

21	Noise level	< 90 dB As per NEMA TR-1 standard
22	Flux density	Not to exceed 1.9 Wb/sq.m. at any tap position with +/-10% voltage variation from voltage corresponding to the tap. Transformer shall also withstand following over fluxing conditions due to combined voltage and frequency fluctuations: a) 110% for continuous rating. b) 125% for at least one minute. c) 140% for at least five seconds. Bidder shall furnish over fluxing char. up to 150%
23	Air Clearance	As per CBIP
24	Only Type -Tested transformers shall be used.	

\* Single Line Diagram (SLD) will be finalized during detailed engineering.

#### **Protection requirements**

Sl. No.	Relay Code	Relay Name
1	50	Instantaneous Overcurrent
2	51	AC Time Overcurrent
3	50N & 50G	Neutral & Residual Instantaneous Overcurrent
4	51N & 51G	Neutral & Residual Time Overcurrent
5	86	Master Trip
6	94	Anti-Pumping
7	95	Trip Circuit Supervision
8	80	DC Failure
9	49	WTI and OTI
10	74	Pressure Relief
11	63	Buchholz

#### **Construction Details**

##### **General**

- i. Transformer shall be constructed in accordance to IS: 2026 and IS: 3639 or equivalent to any other international standard. Transformer shall be complete & functional in all respect and shall be in scope of supplier.
- ii. It is the responsibility of the Contractor to ensure that the transformer comply with all the requirements of inverter provided by the inverter manufacturer.

The other important construction particulars shall be as below.

- iii. The Transformer tank and cover shall be fabricated from high grade low carbon plate steel of tested quality. The tank and the cover shall be of welded construction and there should be provision for lifting by crane.
- iv. A double float type Buchholz relay conforming to IS: 3637 shall be provided.
- v. Suitable Inspection hole(s) with welded flange(s) and bolted cover(s) shall be provided on the tank cover. The inspection hole(s) shall be of sufficient size to afford easy access to the lower ends of the bushings, terminals etc.
- vi. All bolted connections to the tank shall be fitted with suitable oil-tight gaskets which shall give satisfactory service under the operating conditions for complete life of the transformer if not opened for maintenance at site
- vii. The transformer conservator shall be provided with Atmosal (Bladder) type single compartment with conventional single compartment conservator. The top of the conservator shall be connected to the atmosphere through indicating type cobalt free silica gel breather (in transparent enclosure). Silica gel shall be isolated from atmosphere by an oil seal.
- viii. Transformer shall have adequate capacity Conservator tank to accommodate oil preservation system and volumetric expansion of total transformer oil.
- ix. The radiators shall be detachable type, mounted on the tank with shut off valve at each point of connection to the tank, lifts, along with drain plug/valve at the bottom and air release plug at the top.
- x. M. Box shall be of sheet steel, dust and vermin proof provided with proper lighting and thermostatically controlled space heaters. The degree of protection shall be IP 55. Marshalling Box of all transformers shall be preferably Tank Mounted. One dummy terminal block in between each trip wire terminal shall be provided. At least 20% spare terminals shall be provided on each panel. The gasket used shall be of neoprene rubber. Also, Marshalling Box, shall be at least 450 mm above ground level. Wiring scheme (TB details) shall be engraved in a stainless steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door.
- xi. Winding, core and other supporting arrangement etc. should be same as that of successful type tested (Short Circuit, impulse and temperature rise test) transformer.
- xii. Transformer shall be designed for at least 5% total harmonic distortion (THD) to withstand distortion generated by the inverter as well as possible outside harmonics from the network.
- xiii. The transformer shall be suitable for continuous operation with a frequency variation of  $\pm 2.5\%$  from nominal frequency of 50 Hz without exceeding the specified temperature rise.
- xiv. Inverter Transformer shall have shield winding between LV & HV windings. Each LV winding must be capable of handling non-sinusoidal voltage with voltage gradient as specified by the inverter manufacturer. Also, shield winding shall be taken out from tank through shield bushing and the same shall be brought down to the bottom of the tank using copper flat and support insulator for independent grounding.
- xv. Vector group of inverter transformer shall be as per the inverter manufacturer requirement. Short circuit test of transformer should be conducted on the same configuration.
- xvi. Neutral bushing of Inverter transformer shall be brought outside the tank for the testing purpose. It shall be covered with MS sheet and a sticker "For testing purpose only. Do not earth".
- xvii. Transformer shall have winding temperature sensors and Winding Temperature Indicator (WTI) with requisite set of remote signalling contacts for alarm and trip operations.

- xviii. All external surface of the transformer shall be painted with two coats of epoxy-based paint of colour shade as decided by the REIL / Customer. Internal surface of cable boxes and marshaling box shall be painted with epoxy enamel white paint. The minimum dry film thickness (DFT) shall be 100 microns.
- xix. LV and HV cable box shall be provided with disconnecting chamber to facilitate the movement of transformer without disturbing cable box and termination.
- xx. Bi-directional wheel/skids cover lifting eyes, transformer-lifting lugs, jacking pads, towing holes, core and winding lifting lugs, inspection cover, rating plate, valve schedule plate, accessories and terminal marking plates, two nos. of earthing terminals shall be provided.

### **Windings**

- i. The bidder shall ensure that windings of all transformers are made in dust proof & conditioned atmosphere.
- ii. The conductors shall be of electrolytic grade copper free from scales & burrs.
- iii. All windings of the transformers shall have uniform insulation.
- iv. Tapping shall be so arranged as to preserve the magnetic balance of the transformer at all voltage ratio.

### **Core**

- i. The core shall be constructed from non-ageing, cold rolled, super grain oriented silicon steel laminations equivalent to M4 grade steels or better.
- ii. Core isolation level shall be 2 kV (rms.) for 1 minute in air.
- iii. Adequate lifting lugs will be provided to enable the core & windings to be lifted.

### **Insulating oil**

No inhibitors shall be used in the transformer oil. The oil supplied with transformers shall be new and previously unused and must conform to following while tested at supplier's premises and shall have following parameters.

<b>Sl. No.</b>	<b>Properties</b>	<b>Permissible values</b>
1	Kinematic Viscosity, mm <sup>2</sup> /s	=<12 at 40 deg.C =<1800 at (-)30 deg.C
2	Flash Point,deg. C	>=140 deg.C
3	Pour point, deg. C	=<(-)40 deg. C
4	Appearance	Clear, free from sediment and suspended matter
5	Density kg/dm <sup>3</sup> at 20 deg. C	=<0.895
6	Interfacial Tension N/m at 25 deg. C	>=0.04
7	Neutralisation value, mgKOH/g	=< 0.01
8	Corrosive sulphur	Non Corrosive
9	Oxidation Stability -Neutralization value, mgKOH/g -Sludge, % by mass	=<1.2 =<0.8

10	Breakdown voltage As delivered, kV After treatment, kV	>=30 >=70
11	Water content mg/kg	=< 30 in bulk supply =<40 in drum supply
12	Anti-oxidants additives	Not detectable
13	Dissipation factor, at 90deg. C And 40 Hz to 60 Hz	=<0.005
14	PCA content	=<1%
15	Impulse withstand Level, kVp	>=145
16	Gassing tendency at 50 Hz after 120 min, mm <sup>3</sup> /min	5

### **Bushings**

- i. Bushing shall be oil communicating type with porcelain insulator.
- ii. No arcing horns to be provided on the bushings.
- iii. Inverter transformer LV bushing palms shall be silver/tin plated.

### **Bushing CTs**

- i. They shall be of adequate rating for protection as required, WTI etc. All CTS (except WTI) shall be mounted in the turret of bushings.
- ii. All CT terminals shall be provided as fixed type terminals on the Marshalling box to avoid loose connection leading to CT opening. Plug in type connectors shall be used for CT.

### **Valves**

All valves up to and including 50 mm shall be gun metal or of cast steel. Sampling & drain valves should have zero leakage rate.

### **Gaskets**

- i. Gasket shall be fitted with weather proof, hot oil resistant, rubberized cork gasket.
- ii. If gasket is compressible, metallic stops shall be provided to prevent over compression.

The gaskets shall not deteriorate during the life of transformer if not opened for maintenance at site. All joints flanged or welded associated with oil shall be such that no oil leakage or sweating occurs during the life of transformer. The quality of these joints is considered established, only if the joints do not exhibit any oil leakage or sweating for a continuous period of at least 3 months during the guarantee period. In case any sweating / leakage is observed, contractor shall rectify the same & establish for a further period of 3 months of the same.

### **Painting**

<b>Parts name</b>	<b>Type of paint</b>	<b>No. of coats</b>	<b>Total dft</b>
Inside of tank and accessories (except M Box)	Oil & heat resistant fully glossy white	1 coat	At least 30 micron
External surface of transformer and accessories including M Box	Chemical resistant epoxy zinc phosphate primer, MIO (Micaceous iron oxide) as intermediate paint followed by	1 coat	Atleast 100 micron

(except radiators)	polyurethane finish paint (RAL 5012 Blue)		
External Radiator surface	Anticorrosive primary paint followed by high quality full glossy outer finish paint (RAL 5012 Blue)	2 coats each	At least 100 micron
Internal Radiator surface	Hot oil proof, low viscosity varnish and subsequent flushing with transformer oil		
Internal surface of M Box	Chemical resistant epoxy zinc phosphate primer followed by chemical and heat resistant epoxy enamel white paint	2 coats each	Not less than 100 micron

### **Testing and Inspection**

- i. In case the bidder/contractor has conducted such specified type test(s) within last ten years as on the date of bid opening, he may submit the type test reports to the owner for waiver of conductance of such type test(s). These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.
- ii. In case the Bidder is not able to submit report of the type test(s) conducted within last ten years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract at no additional cost to the REIL / Customer and submit the reports for approval.

### **Routine Tests**

- i. All routine test shall be carried out in accordance with IEC 60076 & IEC 60076-1.
- ii. Measurement of winding resistance at each tap.
- iii. Measurement of voltage ratio between HV and LV windings at each tap.
- iv. Check of vector group.
- v. Measurement of short-circuit impedance and load loss.
- vi. Magnetic Balance and Magnetising Current Test.
- vii. Measurement of no-load loss and no-load current.
- viii. Load Loss & Short Circuit Impedance Measurement on principal & Extreme taps.
- ix. Measurement of capacitance & tan delta to determine capacitance between winding & earth.
- x. Partial discharge measurement.
- xi. Induced overvoltage test.
- xii. Measurement of insulation resistance.
- xiii. Marshalling box functional test.
- xiv. IR measurement on wiring of Marshalling Box.

### **Type Test**

Type Test shall be carried out on one transformer of each rating.

- i. Lightning impulse (Full & Chopped Wave) test on windings (as per IEC 60076-3).
- ii. Short circuit test (special test) as per IEC 60076-5.
- iii. Temperature Rise test at a tap corresponding to maximum losses as per IEC 60076. Gas Chromatography shall be conducted on oil sample taken before & immediately after Temperature Rise test. Gas analysis shall be as per IS: 9434 (based on IEC: 60567), results will be interpreted as per IS: 10593 (based on IEC:60599).
- iv. Measurement of harmonics of no load current (special test)
- v. Measurement of acoustic noise level as per NEMA TR-1 (special test).
- vi. Tank Vacuum & Pressure Test (as per CBI norms)

### **Special Tests**

- (i) Measurement of zero-sequence impedance as per IEC 60076-1
- (ii) Measurement of harmonics of no-load current as per IEC 60076-1
- (iii) Measurement of acoustic noise level as per NEMA TR-1
- (iv) Short-circuit withstand test as per IEC 60076-5

In case the contractor is not able to submit the test reports during detailed engineering, the contractor shall submit the reports of type/special tests either conducted by NABL accredited laboratory or witnessed by REIL / Customer.

### **Tests at Site**

After erection at site all transformer(s) shall be subjected to the following tests.

- (i) Measurement of voltage ratio
- (ii) Check of vector group
- (iii) Magnetic balance test
- (iv) Measurement of insulation resistance

In case the equipment is not found as per the requirements of the Technical Specifications of tender, all expenses incurred during site testing will be to the Contractor's account and the equipment shall be replaced by him at free of cost.

### **NOTE: -**

All the type and special tests shall be conducted after performing Short Circuit Test. If Tank Vacuum & Pressure Test is to be carried out then it shall be conducted before ShortCircuit test.

- a. Inverter Transformer LV winding Di-electric tests shall be carried out corresponding to levels (as per IEC 60076) for 3.6 kV class.
- b. Fire Fighting arrangements for Transformers shall be provided if applicable as per statutory requirements.

- c. Firewall as applicable (as per IS 3034) shall be provided of minimum 230 mm thickness of RCC wall subject to PMCs/Owners approval.
- d. Transformer efficiency shall be as per Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electrical Lines) regulation, 2010.
- e. Danger plate indicating, "entry prohibited under energized condition" of the transformer shall be provided as per statutory requirements.

**f. Rating plate**

- i. Name of manufacturer
- ii. Serial number
- iii. Year of manufacture
- iv. Number of phases
- v. KVA or MVA rating
- vi. Frequency
- vii. Voltage ratings.
- viii. Tap voltages.
- ix. Connection diagram.
- x. Cooling class
- xi. Phasor or vector diagram
- xii. % impedance between primary and secondary
- xiii. Approximate mass or weight of the transformer
- xiv. Type of insulating liquid.
- xv. Conductor material of each winding.
- xvi. Oil volume (of each transformer Container/Compartment)
- xvii. Valve schedule Plate
- xviii. The name-plate shall contain the information of all the valves, their locations, quantities and schematics for the valve.
- xix. OCTC plate
- xx. Type
- xxi. Serial number
- xxii. Year of manufacture
- xxiii. Phase
- xxiv. Frequency
- xxv. Steps (Number)
- xxvi. Steps voltages.
- xxvii. Control voltage.
- xxviii. Weight with and without oil

**Marshalling Box**

- i. Name of manufacturer

- ii. Serial number
- iii. Year of manufacture
- iv. Purchase order No.
- v. Engraved drawing of control circuit, CT/ PT circuit and TB.

### **Oil filling instruction plate of conservator**

Step wise process for filling the oil in conservator

The accessories listed above are indicative only. Accessories which are not mentioned above but required for satisfactory operation of the transformers are deemed to be included in the contract without extra charges.

### **Warranty**

The transformer shall be warranted for minimum of 5 (five) years against all material/ manufacturing defects and workmanship.

### **Approval**

The Detailed Design Report Submitted by the contractor to REIL / Customer must contain but not limited to the following details of the transformers:

- Detailed specification including Fittings and Accessories
- Outline dimension/GA drawings of transformers.
- Bushing Assembly drawings (for both HV&LV).
- Marshalling Box GA & Connection Drawings.
- Transport drawings, showing main dimensions and weight of each package.
- Instruction plate for oil filling procedure for Air cell conservator
- Foundation details
- Tap-changing equipment
- Rating & Property plate diagrams
- Necessary test certificates and type test reports.
- GTP shall be provided by the contractor as per Proforma provided by REIL / Customer during approval.

A joint inspection will be done by REIL / Customer and authorized representatives of the contractor at the manufacturer's workshop. Testing and inspection of the transformers will be carried out as per relevant Indian Standard. Arrangements for the aforesaid testing and inspection at manufacturer's end are to be provided by the contractor.

Prior to the delivery of the product, the contractor shall submit but not limited to the following documents:

- Guarantees
- Instructions for installation and operation manual
- Safety precautions
- Test reports for routine tests and acceptance tests etc.
- Detailed schematics of all power instrumentation and control equipment and Sub systems along with their interconnection diagrams. Schematics shall



indicate wiring diagrams, their numbers and quantities, type and ratings of all components and sub systems etc.

The contractor can deliver the product to the site only after receiving such approval against their request in writing from REIL / Customer.

5. **33 KV HT Switchgear**

**Switchgear Panel**

- i. The switchgear boards shall have a single front, single tier, fully compartmentalized, metal enclosed construction complying with clause No. 3.102 of IEC 62271-200, comprising of a row of freestanding floor mounted panels.
- ii. The circuit breakers and bus VTs shall be mounted on withdrawable trucks which shall roll out horizontally from service position to isolated position. For complete withdrawal from the panel, the truck shall rollout on the floor or shall roll out on telescopic rails. In case, circuit breaker is to be rolled out on telescopic rails, bidder to provide suitable trolley for withdrawal and insertion of the truck from and into the panel at each location i.e. switchgear room. Testing of breaker shall be possible in isolated position by keeping the control plug connected.
- iii. The trucks shall have distinct SERVICE and ISOLATED positions. It shall be possible to close the breaker compartment door in isolated position to retain the specified degree of protection of switchgear panel. Circuit Breaker rack-in and rack-out from service to test, test to isolated position or vice-versa shall be possible only in the compartment door closed condition.
- iv. Separate earthing trucks shall be provided for earthing of busbars and incoming/outgoing feeders. The trucks shall have voltage transformer to indicate presence of voltage prior to earthing. An audible alarm shall also be provided in case of voltage on the earthing terminal. Integral earth switches may also be considered instead of earthing trucks. The earthing truck/switch shall have short circuit withstand capability equal to that of the associated switchgear panel.
- v. The switchgear assembly shall be dust, moisture, rodent and vermin proof.
- vi. The control/ relay compartments shall have degree of protection not less than IP 5X in accordance with IS/IEC 60947. However, remaining compartments can have a degree of protection of IP 4X. If louvers are provided, shall have very fine brass or GI mesh screen. Tight fitting gaskets/ gaskets are to be provided at all openings in relay compartment.
- vii. Numerical relays shall be fully flush mounted on the switchgear panels at a suitable height.
- viii. The switchgear shall be specially design to withstand internal explosion etc. so that it should not endanger the operating personal while operating the breaker. In addition, pressure relief device shall be provided in each high voltage compartment of a panel for vent out the gases that may be generated in case of fault without spreading to other compartment. The pressure relief device shall not however reduce the degree of protection of panels under normal working condition.
- ix. Enclosure shall be constructed with rolled steel sections. The doors and covers shall be constructed from cold rolled steel sheets of 2.00mm or higher thickness. Gland plates shall be 2.5mm thick hot or cold rolled steel section and for non-magnetic material it shall be 3.0mm.
- x. Total height of the switchgear panels shall not exceed 2600 mm. The height of switches, push buttons and other hand operated devices shall not exceed 1800mm and shall not be less than 700mm. Switchgear shall be cooled by natural air flow.

- xi. Suitable base frame made out of steel channels shall be supplied along with necessary anchor bolts and other hardware, for mounting of switchgear panels. These should be dispatched in advance so that they may be installed and levelled when the flooring is being done.
- xii. Pressure relief device shall be provided in each high voltage compartment of a panel to safely vent the gases in the event of internal arc. Seal-off bushing arrangement shall be provided between the breaker compartment and bus bar/cable compartments to prevent transfer of arc from one compartment to other.
- xiii. Automatic safety shutters shall be provided to cover up the fixed high voltage contacts on bus bar and cable sides when the truck is moved to TEST position.
- xiv. Degree of protection of the switchgear panel shall not be less than IP 55 as per IEC 60529. Mechanical /Electrical interlocks shall be provided to prevent mal-operation and in particular to ensure the following.
- xv. Mechanical /Electrical interlocks shall be provided to prevent mal-operation and in particular to ensure the following.
  - a) The breaker shall be operated only if it is in SERVICE or TEST position.
  - b) Movement of the breaker truck between SERVICE and TEST positions shall be possible only if the breaker is OFF.
  - c) It shall be possible to open the door only when the breaker is in TEST position.
- xvi. Failure of a control supply / de-energisation / restart of relay shall not initiate any circuit breaker operation.
- xvii. Each switchgear panel shall be provided with thermostatically controlled space heaters, separately for breaker, cable and bus bar compartments, to prevent condensation within the compartment. The space heater shall be connected to 240 V, 50 Hz, single-phase AC supply through suitable switch and fuse.
- xviii. 240 V, 15 A, SPN industrial socket-outlet with ON/OFF switch shall be provided in each panel. Each panel shall be provided with LED lamp rated for 240 V, 50 Hz, single-phase AC supply for interior illumination controlled by door switch.
- xix. Gapless, metal-oxide surge arrestors shall be provided between line and earth in cable compartment of the switchgear panel.
- xx. Suitable lifting hooks shall be provided for each panel.
- xxi. All external surface shall be painted with two coats of epoxy based paint of colour shade RAL 7032. Internal surface shall be painted with epoxy enamel white paint. The minimum dry film thickness (DFT) shall be 100 micron.

### **Circuit Breakers**

- i. The circuit breakers shall be of Vacuum type.
- ii. They shall comprise of three separate, identical single pole interrupting units, operated through a common shaft by a sturdy operating mechanism. An arrangement of two breakers in parallel to meet specified current rating shall not be acceptable.
- iii. Circuit breaker shall be restrike free, stored energy operated, anti-pumping and trip free type. Motor wound closing spring charging shall be provided for each breaker, even if it has built-in mechanical anti-pumping features. During closing, main poles shall not rebound and mechanism shall not require adjustment. Suitable dampers shall be provided to withstand the impact at the end of opening stroke.

- iv. The operating mechanism shall be such that failure of any auxiliary spring shall not prevent tripping and shall not lead to closing or tripping of circuit breaker. Failure of any auxiliary spring shall also not cause damage to the circuit breaker or endanger the operator.
- v. Mechanical indicators shall be provided on the breaker trucks to indicate OPEN/ CLOSED conditions of the circuit breaker and charged/ discharge conditions of the closing spring. An operation counter of breaker shall be visible without opening the breaker compartment door.
- vi. The closing coil and spring charging motor shall operate satisfactorily at all values of control supply voltage 220VDC.
- vii. The time taken for charging of closing spring shall not exceed 30 seconds. The spring charging shall take place automatically preferably after closing operation. Breaker operation shall be independent of the spring charging motor which shall only charge the closing spring. Opening spring shall get charged automatically during closing operation. As long as power supply is available to the charging motor a continuous sequence of closing and operations shall be possible. One open-close-open operation of the circuit breaker shall be possible after failure of supply to the motor.
- viii. The Bidder may 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, pneumatic pressure etc. While furnishing the proof of the total break time of complete circuit breaker, the Bidder may specifically bring out the effect of non-simultaneity between same pole and poles and show how it is covered in the guaranteed total break time.
- ix. Bidder shall indicate the noise level of breaker at distance of 50 to 150 m from base of the breaker.
- x. The circuit breaker will normally be controlled from remote control panels through closing and shunt trip coils. The local control console of relay flush mounted on the switchgear would normally use only for testing of circuit breaker in isolated position and for tripping it in an emergency. The closing and opening of the breaker shall also be possible from laptop through front serial port of the relay to facilitate commissioning activities.
- xi. 6NO and 6NC auxiliary contacts per pole shall be provided as spare contacts.
- xii. Each panel shall have two separate limit switches, one for the service position and other for isolated position. Each of these limit switches shall have at least four (4) contacts which shall close in the respective positions.

#### **Numerical Relays and Networking**

- i. All circuit breaker feeders shall be provided with communicable numerical relays (IED, i.e. Intelligent Electronic Device) complying with IEC-61850, having protection, control, measurement and monitoring features. These relays shall be networked and suitably interfaced with the Solar SCADA system for dynamic SLD display, status monitoring, measurements, event / alarm displays, reports, etc. The relays shall be flush mounted on panel front with connections from the inside. These numerical relays shall be of types as

proven for the application and shall be subject to REIL / Customer's approval. Numerical relays shall have appropriate setting ranges, accuracy, resetting ratio and other characteristics to provide required sensitivity. All equipment's shall have necessary protections.

- ii. The numerical relay shall be capable of measuring and storing values of a wide range of quantities, events, faults and disturbance recording. The alarm/ status of each protection function and trip operation shall be communicated to solar SCADA. The numerical relays shall have built in features / hardware interface to provide such inputs to solar SCADA for analog / digital value.
- iii. All relays shall be rated for control supply voltage (AC OR DC) shall be capable of satisfactory continuous operation between 80-120% of the rated voltage.
- iv. Failure of a control supply and de-energization of a relay shall not initiate any circuit breaker operation.
- v. All numerical relays shall have freely programmable optically isolated binary inputs (BI) and potential free binary output (BO) contacts as per the requirement of control schematics. The quantities of such input / outputs shall be finalized during detailed engineering.
- vi. All the numerical relays shall have communications on two ports, local front port communication to laptop and rear port on IEC 61850 to communicate with the interface equipment for connectivity with the Solar SCADA. Latest version of hardware and Software for interfacing the numerical relays with laptop has also to be provided.
- vii. All numerical relays shall have adequate processor memory for implementing the programmable scheme logic required for the realization of the protection/control schemes in addition to the built in protection algorithms.
- viii. All numerical relays shall have features for electrical measurements including voltage, current, power (active and reactive), frequency, and power factor and energy parameters. Measurement accuracy shall be 1% of rated RMS current and voltage.
- ix. Relays shall have event recording feature, recording of abnormalities and operating parameters with time stamping. Sequence of events shall 1ms resolution at device level.
- x. All numerical relays shall have provision of both current and voltage inputs. Relays shall be suitable for both residually connected CT input as well as CBCT input. Number of CT inputs shall be adequate for protections detailed elsewhere but not less than 4 sets, 3 nos. for phase fault & 1 no. For earth fault. The Numerical relays in the Incomers shall have at least 5 CT inputs. Relays shall be suitable for CT secondary current of 1A. All transformer feeder relays shall have provision for 3 VT inputs. Relays used in incomers, ties and bus couplers shall have provision of two sets of voltage signal inputs for the purpose of synchronization.
- xi. All CT terminals on the relays shall be of fixed type suitable for connection of ring-type lugs to avoid any hazard due to loose connection leading to CT open-circuit. In no circumstances Plug In type connectors shall be used for CT / VT connections.
- xii. All numerical relay shall have key pad/ keys to allow relay settings from relay front. All hand reset relays shall have reset button on the relay front.
- xiii. Master trip (86) and non-86 trips shall be software configurable to output contacts and no separate master trip relay shall be used.

- xiv. Making, breaking and continuous capacity of the relay contacts shall be adequate enough for the circuits in which they are used.
- xv. Relays shall have self-diagnostic feature with self-check for power failure, programmable routines, memory and main CPU failures and a separate output contact for indication of any failure.
- xvi. Relays shall have at least two sets or groups of two different sets of adoptable settings. Relays shall have multiple IEC/ ANSI programmable characteristics. The numerical relay shall have the following protection functions. The protection functions shall be selectable from any of the IEC characteristic curves.
  - a) Definite time (DT) phase over current protection
  - b) Inverse Definite Minimum Time (IDMT) phase over current protection
  - c) Definite time (DT) earth fault current protection
  - d) Inverse Definite Minimum Time (IDMT) earth fault current protection
  - e) Under Voltage protection
  - f) Over Voltage protection
- xvii. Transformer feeder protection relay shall have provision for the following additional protection functions.
  - (i) Buchholz alarm & trip
  - (ii) Oil Temperature Indicator (OTI) alarm & trip
  - (iii) Winding Temperature Indicator (WTI) alarm & trip
  - (iv) Pressure Relief Valve (PRV) trip
  - (v) Magnetic Oil Gauge (MOG) alarm
- xviii. Design of the relay must be immune to any kind of electromagnetic interference. Vendor shall submit all related type test reports for the offered model along with the offer.
- xix. All cards / hardware of numerical relays shall be suitable for operation in Harsh Environmental conditions with respect to high temperature, humidity & dust.
- xx. All I/O s shall have galvanic isolation. Analog inputs shall be protected against switching surges, harmonics etc.
- xxi. Numerical relays shall have feature for Time synchronization through the SCADA System / networking. The resolution of time synchronization shall be +/- 1.0 millisecond or better throughout the entire system.
- xxii. Relays & Ethernet switches shall be suitable to accept both AC & DC supplies with range 120V or 240V with tolerance of 70 % to 120 % of rated voltage & shall be finalized during detailed engineering.
- xxiii. Disturbance Record waveforms, event records & alarms shall be stored in Non-volatile memory and failure of control supply shall not result in deletion of any of these data.
- xxiv. The numerical relay shall be provided with backlit alphanumeric LCD to access protection settings, measurement parameters, fault and event records. Read and write access to protection settings shall be password protected.

### **Bus-bars and Insulators**

- i. All bus bar and jumper connections shall be of high conductivity aluminium alloy. They shall be adequately supported on insulators to withstand electrical and mechanical stresses due to specified short circuit currents.
- ii. Bus bar cross-section shall be uniform throughout the length of switchgear. Bus bars and other high voltage connection shall be sufficiently corona free at maximum working voltage.
- iii. Contact surfaces at all joints shall be silver plated or properly cleaned and non-oxide grease applied to ensure an efficient and trouble free connection. All bolted joints shall have necessary plain and spring washers. All connection hardware shall have high corrosion resistance. Bimetallic connectors or any other technically proven method shall be used for aluminium to copper connections.
- iv. Bus bar insulators shall be of arc and track resistant, high strength, non-hygroscopic, non-combustible type and shall be suitable to withstand stresses due to over-voltages, and short circuit current. Bus bar shall be supported on the insulators such that the conductor expansion and contraction are allowed without straining the insulators.
- v. Successful Bidder shall furnish calculation establishing adequacy of bus bar sizes for the specified continuous and short time current ratings.

### **Codes and Standards**

<b>Standard/Code</b>	<b>Description</b>
IEC 62271-1	High Voltage Switchgear and Control gear - Part 1: Common Specifications
IEC 62271-100	High Voltage Switchgear and Control gear - Part 100: AC Circuit Breakers
IEC 62271-102	High Voltage Switchgear and Control gear - Part 102: AC Disconnectors and Earthing Switches
IEC 62271-200	High Voltage Switchgear and Control gear - Part 200: AC Metal Enclosed Switchgear and Control gear for Rated Voltages Above 1 kV and Up to and Including 52 kV
IEC 61869	Instrument Transformers
IS 3231	Electrical relays for power systems protection
IEC 60255	Measuring relays and protection equipment
IEC 61850	Communication networks and systems for power utility automation
IEC 61131-3	Programmable controllers - Part 3: Programming languages
IS 9385	High voltage fuses
IS 9431	Indoor post insulators of organic material for systems with nominal voltages greater than 1000 V up to and including 300KV
IEC 60099-4	Surge arresters - Part 4: Metal-oxide surge arresters without gaps for A.C. systems
IS 3070-3	Lightning Arresters for Alternating Current Systems - Part 3: Metal Oxide Lightning Arresters Without Gaps
IEC 62052-11	Electricity metering equipment (A.C.) - General

	requirements, tests and test conditions - Part 11: Metering equipment
IEC 62053	Electricity metering equipment (A.C.) – Particular requirements
IS 14697	AC Static Transformer Operated Watthour and Var-hour Meters, Class 0.2S and 0.5S

### **Technical Parameters**

<b>SYSTEM PARAMETERS</b>		
1	Nominal System voltage	33KV
2	Highest System voltage	36KV
3	Rated Frequency	50 Hz
4	Number of phases/ poles	3
5	System neutral earthing	Solidly grounded
6	One-minute power frequency withstand voltage	
	Type Test	70 KV
	Routine test	70 KV
7	1.2/50 microsecond Impulse withstand voltage	170 KV
8	Minimum system fault level	25 KA (rms)
9	Short time rating for bus bars, ckt. breakers, current transformers and switchgear assembly	25 KA for 1 sec.
10	Dynamic withstand rating	2.5 times of system fault current
11	Control supply voltage	220V DC
12	Maximum ambient air temperature	50 deg. C

### **Bus Bar**

<b>BUS BARS</b>		
1	Continuous current rating at 50 deg. C	As Per Requirement
2	Temperature Rise allowed above ambient	40 Deg. C for plain joints and 55 deg C for silver plated joints

### **Current Transformer**

<b>CURRENT TRANSFORMER</b>		
1	Secondary Current	1A
2	Class of insulation	Class E or better
3	Rated output of each	Adequate for the relays and devices connected, but not less than five (5) VA.

4	Accuracy class	
5	Protection	Class PS for Differential & REF and Core Balance CTs (CBCT); 5P20 for other protection CTs;
6	Measurement	0.2S
5	Minimum primary earth fault current to be detected by CBCT	3
6	Instrument Security factors for Measurement CTs	5
7	Number of terminals in marshalling box	All terminals of control circuits wired up to marshalling box plus 20% spare terminals

### **Circuit Breakers**

<b>CIRCUIT BREAKERS</b>		
1	The circuit breakers current rating shall be at least 800Amp which is at an ambient of 50 deg. C.	
2	Short circuit breaker current	25 kA
	A.C. component	25 kA or system requirement whichever is higher
	D.C. component	As per IS: 13118 or IEC-62271
3	Short Circuit making current	2.5 times of system fault current (peak)
4	Operating Duty	O-3 Sec.-CO-3 Min-CO
5	Total break time	Not more than 4 cycles
6	Total make time	Not more than 5 cycles
7	Operating Mechanism	Motor wound spring charged stored energy type as per IEC-62271

### **Voltage Transformers**

<b>VOLTAGE TRANSFORMERS</b>		
1	Rated voltage factor	2 continuous for all VTs
2	Class of insulation	Class E or better
3	Other parameters	BUS PT-0.5 Class, VA req. adequate for application. Line PT-0.5 Class for sync. / 3P



		for door interlocks & protection, VA req. adequate for application.
4	One Minute Power frequency withstand voltage for secondary winding	2 kV RMS
5	Number of terminals in control Cabinet	All terminals of control circuits wired up to marshalling box plus 10 terminals spare
6	Partial discharge level	10 Pico Coulombs max.

Minimum 10% spare feeders of each rating shall be provided in the switchgear subjected to minimum one feeder.

Integral Earth switch and Capacitive Voltage Indicator at rear side of the HT panel shall be incorporated.

### **Earthing**

An earth bus made of copper or aluminium shall be provided throughout the length of the panel. It shall be bolted to the framework of each panel and brazed to each breaker earthing contact bar.

The earth bus shall have sufficient cross section to carry maximum fault current without exceeding the allowable temperature rise.

All non-current carrying conductors of the panel shall be connected to the earth bus. All joints to the earth bus shall be made through at least two bolts. Hinged doors shall be earthed through flexible earthing braid of adequate cross section. Suitable provision shall be provided at each end of the earth bus for connection with Earth conductor.

Positive earthing of the breaker truck and frame shall be maintained when it is in the connected position and in all other positions whilst the auxiliary circuits are not totally disconnected.

All metallic cases of relays, instruments and other panel-mounted equipment shall be connected to earth bus by independent copper wires of size not less than 2.5 sq. mm with green colour insulation.

### **Testing and Inspection**

Type test reports as mentioned in the following clause shall be submitted for approval.

#### **Type Tests**

The switchgear panel shall be of type tested design. The following type test reports shall be submitted during detailed engineering. The tests should have been conducted on the similar equipment by NABL accredited laboratory.

<b>Test</b>	<b>Standard</b>	<b>Relevant IEC Clause</b>
<b>Switchgear Panel</b>		
Dielectric tests		

Power frequency voltage test	IEC 62271-200	6.2.6.1
Lightning impulse voltage test	IEC 62271-200	6.2.6.2
Dielectric tests on auxiliary and control circuits	IEC 62271-200	6.2.10
Measurement of the resistance of the main circuit	IEC 62271-200	6.4.1
Temperature-rise tests	IEC 62271-200	6.5
Short-time withstand current and peak withstand current tests	IEC 62271-200	6.6
Verification of the IP coding	IEC 62271-200	6.7.1
Verification of making and breaking capacities	IEC 62271-200	6.101
Mechanical operation test	IEC 62271-200	6.102
Internal arc test	IEC 62271-200	6.106
<b>Circuit Breaker</b>		
Mechanical operation test at ambient air temperature (M2 Class)	IEC 62271-100	6.101.2
Basic short-circuit test duties	IEC 62271-100	6.106
<b>Relays</b>		
Vibration tests	IEC 60255-21-1	
Shock and bump tests	IEC 60255-21-2	
Seismic tests	IEC 60255-21-3	
Electromagnetic compatibility requirements	IEC 60255-26	
Product safety requirements	IEC 60255-27	
Common requirements	IEC 60255-1	
Functional requirements	Relevant parts of IEC 60255-100 series	
Communication requirements	IEC 61850	
<b>Current Transformers</b>		
Temperature-rise test	IEC 61869-2	7.2.2
Impulse voltage withstand test on primary terminals	IEC 61869-2	7.2.3
Tests for accuracy	IEC 61869-2	7.2.6
Short-time current tests	IEC 61869-2	7.2.201
<b>Voltage Transformer</b>		
Temperature-rise test	IEC 61869-3	7.2.2
Impulse voltage withstand test on primary terminals	IEC 61869-3	7.2.3
Electromagnetic Compatibility tests	IEC 61869-3	7.2.
Test for accuracy	IEC 61869-3	7.2.5
Short-circuit withstand capability test	IEC 61869-3	7.2.301

In case the contractor is not able to submit the test reports during detailed engineering, the contractor shall submit the reports of type/special tests either conducted by NABL accredited laboratory or witnessed by REIL / Customer.

#### **Routine Tests**

All acceptance and routine tests as per the specification and relevant standards IEC 62271-200 & IEC 62271-100 shall be carried out. Charges for these shall be deemed included in the equipment price.

### **Commissioning Checks/Test:**

After installation of panels, power and Control wiring and connections, Contractor shall perform commissioning checks as listed below to verify proper operation of switchgear / panels and correctness of all equipment in all respects. In addition, the Contractor shall carry out all other checks and tests recommended by the manufacturers.

### **General**

- i. Check nameplate details according to specification.
- ii. Check for physical damage
- iii. Check tightness of all bolts, clamps and connecting terminals
- iv. Check earth connections.
- v. Check cleanliness of insulators and bushings
- vi. Check heaters are provided
- vii. H.V. test on complete switchboard with CT & breaker in position.
- viii. Check all moving parts are properly lubricated.
- ix. Check for alignment of bus bars with the insulators to ensure alignment and fitness of insulators.
- x. Check for interchangeability of breakers.
- xi. Check continuity and IR value of space heater.
- xii. Check earth continuity for the complete switchgear board.
- xiii. Circuit Breakers**
- xiv. Check electrical and mechanical interlocks provided.
- xv. Checks on spring charging motor, correct operation of limit switches and time of charging
- xvi. All functional checks**
- xvii. Current Transformers
- xviii. IR Value between windings and winding terminals to body.
- xix. Polarity tests.
- xx. Ratio identification checking of all ratios on all cores by primary Injection of current.
- xxi. Magnetization characteristics & secondary winding resistance.
- xxii. Spare CT cores, if any to be shorted and earthed.
- xxiii. Voltage Transformers**
- xxiv. Insulation resistance test.
- xxv. Ratio test on all cores.
- xxvi. Polarity test**
- xxvii. Line connections as per connection diagram.

- xxviii. Cubicle Wiring
- xxix. Check all switch developments.
- xxx. It should be made sure that the wiring is as per relevant drawings.
- xxxi. All interconnections between panels shall similarly be checked.
- xxxii. All the wires shall be checked for IR value to earth.
- xxxiii. Functional checking of all control circuit e.g. closing, tripping interlock, supervision and alarm circuit including proper functioning of component / equipment.
- xxxiv. Check terminations and connections.
- xxxv. Wire ducting.

### **Measuring Instruments**

All the measuring instruments shall be digital, flush mounting type with communication Facility.

All feeders shall be provided with digital Multi-Function Meter (MFM). ABT/Tri Vector Meter (TVM) shall be provided for the solar incomer feeder at 33KV. The accuracy class of MFM shall be 0.5 and that of ABT/TVM shall be 0.2S.

Measuring instruments shall have provision to display the following parameters.

- (i) Line and phase voltages
- (ii) Line and phase currents
- (iii) Active power, Reactive power, Apparent power
- (iv) Frequency
- (v) Power factor
- (vi) Total Harmonic Distortion (THD)

### **Warranty**

The HT panel unit shall be warranted for minimum of 5 (five) years against all material/ manufacturing defects and workmanship.

### **Approval**

Documents/Drawings

- i. Guaranteed Technical Particular (GTP) Datasheet.
- ii. General Arrangement (GA) Drawing and Foundation details
- iii. Schematic diagram
- iv. Bus bar sizing calculation
- v. Bill of Materials
- vi. Quality Assurance Plan (QAP)

6. **Compact Sub-Station (CSS)**

**Standards and Codes**

Compact Sub-Station (CSS) shall comply with the latest edition of the following standard including amendments.

Standard/Code	Description
IEC 62271-202	High-voltage/ low-voltage prefabricated substation

**Design Criteria**

Compact Sub-Station shall consist of 800KVA, PCU output voltage/33 KV, ONAN inverter duty transformer, and 33KV SF6 insulated/VCB breaker panel.LT switchgear of suitable voltage in compliance with inverter maximum output voltage with all accessories, interconnections, fittings and auxiliary equipment. The Contractor may propose to keep PCU also inside the CSS. The complete unit shall be installed on a substation plinth (base) as Outdoor substation.

The pre-fabricated compact substation shall be designed for

- (a) Compactness
- (b) Fast installation
- (c) Maintenance free operation
- (d) Safety for operator & public.

For continuous operation at specified ratings, temperature rise of the all the components of CSS shall be limited to permissible values stipulated in the relevant standard and / or this specification.

**Service Conditions**

The Package substation shall be suitable for continuous operation under the basic service conditions indicated below.

- i) Ambient Temperature 50°C
- ii) Relative Humidity Up to 95%
- iii) Altitude Up to 1000 m

**Construction**

The CSS shall have separate compartments for transformer, RMU and LT switchgear with suitable safety barriers. Each compartment shall be provided with doors and pad locking arrangement. All doors shall have proper interlocks for safety of the operator.

High Voltage terminals of the transformer shall be connected to switchgear using Aluminium cable/flexible bus-bar.

The CSS Enclosure shall be made of sheet steel tropicalized to local weather conditions.

Degree of protection of the enclosure shall be NEMA 4X or IP 66 for HT & LT switchgear compartment and NEMA 3 (or IP 54) for transformer compartment.

The Enclosure shall be painted with the colour approved by the REIL / Customer. The paint shall be carefully selected to withstand tropical heat, rain and salt mist. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.

All enclosures/metal frames of CSS, transformer, RMU and LT switchgear shall be properly earthed. The continuity of the earth system shall be ensured taking into account the thermal and mechanical stress caused by the current it may have to carry.

Adequate ventilation arrangement shall be provided for natural ventilation of the CSS. Internal lighting with door operated switch shall be provided for each compartment separately.

The CSS shall contain all safety accessories like voltage detection rod, fire extinguishers, gloves etc.

Danger Boards, Safety notices, manufacturer's operating instructions etc shall be durable and clearly legible.

The CSS shall be completely assembled at factory. No site assembly is allowed.

### **Warranty**

The Compact Sub-station shall be warranted for minimum of 5 (five) years against all material/ manufacturing defects and workmanship.

### **Test Certificates/Reports**

Type test reports as mentioned in the following clause shall be submitted for approval.

### **Type Tests**

The CSS shall be of type tested design. Type test reports as per IEC 62271-202 shall be submitted during detailed engineering. The tests should have been conducted on the similar equipment by NABL accredited laboratory.

In case the contractor is not able to submit the test reports during detailed engineering, the contractor shall submit the reports of type/special tests either conducted by NABL accredited laboratory or witnessed by REIL / Customer.

### **Routine Tests**

Routine tests and acceptance tests shall be as per the Quality Assurance Plan (QAP) approved by the REIL / Customer.

## **7. AC CABLES**

Standards and Codes

All AC Cables shall conform to the following standards and codes.

IS 7098	Cross linked polyethylene insulated PVC sheathed cables, Part 1: For working voltage up to and including 1100 V
IS 7098	Cross linked Polyethylene Insulated Thermoplastics Sheathed Cables Part 2:for Working Voltages from 3.3 kV up to and Including 33 kV

The minimum size of cable based on 33 kV voltage level power application shall be 3CX150Sqmm.

All AC cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses develop under steady state and transient