
g. Radio interference voltage and corona tests
h. Short circuit test

15.0 **NAME PLATE DATA**

15.1 A stainless steel name plate shall be placed on the operating mechanism cubicle and shall include at least the following with engraved text in accordance with valid IEC 62271-100 which shall be visible in position of nominal service and installation.

a. Contract No./P.O. & date
b. Manufacturer's name.
c. Manufacturer's type designation and serial number.
d. Year of manufacture
e. Standard to which manufactured
f. Rated voltage, U_r (kV)
g. Rated frequency, (Hz)
h. Rated normal current, (A)
i. Rated operating Sequence.
j. Rated lightning impulse withstand voltage, (kV)
k. Rated symmetrical breaking capacity, (kA)
l. Rated short time current (1 sec.) (kA)
m. Making capacity, (kA)
n. Rated out of phase breaking current, (kA)
o. Rated line charging breaking current, (kA)
p. Rated cable charging breaking current, (kA)
q. First pole to clear factor
r. Total break time at rated breaking current in ms. (cycles).
s. Reclosing time, (msec).
t. Maximum RIV level at 500 KHz, 110% of rated voltage, (µV)

u. Rated supply voltage of auxiliary circuit, (V)
v. Rated supply voltage of closing & opening devices and ranges of operating voltages.
w. Type of operating mechanism
x. Weight per pole, (kg)
y. No. of trip coils per pole
z. Volume and weight of SF6 gas per pole, (litre/kg)
za. Rated pressure of SF6 gas at 20^{o}C (bars)
zb. Mass per pole with SF6 gas, (kg)
zc. Total mass of complete circuit breaker, (kg)

16.0 SPARE PARTS

16.1 The following mandatory spare parts shall be supplied free of charge for each group of five sets of circuit breakers of same characteristics and ratings:-

Sr. No.	Description	Quantity
1.	Single Pole circuit breaker complete with support insulator but excluding operating mechanism, base frame steel supporting structure	1 No.
2.	Closing coils	1 No.
3.	Trip coils	1 Nos.
4.	SF6 gas in standard container of 40kg.	1 container
5.	Complete set of control and shut off valves alongwith seals.	1 Set
6.	Gas density monitors	1Nos.
7.	SF6 Gas filling kit containing control valve for connection to gas container and 20m gas filled hose with connector	1 Set
8.	Handles for Manual Charging of closing springs	5 Nos.

16.2 The bids offering circuit breakers without above spare parts will be loaded @ five percent of the bid price for comparison purpose.

17.0 SPECIAL TOOLS

17.1 A set of standard tools required for the purpose of maintenance and over-hauling of circuit breakers shall be supplied free of charge for each lot of five circuit breakers. The list of standard tools shall be furnished with the bid and also at the time of approval of drawings.

17.2 The bids offering circuit breakers without above tools will be loaded @ one percent of the bid price for comparison purpose.

18.0 **TESTS**

18.1 All type and routine tests shall be performed in accordance with the IEC Publication 62271-100 amended to date.

18.2 **Type Tests**

18.2.1 Identification of Circuit Breakers for Type Test

The type test reports shall incorporate design information and details sufficient to identify the design of the tested circuit breaker with that of other circuit breakers proposed to be of the same design and construction. Such information shall include, but is not restricted to the following:

i) Drawing of circuit breaker general assembly.

ii) Details of arc control devices, contacts and operating and coupling mechanism of the breaker.

iii) The outline and other important dimensions such as the travel of moving contacts etc.

iv) The details of mountings, fixings and insulators.

v) The working details of operating mechanisms such as operating voltage and pole pieces for operating coils, etc.

vi) The resistance of main circuit measured before and after the type tests

18.2.2 The following type tests in accordance with IEC 62271-100 shall be made on a complete three pole circuit breaker having same current & voltage ratings to be supplied in presence of two representatives one from Design, NTDC and other from purchaser at an STL approved Lab at the cost and arrangement of the manufacturer including travel expenses, boarding, lodging and daily allowance for the representatives to prove compliance with the requirements as listed in this specification after every ten years. However, duly certified and complete type test reports for tests carried out by an independent lab like KEMA Lab Holland, CESI Lab Italy on the complete three pole circuit breaker having same design, current & voltage ratings shall be acceptable in lieu of actual tests provided the dates of testing shall not be more the 10 years from the date of opening of the bid. The test report having higher current carrying capacity shall be acceptable only if the bidder shall undertake to supply the exactly the same higher current rating breaker in lieu of the lower current rating breaker as ordered, otherwise the bidder shall have to perform all the type tests on the offered current rating circuit breakers. Test carried out at manufacturer's own/approved lab will not be accepted if not witnessed by the NTDC representative.

1- Dielectric tests.
2- Radio Interference Voltage Test.
3- Measurement of the resistance of the main circuit.
4- Measurement of Temperature and Temperature-Rise.
5- Temperature rise test of control and auxiliary circuit.
6- Short-time withstand current and peak withstand current tests.
7- Verification of IP coding test.
8- Tightness test.
9- Electromagnetic Compatibility (EMC) tests.
10- Mechanical operation test at ambient temperature including extended mechanical endurance test.
11- High Temperature test.
12- Static terminal load test.
13- Short-circuit current making and breaking tests.
14- Critical current test.
15- Earth fault test.
16- Capacitive current switching tests.
17- Short-line fault test.
18- Out of phase making & breaking test.
19- Electrical Endurance test.

The type test report for the above tests alongwith complete drawings of tested circuit breaker duly stamped by the lab shall be submitted with the bid.

18.3 **Routine Tests**

18.3.1 The manufacturer shall perform routine tests on all circuit breakers according to respective clauses of IEC-62271-100 and test reports shall be submit at the time of pre-delivery inspection. The following routine tests shall be witnessed by the two representatives one from Design, NTDC and other from purchaser at the cost and arrangement of the manufacturer including travel expenses, boarding, lodging and daily allowance for the representatives to prove compliance with the requirements as listed in this specification on 10% of the quantity of ordered circuit breakers to be selected randomly from the total lot of circuit breakers.

a. i) Verification of name plate data.
ii) Check of constructional and performance requirement.
iii) Visual & dimensional verification of circuit breaker assembly, steel supporting structures, terminal head and terminal connectors.
iv) Check earth terminal and quality of paint.
v) Check all wiring in accordance with the approved drawing
vi) Verification of all components/devices used in operating mechanism/control cabinet according to the approved drawing.
vii) Checking of motor & spring charging requirements.
viii) Checking of anti pumping function.
ix) Checking of spare auxiliary contacts.
x) Check function of SF6 gas density monitor.

xi) Measurement of creepage distance.
xii) Verify all components/devices are correctly labelled.
xiii) Check all interlocking arrangements/functions.
xiv) Verification of Technical Data values.
xv) Verification of manufacturer's type & routine test reports of insulators, steel supporting structures, terminal head and terminal connectors according to relevant IEC standards.

b. Inspection of spare parts & special tools as mentioned in clause No.16 & 17. A list of the same shall be included in the inspection certificate.

c. Measurement of the resistance of the main circuit. The measured resistance should not exceed the resistance of the type tested circuit breaker and approved by Design, NTDC.

d. Mechanical operating tests.

Mechanical operating tests shall include the following:

i) At maximum supply voltage of operating devices and of auxiliary and control circuits and maximum pressure for operation:
- Five closing operations and Five opening operations;

ii) At specified minimum supply voltage of operating devices and of auxiliary and control circuits and minimum functional pressure for operation:
- Five closing operations and Five opening operations;

iii) At rated supply voltage of operating devices and of auxiliary and control circuits and rated pressure for operation:
- Five closing operations and Five opening operations;
- Five close-open operating cycles with the tripping mechanism energized by the closing of the main contacts;
- Five open close operating cycles O – t - C where t shall be not more than the time interval specified for the rated operating sequence (t = 0.3 seconds/dead time for circuit-breakers intended for rapid auto-reclosing).

vii) For all required operating sequences the following shall be performed and records made of the closing and opening operations:-
- Mechanical characteristics for opening & closing operations
- Measurement of closing time.
- Measurement of Opening time.
- Time travel Chart
- Stored energy operations tests.

v) After completion of the required operating sequences, the following tests and inspections shall be performed:-

- Connections shall be checked;
- The control and/or auxiliary switches shall correctly indicate the open and closed positions of the circuit-breaker;
- All auxiliary equipment shall operate correctly at the limits of supply voltage of operating devices and of auxiliary and control circuits and/or pressures for operation.

vi) Furthermore the following tests and inspections shall be made:-

- Measurement of the resistance of heaters and of the control coils;
- Inspections of the wiring of the control, heater and auxiliary equipment circuits and checking of the number of auxiliary contacts, in accordance with the order specification;
- Inspection of control cubicle
- Recharging duration(s);
- Operation of electrical, mechanical interlocks and signalling devices;
- Operation of anti-pumping device;
- General performance of equipment within the required tolerance of the supply voltage;
- If adjustments are required during the mechanical operating tests, the complete test sequence shall be repeated following the adjustments.

e. Power frequency voltage with-stand dry tests on the main circuit.

f. Tests on control and auxiliary circuits.

This includes dry short duration power frequency voltage withstand test, inspection of auxiliary & control circuits, verification of conformity to the circuit diagram and wiring, components, functional tests, verification of protection against electric shock and degree of protection (IP Code)

18.3.2 The acceptance/inspection certificate clearly indicate the performance of above tests during pre-delivery inspection/testing and test results shall be submitted to the Purchaser.

19.0 DRAWINGS AND DESCRIPTIVE DATA

19.1 Data to be submitted with the bid

19.1.1 Supply record of offered type, current & voltage rating circuit breaker for last five years on the following format:

Sr. No.	Contract/Purchase Order No. & date	Quantity	Current rating	Delivery period	Client Address/ Phone/ Fax No./ E-mail, etc.

19.1.2 The schedule of technical data duly filled-in attached hereto. The word indicating "as per specification/standard" will not be acceptable.

19.1.3 The module indicating the equipment in the circuit breaker assembly and components used in the operating mechanism, control cubicle, etc.

19.1.4 Manufacturer's catalogues/drawings as required in the schedule of technical data.

19.1.5 Non submission of completely filled-in schedule of technical data and supply record on the above format or submission of incomplete information/data as mentioned above with the bid, may render the bid non-responsive.

19.2 Approval Drawings and Data to be submitted after Award of Contract/Purchase Order

The following drawings/descriptive data shall be submitted for approval of Design Department NTDC before manufacturing the equipment:

i. Schedule of technical data duly filled-in along with supporting documents.

ii. Instruction Manual for installation indicating site test procedure before energizing/operation, maintenance/replacement of components procedure and storing requirements of the Circuit breaker.

iii. Name plate data of the circuit breaker and charging mechanism.

iv. Dimensional & outline drawing of circuit breaker showing dimensions of each individual part including terminal studs for high voltage connections and size of terminals for earthing.

v. Foundation/grouting drawings showing static and dynamic loading of circuit breaker during the opening and closing operation and other design data.

vi. Schematic and wiring diagrams of control scheme including closing, tripping, auxiliary circuits, alarm & Interlocking circuits, and operating mechanism shall be furnished on individual page with cross reference. Trip-1 & Trip-2 circuit shall be segregated.

vii. Description & quantity of components/ equipments/ devices indicating the symbols with their manufacturer's name & country of origin and electrical characteristics, etc.

viii. Dimensional drawings of outdoor control cubicle.

ix. The chart or the curve and the procedure for showing the breaker rating factors for evaluating the breaking capacity on various auto-reclosing duty cycles of the offered circuit breakers.

x. Drawing of steel supporting structures, terminal head and connectors with type test report.

xi. List of spare parts and tools to be supplied.

xii. Earth quake simulation test and response calculations.

20.0 PACKING

The circuit breaker and all allied material including steel supporting structures shall be supplied in packing suitable for transport by rail/road and sea as per international practice. Special precaution may be essential for protection of insulation during transport to prevent moisture absorption due, for instance, to rain, snow or condensation. In every package of equipment for shipment one number installation, erection, maintenance and operation instruction book enclosed in water proof material shall be provided. Bill of quantity shall indicate the quantity, size, length, weight and assembly mark of each member of structure including nuts & bolts, washers, plates, foundation bolts and all fittings complete for structure, circuit breaker including terminal head & connector etc.

21.0 ENCLOSURES

Following drawings and data sheets are attached herewith:

1. Schedule of technical data for circuit breaker
2. Circuit breaker supporting structure — Drawing No. PDW/TS/3217
3. Mono-metallic terminal connector — Drawing No. PDW/DF-309(1)
4. Bimetallic terminal connector — Drawing No. PDW/DF-325

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SCHEDULE OF TECHNICAL DATA FOR CIRCUIT BREAKER

GENERAL

1. Manufacturer's name & address _____
   (Attach Manufacturer's catalogue/broucher with the bid)

2. Type/designation of offered circuit breaker _____

3. Offered Circuit Breaker Class
   - i. w.r.t Mechanical Endurance _____
   - ii. w.r.t Electrical Endurance _____
   - iii. w.r.t.Capacitive Current Breaking _____
   - iv. w.r.t Connection to Overheard Line _____

4. No. of poles of Circuit Breaker _____

5. Suitability for three phase/single phase operation and rapid reclosing _____

6 Is the offered circuit breaker conforms to all constructional & performance requirements of the specification (if not, give list of deviations) _____

7. Type Tests.
   - i. Report issuing lab with No. and Date _____
     (Attach copy of type test reports)
   - ii. Current rating of tested circuit breaker _____
   - iii. Rated Short Circuit Breaking Current _____
   - iv. Rated duration of short circuit current _____
   - v. Resistance of Main circuit of tested circuit breaker. _____
   - vi. Whether complete type test as per IEC 62271-100 were carried out at an independent lab.(if not, give details). Yes/No
   - vii. Whether the details of circuit breaker for type tests as required in clause 18.2.1 have been attached with the bid Yes/No

RATINGS

1.	Rated voltage(U_r), rms	(kV)	_____
2.	Nominal voltage, rms	(kV)	_____
3.	Highest operating voltage	(kV)	_____
4.	Lowest operating voltage	(kV)	_____
5.	Lightning Impulse withstand voltage		
	i) Phase to Phase	(kV)	_____
	ii) Phase to Earth	(kV)	_____
6.	One minute Power Frequency withstand voltage		
	i) Phase to Phase	(kV)	_____
	ii) Phase to Earth	(kV)	_____
7.	Rated Frequency	(Hz)	_____
8.	Rated Continuous current of offered circuit breaker	(A)	_____
9.	Max. continuous current of offered Circuit Breaker	(A)	_____
10.	Rated short circuit breaking current for 1 sec, rms	(kA)	_____
11.	Rated short circuit breaking current for 3 sec, rms	(kA)	_____
12.	Rated D.C. component	(%)	_____
13.	Rated short time withstand current for 1 sec, rms	(kA)	_____
14.	Rated short time withstand current for 3 sec, rms	(kA)	_____
15.	Rated peak withstand current, rms	(kA)	_____
16.	Rated short-circuit making current (Peak)	(kA)	_____
17.	Rated operating sequence		_____
18.	Rated out-of-phase breaking current at rated voltage	(kA)	_____

19. Line-charging breaking capacity:

    i) Rated current (kA) _____
    ii) Over voltage factor (p.u) _____

20. Cable charging breaking current at rated voltage (kA) _____

21. Single capacitor bank breaking current (A) _____

22. Rated Back to back capacitor bank switching current (A) _____

23. Max. RIV at 1 MHz at 10% above rated voltage ($1.1U_r/\sqrt{3}$) (μV) _____

24. First Pole to Clear Factor (FPCF)

25. Resistance of main circuit of the offered circuit breaker at 20^oC ambient temperature (μΩ) _____

26. Transient recovery voltage for terminal faults (1.5 F.P.C. factor)

    i) At 100% rated short circuit breaking current

u_l- first reference voltage	(kV)	_____
t_1- first time co-ordinate	(μ Sec)	_____
u_c- TRV peak value	(kV)	_____
t_2- second time co-ordinate	(μ Sec)	_____
t_d- time delay	(μ Sec)	_____
u´- voltage co-ordinate	(kV)	_____
t´- third time co-ordinate	(μ Sec)	_____
u_1/t_1- Rate of Rise of Recovery Voltage	(kV/μSec)	_____
K_{af} - Amplitude Factor	(p.u)	_____

    ii)At 60% rated short circuit breaking current:

u_l- first reference voltage	(kV)	_____
t_1- first time co-ordinate	(μ Sec)	_____
u_c- reference voltage TRV peak value	(kV)	_____
t_3- time to reach u_c	(μ Sec)	_____
t_d- time delay	(μ Sec)	_____
u´- delay line voltage co-ordinate	(μ Sec)	_____
t´- delay line time co-ordinate	(kV)	_____
t_3- initial rate of rise	(μ Sec)	_____
u_1/t_1- Rate of Rise of Recovery Voltage	(kV/μSec)	
K_{af} - Amplitude Factor	(p.u)	_____

    _____

iii)At 30% rated short circuit breaking current

u_l- first reference voltage	(kV)	_____
t_1- first time co-ordinate	(µ Sec)	_____
u_c- reference voltage TRV peak value	(kV)	_____
t_3- time to reach u_c	(µ Sec)	_____
t_d- time delay	(µ Sec)	_____
u´- delay line voltage co-ordinate	(µ Sec)	_____
t´- delay line time co-ordinate	(kV)	_____
t_3- initial rate of rise	(µ Sec)	_____
u_1/t_1- Rate of Rise of Recovery Voltage	(kV/µSec)	_____
K_{af} - Amplitude Factor	(p.u)	_____

iv) At 10% rated short circuit breaking current

u_l- first reference voltage	(kV)	_____
t_1- first time co-ordinate	(µ Sec)	_____
u_c- reference voltage TRV peak value	(kV)	_____
t_3- time to reach u_c	(µ Sec)	_____
t_d- time delay	(µ Sec)	_____
u´- delay line voltage co-ordinate	(µ Sec)	_____
t´- delay line time co-ordinate	(kV)	_____
t_3- initial rate of rise	(µ Sec)	_____
u_1/t_1- Rate of Rise of Recovery Voltage	(kV/µSec)	_____
K_{af} - Amplitude Factor	(p.u)	_____

27. Transient Recovery Voltage for short line faults

u_1- first reference voltage	(kV)	_____
t_1- first time co-ordinate	(µ Sec)	_____
u_c- TRV peak value	(kV)	_____
t_2- second time co-ordinate	(µ Sec)	_____
t_d- time delay	(µ Sec)	_____
u´- voltage co-ordinate	(kV)	_____
t´- third time co-ordinate	(µ Sec)	_____
u_1/t_1- Rate of Rise of Recovery Voltage	(kV/µSec)	_____
K_{af} - Amplitude Factor	(p.u)	_____

28. Transient Recovery Voltage for out of phase

u_1- first reference voltage	(kV)	_____
t_1- first time co-ordinate	(µ Sec)	_____
u_c- TRV peak value	(kV)	_____
t_2- second time co-ordinate	(µ Sec)	_____
t_d- time delay	(µ Sec)	_____
u´- voltage co-ordinate	(kV)	_____
t´- third time co-ordinate	(µ Sec)	_____
u_1/t_1- Rate of Rise of Recovery Voltage	(kV/µSec)	_____
K_{af} - Amplitude Factor	(p.u)	_____

PERFORMANCE DATA

1. Maximum ambient temperature range (°C) _____

2. Whether circuit breaker is capable of switching of :
   - i) Power Transformers Yes/No
   - ii) Capacitor Banks Yes/No
   - iii) Charging current of over head lines/cables Yes/No

3. Resistance of main circuit at 20°C (μΩ) _____

4. Current carrying capacity of offered circuit breaker at different ambient temperatures (Attach Ambient Temperature Vs Current curve with the bid)
   - i. Max. Continuous Current at 50°C Ambient (A) _____
   - ii. Max. Continuous Current at 40°C Ambient (A) _____
   - iii. Max. Continuous Current at 30°C Ambient (A) _____
   - iv. Max. Continuous Current at 20°C Ambient (A) _____
   - v. Max. Continuous Current at 10°C Ambient (A) _____

5. Temperature rise at at 50°C Ambient Temperature:
   - i) Contacts (°C) _____
   - ii) Terminals (°C) _____
   - iii) Other metal parts (°C) _____

6. i) Rated voltage of :
   - a) Closing coil (V DC) _____
   - b) Tripping coil (V DC) _____

   ii) Rated power consumption of :
   - a) Closing coil (W) _____
   - b) Tripping coil (W) _____

7. i) Heater voltage (V) _____
   ii) Heater Power (Watts) _____

8.	Range of rated control and auxiliary supply viz:		
	i) Control- Max./Min.	(V DC)	_____
	ii) Charging Motor-Max./Min.	(VDC)	_____
	iii) Tripping voltage – Max./Min.	(V DC)	_____
	iv) Three phase AC system	(VAC)	_____
9.	Tolerance in operating time	(m sec)	_____
10.	Rated closing time	(m sec)	_____
11.	Rated break time	(m sec)	_____
12.	Rated make time	(m sec)	_____
13.	Rated dead time	(m sec)	_____
14.	Rated open-close time	(m sec)	_____
15.	Rated close-open time	(m sec)	_____
16.	Rated Arcing time	(m sec)	_____
17.	Rated pre-arcing time	(m sec)	_____
18.	Rated reclosing time	(m sec)	_____
19.	Rated Re-make time	(m sec)	_____
20.	Rated opening time	(m sec)	_____
21.	Maximum clearing time during test duty T_{100a}	(m sec)	_____
22.	No. of switching operations permissible at:		
	i) 100% short circuit breaking current	(No.)	_____
	ii) 60% short circuit breaking current	(No.)	_____
	iii) 30% short circuit breaking current	(No.)	_____
	iv) Max. continuous current carrying capacity	(No.)	_____
23.	Max. time interval between first and last pole for 3 phase pole operation	(m sec)	_____
24.	Make-break time	(m sec)	_____
25.	Pre-Insertion time	(m sec)	_____
26.	Min. close duration	(m sec)	_____

27.	Min. Trip duration	(m sec)	_____
28.	Electrical Endurance	(Nos.)	_____
29.	Mechanical endurance	(Nos.)	_____
30.	Max. noise at a distance of 10m from the breaker and 2meter from base during opening and closing operation	(dB)	_____

CONSTRUCTION

(Attach internal view of a pole of circuit breaker showing all the components with a detail legend with the bid)

1.	No. of breaks per pole	(No.)	_____
2.	No. of trip coils for pole	(Nos.)	_____
3.	Total length of break per pole	(mm)	_____
4.	No. of operating mechanism for 3-phase circuit breaker		_____
5.	Whether two electrically independent & identical trip coils for each pole of the circuit breaker have been provided.		Yes/No
6.	Whether two electrical independent sets of wiring, terminals and protection equipment have been provided		Yes/No
7.	Whether circuit breaker is trip free		Yes/No
8.	Provision of anti pumping device		Yes/No
9.	Degree of protection of outdoor control cubical		_____
10.	Thickness of control cubical sheet		_____
11.	Material of sheet.		_____
12.	Whether all the shut valves are provided in the operating mechanism		Yes/No
13.	Type of operating mechanism:		
	i) Opening mechanism		_____
	ii) Closing mechanism		_____

14.	i)	Rated voltage of the charging motor in the operating mechanism	(V)	_____
	ii)	Total power consumption of motor	(Watts)	_____
15.		Whether thermal magnetic protection provided for the motor.		Yes/No
16.		Whether emergency manual charging & release of spring is possible without electrical operation		Yes/No
17.		Whether the indicator to show the charged/discharged state of spring has been provided in the operating mechanism		Yes/No
18.		Whether all the local & remote control indications as mentioned at clause 8 have been available. (If not, give details)		Yes/No
19.		Whether all functional requirements as listed in 9.1 have been complied. (If not, give details)		Yes/No
20.		No. of close open operation possible with the stored energy	(No.)	_____
21.		Time required for the motor to recharge the closing spring		_____
22.		Description of safety alarms provided		
		a)_____		_____
		b)_____		_____
		c)_____		_____
		d)_____		_____
		e)_____		_____
23.	i)	Whether SF6 gas conforms to IEC 376		Yes/No
	ii)	Normal SF6 gas Pressure at $20^{o}C$	(Bars)	_____
	iii)	Maximum SF6 gas Pressure at $20^{o}C$	(Bars)	_____
	iv)	Minimum SF6 gas Pressure at $20^{o}C$	(Bars)	_____
	v)	SF6 gas Pressure alarm Stage-I	(Bars)	_____
	vi)	SF6 gas Pressure alarm Stage-II	(Bars)	_____
	vii)	Total volume of SF6 gas per pole	(Litres)	_____
	viii)	Leakage of SF6 gas per year per circuit breaker	(ml)	_____
24.		No. of earthing terminals for $95mm^2$ copper conductor	(Nos.)	_____
25.		Material of Earthing terminal		_____

26. Capability of carrying rated short time current of earthing terminal (kA) _____

27. Contacts:

    i) Material _____
    ii) Type of plating _____
    iii) Thickness of plating material _____
    iv) Contact pressure _____
    v) Dimensions _____
    vi) Current density at continuous current (A/mm^2) _____

28. i) Total No. of auxiliary contacts:
        a) Normally Open _____
        b) Normally Closed _____

    ii) No. of spare auxiliary contacts:
        a) Normally Open _____
        b) Normally Closed _____

29. Thickness of galvanized steel sheet used for outdoor control cubical (mm) _____

30. Dimensions of inspection window of outdoor control cubicle (mm) _____

31. Whether all wiring comply with clause 11.9.4 Yes/No

32. Whether the outdoor control cubicle comply with the requirements of clause 11(if not, give detail) Yes/No

33. Type of gasket to prevent ingress of moisture _____

34. Whether the AC circuit of outdoor control cubicle is fitted with non-flammable transparent plastic cover to prevent accidental contact with lower part _____

35. No. of extra terminals for future termination _____

36. Size of cable used in wiring (mm^2) _____

37. Minimum height of circuit breaker (mm) _____

38. Minimum phase spacing between poles (mm) _____

39. Minimum earth clearance of circuit breaker (mm) _____

40. Minimum clearance between moving and stationary parts when the circuit breaker in the open position (mm) _____

41. i) Minimum creepage distance between live terminals (mm) _____
    ii) Minimum creepage distance phase to earth (mm) _____

42. Size and section of terminal bolts (attach drawing) (mm) _____

43. Impact vertical loading per pole (kg/kN) _____

44. Horizontal loading of operating mechanism. (kg/kN) _____

45. Impact vertical loading of operating mechanism. (kg/kN) _____

46. Maximum shock load on foundation while opening on fault. (kg) _____

47. Dimensions for steel support:

    i) Height _____
    ii) Breadth _____
    iii) Width _____
    iv.) Structure fixing foundation details _____

48. Circuit breaker withstand capability
    i) Wind velocity m/sec _____
    ii) Wind Load m/sec _____
    iii) Earth quake
        a) Richer-scale
        b) Horizontal acceleration (g)

49. Foundation Loading details. _____

50. Terminal Connectors suitable for 600 mm^2 Al. Conductor (Attach manufacturer's broucher/drawings with the bid)

    i) Manufacturer's Name _____
    ii) Type
    iii) Weight
    iv) Current carrying capacity
    v) Short circuit withstand current
    vi) Tensile Strength
    vii) Elongation
    viii) Hardness
    ix) Type Tests (Attach copy)

51. Weight per pole of circuit breaker (kg) _____

52. Weight of complete circuit breaker (kg) _____

INSULATOR

1. Manufacturer/country of origin (Attach catalogue/broucher/drawing with the bid) _____

2 Type of insulator _____

3. Diameter of insulator _____

4. No. of units per column _____

5. Creepage distance (Phase to Earth) _____

6. Phase to phase clearance _____

7. Type test report issuing lab with No. & date (Attach copy of test report) _____

8. Power frequency withstand test voltage
   a) Dry 1 minute _____
   b) Wet 10 sec _____

9. Impulse withstand voltage _____

10. Max RIV at 1 MHz

11. Ultimate strength of column _____

12. Withstand Pressure

i)	Cantilever	(N)
ii)	Tension	(N)
iii)	Torsion	(N)
iv)	Compression	(N)
v)	Bending	(N)

13. Material and colour _____

STEEL STRUCTURE
(Attach drawing/photograph with the bid)

1. Name of Manufacturer/Country of origin _____

2. Tensile Strength of angles, nuts & bolts Min./Max. Kg/mm^2 _____

3.	Yield point Min.	Kg/mm^2	_____
4.	Elongation in 200m guage	(%)	_____
5.	Weight of Zinc Coating of angles/nuts & bolts		_____
6.	Thickness of zinc coating angles/nuts & bolts		_____
7.	Hardness of nuts & bolts		_____
8.	Total weight of supporting steel structure with foundation bolts		_____
9.	Designed soil bearing capacity		_____
10.	Seismic withstand stress/magnitude. (Attach design calculations)		_____

TERMINAL HEAD:
(Attach drawing/photograph with the bid)

1.	Name of Manufacturer		_____
2.	Material of terminal head		_____
3.	Current Carrying Capacity of terminal head		_____
4.	Dimensions of terminal head	(mm)	_____
5.	Material of terminal head		_____
6.	Weight of terminal head		_____
7.	Whether 4 Nos. two way terminal head are provided.		Yes/No

CONNECTORS
(Attach drawing/photograph with the bid)

1.	Name of Manufacturer/Country of origin	_____
2.	Material of connector (Whether Monometallic aluminium alloy or Bimetallic)	_____
3.	Material of keeper	_____
4.	Current Carrying Capacity of connector	_____

5.	Tensile Strength (Aluminium/Copper)		_____
6.	Elongation (Aluminium/Copper)	%	_____
7.	Hardness of Aluminium/Copper		_____
8.	Electrical conductivity of Aluminium/Copper		_____
9.	Short Circuit Rating		_____
10.	Material of Nuts & Bolts		_____
11.	Tensile Strength of Nuts & Bolts		_____
12.	Brinell Hardness of Nuts & Bolts		_____

NAME PLATE DATA

1.	Whether the data listed in clause 14 is engraved on the name plate	_____
2.	Material/Thickness of name plate	_____

SPARES & SPECIAL TOOLS

1.	Whether spares & tools as required at clause 15 will be provided with each lot of circuit breakers	Yes/No
2.	Whether special tools as per clause 16 been provided with each lot of circuit breaker for maintenance & repair (Attach detail list)	Yes/No

PACKING AND SHIPPING

1.	No. of packages to be shipped	((Nos.)	_____
2.	Weight of each package	(kg)	_____

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