**SECTION B – External Electrification Works**

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**SECTION B– External Electrification Works**

# TECHNICAL SPECIFICATIONS

# TECHNICAL SPECIFICATIONS

# 33/66 KV HT POWER SUPPLY SYSTEM- RMU PANEL:-

**1 SCOPE OF SUPPLY**

This specification covers design, manufacture, shop testing, inspection, packing, delivery to site, erection, testing and commissioning of Metal Enclosed, panel type, extensible Outdoor SF6 RING MAIN UNIT (RMU) fully type tested according to IEC 62271-200 standards. The contractor to coordinate and plan with State Electricity Board regarding the supply source of the HT power and its feasibility inside the site area.

The RMU should be complete with all components necessary for its effective and trouble free operation along with associated equipment etc. such components should be deemed to be within the scope of Contractor.

The design of the switchgear should be exclusive and specific responsibility of Contractor and should be comply with current good engineering practice, the relevant codes and recommendation, the project specific requirements.

The RMU should be fixed type SF-6 insulated, vacuum circuit breakers with O/C & E/F relay for the protection of the transformer. It should be maintenance free equipment, having stainless steel robotically welded enclosure.

# STANDARDS AND REFERENCE DOCUMENTS

1. **Codes and Standards**

The RING MAIN UNIT (RMU) should be designed, manufactured and tested according to the latest version of:

IEC 60694 Common specifications for high-voltage switchgear and control gear standards.

IEC 62271-200 : A.C metal-enclosed switchgear and control gear for rated voltages above 1KV and up to and including 72KV and the IEC Codes herein referred.

IEC 62271-102: Alternating current disconnectors (isolators) and earthing switches

IEC 60529 : Classification of degrees of protection provided by enclosures

IEC 60265 High-voltage switches-Part 1: Switches for rated voltages above 1kV and less than 52 kV

IEC 60056 : Circuit breakers

IEC 62271-105 High-voltage alternating current switch-fuse combinations

IEC 60185 Current transformers

IEC 60186 Voltage transformers

IEC 60255 Electrical relays

Any other codes recognized in the country of origin of equipment might be considered provided that they fully comply with IEC standards.

The design of the switchgear should be based on safety to personnel and equipment during operation and maintenance, reliability of service, ease of maintenance, mechanical protection of equipment, interchangeability of equipment and ready addition of future loads.

# SF6 Insulated Compact Ring Main Unit (RMU)

Offered 33/66/132 KV SF6 Outdoor, Extensible, Ring Main Unit (RMU), should comprise of 630A Load break Switches & 630 A Vacuum “T” OFF Circuit Breaker with (3 O/C & 1E/F) Relays. Various combinations of Load break switch and VCB shall be possible to configure the switchboards as per the site requirements. Maximum four functional units (cable switch/ VCB) can be accommodated in one single tank so as to make it more compact and reliable.

**(A) Load break switch (630A)**

Load break switch should have the following:-

* Manually operated 33 KV, 630A Load Break switch shall be a two-positioning Load Break puffer switch using SF-6 gas as an arc quenching medium and separate Earthing Switch with making capacity.
* “Live Cable” LED Indicators through Capacitor Voltage Dividers mounted on the bushings
* Mechanical ON/OFF/EARTH Indication
* Anti-reflex operating handle
* Cable Testing facility inside cable boxes without disconnecting the Cable terminations
* Cable boxes suitable for 1 X 3C x 300 sq mm XLPE Cable with right angle Cable Termination Protectors.
* Cable boxes should be Arc Proof and interlocked with respective Earthing Switches. For safety of operator it should not be possible to open the cable box unless the earth Switch is ON.

**(B) Circuit Breaker (630A)**

Circuit Breaker should have the following:

* Manually operated 630 Amp Vacuum circuit breaker with auto reclosing duty and rated operating sequence of O - 0,3s - CO - 15s – CO.
* Two position operating mechanism for series downstream disconnector and earth switch.
* Mechanical ON/OFF/EARTH/SPRING CHAGRE Indication
* Operation Counter
* Integrated operating handle fixed with breaker
* “Live Cable” LED Indicators thru Capacitor Voltage Dividers mounted on the bushings.
* 3O/C + 1E/F self powered relay with Low and High set for Over current and Earth Fault with ring core CT on cables.
* Cable boxes suitable for 1 X 3C x 300 sq mm XLPE Cable with right angle Cable Termination protectors
* Cable boxes should be Arc Proof and interlocked with respective Earthing Switches. For safety of operator it should not be possible to open the cable box unless the earth Switch is ON.

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# GENERAL TECHNICAL REQUIREMENTS

1. **Service Conditions**

* The Ring Main unit shall be suitable for operations at a height of 1000 meters above sea level, IEC 60120.
* The RMU shall be capable of operating normally within the following temperature ranges:
  + Maximum air temperature : +45 deg C
  + Maximum value for 24 Hr mean : +35 deg C
  + Minimum air temperature : - 25 deg C
    - The Compact switchgear shall be capable of being exposed to high relative humidity (max 95%) and ambient air pollution.
    - The Compact switchgear shall be capable of being operated in electrically exposed locations.

1. **Design Parameters**

***4.2.1 Ring Main Unit, Electrical data***

|  |  |  |
| --- | --- | --- |
| ***Rated Voltage*** | **KV** | ***36KV*** |
| *Power Frequency Withstand Voltage*  *- Across Disconnector* | *KV* | *70*  *80* |
| *Impulse Withstand Voltage*  *- Across Disconnector* | *KV* | *170*  *195* |
| *Rated Frequency* | *Hz* | *50* |
| *Rated Current Busbars* | *A* | *630* |
| *Rated Current (Cable Switch)* | *A* | *630* |
| *Rated Current (Vacuum Circuit Breaker)* | *A* | *630* |
| ***Breaking Capacities:*** |  |  |
| *Active Load* | *A* | *630* |
| *Closed Loop (Cable Switch)* | *A* | *630* |
| *Off Load Cable Charging (Cable switch)* | *A* | *20* |
| *Earth Fault (Cable Switch)* | *A* | *60* |
| *Earth Fault Cable Charging (Cable Switch)* | *A* | *35* |
| *Short Circuit Breaking Current (Vacuum Circuit Breaker)* | *KA* | *25* |
| *Rated Making Capacity* | *kA* | *50* |
| *Rated Short Time Current 1 Sec* | *kA* | *25* |

***4.2.2 General data, enclosure and dimensions***

|  |  |
| --- | --- |
| *Standard to which Switchgear complies* | *IEC* |
| *Type of Ring Main Unit* | *Metal Enclosed, Panel type, Compact Module.* |
| *Number of phases* | *3* |
| *Whether RMU is type tested* | *Yes* |
| *Whether facility is provided with pressure relief* | *Yes* |
| *Insulating gas* | *SF6* |
| *Nominal operating gas pressure* | *1.4 bar abs. 20° C* |
| *Gas leakage rate / annum %* | *<0.1 % per annum* |
| *Expected operating lifetime* | *30 years* |
| *Whether facilities provided for gas monitoring* | *Yes, temperature compensated manometer* |
| *Material used in tank construction* | *Stainless steel sheet, 2 mm* |

***No Operations, degree of protection and colours***

|  |  |
| --- | --- |
| *Means of switch operation* | *separate handle* |
| *Means circuit breaker operation* | *handle and push buttons* |
| *Rated operating sequence of Circuit Breaker* | *O – 0.3s – CO – 15s – CO* |
| *Total opening time of Circuit Breaker* | *approx. 40-80ms* |
| *Closing time of Circuit Breaker* | *approx. 40-70ms* |
| *Mechanical Endurance class of Switch & Circuit Breaker* | *M1* |
| *Electrical Endurance Class:*  *Vacuum Circuit Breaker*  *Load Break Switch*  *Earth Switch* | *E1*  *E3*  *E2* |
| *Principle Switch Disconnector* | *2 position puffer switch* |

***Degree of protection:***

|  |  |
| --- | --- |
| *High Voltage live parts,* | *SF6 tank IP 67* |
| *Front cover mechanism* | *IP 2X* |
| *Cable covers* | *IP 3X* |

***Colours:***

|  |  |
| --- | --- |
| *Front cover* | *RAL 7035* |
| *Side and cable cover* | *RAL 7035* |
| *Enclosure* | *Dark Admiral Grey* |

1. **General Structural and Mechanical Construction**

The offered RMU should be of the fully arc proof metal enclosed, free standing, floor mounting, flush fronted type, consisting of modules assembled into one or more units. Each unit is made of a robotically welded sealed-for life stainless steel tank of thickness not less than 2 mm filled with SF6, containing all high voltage components sealed off from the environment with Ingress protection IP67. The enclosure should meet the ‘sealed pressure system’ criterion in accordance with IEC 62271-200 standard (i.e. a system for which no handling of gas is required throughout the 30 years of service life), so that no refilling of gas is required. In addition, manufacturer shall confirm that maximum leakage rate is lower than 0.1% per year. All SF6 enclosures have to pass the leakage test with Helium, before being gas filled with SF6. Due to the characteristics of Helium this test will detect any leakage. The overall design of the switchgear should be such that front access only is required. It should be possible to erect the switchboard against a substation wall, with HV and LV cables being terminated and accessible from the front.

RMU must have a pressure relief device at the bottom of the stainless steel housing to ensure that in the rare case of an internal arc, the high pressure caused by the arc will be released and the hot gases are allowed to be exhausted out at the bottom of the cubicle towards back side to ensure complete safety to the operator. A controlled direction of flow of the hot gas should be achieved.

1. **DIELECTRIC MEDIUM**

SF6 gas shall be used for the dielectric medium for 33/66KV RMU’s in accordance with IEC376. It is preferable to fit an absorption material in the tank to absorb the moisture from the SF6 gas and to regenerate the SF6 gas following arc interruption. The SF6 insulating medium shall be constantly monitored via a temperature compensating gas pressure indicator offering a simple go, no-go indication. Maximum gas pressure shall be 1.4 bar absolute.

1. **Load Break Switch (630 Amp cable feeder)**

It should consist of an SF6 cubicle housing a switch disconnector and an earthing switch. Bus bars and all electrical connections are located inside the tank. The switch positions are closed – open – earthed. The operating shafts for the switches should be have rotary seals where they enter the SF6 cubicle. The operating mechanisms should be located outside on the front of the SF6 tank. Cable bushings should be located on the front of the SF6 cubicle in a separate cable compartment. Front covers containing the mimic diagram and having a degree of protection IP2XC close the fronts.

1. **Circuit Breakers (630 Amp Transformer feeder)**

The 630Amp T-off circuit breaker module should consist of an SF6 cubicle housing a fixed type vacuum circuit breaker and a series disconnector &earthing switch. An integrated relay and related CTs is used for tripping of the circuit breaker. Bus bars and all electrical connections should be located inside the tank. The operating shafts for the switch disconnector should have rotary seals where they enter the SF6 cubicle. The operating mechanisms are located outside on the front of the SF6 tank. Bolted type cable bushings should be located on the front of the SF6 cubicle in a separate cable compartment. Front covers containing the mimic diagram having a degree of protection IP2XC seal off the fronts.

Vacuum bottles should be use as interrupters of the currents. The make of vacuum bottles should be same as that of RMU. The circuit breaker main circuit should be connected in series with a three-position disconnector –earthing switch. The operation between circuit breaker and disconnector earthing must be interlocked. VCB shall use a self powered relay with low burden trip coil. Relay shall draw the required energy from ring core CTs mounted on cables in the cable compartment.

1. **Earthing of the Main Circuit**

Each disconnector/VCB shall be provided with an integral earth switch. Earthing switches should be rated equal to the switchgear rating. Earthing switches should be quick make type capable of making Rated Fault Current. Earthing switch should be operated from the front of the cubicle by means of a removable handle. The earthing switch can be closed only when the disconnector is open. Mechanical interlocking systems shall prevent all operator errors such as closing the earth switch when switch is closed. The HT cables are terminated in the dedicated cable compartment. At the bottom of the cable compartment, an earthing bar system made of copper with a minimum cross section of 120 sqmmshould be fitted.

1. **Operating Mechanisms & Interlocking**

All mechanisms should be situated in the mechanism compartment outside the SF6-tank and behind the front covers with degree of protection of IP2X. This gives the opportunity of easy access to all operating mechanisms if retrofit or service should be required. The speed of operation of these mechanisms is independent of how fast the handle is operated. All units shall be equipped with interlocked cable covers. This will prevent access to the cable compartment before earthing switch is in closed position. It will also be impossible to operate switch disconnector to closed position before cable compartment cover is put back in place.

Each switch mechanism is equipped with a padlocking device. When adding a padlock to this device, the access to operate the mechanism will be prevented. This device has three holes with diameter 9 millimeter. All operating mechanisms are equipped with true position indicators for all switches. In order to safeguard true indication, indicators are directly connected to the operating shafts of the switches inside the SF6 tank. Operating handle shall have an anti-reflex system which prevents an immediate re-operation of the switch.

In rare case of mechanism failure, it shall be possible to replace the same at site without requiring SF6 gas refilling.

1. **Load Break Switch Mechanism**

The mechanism shall have two operating shafts; the upper one for the load break switch and the lower one for the earthing switch. Both shafts are single spring operated and are directly connected to the switches inside the SF6 enclosure.

Due to the mechanical interlock between the upper and the lower operating shaft, it is impossible to operate the load break switch when the earthing switch is in earthed position or to operate the earthing switch when the load break switch is in closed position.

1. **Breaker Mechanism**

This module has two mechanisms; the upper one is for circuit-breaker and the lower one with two operating shafts is for disconnector and earthing switch.

The breaker mechanism can be charged by motor or manually by the integrated charging lever. The vacuum circuit-breaker has the possibility of rapid auto-reclosing duty. By means of mechanical push buttons it is possible to close and open the circuit breaker. The opening spring is always charged when the circuit-breaker is in closed position and will be ready to open immediately if the protection relay gives a trip signal. If the mechanism is recharged after closing, it is possible to perform open - close - open sequence.

The lower mechanism is identical to the load break switch module. There is a mechanical interlock between these two mechanisms which prevents operation of the disconnector and the earthing switch when the circuit-breaker is in closed position. When the earthing switch is in closed position it is impossible to operate the disconnector, but the circuit-breaker can be closed for testing purposes.

1. **Busbars**

Comprising the 3 single phases copper bus bars and the connections to the switch or circuit breaker. The bus bar should be integrated in the cubicle Bus bars should be rated to withstand all dynamic and thermal stresses for the full length of the switchgear.

1. **Front Covers**

Upper and lower front covers shall be manufactured with 2 millimeter Aluzinc and covered with a polycarbonate foil. These foils contain the mimic diagram of the main circuit with the position indicators for the switching devices. Background colour for these foils is grey RAL 7035, which makes the black single line diagram to stand out for easy optical reading of position indicators. Both the upper and lower front covers are removable. The voltage indicators are situated on the front panels.

1. **Position Indicators**

The position indicators shall be visible through the front cover and must be directly linked to the operating shaft of the switching devices. The operator shall be able to confirm the closing of earth switch. Same can be accomplished either by providing a viewing window for earth switch or by means of true position indication duly type tested as per IEC 62271-102 sub clause A.6.105 to verify proper functioning of position indicating device.

1. **Voltage Indicators**

The voltage indicators are situated on the front cover, one for each module, and indicate the voltage condition of each incoming cable. Identification of the phases is achieved with labels L1, L2 and L3 on the front of the voltage indicators. The voltage indicator satisfies the requirements of IEC61243.

1. **Cable Compartment**

It should be possible to terminate up to a 1x 3c x300 sqmm core HV cables in each cable compartment. The cable compartments should be in front and cable entry shall be from bottom. The access to the compartment will be possible by removing the cable cover only when earth switch is ON. Cable Compartments should be Arc Proof and interlocked with respective Earth Switches. Each module has a separate cable compartment that is segregated from each other by means of a partition wall. A partition wall should be fitted to divide the cable compartment from the rear side of the switchgear. In case of an arc inside the tank, followed by the opening of the pressure relief, the partition wall prevents the hot gases flowing out from the pressure relief to enter the cable compartments. All covers are removable. It should be possible to perform cable testing inside the cable boxes without disconnecting the cables.

1. **Current Transformer**

All current transformers should be complying with IEC 60185.

Current transformers should be of ring core, dry type, with ratings and ratios as required. Cable current transformers used in circuit breaker modules should be maximum 100mm wide and shall have sufficient VA burden for operation of self powered relays and low energy trip coil. Current transformers shall be placed in the cable covers so that it can be easily replaced at site without removing the bushings.

1. **Auxiliaries**

The switchgear should be prepared for options like motor operation, auxiliary contacts and short-circuit indicators. Necessary terminal blocks and wiring etc. should be placed behind the front cover or in LV box of each module.

1. **Fault Passage Indicators**

These shall facilitate quick detection of faulty section of line. The fault indication may be on the basis of monitoring fault current flow through the device. The unit should be self-contained requiring no auxiliary power supply. The FPI shall be integral part of RMU to avoid thefts. The FPI shall have clear display, automatic reset facility and shall be SCADA compatible.

1. **Retrofit**

Units shall be fully SCADA compatible. Retrofitting/motorization at site shall be possible at a later date for cable switches as well as T- OFF circuit Breaker to enable remote operation and monitoring.

# Manufacturing Facility

The manufacturer shall ensure workmanship of high quality. There shall be adequate machinery tools and tackles such that the product shall meet the internationally accepted standards. Facility should be certified for ISO 9001, 14001 and OHSAS 18001.The manufacturing facility shall be equipped with the following:

* Robotic welding station for stainless steel main tank, ensuring a leak rate of less than 0.1% per year.
* Work benches with pneumatic adjustable work benches and torques wrenches, giving flexibility to workmen for proper tightness of internal components of sealed tank.
* State of the art fully automatic gas filling and leakage testing machine for ensuring the quality of sealing and have precision to measure leak rate less than 0.1% per year.
* High voltage testing station to have high voltage power frequency test and partial discharge measurement.
* Computerized system to measure time travel characteristic of breaker before sealing the tank.

# TESTING AND CERTIFICATION.

**6.1 Type Tests.**

Units should be type tested in accordance with IEC standards 60056, 62271-102, 60265,

62271-200, 62271-105,60529 and 60694.

**6.2 Routine tests**

Routine tests should be carried out in accordance with IEC 62271-200 standards. These tests should be ensure the reliability of the unit.

1. **DOCUMENTATION**

An instruction manual should be provided with necessary information for receiving, handling, storage, installation, operation and maintenance.

Routine test certificate should be follow each unit, and standard schematic drawings should be delivered for Ring Main Units. Compact Switchgear should be have drawings that consist of system single line drawings, general arrangement and schematic drawings for order specific units.

All drawings shall confirm to International Standards Organization (ISO) “A” series of drawing sheets/Indian Standards Specification IS : 11065. All dimensions and data shall be in ink and suitable for microfilming. All dimensions and data shall be in S.I. Units.

# List of drawings and Documents

The Contractor shall furnish four sets of relevant descriptive and illustrative published literature, pamphlets and the drawings for preliminary study along with offer.

* General outline drawings showing dimensions and shipping weights, quantity of Insulating media.
* Sectional views showing the general constructional features of the circuit breaker
* Including operating mechanism, arcing chambers, and contacts with lifting dimensions for maintenance.
* Drawings showing control cabinets and circuit diagrams for operating mechanism.
* Schematic diagrams of breaker offered for control and supervision
* Structural drawings for support structures.
* Foundation plan and loading data and foundation design.
* Drawings showing the complete operation cycle of the Ring Main Unitwith description.

1. **TRAINING**

Installation of the switchgear should be required no special tools. Optional product training should be available at the manufacturer’s facility.

# 

# 33 kV HT Panel - GIS SWITCHGEAR

This specification describes a type-tested, metal-enclosed and gas-insulated medium voltage switchgear system for indoor installation. The technical data and the design necessary for this project can be found in the following description and the single line diagram.

The switchgear system is to be designed in accordance with IEC 62271-200 as follows

- Partition class PM

- Loss of service continuity category LSC2

The Contractor is to demonstrate certification of the manufacturing works to IEC ISO 9001 and IEC IS0 14001 on the introduction and application of a quality and environmental management system, and to attach copies of the certificate(s) to the submittal.

Routine tests are to be performed on the medium voltage switchgear system and the main switching devices at the manufacturing works in accordance with IEC 62271-200, and evidence provided in the form of test records. They are to be an integral part of the final (as-built) documentation.

1. **Standards and codes**

The delivery must comply with at least the following technical standards and codes:

|  |  |
| --- | --- |
| 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 60044-1 | Instrument transformers – Part 1: Current transformers |
| IEC 60044-2 | Instrument transformers – Part 2: Inductive voltage transformers |
| IEC 60529 | Degrees of protection provided by enclosures (IP code) |
| IEC 60694 | High-voltage switchgear and control gear: Common specifications |
| IEC 62271-100 | High-voltage switchgear and control gear – Part 100: Alternating current circuit-breakers |
| IEC 61243-5 | Live working – Voltage detectors – Part 5: Voltage detecting systems (VDS) |
| BGV A3 | Accident prevention regulations: Electrical systems and equipment |

1. **Specification of the switchgear system**

2.1 Design criteria

|  |  |
| --- | --- |
| Rated voltage | 36 kV |
| Operating voltage | 33 kV |
| Rated power frequency withstand voltage | 70 kVrms |
| Rated lightning impulse withstand voltage | 170 kVpeak |
| Rated frequency | 50 Hz |
| Rated current of busbar | 1250 A |
| Rated current of incoming feeder panel  (with circuit-breaker) | 1250 A |
| Rated current of transformer feeder panel  (with circuit-breaker) | 1250 A |
| Rated current of outgoing feeder panel  (with fuse switch-disconnector) | 1250 A |
| Rated current for sectionalizer panel and riser panel  each with integrated busbar measurement | 1250 A |
| Rated short-time current, 3 s | 31.5 kA |
| Rated peak withstand current | 78.75 kA |
| Rated short-circuit breaking current CB, 3 s | 31.5 kA |
| Rated short-circuit making current CB | 78.75 kA |
| Rated operating sequence O – 0.3 s - CO - 3 min - CO | Yes |
| Resistance to internal arc faults, 1 sec. | 31.5 kA |
| Insulating gas | SF6 |
| Paint colour, RAL | 7035 |
| Panel width for panels with rated current ≤ 1250A max. | 600 mm |
| Panel depth, max.: | 1400 mm |
| Panel height, max.: | 2400 mm |
| Uniform height of cable terminations | Yes |
| Height of cable terminations in all panel variants | > 650 mm |
| Side by side installation of panels without gas work at site | Yes |
| Gas extraction and topping up device for maintenance | Yes |
| Tool-related accessibility of all high voltage components ensured. Reparability | Yes |
| Auxiliary power supply | 110V DC |

2.2 Service conditions

Design for indoor installation to IEC 62271-1, VDE 0670 Part 1000 with the following minimum values:

|  |  |  |
| --- | --- | --- |
| Ambient temperature, max. | °C | 45 |
| Maximum 24h average | °C | 35 |
| Ambient temperature, min. | °C | - 5 |
| Site altitude above sea level, max. | M | 1000 |

According to the standard, the ambient air must not be significantly contaminated by dust, smoke, corrosive or flammable gases or salts.

2.3 Internal arc fault testing

The behavior in the case of internal arc faults is to be demonstrated by tests. The test must comply with IEC 62271-200 (VDE 0671 Part 200). The required internal arc classification (IAC) is **AFLR**

- A = Accessibility A – for authorized personnel only

- F = Front

- L = Lateral

- R = Rear

2.4 System design

The requirement is for a factory-assembled, type-tested, gas-insulated and metal-enclosed single busbar switchgear system for 36 kV for indoor installation, in which the circuit-breakers and three position switch-disconnectors are located in a three-phase, common gas compartment partitioned panel by panel. Cable connection is effected via an outer cone system appropriate to the current level with access from the front.

The system must be equally suitable for remote and/or local operation.

The switchgear system is to be designed in accordance with VDE0671 Part 200 as follows:

- Partition class PM

- Loss of service continuity category LSC2.

Each gas-filled panel module must be individually assembled and transported. Connection of several panels to form a single gas compartment or gas block is not permissible.

The structure of the switchgear system must ensure optimum availability and reliability. Furthermore, reliable protection for the operators must be ensured.

The system must provide service personnel with the opportunity at site to open gas compartments and replace the individual high voltage components if necessary.

The switchgear system must be suitable for free-standing installation.

The system structure must permit subsequent extension without opening a gas compartment. The switchgear system is to be extendable at both ends.

2.5 Enclosures and compartments

2.5.1 Gas compartment technology

The gas compartments must be three-phase enclosed as a sealed pressure system to IEC62271-1, VDE 0670 Part 1000.

Bushings and sockets which are installed gas-tight in the external walls of the gas tanks are to be easy to replace, e.g. in the case of damage.

Each gas compartment is to be permanently monitored by a temperature-compensated pressure sensor (density sensor). As soon as the pressure falls below the minimum operating pressure, the gas loss must be indicated by an alarm signal.

There must be an opportunity to top up the system to operating pressure in the case of loss of gas, so as to ensure that operation is maintained and scheduled repairs can be performed at site without having to shut the system down.

2.5.2 Degrees of protection

At least the following degrees of protection are to be maintained to protect persons from contact with hazardous parts and against the ingress of foreign objects:

|  |  |  |
| --- | --- | --- |
| -Degree of protection of the system to IEC 62271-200  - Live high voltage parts  - Mechanical operator control area  - Low voltage compartment |  | IP4X  IP65 IP3X IP3X |

All low voltage switching devices and components, miniature circuit-breakers, relays, modular terminals, cables and wiring etc. installed must comply with the relevant DIN VDE and/or IEC standards.

2.5.3 Operating mechanisms and interlocks

The circuit-breakers are to be equipped with stored-energy spring mechanisms with charging motors. Only permanently installed circuit-breakers with vacuum interrupters in the form of three-phase switching devices are permissible. The operating mechanism must be located outside the gas compartment and should be replaceable. Furthermore, the complete circuit-breaker, i.e. the poles in the gas compartment and the operating mechanism outside, must be jointly replaceable as a unit located on a mounting plate.

The disconnector to be used shall be a three position disconnector as a combined disconnector / earthing switch, so that simultaneous switch positions for connecting and earthing are precluded.

Earthing is to take place via the circuit-breaker, with the three position disconnector preparing the connection to earth off-circuit. Earthing proper is to be performed by the circuit-breaker. It must not be possible to switch directly between the DISCONNECTING and EARTHING functions or back. Operation of the three position disconnector may only be possible when the circuit-breaker is open. Operation of the circuit-breaker must only be possible when the three position disconnector is in the relevant defined limit position.

2.6 Panels

2.6.1 General description

The panels are to be designed in accordance with IEC 62271-200 as follows:

- Partition class PM

- Loss of service continuity category LSC2

* Internal Arc proof (IAC 1 sec)

The panels are to be enclosed on all sides, including the cable termination compartment, and are to consist of the following compartments:

* Core module (SF6) for the switching devices
* Busbar, solid-insulated
* Cable termination compartment with cable fastenings
* Operating mechanism bay with all mechanisms
* Removable low voltage compartment to accommodate the multifunctional protection and control units, and miniature circuit-breakers, auxiliary contactors and terminals.

Each gas compartment must be equipped with a filler/extraction valve for extraction of the SF6 from the system at site at the end of its service life.

Each compartment must have its own pressure relief system which safely responds to internal faults and extensively prevents any permanent deformation of the compartments. Gases emerging from the core module (SF6) and the cable termination compartment are to be channelled to the rear and discharged into the switchgear room. Pressure relief into the false floor cavity or cable basement is not permissible.

It must in general be possible to convert a busbar which was designed for 1250A to 2000A in the course of an extension of the switchgear system, by replacing components of the busbar only. The gas compartments of the existing panels are not to be affected.

Each core module is to be tested at the works as a unit, filled with insulating gas and prepared for transport as an individual unit. Gas work at site is not permissible.

The switchgear system is to be designed in such a way that an individual panel can be removed from the row of panels without any gas work.

The completely installed switchgear system is to be closed off at both ends with end covers.

Extension of the switchgear system at both ends must be possible.

2.6.2 Core module (SF6) with corresponding switching devices

The SF6 -insulated core module for each panel shall consist of the following:

* Sealed stainless steel tank
* Tee-off bars in copper
* Bushings to the busbars outside the core module
* Three position disconnector inside and manual operating mechanism outside the gas compartment
* Vacuum circuit-breaker with poles inside the gas compartment and stored-energy spring mechanism with charging motor and manual charging mechanism outside the gas compartment
* Or three position switch-disconnector with fuse box
* 1 set outer cone sockets
* Pressure relief device
* Filler/extraction valve
* Temperature-compensated pressure sensor

The outgoing side of the switch is to be routed via gas-tight bolted bushings of the outer cone type into the cable termination compartment in such a way that standardized cable plugs can be used.

2.6.3 Busbars outside the gas compartment

The busbar system is to consist of silicone rubber-insulated copper bars and adapters, forming a high dielectric strength current connection from panel bushing to panel bushing above the core modules with touch-proof insulation.

It must be possible to perform busbar measurements, i.e. current and voltage detection, at freely selectable positions directly on the busbar system.

2.6.4 Cable termination compartment

The cable termination compartment is to be equipped with the following:

* Cable entry floor plate with grommets
* Cable mounting bars and cable fastening clamps
* Copper earthing bar for connection of the cable screens
* Ring core current transformers on the outer cone plug connector system of the cable feeder

Facilities are to be created in the cable termination compartment to accommodate up to 3 parallel cable systems, window-type current transformers, connection of capacitive voltage measurement systems and cable support beam.

The cable termination compartment is to be firmly closed off by a cover. The pressure withstand capability must be at least 87% of rated short-circuit current.

As an option, the cable termination compartment cover can be interlocked with the earthing switch.

The cable termination compartment is to be closed off from panel to panel and to the outside by flameproof plug-in shutters. Pressure relief is to be panel by panel, to the rear. Pressure relief into the false floor cavity is not permissible.

The earthing bar must be prepared in such a way that it can be bolted together from panel to panel.

2.6.5 Operating mechanism bay with all mechanisms

The operating mechanism bay is to be located at the front in front of the core module. It is to be dimensioned sufficiently to accommodate all the operating mechanisms. A mechanical mimic diagram facilitating local operator control is to be integrated in the front of the operating mechanism bay – the operator control area.

2.6.6 Removable low voltage compartment

A removable low voltage compartment is to be located above the operating mechanism bay. This must provide sufficient space for the installation of secondary systems, including terminals, connections for auxiliary power and, where appropriate, panel communications.

The front door is to contain all the necessary cut-outs for the protection relays and other control and signaling units.

The earthing of the front door must be low inductance with flat cable.

The secondary equipment is to be installed on aluminium top hat rails.

There must be the option of entering external secondary cables from the top or bottom.

2.6.7 Corrosion protection and external paintwork

The front doors, the front covers and side covers are to be provided with long-term corrosion protection, for instance as multiple powder coating with subsequent stoving or equivalent.

The colour is to be RAL 7035.

Other metal parts, e.g. the side walls of the low voltage compartments or auxiliary structures are to be manufactured from AluZink sheet, aluminium, stainless steel or equivalent, which does not require any paint treatment.

**3.0 Switching devices**

3.1 Circuit-breakers

Circuit-breakers in accordance with IEC 62271-100 with the following classification are to be used:

* Mechanical service life, class M2 (10000 operating cycles)
* Electrical service life, class E2 with autoreclosing capability

The circuit-breaker operating mechanism is to be located outside the gas compartment and is to be almost maintenance-free under normal operating conditions. The high voltage parts located in the gas compartment must be maintenance-free.

The vacuum circuit-breaker is to be equipped with the following:

* Stored-energy spring for motor and manual charging
* Mechanical ON / OFF pushbuttons
* Shunt release “ON”
* Shunt release “OFF”
* 2nd shunt release “OFF” (for incoming feeder panels only)
* Blocking magnet (optional)
* Mechanical switch position indicator
* Mechanical “charged – discharged” indicator
* Mechanical operating cycle counter
* Auxiliary switches for control and interlocks

All auxiliary switch contacts not required inside the operating mechanism are to be wired via plug connectors to modular terminals.

Each circuit-breaker must be routine tested to IEC 62271-100. The test certificates are to be submitted with the final documentation.

3.2 The three position disconnectors are to be equipped with both manual & electrical operation by motor is also to be possible. Auxiliary switches are to be used to signal the switch positions. The three position disconnector must facilitate the following switch positions:

* Disconnector ON:  
  The circuit between the busbar and circuit-breaker is closed.
* Disconnector OFF:  
  The circuit between the busbar and circuit-breaker is interrupted; the switch is in a neutral position and the conditions for disconnection are fulfilled.
* Earthing switch ON:  
  The circuit between the earthing contacts and the circuit-breaker is closed, the earthing contacts are short-circuited. Earthing itself is effected by the circuit-breaker.
* Earthing switch OFF:  
  The circuit between the earthing contacts and circuit-breaker is interrupted; the switch is in a neutral position and the conditions for disconnection are fulfilled.

The three position disconnector and circuit-breaker are to be effectively mechanically interlocked against each other in such a way that the three position disconnector can only be switched when it is off-circuit.

Three position disconnectors are mandatory. Versions with separate disconnectors and earthing switches are not permissible for safety reasons.

3.3 Secondary systems

3.3.1 Instrument transformers

3.3.1.1 Current transformers

Single or multiple core current transformers are to be used as required. Moulded-on wiring is to be routed uncut to current terminals in the low voltage compartment.

Where necessary, window-type current transformers are to be mounted in all three phases for earth fault current detection.

The transformer ratings are to be selected as well as possible to suit the measuring and protection requirements.

3.3.1.2 Voltage transformers

The voltage transformers are to be offered as single-phase insulated, plug-in transformers.

The following ratios are to be provided:

Incoming feeders Busbar measurement

33kV 0.1kV0.1kV 33kV 0.1kV 0.1kV  
------- : -------- : ------- : -------:--------:-------  
√ 3 √ 3 3 √ 3 √ 3 3

In order to avoid ferroresonance, the open delta winding must be burdened with a corresponding load resistor.

The transformers are to be installed externally metallized and shockproofed, and effectively connected to the panel earthing system.

Isolating devices are to be provided on outgoing feeder voltage transformers, so that, the voltage transformers can be disconnected from the high voltage potential, for example for cable tests. The controls for these isolating devices are to be located in the cable termination compartment.

The secondary wiring of the outgoing feeder voltage transformers is to be routed uncut to terminals in the low voltage compartment. The busbar voltage transformers are to be connected by plug connectors, as the busbars are only assembled at site.

3.3.2 Multifunctional protection, monitoring and signalling device

3.3.2.1 General

The combined feeder protection and control device is to include the functions of protection, control, measurement and monitoring.

The instrument transformer signals are coming from terminal boards to be wired at screw-type terminals to the housing of the device, which is installed in the door. If an automation system is connected, the optical fibre cables are also to be plugged into the housing.

The device must be equipped with a fully graphical display. There must be an RJ45 (Ethernet) programming interface on the display for parameterization of the protection and control functions.

Programming of the devices must be possible both via the operator menu and by means of a PC via a conventional network port on the device. PC-supported parameterization must be possible both by means of a dedicated PC program and by means of a web server integrated in the device. This applies to both local and remote parameterization.

In the local display, designation of the functions to IEC 60617, IEC 61850 and also with user-defined names must be possible.

The control panel is to contain not only the keys for the parameterization and display functions, direct selection keys for switching devices on, off and local/remote switchover.

The combination protection device must cover the following functions in all panels:

3.3.2.2 General functions

**General requirements**

• Local and remote control and feedback signals of the positions of up to eight switching devices

• Double pole control of up to 8 switching devices

• I ntegrated local/remote switchover by pushbutton or control menu with local, remote, and off modes

• Graphical display of the switch positions

• Five freely programmable function keys. Selection by clear text designation of the function on the display.

• The interlocking of switching operations and exchange of higher level signals are to take place via the combined protection and control device. The following variants are possible:

- Interlocking via the IEC61850 bus. In this case, the signals must be transmitted from one device to another within max. 10ms.

(Fulfilment of class 1A P1 of the standard, current state of the art.) In this case, please select a communications interface in section 3.6.4, even if no substation automation system is connected.

The use of this variant is not permissible for devices with slower communication for reasons of safety and availability.

- Interlocking via loop/ring lines and binary inputs

• Display of calculated and directly measured variables as absolute values (numerical). The display is to be either via selectable menus or optionally direct in the single line diagram for freely selectable values.

• Up to 45 LEDs, 3-colour, for signals and alarms, with freely selectable, automatically changing text depending on signal content and LED colour (texts shown on display, on several pages where necessary).

• Internal real time clock for time stamping of the events

• Execution of SPC functions, including logic and memory modules

• Execution of configured protection functions

• Active monitoring of up to 2 release circuits

• Event memory for the last 1000 events (first in - first out)

• Dynamic online display of the logical states of the individual program modules of a combination device connected to the PC via the control program (function chart monitor)

• Time synchronization via the IEC 61850 bus (accuracy 1ms)

• Equipping with at least 30 inputs, 20 outputs, at least 1 additional output for self-monitoring display

• Setting of threshold values for binary inputs and nominal values for analog inputs via the control software

• Signal voltage and power supply to the devices: 48 – 125 V DC or 110-250 VDC and 100-240 VAC.

3.3.2.3 Monitoring and signalling functions

• Disturbance recorder

- Recording of up to 40analog and 64 binary channels

- Recording time 0.5 – 8s (adjustable, depending on polling rate)

- Recording of max. 100 disturbance records

- Triggering by internal or external signals

- Polling rate min. 1.2 kHz

• 3 permanently allocated and 15 programmable (three-colour) signal LEDs with labelling on paper strips, or 45 programmable signal LEDs with designation on the display

• Circuit-breaker condition monitoring

• Display of measured values (primary value) on the display   
(I1, I2, I3, Io, 3 x phase-earth voltage, symmetrical components I1, I2, U1, U2, Io)

• Display of measured values (primary value) on the display   
(I1, I2, I3, Io, U, Uo, S, P, Q, kWh, kVArh, symmetrical components I1, I2, Io)

3.3.2.4 Protection

Protection is to be effected by the multifunctional protection, monitoring and signalling device. The protection functions are dependent on the type of outgoing or incoming feeder.

3.3.2.4.1 Incoming feeder panel (with circuit-breaker)

Multifunctional protection, monitoring and signalling device with the following functions.

• Non-directional overcurrent time protection, 4 stages **50/51**

• Non-directional earth fault protection, 3 stages **50N/51N**

• Overvoltage protection, 3 stages 59

• Undervoltage protection, 3 stages 27

• Synchrocheck SYNC, 25

• Circuit-breaker failure **51BF/62BF**

• Trip circuit supervision **74TC**

• Reclosing lock-out, **86**

3.3.2.4.2 Transformer feeder panel (with circuit-breaker)

Multifunctional protection, monitoring and signalling device with the following functions.

• Transformer differential protection (two-winding) **87T** (as applicable)

• Non-directional overcurrent time protection, HV side, 3 stages **50/51**

• Non-directional overcurrent time protection, LV side, 3 stages **50/51**

• Non-directional earth fault protection, HV side, 2 stages **50N/51N**

• Non-directional earth fault protection, LV side, 2 stages **50N/51N**

• Circuit-breaker failure **51BF/62BF**

• Trip circuit supervision **74TC**

• Reclosing lock-out, **86**

• Transformer auxiliary protection, **63X**

3.3.2.4.3 Sectionalizer panel (with circuit-breaker)

Multifunctional protection, monitoring and signalling device with the following functions.

• Non-directional overcurrent time protection, 4 stages **50/51**

• Non-directional earth fault protection, 3 stages **50N/51N**

• Overvoltage protection, 3 stages **59**

• Undervoltage protection, 3 stages **27**

• Synchrocheck SYNC, 25

• Circuit-breaker failure **51BF/62BF**

• Trip circuit supervision **74TC**

• Reclosing lock-out, **86**

3.3.2.4.4 Communications / interfaces

* 1 set of signals, messages, etc. is to be routed as floating signals to modular terminals for collection there. The “customer area” is to be a separate, enclosed terminal strip with screw-type terminals.
* Connection of an existing substation automation system and interlocking by GOOSE over IEC 61850 is effected by communications interfaces integrated in the protection and control device.

3.3.3 **Wiring, modular terminals and marking**

1. Wiring

Single core non-sheathed cable type H05Z-k/H07Z-k (halogen-free) with the following minimum core cross-sections is to be used as standard:

Loop lines for  
110 V DC, 220 V DC, 230 V AC 2.5 mm² black  
 60 V DC 4.0 mm² black

Control, interlock and   
telecommunications circuits 1.0 mm² black

Releases and mechanism motors 1.0 mm²

Current transformers, secondary 2.5 mm² black

Voltage transformers, secondary 1.5 mm² black

1. Modular terminals

Standard modular terminals from manufacturer Weidmüller with tension clamp connections of the following types, or equivalents, are to be used:

Loop line terminals ZT 2.5/4AN/4 /ZRV2.5/4

Current terminals WTL 6/1

Voltage terminals ZDU 2.5N/4AN

Control / signals ZDU 2.5N/4AN

Plugs for operating mechanisms STGH ZRV 2.5

Terminals for operating mechanisms ZRV 2.5

PE conductor terminals USLKG6N

Customer terminal strip WDU 1.5/BLZ/ 5.08/ZQV

Space is to be provided in each panel for approx. 20 spare terminals.

1. Marking

The equipment is to be marked in accordance with the circuit diagram with printed adhesive identification labels (lettering black, background yellow).

The terminals do not have any functional designation, but are to be marked with the terminal number in accordance with the circuit diagram and terminal diagram.

3.3.4 Switchgear accessories

1 Switchgear system end unit for both ends (left and right)

2 Double bit cell key

2 Manual charging lever for circuit-breaker

2 Operating lever for disconnector function

2 Operating lever for earthing switch function with red marking

2 Operating lever for switch-disconnector

1 Hanger for operating accessories

Transport units, installation and weights

The panels are to be delivered as clearly assignable transport units. They must be fitted with lifting lugs/facilities for safe unloading by crane and transport into the substation.

If special harnesses are required for handling of the panels and transport into the substation, these are to be made available free of charge.

3.4 Packaging, freight and delivery

All parts offered must be packaged in standard commercial packaging and delivered by road truck.

Returnable (reusable) transport packaging is to be taken back immediately at the Contractor’s own cost and risk.

3.5 **Tests**

3.5.1 Type tests

The type tests on the metal-enclosed switchgear must have been performed in an accredited test laboratory. A type test certificate is to be attached to the submittal as documentary evidence. That certificate is to include all the relevant type tests for the technical data of the required system.

The switchgear system is to be designed and tested in accordance with IEC 62271-200 as follows:

- Partition class PM

- Loss of service continuity category LSC2

* Internal arc test for 31.5kA internal arc for 1 sec

3.5.2 Routine tests at the works

Tests are to be performed in accordance with the latest valid VDE / IEC standards. The following tests are to be performed, and the results are to be recorded:

* Function and wiring tests
* Checking of correctness of the devices installed
* Insulation testing of the low voltage circuits
* AC voltage and partial discharge testing of the medium voltage section

3.5.3 Customer inspection at the works

An optional customer inspection of the completed switchgear system at the manufacturer’s works in the form of visual inspection with functional testing of each panel variant is to be included in the tender.

3.5.4 Local testing at site

Local testing is to include the following electrical tests:

* + AC voltage test
  + Insulation resistance test
  + Functional testing of the delivered, installed and connected switchgear system

3.6 **Installation at site**

Installation and testing may only be performed by appropriately trained and authorized personnel, so as to ensure the perfect function of the switchgear.

Installation shall happen without any gas work at site.

# 33 kV HT Cable

**TECHNICAL SPECIFICATION OF 33 kV 3x300mm XLPE Aluminium ARMOURED Cable**

**2.2.1 SCOPE**

This specification covers design, manufacture, inspection, testing and supply of 33kV, 3X300 sq. mm. XLPE armoured cable with effectively earthed distribution system.

**2.2.2 STANDARDS**

2.2.2.1 The materials shall conform in all respects to the relevant International / Indian Standard Specifications with latest amendments thereto.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Title** | | | | **Indian Standard No.** | **International Standard** |
| Specification for Cross linked Polyethylene Insulated PVC Sheathed Cable for working voltages from 3.3 kV up to and including 33 kV | | | | IS:7098 Part II/1985 | IEC : 502 (1983) |
| PVC insulation electric cables. | and | sheath | of | IS:5831/1984 | IEC :502 (1983) |
| Conductors for insulated electric Cables and Flexible cords | | | | IS: 8130/1984 | IEC : 228 (1978) |
| Specification for cable drum | | | | IS : 10418/1982 |  |

Code of practice for installation and maintenance of power cables IS 1255 – 1983

Equipment conforming to other internationally accepted standards, which ensure equal or higher quality than the standards mentioned above, would also be acceptable.

**2.2.3 PRINCIPAL PARAMTERS:**

The material shall conform to the following specific parameters.

|  |  |  |
| --- | --- | --- |
| **S.I. No.** | **Item** | **Specification** |
| 1. | Type of Installation | Outdoor |
| 2 | System Voltage | 33 kV (+10% - 15%) |
| 3 | System Frequency | 50 Hz. + 5% |
| 4 | No. of Phases | Three |
| 5 | System of earthing | Solidly grounded |

* + 1. **TECHNICAL REQUIREMENT**

The cable shall be 33 kV Grade, high conductivity stranded compacted circular conductor, electrolytic grade Aluminium, tapped with semi conducting, 3 core, XLPE insulated, inner PVC sheathed, galvanized steel strip armoured with overall separate extruded PVC outer sheath, conforming generally to IEC-60502/IS: 7098 (Part-II) - 1985 and amendment thereof suitable for 33 kV 3 phase 50 Hz earthed system.

Two distinct sheaths i.e. inner and outer shall be provided. Outer sheathing shall be designed to afford high degree of mechanical protection and shall also be heat, oil, chemicals and weather resistant, common acids, alkalies and saline solution shall not have adverse effect on the material used for PVC outer sheathing.

The cable should be suitable for lying in covered trenches and/or buried direct underground.

* + 1. **CONDUCTOR**

The conductor shall be made from stranded very well compacted, round conductor shall be made of annealed plain copper wires complying the requirement as specified in Table-2 of IS: 8130 /1984 and any amendment thereof.

* + 1. **CONDUCTOR SHIELD**

The conductor shall have a semi-conducting screen, which will ensure perfectly smooth profile to avoid stress concentration. The conductor screen shall be extruded in the same operation as the insulation.

* + 1. **INSULATION**

The XLPE insulation shall be suitable for specified 33 kV system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method shall give very smooth interface between semi-conducting screen and insulation. The insulation of the cables shall be of high standard quality and conform to Clause-11 of IS: 7098 (Part-II)/1985 or latest amendment thereof.

* + 1. **INSULATON SHIELD**

To confine electrical field to the insulation, insulation screening consisting of two parts, namely metallic (non-magnetic) and non-metallic (semi conducting) shall be provided. The non-metallic semi-conducting shield shall be put over the insulation of each core. The insulation shield shall be extruded in the same operation as the conductor shield and the insulation by triple extrusion process. The insulation shield shall be bonded and Strippable, on adequate heat treatment. Metallic shield shall be provided over non- metallic portion as per provision of clause 12.4 of IS: 7098 (Part-II)/1985 and amendment thereof.

* + 1. **INNER SHEATH**

The sheath shall be suitable to withstand the operating conditions and the desired temperature rating of the cable. It shall be of adequate thickness, consistent quality and free from all defects.

* + 1. **ARMOUR**

Galvanized steel strip armouring shall be provided. The dimensions of steel strip shall be as per table 4 of IS: 7098 (Part-II)/1985 and its latest amendment and strip shall conform to latest provisions of IS: 3975 - 1988 and amendment thereof.

* + 1. **OUTER SHEATH**

Extruded PVC outer sheath of type ST-2 as per IS: 5831/1984 and its latest amendment shall be applied over armouring with suitable additives to prevent attack by rodent and termite and its thickness shall be in accordance with Clause -17.32 of IS:7098 (Part-III)/1985 and latest amendment thereof.

* + 1. **CONSTRUCTION**
       1. The cable shall have suitable PVC fillers laid up with insulated cores to provide substantially circular cross section before the inner sheath is applied. The fillers shall be suitable for operating temperature of the cable and compatible with the insulating material.
       2. All materials used in the manufacture of cable shall be new, unused and of finest quality. All materials shall comply with the applicable provisions of the tests of the specification, IS, Indian Electricity Rules, Indian Elect. Act and any other applicable statutory provisions, rules and regulations.
       3. The PVC material used in the manufacture of cable shall be of reputed make. No recycling of the PVC is permitted. The Owner/PMC reserves the right to ask for documentary proof of the purchase of various materials to be used for the manufacture of cable and to check that manufacturer is complying with quality control.

**3. LAYING OF CABLES**

Cables shall be so laid that the maximum bending radius is 20 times the overall diameter for 11 kV cables. Cables shall be laid in masonry trenches, directly on walls/cable trays, directly buried in ground or in pipes/ducts as elaborated below. Cables of different voltages and also power and control cables shall be laid in different trenches with adequate separation. Wherever available space is restricted such that this requirement cannot be met, medium voltage cables shall be laid above HT cables.

**3.1 In Masonry Trenches**

Wherever so specified, cables shall be laid in indoor/outdoor masonry/RCC trenches to be approved by Owner/PMC. Cables shall be laid on MS supports fabricated from minimum 38mm x 38mm x 6mm painted / galvanized angle iron supports grouted in trench walls at intervals not exceeding 600 mm. If required, cables shall be arranged in tier formation inside the trench. Suitable clamps, hooks and saddles shall be used for securing the cables in position and dressing properly so that the clear spacing between the cables shall not be less than the diameter of the cable. Trenches shall be provided with chaquered plate/RCC covers. Wherever so specified, trenches shall be filled with fine sand.

**3.2 On Trays/Walls**

Wherever so specified, cables shall be laid along walls/ceiling or on cable trays. Cable shall be secured in position and dressed properly by means of suitable clamps, hooks, saddles etc. such that the minimum clear spacing between cables is diameter of the cable. Clamping of cables shall be at minimum intervals as below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Type of cables** | **Size** | **Clamping by** | **Fixing intervals** |
| MV & HV | 150 sq mm and above | Clamps 5 mm thick 60 mm wide | 45 cm |

**Note:** The fixing intervals specified apply to straight runs. In the case of bends, additional clamping shall be provided at 30 cm from the center of the bend on both sides.

Cable trays, of sizes as per schedule of quantities and drawings shall be of perforated doubled bend channel/ladder design unless otherwise stated. Cable trays shall be fabricated from minimum 2 mm thick sheet steel and shall be complete with tees, elbows, risers, and all necessary hardware. Cable trays shall comply with the following:

Trays shall have suitable strength and rigidity to provide proper support for all contained cables. Trays shall not have sharp edges, burrs or projections injurious to cable insulation. Trays shall include fittings for changes in direction and elevation. Cable trays and accessories shall be painted with one shop coated of red oxide zinc chromate primer and two side coats of aluminium alkyd paint or approved equivalent. Cable trays shall not have sharp edges, burrs or projection that may damage the insulation jackets of the wiring. Cable trays shall have side rails or equivalent structural members.

Unless otherwise specifically noted on the relevant layout drawing, all cable tray mounting works to be carried out ensuring the following:

Cable tray mounting arrangement type to be as marked on layout drawing. Assembly of tray mounting structure shall be supplied fabricated, erected & painted by the electrical contractor. Tray mounting structures shall be welded to plate inserts or to structural beams as approved by the Owner/PMC. Wherever embedded plates & structural beams are not available for welding the tray mounting structure electrical contractor to supply the MS plates & fix them to floor slab by four anchor fasteners of minimum 16 mm dia having minimum holding power of 5000 Kg at no extra cost. Maximum loading on a horizontal support arm to be 120 Kg. meter of cable run. Width of the horizontal arms of the tray supporting structures to be same as the tray widths specified in tray layout drawings, plus length required, for welding to the vertical supports. The length of vertical supporting members for horizontal tray runs shall be to suit the number of tray tiers shown in tray layout drawings. Spacing between horizontal supports arms of vertical tray runs to be 300 mm. Cable trays will be welded to their mounting supports. Minimum clearance between the top most tray tier and structural member to be 300 mm. Cables in vertical race ways to be clamped by saddle type clamps to the horizontal slotted angels. Clamps to be fabricated from 3 mm thick aluminium strip at site by the electrical contractor to suit cable groups. The structural steel (standard quality) shall be according to latest revision of IS: 226 & 808. Welding shall be as per latest revisions of IS: 816. All structural steel to be painted with one shop coat of red oxide and oil primer followed by a finishing coat of aluminium alkyd paint where any cuts or holes are made on finished steel work these shall be sealed against oxidation by red oxide followed by the same finishing paint. Steel sheet covers wherever indicated to be similarly painted. Trays shall be erected properly to present a neat and clean appearance. Trays shall be installed as a complete system. Trays shall be supported adequately by means of painted MS structural members secured to the structure by dash fasteners or by grouting. The entire cable tray system shall be rigid. Each run of cable tray shall be completed before laying of cables. Cable trays shall be erected so as to be exposed and accessible.

**3.3 Buried Directly in Ground**

**3.3.1 General**

Cables shall be so laid that they will not interfere with under ground structures. All water pipes, sewage lines or other structures which become exposed by excavation shall be properly supported and protected from injury until the filling has been rammed solidly in places under and around them. Any telephone or other cables coming in the way are to be properly shielded as directed by Engineer in charge. Surface of the ground shall be made good so as to conform in all respects to the surrounding ground to the satisfaction of Engineer in charge.

**3.3.2 Routing of cables**

Before cable laying work is undertaken, the route of the cables shall be decided with the Engineer in charge. While shortest practicable route shall be preferred, cable runs shall follow fixed development such as roads, footpaths etc with proper off-sets so that future maintenance and identification are rendered easy. Whenever cables are laid along well demarcated or established roads, the LV/MV cables shall be laid further from the kerb line than HV cables. Cables of different voltages and also power and control cables shall be kept in different trenches with adequate separation. Where available space is restricted, LV/MV cables shall be laid above HV cables. Where cables cross one another, the cables of higher voltage shall be laid at a lower level than the cables of lower voltage. Power and communication cables shall as far as possible cross at right angles. Where power cables are laid in proximity to communications cables the horizontal and vertical clearances shall not normally be less than 60 cm.

**3.3.3 Width of Trench**

The width of trench shall be determined on the following basis. The minimum width of trench for laying single cables shall be 350 mm. Where more than one cable is to be laid in the same trench in horizontal formation, the width of trench shall be increased such that the inter-axial spacing between the cables except where otherwise specified shall be at least 200 mm. There shall be a clearance of at least 150 mm between axis of the end cables and the sides of the trench.

**3.3.4 Depth of Trench**

The depth of trench shall be determined on the following basis:

• Where cables are laid in single tier formation, the total depth of the trench shall not be less than 750 mm for cables upto 1.1 kV and 1000 mm for cables above 1.1 kV.

• When more than one tier of cables is unavoidable and vertical formation of laying is adopted, the depth of trench shall be increased by 300 mm for each additional tier to be formed.

**3.3.5 Excavation of Trenches**

The trenches shall be excavated in reasonably straight lines. Wherever there is a change in direction, suitable curvature of 12 times the overall diameter of the largest cable shall be provided. Where gradients and changes in depths are unavoidable these shall be gradual. Excavation should be done by any suitable manual or mechanical means. Excavated soil shall be stacked firmly by the side of the trench such that it may not fall back into the trench. Adequate precautions shall be taken not to damage any existing cables, pipes or other such installations during excavation. Wherever bricks, tiles or protected covers or bare cables are encountered, further excavation shall not be carried out without the approval of the Owner/PMC. Existing property exposed during trenching shall be temporarily supported or propped adequately as directed by the Engineer in charge. The trenching in such cases shall be done in short lengths, necessary pipes laid for passing cables therein and the trench refilled as required. If there is any danger of a trench collapsing or endangering adjacent structures the sides shall be well shored up with timbering and/or sheathing as the excavation proceeds. Where necessary these may even be left in place when back filling the trench. Excavation through lawns shall be done in consultation with the Engineer in charge. Bottom of the trench shall be level and free from stone, brick, etc. The trench shall then be provided with a layer of clean dry sand cushion of not less than 170 mm.

**3.3.6 Laying of Cable in Trench**

The cable drum shall be properly mounted on jacks or on a cable wheel at a suitable location. It should be ensured that the spindle, jack etc are strong enough to carry the weight of the drum without failure and that the spindle is horizontal in the bearings so as to prevent the drum creeping to one side while rotating. The cable shall be pulled over rollers in the trench steadily and uniformly without jerks or strains. The entire cable length shall, as far as possible, be laid in one stretch. However when this is not possible the remainder of the cable shall be removed by flaking i.e. making one long loop in the reverse direction.

After the cable is uncoiled and laid over the rollers, the cable shall be lifted slightly over the rollers beginning from one end by helpers standing about 10 meters apart and drawn straight. The cable should then be taken off the rollers by additional helpers lifting the cables and then laid in the trench in a reasonably straight line. For short runs and cable sizes upto 50 sq mm 1.1 kV grade the alternative method of direct handling can be adopted with the prior approval of the Owner/PMC. If two or more cables are laid in the same trench care should be taken to preserve relative position. All the cables following the same routes shall be laid in the same trench. Cables shall not cross each other as far as possible. When the cable has been properly straightened the cores shall be tested for continuity and insulation resistance. The cable shall be measured thereafter.

Suitable moisture sealing compound/tape shall be used for sealing of the ends. Cable laid in trenches in a single tier formation shall have a covering of clean dry sand of not less than 170 mm above the base cushion of sand before the protective cover is laid. In the case of vertical multi-tier formation after the first cable has been laid a sand cushion of 300 mm shall be provided over the initial bed before the second tier is laid. If additional tiers are formed each of the subsequent tiers also shall have a sand cushion of 300 mm. The top most cable shall have final sand covering not less than 170 mm before the protective cover is laid. A final protection to cables shall be laid to provide warning to future excavators of the presence of the cable and also to protect the cables against accidental mechanical damage. Such protection shall be with second class bricks of not less than 200 mm x 100 mm x 100 mm (normal size) laid breadth wise for the full length of the cable to the satisfaction of the Engineer in charge. Where more than one cable is to be laid in the same trench this protective covering shall cover all the cables and project at least 50 mm over the sides of the end cables. In addition bricks on edge shall be placed along the entire run on either side of the cable run. The trenches shall then be back filled with excavated earth free from stones or other sharp edged debris and shall be rammed and watered in successive layers not exceeding 300 mm. Unless otherwise specified a crown of earth not less than 50 mm in the centre and tapering towards the side of the trench shall be left to allow for subsidence. The crown of earth should however not exceed to 100 mm so as not to be a hazard to vehicular traffic. Where road berms or lawns have been cut or kerb stones displaced the same shall be repaired and made good to the satisfaction of the Owner/PMC and all surplus earth and rocks removed to places as specified.

Sand filling to be done on both sides 150mm and below and upto 170 height and then brick protection and back filling after that. Check.

All glands should be double compression

**3.3.7 Laying In Pipes/Closed Ducts**

In locations such as road crossings, entry to buildings/poles in paved areas etc., cables shall be laid in pipes or closed ducts. Spun reinforced concrete pipes shall be used for such purposes and the pipe shall not be less than 100 mm in diameter for a single cable and not less than 150 mm for more than one cable. These pipes shall be laid directly in ground without any special bed. Sand cushioning and/or brick tiles need not be used in such installations. Unless otherwise specified the top surface of pipes shall be at a minimum depth of 1000 mm from the ground level when laid under roads, pavements etc.

The pipes for road crossings shall preferably be on the skew to reduce the angle of bend as the cable enters and leaves the crossing. Pipes shall be continuous and clear of debris or concrete before cable is drawn. Sharp edges at ends shall be smoothened to prevent injury to cable insulation or sheathing. No deduction shall be made for sand and bricks not used for cables passing through RCC Hume pipes or for parts of vertical cables at the lighting poles. Wherever so required, cables shall be laid at the bed of the lake through existing PVC pipe as itemized in bill of quantities.

**3.3.8 Laying Of Cables in Floors**

Laying of cables directly in floors shall be avoided and GI pipes of adequate size shall be used wherever necessary. However if the cables have to be laid direct in the floor specific written approval of Owner/PMC shall be obtained and the Contractor shall cut chases, lay the cables and make good the chases to original finish.

**3.3.9 Cable Entry into Buildings**

Cable entry into buildings shall be made through RCC pipes recessed in the floor. RCC Hume pipes shall be provided well in advance for service cable entries. The pipe shall be filled with sand and sealed at both ends with bitumen mastic to avoid entry of water. Suitable size manholes shall be provided wherever required to facilitate drawing of cables as per requirements.

**4 TERMINATION/JOINTING OF CABLES**

Soldered jointing/termination shall be totally avoided. Solder less terminations by using Dowel crimping tools and suitable legs shall be adopted for all cable terminations. Any terminations without use of proper crimping tool shall be liable to be rejected. In the case of aluminium conductors, it is to be ensured that the conductor oxidation is cleaned by means of emery paper and then a thin coat of tin is applied before pinching into any equipment. Heat shrinkable Raychem type or approved equivalent terminations shall be provided for High Voltage cables and Siemens make or approved equivalent make brass double compression glands shall be provided for Medium Voltage cable terminations. Straight through jointing of Medium Voltage or High Voltage cable shall normally be totally avoided. If absolutely unavoidable, such jointing shall be carried out as per procedure to be got specifically approved from Engineer in charge.

**6. CABLE LOOPS**

At the time of the installation approximately 3 meters of surplus cable shall be left

- at each end of the cable.

- on each side of underground straight through/tee/termination joints.

- at entries to buildings.

- and such other places as may be decided by the Engineer in charge.

This cable shall be left in the form of a loop.

Wherever long runs of cable length are installed cable loops shall be left at suitable intervals as specified by the Engineer in charge.

**7. BONDING OF CABLES.**

Where a cable enters any piece of apparatus it shall be connected to the casting by means of an approved type of armoured clamp or gland. The clamps must grip the armouring firmly to the gland or casting, so that in the event of ground movement no undue stress is placed on to the cable conductors.

**8. TESTING**

**8.1 Tests at Manufacturer's Work**

The cables shall be subjected to shop test in accordance with relevant standards to prove the design and general qualities to the cables as below (as per IS 10810) and as per approved GTP (Guarantee Technical Particulars):

• Routine test on each drum of cables.

• Acceptance tests on drums chosen at random for acceptance of the lot.

• Type test on each type of cables, inclusive of measurement of armour DC resistance of power cables.

**8.2 Site Testing**

• All cables before laying shall be tested with a 500 V megger for 1.1 KV grade or with a 2,500/5,000 V megger for cables of higher voltages. The cables cores shall be tested for continuity, absence of cross phasing, insulation resistance to earth/sheath/armour and insulation resistance between conductors.

• All cables shall be subject to above mentioned test during laying, before covering the cables by protective covers and back filling and also before the jointing operations.

• After laying and jointing, the cable shall be subjected to a 1.5 minutes AC/DC pressure test.

• In the absence of facilities for pressure testing in accordance with clause above it is sufficient to test for one minute with 1000 V megger for cables of 1.1 kV grade and with 2,500/5,00 V megger for cables of higher voltages.

8.3 **Test Witness**

Tests shall be performed in presence of representative of Engineer in charge. The Contractor shall give at least fifteen (15) days advance notice of the date when the tests are to be carried out.

1. **WORKMANSHIP AND QUALTIY ASSURANCE**

The workmanship shall be neat, clean and of highest grade/quality

# 33 kV/ 11 kV Power Transformer

**33/11kV, 6/8MVA ONAN/ONAF Transformer with OLTC (Tap settings -5 to +10%, 13steps) and RTCC.**

1. **SCOPE**

1.1 This Specification provides for design, engineering, manufacture, assembly, stage inspection, final inspection and testing before dispatch, packing and delivery at destination Sub-station by road transport, transit insurance, unloading at site /stores of 6/8 MVA, 33/11 KV Power Transformer(s), complete with all fittings, accessories, associated equipments, spares, 10% extra Transformer Oil, required for its satisfactory operation in any of the sub-stations of the Owner/PMC.

1.2 The core shall be constructed either from high grade, non-aging Cold Rolled Grain Oriented (CRGO) silicon steel laminations conforming to HIB grade with lamination thickness not more than 0.23mm to 0.27mm or better( Quoted grade and type shall be used). The maximum flux density in any part of the cores and yoke at normal voltage and frequency shall not be more than 1.5 Tesla. The Contractor shall provide saturation curve of the core material, proposed to be used. Laminations of different grade(s) and different thickness (s) are not allowed to be used in any manner or under any circumstances.

1.3 The scope of supply should also include the provision of type test. The Owner/PMC reserves the right to waive type tests as indicated in the section on Quality Assurance, Inspection and Testing in this specification.

1.4 The Power Transformer shall conform in all respects to highest standards of engineering, design, workmanship, this specification and the latest revisions of relevant standards at the time of offer and the Owner/PMC shall have the power to reject any work or material, which, in his judgement, is not in full accordance therewith. The Transformer(s) offered, shall be complete with all components, necessary for their effective and trouble free operation. Such components shall be deemed to be within the scope of supply, irrespective of whether those are specifically brought out in this specification and / or the commercial order or not. The Owner/PMC reserves the right to reject the transformers if on testing the losses exceed the declared losses beyond tolerance limit as per IS or the temperature rise in oil and / or winding exceeds the value, specified in technical particular or impedance value differ from the guaranteed value including tolerance as per this specification and if any of the test results do not match with the values, given in the guaranteed technical particulars and as per technical specification. The Owner/PMC reserves the right to retain the rejected Transformer and take it into service until the Contractor replaces it, at no extra cost of a new transformer.

Alternatively, the Contractor shall repair or replace the Transformer within a reasonable period as decided by the Owner/PMC to Owner/PMC’s satisfaction at no extra cost.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
|  | **GUARANTEED TECHNICAL PARTICULARS:** |  |  |
| 1 | Name of manufacturer |  | |
| 2 | KVA Rating |  | |
|  | ONAN | 6000 | |
|  | ONAF | 8000 | |
| 3 | No of phase and rated frequency | 3, 50 Hz | |
| 4 | Rated voltage ( kV) |  |  |
|  | HV | 33 | |
|  | LV | 11 | |
| 5 | Connection |  |  |
|  | HV | Delta | |
|  | LV | Star | |
|  | VECTOR GROUP | Dyn11 | |
| 6 | Winding |  |  |
| a | HV | Copper | |
| b | LV | Copper | |
| 7 | Insulation level ( Impulse withstand )(kVpeak) |  |  |
| a | HV | 170 | |
| b | LV | 75 | |
| 8 | Insulation level ( power frequency withstand ) (kVrms) |  |  |
| a | HV | 75 | |
| b | LV | 75 | |
| 10 | Tapping |  |  |
| a | Range | +5% to -10% @ 1.25% | |
| b | No of Steps | 13 | |
| c | On HV | yes | |
| d | Tap changer type | OLTC | |
| 11 | Temperature rise of oil/winding over design ambient temperature of 50(oC) | 50/55(oC) | |
| 12 | Hot spot temperature rise over a maximum yearly weighted temperature of 32 oC | 98 oC | |
| 13 | Short circuit Thermal withstand time secs | 2 | |
| 14 | % Impedance at 75°C, rated current &Frequency (IS Tol) % | 8.35 | |
| 15 | No load loss at rated voltage &frequency ( kW) (IS Tol) | 12 | |
| 16 | Load loss at rated current&75°C (kW) (IS Tol) | 62 | |
| 17 | Efficiency (%) | 0.8 pf | upf |
| a | 100 % load | 99.12 | 99.29 |
| b | 75% load | 99.27 | 99.41 |
| c | 50% load | 99.37 | 99.50 |
| 18 | % Load at which Max Efficiency occurs (%) | 40.42 | |
| 19 | Maximum Efficiency (%) | 99.51 | |
| 20 | Regulation at full load 0.8pf% (%) | 6.77 | |
| 21 | Regulation at full load upf% (%) | 1.11 | |
| 22 | Bushings | HV | LV & LVN |
| a | Reference standard | IS 2099 & IS 3347 | |
| b | Type of bushing | Porcelain | Porcelain |
| c | Voltage Rating kV | 36 | 17.5 |
| d | Current Rating Amps | 250 | 630 |
| e | Fault Current Withstand Level | 50 kA for 1 sec | 50 kA for 1 sec |
| 23 | Weight in Kgs (Approximate) |  |  |
| a | Core and winding | 11500 | |
| b | Tank &Fittings | 10500 | |
| c | Oil | 9500 | |
| d | Total weight | 31500 | |
| 24 | Approximate Overall dimension (in mm) |  | |
| a | Overall Length | 7000 | |
| b | Overall breadth | 5000 | |
| c | Overall Height | 5800 | |
| 25 | Approximate Weight of Heaviest package (KG) | 25000 | |
| 26 | Approximate transport dimensions LxBxH (mm) | 5600x3400x3800 | |
| 27 | Fitting & Accessories as per specification | yes, IS2026 & CBIP | |
| 28 | Reference standard | IS 2026 | |
| 29 | Termination |  |  |
| a | HV | Cable Box | |
| b | LV | Cable Box | |

2.1 **MARSHALLING BOX**

A metal enclosed, weather, vermin and dust proof marshalling box fitted with required glands, locks, glass door, terminal Board, heater with switch, illumination lamp with switch etc. shall be provided with each transformer to accommodate temperature indicators, terminal blocks etc. It shall have degree of protection of IP 55 or better as per IS: 2147 (Refer Clause 3.12).

2.2 **PERFORMANCE**

1. Transformer shall be capable of withstanding for two seconds without damage to any external short circuit, with the short circuit MVA available at the terminals.
2. The maximum flux density in any part of the core and yoke at rated MVA. Voltage and frequency shall be **1.5 Tesla** (maximum).
3. Transformer shall under exceptional circumstances due to sudden disconnection of the load, be capable of operating at the voltage approximately 25% above normal rated voltage for a period of not exceeding one minute and 40% above normal for a period of 5 seconds.
4. The transformer may be operated continuously without danger on any particular tapping at the rated MVA ± 12.5% of the voltage corresponding to the tapping.
5. The thermal ability to withstand short circuit shall be demonstrated by calculation.
6. Transformer shall be capable of withstanding thermal and mechanical stress caused by any symmetrical and asymmetrical faults on any winding.

2.3 **AUXILIARY POWER SUPPLIES**

The following power supplies shall be available at site:

1. AC. 3phase, 400 volts, 50Hz. Earthed
2. AC 1 phase, 230 volts, 50Hz. Earthed
3. 24 V DC.

2.4 **DRAWINGS/ DOCUMENTS INCORPORATING THE FOLLOWING PARTICULARS**

**SHALL BE SUBMITTED by Contractor**

1. General outline drawing showing shipping dimensions and overall dimensions, net weights and shipping weights, quality of insulating oil, spacing of wheels in either direction of motion, location of coolers, marshalling box and tap changers etc.
2. Assembly drawings of core, windings etc. and weights of main components / parts.
3. Height of center line on HV and LV connectors of transformers from the rail top level.
4. Dimensions of the largest part to be transported.
5. GA drawings / details of various types of bushing
6. Tap changing and Name Plate diagram
7. Type test certificates of similar transformers.
8. Illustrative & descriptive literature of the Transformer.
9. Maintenance and Operating Instructions.

2.5 **MISCELLANEOUS**

1. Padlocks along with duplicate keys as asked for various valves, marshalling box etc. shall be supplied by the contractor, wherever locking arrangement is provided.
2. Foundation bolts for wheel locking devices of Transformer shall be supplied by the Contractor.

2.6 DELIVERY

The full quantity of the equipments shall be delivered as per the delivery schedule appended to this specification.

2.7 SCHEDULES

All Schedules annexed to the specification shall be duly filled by the Vendor/ Contractor and submitted

2.8 ALTITUDE FACTOR

If the equipment is to be installed in the hilly area, necessary correction factors as given in the Indian Standard for oil temperature rise, insulation level etc. shall be applied to the Standard Technical Parameters given above.

2.9 NAME PLATE

Transformer rating plate shall contain the information as given in clause 15 of IS-2026 (part-I). The details on rating plate shall be finalized during the detailed engineering. Further, each transformer shall have inscription of Employer’s name. The name plate shall also include (i) The short circuit rating , (ii) Measured no load current and no load losses at rated voltage and rated frequency, (iii) measured load losses at 750 C ( normal tap only ), (iv) D.C resistance of each winding at 750 C.

1. **SERVICE CONDITIONS**

The service conditions shall be as follows

|  |  |  |
| --- | --- | --- |
| ♦ | maximum a altitude above sea level | 1,000m |
| ♦ | maximum ambient air temperature | 50° C |
| ♦ | maximum daily average ambient air temperature | 35° C |
| ♦ | minimum ambient air temperature | 5° C |
| ♦ | maximum temperature attainable by an object exposed to the sun | 60 ° C |
| ♦ | maximum yearly weighted average ambient temperature | 32° C |
| ♦ | maximum relative humidity | 100% |
| ♦ | average number of thunderstorm days per annum (isokeraunic level) | 70 |
| ♦ | average number of rainy days per annum | 120 |
| ♦ | average annual rainfall | 1500 mm |
| ♦ | maximum wind pressure | 260Kg / m2 |

Environmentally, the region where the equipment will be installed includes coastal areas, subject to high relative humidity, which can give rise to condensation. Onshore winds will frequently be salt laden. On occasions, the combination of salt and condensation may create pollution conditions for outdoor insulators.

Therefore, outdoor material and equipment shall be designed and protected for use in exposed, heavily polluted, salty, corrosive, tropical and humid coastal atmosphere.

1. **SYSTEM CONDITIONS**

The equipment shall be suitable for installation in supply systems of the following characteristics.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ♦ | Frequency |  | 50 | Hz± 5% |
| ♦ | Nominal system voltages |  | 33 | KV |
|  |  |  | 11 KV | |
| ♦ | Maximum system voltages | 33KV System | 36.3 KV | |
|  |  | 11 KV System | 12 KV | |
| ♦ | Nominal short circuit level ( Basing on | 33 KV System | **1.7 KA** | |
|  | apparent power ) | 11 KV System | **5.1 KA** | |
| ♦ | Insulation levels : | 33 KV System | 170 KV(peak) | |
|  | 1.2/50 µ sec impulse withstand voltage | 11 KV System | 95 KV (peak) | |
| ♦ | Power frequency one minute withstand (wet and | 33 KV System | 70 | KV(rms) |
|  | dry) voltage |  |  |  |
|  |  | 11 KV System | 28 | KV (rms) |
| ♦ | Neutral earthing arrangements : | 11 KV System | Solidly earthed | |

**5** **CODES & STANDARDS**

5.1 (i) The design, material, fabrication, manufacture, inspection, testing before dispatch and performance of power transformers at site shall comply with all currently applicable statutory regulations and safety codes in the locality where the equipment will be installed. The equipment shall also conform to the latest applicable standards and codes of practice. Nothing in this specification shall be construed to relieve the contractor of this responsibility.

5.2 The equipment and materials covered by this specification shall conform to the latest applicable provision of the following standards.

|  |  |  |
| --- | --- | --- |
| IS:5 | : | Colour for ready mixed paints |
| IS:325 | : | Three Phase Induction Motors |
| IS:335 | : | New insulating oil for transformers, switch gears |
| IS:1271 | : | Classification of insulating materials for electrical machinery |
|  |  | and apparatus in relation to their stability in services |
| IS:2026(Part I to IV) | : | Power Transformer |
| IS:2071 | : | Method of high voltage testing |
| IS:2099 | : | High voltage porcelain bushings |
| IS:2147 | : | Degree of protection |
| IS:2705 | : | Current Transformers |
| IS:3202 | : Code of practice for climate proofing of electrical equipment | |
| IS:3347 | : | Dimensions for porcelain Transformer Bushings |
| IS:3637 | : | Gas operated relays |
| IS:3639 | : | Fittings and accessories for power Transformers |
| IS:5561 | : | Electric Power Connectors |
| IS:6600/BS:CP‟10:0 | : | Guide for loading of oil immersed Transformers |
| IS:10028 | : Code of practice for selection, installation and maintenance | |
|  |  | of transformers, Part I. II and III |
| C.B.I.P. Publication | : | Manual on Transformers |

If the standard is not quoted for any item, it shall be presumed that the latest version of Indian Standard shall be applicable to that item.

The equipment complying other internationally accepted standards, may also be considered if they ensure performance superior to the Indian Standards.

5.3 **DRAWINGS**

1. The contractor shall furnish following drawings/documents incorporating the transformer rating for approval.
2. Detailed overall general arrangement drawing showing front and side elevations and plan of the transformer and all accessories including radiators and external features with details of dimensions, spacing of wheels in either direction of motion, net weights and shipping weights, crane lift for un-tanking, size of lugs and eyes, bushing lifting dimensions, clearances between HV and L.V terminals and ground, quantity of insulating oil etc.
3. Assembly drawings of core and winding and weights of main components / parts
4. Foundation plan showing loading on each wheel land jacking points with respect to centre line of transformer.

1. GA drawings details of bushing and terminal connectors.
2. Name plate drawing with terminal marking and connection diagrams.
3. Wheel locking arrangement drawing.
4. Transportation dimensions drawings.

viii) Magnetization characteristic curves of PS class neutral and phase side current transformers, if applicable.

1. Interconnection diagrams.
2. Over fluxing withstand time characteristic of transformer.
3. GA drawing of marshalling box.
4. Control scheme/wiring diagram of marshalling box.
5. Technical leaflets of major components and fittings.

xiiv) As built drawings of schematics, wiring diagram etc.

1. Setting of oil temperature indicator, winding temperature indicator.
2. Completed technical data sheets.
3. Details including write-up of tap changing gear.
4. HV conductor bushing.
5. Bushing Assembly.
6. Bi-metallic connector suitable for connection to 100 mm2 up to 232 mm2 AAAC Conductor.
7. GA of LV cable Box.

xxii) Radiator type assembly.

1. All drawings, documents, technical data sheets and test certificates, results calculations shall be furnished.

5.4 Any approval given to the detailed drawings by the Owner/PMC shall not relieve the contractor of the responsibility for correctness of the drawing and in the manufacture of the equipment. The approval given by the Owner/PMC shall be general with overall responsibility with contractor.

1. **GENERAL CONSTRUCTIONAL FEATURES**

6.1 All material used shall be of best quality and of the class most suitable for working under the conditions specified and shall withstand the variations of temperature and atmospheric conditions without distortion or deterioration or the setting up of undue stresses which may impair suitability of the various parts for the work which they have to perform.

6.2 Similar parts particularly removable ones shall be interchangeable.

6.3 Pipes and pipe fittings, screws, studs, nuts and bolts used for external connections shall be as per the relevant standards. Steel bolts and nuts exposed to atmosphere shall be galvanized.

6.4 Nuts, bolts and pins used inside the transformers and tap changer compartments shall be provided with lock washer or locknuts.

6.5 Exposed parts shall not have pockets where water can collect.

6.6 Internal design of transformer shall ensure that air is not trapped in any location.

6.7 Material in contact with oil shall be such as not to contribute to the formation of acid in oil.

Surface in contact with oil shall not be galvanized or cadmium plated.

6.8 Labels, indelibly marked, shall be provided for all identifiable accessories like Relays, switches current transformers etc. All label plates shall be of in corrodible material.

6.9 All internal connections and fastenings shall be capable of operating under overloads and

over-excitation, allowed as per specified stands without injury.

6.10 Transformer and accessories shall be designed to facilitate proper operation, inspection, maintenance and repairs.

6.11 No patching, plugging, shimming or other such means of overcoming defects, discrepancies or errors will be accepted.

6.12 Schematic Drawing of the wiring, including external cables shall be put under the prospane sheet on the inside door of the transformer marshalling box.

6.13 Painting

6.13.1 All paints shall be applied in accordance with the paint manufacturer‟s recommendations.

Particular attention shall be paid to the following:

1. Proper storage to avoid exposure as well as extremes of temperature.
2. Surface preparation prior to painting.
3. Mixing and thinning
4. Application of paints and the recommended limit on time intervals between coats.
5. Shelf life for storage.

6.13.1.1 All paints, when applied in normal full coat, shall be free from runs, sags, wrinkles, patchiness, brush marks or other defects.

6.13.1.2 All primers shall be well marked into the surface, particularly in areas where painting is evident, and the first priming coat shall be applied as soon as possible after cleaning. The paint shall be applied by airless spray according to the manufacturer’s recommendations. However, wherever airless spray is not possible, conventional spray be used with prior approval of Owner/PMC.

6.13.1.3 The Contractor shall, prior to painting protect nameplates, lettering gauges, sight glasses, light fittings and similar such items.

6.13.2 **Cleaning and Surface Preparation**

6.13.2.1 After all machining, forming and welding has been completed, all steel work surfaces shall be thoroughly cleaned of rust, scale, welding slag or spatter and other contamination prior to any painting.

6.13.2.2 Steel surfaces shall be prepared by Sand/Shot blast cleaning or Chemical cleaning by Seven tank process including Phosphating to the appropriate quality.

6.13.2.3 The pressure and Volume of the compressed air supply for the blast cleaning shall meet the work requirements and shall be sufficiently free from all water contamination prior to any Painting.

6.13.2.4 Chipping, scraping and steel wire brushing using manual or power driven tools cannot remove firmly adherent mill-scale and shall only be used where blast cleaning is impractical.

6.13.3 **Protective Coating**

As soon as all items have been cleaned and within four hours of the subsequent drying, they shall be given suitable anticorrosion protection.

6.13.4 **Paint Material**

Followings are the type of paints that may be suitably used for the items to be painted at shop and supply of matching paint to site:

1. Heat resistant paint (Hot oil proof) for inside surface.
2. For external surfaces one coat of Thermo Setting Paint or 2 coats of Zinc chromate followed by 2 coats of POLYURETHANE. The color of the finishing coats shall be dark admiral grey conforming to No.632 or IS 5:1961.

6.13.5 **Painting Procedure**

6.13.5.1 Al painting shall be carried out in conformity with both specifications and with the paint manufacture‟s recommendations. All paints in any one particular system. Whether shop or site applied, shall originate from one paint manufacturer.

6.13.5.2 Particular attention shall be paid to the manufacture‟s instructions on storage, mixing, thinning and pot life. The paint shall only be applied in the manner detailed by the manufacturer e.g. brush, roller, conventional or airless spray and shall be applied under the manufacturer‟s recommended conditions. Minimum and maximum time intervals between coats shall be closely followed.

6.13.5.3 All prepared steel surfaces should be primed before visible re-rusting occurs or within 4 hours whichever is sooner. Chemical treated steel surfaces shall be primed as soon as the surface is dry and while the surface is warm.

6.13.5.4 Where the quality of film is impaired by excess film thickness,(wrinkling, mud cracking or general softness) the Contractor shall remove the unsatisfactory paint coatings and apply another. As a general rule, dry film thickness should not exceed the specified minimum dry film thickness by more than 25% . In all instances, where two or more coats of the same paints are specifies, such coatings may or may not be of contrasting colors.

6.13.5.5 Paint applied to items that are not be painted, shall be removed by Contractor, leaving the surface clean, un-stained and undamaged.

6.13.6 **Damages to Paints Work**

6.13.6.1 Any damage occurring to any part of the painting scheme shall be made good to the same standard of corrosion protection and appearance as that originally employed.

6.13.6.2 Any damaged paint work shall be made as follows:

1. The damaged area, together with an area extending 25mm around its boundary, shall be cleaned down to bare metal.
2. A priming coat shall immediately applied, followed by a full paint finish equal to that originally applied and extending 50mm around the perimeter of the originally damaged.

6.13.6.3 The repainted surface shall present a smooth surface. This shall be obtained by carefully chamfering the paint edges before & after priming.

6.13.7 **Dry Film Thickness**

6.13.7.1 To the maximum extent practicable, the coats shall be applied as a continuous film of uniform thickness and free of pores. Over-spray, skips, runs, sags and drips should be avoided. The different coats may or may not be same color.

6.13.7.2 Each coat of paint shall allowed to hardened before the next is applied as per manufacture‟s recommendations.

6.13.7.3 Particular attention must be paid to full film thickness at edges.

6.13.7.4 The requirement for the dry film thickness (DFT) of paint and the material to be used shall be as given below:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sl.** |  | **Paint Type** | Area to be painted | No. of Coats | Total Dry film Thickness (Min) |
| 1. | Liquid paint | |  |  |  |
|  | a) | Zinc | Out side | 02 | 45 micron |
|  |  | Chromate(Primer) |  |  |  |
|  | b) | Polyurethane |  |  |  |
|  |  | (Finish Coat) | Out side | 02 | 35 micron |
|  | c) | Hot Oil paint | inside | 01 | 35 micron |
|  |  |  |  |  |  |

**7.0 DETAILED DESCRIPTION**

**7.1 Tank**

7.1.1 The Transformer tank and cover shall be fabricated from high grade low carbon plate steel of tested quality. The tank and the shall be of welded construction.

7.1.2 Tank shall be designed to permit lifting by crane or jacks of the complete transformer assembly filed with oil. Suitable lugs and bossed shall be provided for this purpose.

7.1.3 All breams, flanges, lifting lugs, braces and permanent parts attached to the tank shall be welded and where practicable, they shall be double welded.

7.1.4 The main tank body of the transformer, excluding tap changing compartments and radiators, shall be capable of withstanding pressure of 760mm of Hg.

7.1.5 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.

7.1.6 Gaskets of nitrile rubber or equivalent shall be used to ensure perfect oil tightness. All gaskets shall be closed design (without open ends) and shall be of one piece only. Rubber gaskets used for flange type connections of the various oil compartments, shall be laid in grooves or in groove-equivalent sections on bolt sides of the gasket, throughout their total length. Care shall be taken to secure uniformly distributed mechanical strength over the gaskets and retains throughout the total length. Gaskets of neoprene and / or any kind of impregnated / bonded core or cork only which can easily be damaged by over-pressing are not acceptable. Use of hemp as gasket material is also not acceptable.

7.1.7 Suitable guides shall be provided for positioning the various parts during assemble or dismantling. Adequate space shall be provided between the cores and windings and the bottom of the tank for collection of any sediment.

7.2 Tank Cover

The transformer top shall be provided with a detachable tank cover with bolted flanged gasket joint. Lifting lugs shall be provided for removing the cover. The surface of the cover shall be suitable sloped so that it does not retain rain water.

7.3 UNDER CARRIAGE

7.3.1 The transformer tank shall be supported on steel structure with detachable plain rollers completely filled with oil. Suitable channels for movement of roller with transformer shall be space accordingly, rollers wheels shall be provided with suitable rollers bearings, which will resist rust and corrosion and shall be equipped with fittings for lubrication. It shall be possible to swivel the wheels in two directions, at right angle to or parallel to the main axis of the transformers.

7.4 CORE

7.4.1 Stage level inspection for core construction shall be carried out by the Owner/PMC.

7.4.2 Each lamination shall be insulated such that it will not deteriorate due to mechanical pressure

and the action of hot transformer oil.

7.4.3 The core shall be constructed either from high grade, non-aging Cold Rolled Grain Oriented (CRGO) silicon steel laminations conforming to HIB grade with lamination thickness not more than 0.23mm to 0.27mm or better( Quoted grade and type shall be used). The maximum flux density in any part of the cores and yoke at normal voltage and frequency shall not be more than 1.5 Tesla. The Contractor shall provide saturation curve of the core material, proposed to be used. Laminations of different grade(s)\_ and different thickness (s) are not allowed to be used in any manner or under any circumstances.

7.4.4 (A)The Contractor shall offer the core for inspection starting from the destination port to enable Employer for deputing inspecting officers for detail verification as given below and approval by the Owner/PMC during the manufacturing stage. Contractor shall call notice for the purpose should be accompanied with the following documents as applicable as a proof towards use of prime core material :purpose should be accompanied with the following documents as applicable as a proof towards use of prime core material:

The core coils, if found suitable, are to be sealed with proper seals which shall be opened in presence of the inspecting officers during core- cutting at the manufacturer’s or it’s sub-vendor’s premises as per approved design drawing.

a) Purchase Order No. & Date.

b) Invoice of the Contractor

c) Mills test certificate

1. Packing list
2. Bill of lading
3. Bill of entry certificate to customs

Core material shall be directly procured either from the manufacturer or through their accredited marketing organization of repute, but not through any agent.

7.4.4 (B) For Transformer Manufacturer (TM), who has in-house core-cutting facility, the

core coils shall be verified at their works as per followings along with witnessing of core-cutting.

a) Purchase Order No. &Date ;

b) No. of packed coils with Package Nos.

c) Gross Weight.

d) Net Weight :

e) Port of loading.

f) Port of Discharge ;

g) Name of the Ocean Vessel :

h) Grade & Thickness of Core Material :

i) Any other information as mentioned on the body of packed coils.

7.4.5 The laminations shall be free of all burrs and sharp projections. Each sheet shall have aninsulting coating resistant to the action of hot oil.

7.4.6 The insulation structure for the core to bolts and core to clamp plates, shall be such as towithstand 2000 V DC voltage for one minute.

7.4.7 The completed core and coil shall be so assembled that the axis and the plane of the outersurface of the core assemble shall not deviate from the vertical plane by more than 25mm.

7.4.8 All steel sections used for supporting the core shall be thoroughly shot or sand blasted, aftercutting, drilling and welding.

7.4.9 The finally assembled core with all the clamping structures shall be free from deformation and shall not vibrate during operation.

7.4.10 The core clamping structure shall be designed to minimize eddy current loss.

7.4.11 The framework and clamping arrangements shall be securely earthed.

7.4.12 The core shall be carefully assembled and rigidly clamped to ensure adequate mechanical strength.

7.4.13 Oil ducts shall be provided, where necessary, to ensure adequate cooling inside the core. The welding structure and major insulation shall not obstruct the free flow of oil through such ducts.

7.4.14 The design of magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itselfor to the earth clamping structure and production of fluxcomponent at right angle to the plane of the lamination, which may cause local heating. The supporting framework of the cores shall be so designed as to avoid the presence of pockets, which would prevent complete emptying of the tank through the drain valve or cause trappingof air during filling.

7.4.15 The construction is to be of boltless core type. The core shall be provided with lugs suitable for lifting the complete core and coil assembly. The core and coil assemble shall be so fixed in the tank that shifting will not occur during transport or short circuits.

7.4.16 The temperature gradient between core & surrounding oil shall be maintained less than20 deg. Centigrade. The manufacturer shall demonstrate this either through test (procurement to be mutually agreed) or by calculation.

7.5 INTERNAL EARTHING

7.5.1 All internal metal parts of the transformer, with the exception of individual laminations andtheir individual clamping plates shall be earthed.

7.5.2 The top clamping structure shall be connected to the tank by a copper strap. The bottomclamping structure shall be earthed by one or more the following methods:

a) By connection through vertical tie-rods to the top structure.

b) By direct metal to metal contact with the tank base.

c) By a connection to the structure on the same side of the core as the main earth connectionto the tank.

7.5.3 The magnetic circuit shall be connected to the clamping structure at one point only and thisshall be brought out of the top cover of the transformer tank through a suitably rated insulator.

A disconnecting link shall be provided on transformer tank to facilitate disconnections fromground for IR measurement purpose.

7.5.4 Coil clamping rings of metal at earth potential shall be connected to the adjacent coreclamping structure on the same side as the main earth connections.

7.6 **WINDING**

7.6.1 Winding shall be subjected to a shrinking and seasoning process, so that no further shrinkage occurs during service. Adjustable devices shall be provided for taking up possible shrinkage in service.

7.6.2 All low voltage windings for use in the circular coil concentric winding shall be wound on a performed insulating cylinder for mechanical protection of the winding in handling and placing around the core.

7.6.3 Winding shall not contain sharp bends which might damage the insulation or produce high dielectric stresses. No strip conductor wound on edge shall have width exceeding six times the thickness.

7.6.4 Materials used in the insulation and assembly of the windings shall be insoluble, non catalytic and chemically inactive in the hot transformer oil and shall not soften or the otherwise affected under the operating conditions.

7.6.5 Varnish application on coil windings may be given only for mechanical protection and not for improvement in dielectric properties. In no case varnish or other adhesive be used which will seal the coil and prevent evacuation of air and moisture and impregnation by oil.

7.6.6 Winding and connections shall be braced to withstand shocks during transport or short circuit.

7.6.7 Permanent current carrying joints in the windings and leads shall be welded or brazed.

Clamping bolts for current carrying parts inside oil shall be made of oil resistant material which shall not be affected by acidity in the oil steel bolts, if used, shall be suitably treated.

7.6.8 Terminals of all windings shall be brought out of the tank through bushings for external connections.

7.6.8.1 The completed core and coil assemble shall be dried in vacuum at not more than 0.5mm of mercury absolute pressure and shall be immediately impregnated with oil after the drying process to ensure the elimination of air and moisture within the insulation. Vacuum may be applied in either vacuum over or in the transformer tank.

7.6.8.2 The winding shall be so designed that all coil assembles of identical voltage ratings shall be interchangeable and field repairs to the winding can be made readily without special equipment. The coils shall have high dielectric strength.

7.6.8.3 Coils shall be made of continuous smooth high grade electrolytic copper conductor, shaped and braced to provide for expansion and contraction due to temperature changes.

7.6.8.4 Adequate barriers shall be provided between coils and core and between high and low voltage coil. End turn shall have additional protection against abnormal line disturbances.

7.6.8.5 The insulation of winding shall be designed to withstand voltage stress arising from surge in transmission lines due to atmospheric or transient conditions caused by switching etc.

7.6.8.6 Tapping shall not be brought out from inside the coil or from intermediate turns and shall be so arranged as to preserve as far as possible magnetic balance of transformer at all voltage ratios.

7.6.8.7 Magnitude of impulse surges transferred from HV to LV windings by electro magnetic induction and capacitance coupling shall be limited to BILL of LV winding.

7.6.8.8 The current density adopted in all winding shall not exceed 2.4 A/mm2. The total net cross sectional area of the strip conductors for calculating current density for each winding shall be obtained after deducting the copper area lost doe to rounding up of the sharp edges at the rectangular conductors.

7.7 INSULATING OIL

7.7.1 The insulating oil for the transformer shall be of EHV grade, generally conforming to IS: 335. No inhibitors shall be used in the oil.

7.7.2 The quantity of oil required for the first filling of the transformer and its full specification shall be stated in the submittal. All fittings, accessories and new transformer oil required for first filling plus 10% extra oil shall be provided by contractor. The extra quantity of oil shall be supplied in non-returnable drums along with the oil required for the radiator banks.

7.7.3 The design and materials used in the construction of the transformer shall be such as to reduce the risk of the development of acidity in the oil.

7.7.4 The contractor shall warrant that oil furnished is in accordance with the following specifications.

Valves shall be of forged carbon steel upto 50mm size and of gun mental or of cast iron bodies with gun metal fittings for sizes above 50mm. They shall be of full way type with screwed ends and shall be opened by turning counter clockwise when facing the hand wheel. There shall be no oil leakage when the valves are in closed position.

Each valve shall be provided with an indicator to show the open and closed positions and shall be provided with facility for padlocking in either open or closed position. All screwed valves shall be furnished with pipe plugs for protection. Padlocks with duplicate keys shall be supplied along with the valves.

All valves except screwed valves shall be provided with flanges having machined faced drilled to suit the applicable requiremen5ts, Oil tight blanking plates shall be provided for each connection for use when any radiator is detached and for all valves opening to atmosphere. If any special radiator valve tools are required the contractor shall supply the same.

Each transformer shall be provided with following valves on the tank:

Drain valve so located as to completely drain the tank.

Two filter valves on diagonally opposite corners of 50mm size.

Oil sampling valves not less than 8mm at top and bottom of main tank.

One 15mm air release plug.

Valves between radiators and tank.

Drain and filter valves shall be suitable for applying vacuum as specified in the specifications.

7.9 **ACCESSORIES**

7.9.1 **Bushing**

1. All porcelain used in bushings shall be homogeneous, non-porous, uniformly glazed to brown colour and free from blisters, burns and other defects.
2. Stress due to expansion and contraction in any part of the bushing shall not lead to deterioration.
3. Bushing shall be designed and tested to comply with the applicable standards.
4. Liquid oil – filled bushings shall be equipped with liquid level indicators and means for sampling land draining the liquid. The angle of inclination to vertical shall not exceed 30 degree.
5. Oil in oil-filled bushings shall meet the requirements of the transformer oil standards.
6. Bushing rated for 400A and above shall have non-ferrous flanges and hardware.
7. Fittings made of steel or malleable iron shall be galvanized
8. Bushing shall be so located on the transformers that full flashover strength will be utilized. Minimum clearances as required for the BIL shall be realized between live parts and live parts to earthed structures.
9. All applicable routine and type tests certificates of the bushings shall be furnished for approval.
10. Bushing shall be supplied with bi-metallic terminal connector/ clamp/ washers suitable for fixing to bushing terminal and the Owner/PMC specified conductors. The connector/clamp shall be rated to carry the bushing rated current without exceeding a temperature rise of 550C over an ambient of 500 C. The connector/clamp shall be designed to be corona free at the maximum rated line to ground voltage.
11. Bushing of identical voltage rating shall be interchangeable.
12. The insulation class of high voltage neutral bushing shall be properly coordinated with the insulation class of the neutral of the low voltage winding.
13. Each bushing shall be so coordinated with the transformer insulation that all flashover will occur outside the tank.

7.9.2 **Protection & Measuring Devices**

**i) Oil Conservator Tank**

1. The Conservator tank shall have adequate capacity between highest and lowest visible levels to meet the requirement of expansion of the total cold oil volume in the transformer and cooling equipment.
2. The conservator tank shall be bolted into position so that it can be remove for cleaning purposes.
3. The conservator shall be fitted with magnetic oil level gauge with low level electrically insulated alarm contact.
4. Plain conservator fitted with silica gel breather.

**ii) Pressure Relief Device.**

The pressure relief device provided shall be of sufficient size for rapid release of any pressure that may be generated in the tank and which may result in damage of the equipment. The device shall operate at a static pressure of less than the hydraulic test pressure of transformer tank. It shall be mounted direct on the tank. A pair of electrically insulated contract shall be provided for alarm and tripping.

**iii) Buchholz Relay**

A double float type Buchholz relay shall be provided., Any gas evolved in the transformer shall collect in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation. A copper tube shall be connected from the gas collector to a valve located about 1200 mm above ground level to facilitate sampling with the transformer in service. The device shall be provided with two electrically independent potential free contracts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure.

**iv) Temperature Indicator**

**a) Oil Temperature Indicator (OTI)**

The transformers shall be provided with a mercury contact type thermometer with 150 mm dial for top oil temperature indication. The thermometer shall have adjustable, electrically independent potential free alarm and trip contacts. Maximum reading pointer and resetting device shall be mounted in the local control panel. A temperature sensing element suitably located in a pocket on top oil shall be furnished. This shall be connected to the OTI by means of capillary tubing. Accuracy class of OTI shall be ± 1% or better. One No electrical contact capable of operating at 5 A ac at 230 volt supply.

**b) Winding Temperature indicator(WTI)**

A device for measuring the hot spot temperature of the winding shall be provided. It shall comprise the following.

1. Temperature sensing element.
2. Image Coil.
3. Mercury contacts.
4. Auxiliary CTS, If required to match the image coil, shall be furnished and mounted in the local control panel.
5. 150mm dial local indicating instrument with maximum reading pointer mounted in local panel and with adjustable electrically independent ungrounded contacts, besides that required for control of cooling equipment, one for high winding temperature alarm and on for trip.
6. Calibration device.
7. Two number electrical contact each capable of operating at 5 A ac at 230 Volt supply.

7.9.3 **Oil Preservation Equipment**

7.9.3.1 **Oil Sealing**

The oil preservation shall be diaphragm type oil sealing in conservator to prevent oxidation and contamination of oil due to contact with atmospheric moisture.

The conservator shall be fitted with a dehydrating filter breather. It shall be so designed that.

1. Passage of air is through a dust filter & Silica gel.
2. Silica gel is isolate from atmosphere by an oil seal.
3. Moisture absorption indicated by a change in colour of the crystals of the silica gel can be easily observed from a distance.
4. Breather is mounted not more than 1400 mm above rail top level.

7.10 **MARSHALLING BOX**

1. Sheet steel, weather, vermin and dust proof marshalling box fitted with required glands, locks, glass door, terminal Board, heater with switch, illumination lamp with switch, water-tight hinged and padlocked door of a suitable construction shall be provided with each transformer to accommodate temperature indicators, terminal blocks etc. The box shall have slopping roof and the interior and exterior painting shall be in accordance with the specification. Padlock along with duplicate keys shall be supplied for marshalling box. The degree of protection shall be IP-55 or better.
2. The schematic diagram of the circuitry inside the marshalling box be prepared and fixed inside the door under a prospone sheet.
3. The marshalling box shall accommodate the following equipment:

a) Temperature indicators.

1. Space for accommodating Control & Protection equipment in future for the cooling fan (for ONAF type cooling, may be provided in future).
2. Terminal blocks and gland plates for incoming and outgoing cables.

All the above equipments except c) shall be mounted on panels and back of panel wiring shall be used for inter-connection. The temperature indicators shall be so mounted that the dials are not more than 1600 mm from the ground level and the door (s) of the compartment(s) shall be provided with glazed window of adequate size. The transformer shall be erected on a plinth which shall be 2.5 feet above ground level.

1. To prevent internal condensation, a metal clad heater with thermostat shall be provided. The heater shall be controlled by a MCB of suitable rating mounted in the box. The ventilation louvers, suitably padded with felt, shall also be provided. The louvers shall be provided with suitable felt pads to prevent ingress of dust.
2. All incoming cables shall enter the kiosk from the bottom and the gland plate shall not be less than 450 mm from the base of the box. The gland plate and associated compartment shall be sealed in suitable manner to prevent the ingress of moisture from the cable trench.
3. The control connection, wiring etc. shall be as per Clause 3.15 of this specification.

7.11 **TAPCHANGER**

7.11.1 **ON-LOAD TAP-CHANGERS WITH REMOTE TAP CHANGE CONTROL**

Each transformer shall be provided with a on-loan tap-changer connected to the high voltage winding. The on-load tap-changer shall be capable of withstanding the voltages described earlier and shall comply with the requirements of IEC-214, latest revision. It‟s tapping range, number of steps and tap positions shall be as specified.

Adequate access for personnel shall be provided for inspection and maintenance. The guaranteed interval between maintenance periods for the diverter switch shall be 10 years or 50,000 operations. It shall not be possible for oil in the diverter switch compartment to come in contact with the oil in the main transformer tank.

The tap-changer shall be driven by a motor operated mechanism incorporating a stored energy device which shall ensure that once a change of tap begins it is completed and so shall ensure that the mechanism does not fail in an intermediate position on loss of the supply voltage to the motor. The motor shall be rated for 400/230V, 50 Hz and shall operate satisfactorily at any voltage between 85% and 110% of rated voltage.

A tap-changer mechanism box with hinged door and mounted on the transformer tank at a convenient height shall contain all electrical and mechanical parts associated locally with control of the tap-changer. Remote tap-changer controls shall also be provided at a transformer control panel (one per transformer, to be supplied under this contract) in the control room.

Facilities for electrical raise and lower operation (Control switch or push button) as well as mechanical operation shall be provided as the tap-change mechanism box. An interlock shall be provided which shall interrupt the electric supply to the drive motor when the manual mechanical operating device is engaged. The motor drive control shall be such that on initiation of a tap-change operation by means of a control switch or push-button the tap-changer shall complete its movement form one service position to an adjacent one irrespective of whether or not the control switch or push button has been operated continuously during the running time or motor drive. Another operation shall only be possible when the previous operation has been completed, the control switch or push button has been released and the control system is again in the rest position.

The tap-changer arrangement shall be such that a command to raise tap-numbers shall result in an increase in the secondary voltage with constant voltage applied to the high voltage winding.

An under and over voltage monitoring relay fed with line voltage from the Employer’s voltage transformers on the low voltage side of the transformer and capable of being set in a continuously variable range from 90% to 115% normal voltage (110V) shall be used to give visual and audible signals at the remote tap change control panel if the LV voltage lies above or below preset values.

Limit switches shall be provided to prevent over-running of the tap-change mechanism. These shall be directly connected in the motor circuit. In addition mechanical end stops shall be fitted to prevent over-running of the mechanism under any conditions. A counter shall be provided to indicate the number of tap-change operations that have been taken place.

A mechanical tap-position indicator shall be provided and it shall be visible from ground level through a window in the door of the mechanism box. Position transmitter e.g. dial switches shall be provided to:

a. Signal tap position to the control cabinet in the control room.

b. Signal “out of step” under parallel operating conditions.

A Remote/Local switch shall be provided at the mechanism box to select either remote or local operation. When this switch is turned to the Remote position control shall be passed to the control cabinet in the control room. It should be possible to use only one control, i.e. Local or Remote.

It shall be possible to operate a transformer tap-changer independently or in parallel with the tap-changers of other similar transformers in the same substation in either a “master” or “follower” mode. In addition, when operating independently or in parallel in the master mode, it shall be possible to have manual operation by means of control switch, push button or, (in future) automatic operation by means of an automatic voltage regulating relay. Contacts shall be provided for future SCADA control of the tap-changer and for reporting of the tap position and mode of control to the SCADA system. The paralleling scheme shall use the in- step principle and shall have provision for operating singly or in parallel in any combination. It shall be possible for any transformer in a group to be selected as either the master or follower for that group when operating in parallel. Each transformer control panel shall therefore have a manual/automatic control switch or push buttons, independent/master/follower control switch or push buttons as well as “raise” and lower” control switches or push buttons. Interlock shall be provided to avoid independent operation when the transformers are running in parallel. There should not be any out-of-step during such operation.

The control scheme shall be capable of extension to cater for the total number of transformers to be installed in any future development of the substation. The control mode selected shall be indicated on the front of the control cabinet.

Each transformer shall have a miniature circuit breaker (MCB) on the AC distribution cabinet through which the 400/230V, 50 Hz supply to its tap-changer and temperature controls is passed. Separate MCB‟s shall be provided at the mechanism box for protection of the motor and control circuits. The control circuits shall operate at 110V single phase, to be supplied from a transformer having a ratio of 230/55-0-55 V, with the center point earthed through a removable link mounted in the marshalling box or tap-changer mechanism box.

Each tap-changer mechanism box shall be fitted with an anti-condensation space heater (230V AC) controlled by a humidistat with variable range. A lamp for illumination purposes controlled by a door switch shall be provided. Solar gain can give rise to high temperature within a mechanism box. Adequate ventilation shall be provided to ensure that all equipment contained therein shall operate satisfactorily under these conditions.

A terminal block with terminals rated for 10 A continuous current, 650V grade of moulded insulating materials shall be provided for panel wiring and external connection. Ten percent spare terminals shall be provided in each mechanism box.

The tap changer mechanism box shall be outdoor, weatherproof type, dust, vermin and damp proof with a degree of protection of IP54 of IEC 529 or IS 13947 equivalent.

7.11.3 **Transformer Tap Change Control Panel**

The indoor panel suitable for installation in the Employer’s control room mentioned above shall contain.

Raise and Lower push buttons or switch.

Independent / master / follower selector switch.

Remote tap position indicator.

Necessary audible & visual alarms.

Out of step relay with two spare contacts ( 2 NO + 2 NC )

In addition to the above the Transformer tap change control panel shall have an audible and visual annunciation system for the following trips and alarms.

Oil temperature alarm Oil

temperature trip Winding

temperature alarm Winding

temperature trip Buchholz

alarm

Buchholz trip

Surge relay trip(OLTC gear)

Low oil level alarm

Tap changer out-of-step alarm

Failure of D.C supply alarm

Two spare windows shall be supplied on each panel

Indicating lamps shall be panel mounted type with rear terminal connections. Lamps shall be provided with series connected resistors preferably built within the lamp assembly. Lamps shall have screwed translucent lamp covers to diffuse light and shall be continuously rated for 120 percent of the 24 volt DC supply from a power pack having desired capacity. The „DC supply failure‟ lamp shall operate from the AC supply and be rated for 230 Volt AC. The wattage of the lamps shall be not more than five watts. Bulbs and lenses shall be interchangeable and easily replaceable from the font of the panel.

The Annunciation scheme with facia windows and alarm bells shall work as follows.

Annunciation scheme functions

|  |  |  |
| --- | --- | --- |
| **Incident** | **Alarm Bell** | **Facia Window** |
| Fault occurrence | Ringing | Light flashing |
| Sound cancel | Off | Light flashing |
| Acknowledge | Off | Steady light |
| Fault cleared and reset | Off | Clear |
| Lamp test | Off | Steady |

Any new annunciation operating after the operation of the „sound cancel‟ shall cause audible and visual alarm even if the process of acknowledging the previous alarm is going on or has yet to be carried out. Resetting facilities for the flasher and audible alarm circuits of the annunciator shall be provided, and provision shall be made for switching off the entire annunciation system. Two spare windows shall be provided.

The control and relay panel shall be metal clad, dust, moisture, rodent and vermin proof with degree of protection not less than IP 41 specified in IEC :529/ IS : 13947. Panels shall have folded construction and be of unit type. Each panel shall be a free standing structure, independent floor mounting type and shall be manufactured from cold rolled sheet steel of thickness not less than 2.5 mm. There shall be sufficient reinforcement to provide level surfaces, resistance to vibration and rigidity during transportation, installation and service. The panel shall be painted as specified in the clause on “painting” in the specification.

Design, material selection and workmanship shall be such as to result in neat appearance inside and outside with no welds, rivets or bolt ends apparent from outside, with all exterior surfaces even and smooth. The equipment on the front of the panel shall be matched to give neat uniform appearance.

All doors and removable covers shall be gasketted all round with neoprene bonded gaskets, Ventilating louvers shall be provided with screens and filters. The screen shall be made of non corroding metal like brass or galvanized iron wire mesh.

The transformer tap change control panel shall be supplied with all necessary internal wiring, terminal blocks, relays and alarms to provide the above listed alarm and trip functions.

Panel wiring shall be suitably bunched and clamped for neat appearance. The conductors used for wiring purpose shall be PVC insulated 650 Volt grade semi-flexible heat resistant, flame retardant and vermin proof electrolytic copper cable conforming to IEC : 227 or IS : 1554. The wiring shall be securely supported and taken through PVC troughs. All panel wiring shall be capable of withstanding a voltage of 2 KV AC 50 Hz for one minute.

Terminal blocks of brass studs rated for 10 amps continuous current, 650 volt DC grade covered by moulded insulating materials with adequate electrical clearance shall be provided for terminating the panel wiring and outgoing connections. The termination shall be made by crimping lugs or bare conductor with insulating sleeves at the ends. The arrangement can be horizontal or vertical as per standard practice adopted by the manufacturer. All terminals must be numbered and wire terminations provided with numbered ferrules for identification. All numbering and marking including those in wiring diagrams shall follow the guidelines provided in IS : 11353. Ten percent spare terminals shall be provided.

A separate removable gland plate shall be provided at the bottom of each panel for entry of PVC insulated control and auxiliary power cables in the cabinet. At least five electroplated brass cable glands of approved sizes with shrouds shall be provided in the gland plate for these cables. Provision shall be made for earthing of the cable armours in the glands.

7.12 **FITTINGS AND ACCESSORIES**

The following fittings and accessories shall be provided on the transformers:

* + 1. Conservator with isolating valves, oil filling hole with cap and drain valve. The conservator vessel shall be filled with constant oil pressure diaphragm oil sealing system.
    2. Magnetic type oil level gauge (150 mm dia) with low oil level alarm contacts.
    3. Prismatic/ toughened glass oil level gauge.
  1. Silica gel breather with oil seal and connecting pipe complete with first fill of activated silica gel or Alumina mounted at a level of 1300 mm above ground level.
     1. A double float type Buchholz relay with isolating valve. Bleeding pipe and a testing cock, the test cock shall be suitable for a flexible (pipe connection for checking its operation). A 5mm dia. Copper pipe shall be connected from the relay test cock to a valve located at a suitable height above ground level to facilitate sampling of gas with the transformer in service. Interconnection between gas collection box and relay shall also be provided. The device shall be provided with two electrically independent ungrounded contacts, one for alarm on gas accumulation and the other for tripping on sudden oil surge. These contacts shall be wired upto transformer marshalling box. The relay shall be provided with shut off valve on the conservator side as well as on the tank side.
        1. Pressure relief devices (including pressure relief valve) and necessary air equalizer connection between this and the conservator with necessary alarm and trip contacts.
     2. Air release plugs in the top cover.
  2. Inspection cover, access holes with bolted covers for access to inner ends of bushing etc.

ix) Winding temperature (hot spot) indicating device for local mounting complete in all respects. Winding temperature indicator shall have three set of contacts to operate at different settings:

* + 1. To provide winding temperature high alarm
    2. To provide temperature too high trip
  1. Dial thermometer with pocket for oil temperature indicator with one set of alarm and one set of trip contacts and maximum reading pointer.

1. Lifting eyes or lugs for the top cover, core and coils and for the complete transformer.
   1. Jacking pads
2. Haulage lugs.
3. Protected type mercury / alcohol in glass thermometer and a pocket to house the same.

* 1. Top and bottom filter valves on diagonally opposite ends with pad locking arrangement on both valves.
  2. Top and bottom sampling valves.
  3. Drain valve with pad locking arrangement
  4. Rating and connection diagram plate.
  5. Two numbers tank earthing terminals with associated nuts and bolts for connections to Employer’s grounding strip.
  6. Bi-directional flagged rollers with locking and bolting device.
  7. Marshalling Box (MB)
  8. Shut off valve on both sides of flexible pipe connections between radiator bank and transformer tank.

1. Cooling Accessories :
   * 1. Requisite number of radiators provided with :-
        + One shut off valve on top
        + One shut off valve at bottom
        + Air release device on top
        + Drain and sampling device at bottom
        + Lifting lugs.
     2. Air release device and oil drain plug on oil pipe connectors :
   1. Terminal marking plates for Current Transformer and Main Transformer
   2. On- Load Tap Changer
   3. Oil Preservation Equipment
2. Oil Temperature indicator

**Note :**

(i) The fittings listed above are indicative and any other fittings which are generally required for satisfactory operation of the transformer are deemed to be included in the quoted price of the transformer.

1. The contacts of various devices required for alarm and trip shall be potential free and shall be adequately rated for continuous, making and breaking current duties as specified.

7.13 **CONTROL CONNECTIONS AND INSTRUMENT AND WIRING** **TERMINAL**

**BOARD AND FUSES**

1. Normally no fuses shall be used anywhere instead of fuses MCB‟s (both in AC & DC circuits) shall be used. Only in cases where a MCB cannot replace a fuse due to system requirements, a HRC fuse can be accepted.
2. All wiring connections, terminal boards, fuses MCB‟s and links shall be suitable for tropical atmosphere. Any wiring liable to be in contact with oil shall have oil resisting insulation and the bare ends of stranded wire shall be sweated together to prevent seepage of oil along the wire.
3. Panel connections shall be neatly and squarely fixed to the panel. All instruments and panel wiring shall be run in PVC or non-rusting metal cleats of the compression type. All wiring to a panel shall be taken from suitable terminal boards.
4. Where conduits are used, the runs shall be laid with suitable falls, and the lowest parts of the run shall be external to the boxes. All conduit runs shall be adequately drained and ventilated. Conduits shall not be run at or below ground level.
5. When 400 volt connections are taken through junction boxes or marshalling boxes, they shall be adequately screened and 400 volts Danger Notice must be affixed to the outside of the junction boxes or marshalling box. Proper colour code for Red, Yellow, Blue wires shall be followed.
6. All box wiring shall be in accordance with relevant ISS. All wiring shall be of stranded copper (48 strands ) of 1100 Volt grade and size not less than 2.5 sq.mm
7. All wires on panels and all multi-core cables shall have ferrules, for easy identifications, which bear the same number at both ends, as indicated in the relevant drawing.
8. At those points of interconnection between the wiring carried out by separate contractors, where a change of number cannot be avoided double ferrules shall be provided on each wire. The change of numbering shall be shown on the appropriate diagram of the equipment.
9. The same ferrule number shall not be used on wires in different circuits on the same panels.
10. Ferrules shall be of white insulating material and shall be provided with glossy finish to prevent the adhesion of dirt. They shall be clearly and durably marked in black and shall not be affected by dampness or oil.
11. Stranded wires shall be terminated with tinned Ross Courtney terminals, claw washers or crimped tubular lugs. Separate washers shall be suited to the size of the wire terminated. Wiring shall, in general, be accommodated on the sides of the box and the wires for each circuit shall be separately grouped. Back of panel wiring shall be arranged so that access to the connecting items of relays and other apparatus is not impeded.
12. All circuits in which the voltage exceeds 125 volts, shall be kept physically separated from the remaining wiring. The function of each circuit shall be marked on the associated terminal boards.
13. Where apparatus is mounted on panels, all metal cases shall be separately earthed by means of stranded (48 No.) copper wire of strip having a cross section of not less than 2 sq. mm where strip is used, the joints shall be sweated. The copper wire shall have green coloured insulation for earth connections.
14. All wiring diagram for control and relay panel shall preferably be drawn as viewed from the back and shall show the terminal boards arranged as in services.
15. Terminal block rows should be spaced adequately not less than 100 mm apart to permit convenient access to external cables and terminations.
16. Terminal blocks shall be placed with respect to the cable gland ( at a minimum distance of 200as to permit satisfactory arrangement of multicore cable tails.

1. Terminal blocks shall have pairs of terminals for incoming and outgoing wires. Insulating barriers shall be provided between adjacent connections. The height of the barriers and the spacing between terminals shall be such as to give adequate protection while allowing easy access to terminals. The terminals shall be adequately protected with insulating dust proof covers. No live metal shall be exposed at the back of the terminal boards. CT terminals shall have shorting facilities. The terminals for CTs should have provision to insert banana plugs and with isolating links.
2. All interconnecting wiring, as per the final approved scheme between accessories of transformer and marshalling box is included in the scope of this specification and shall be done by the Contrator.
3. The schematic diagram shall be drawn and fixed under a transparent prospane sheet on the inner side of the marshalling box cover.
4. To avoid condensation in the Marshalling Box, a space heater shall be provided with an MCB and thermostat.
5. Suitable MV, LED light shall be provided in the Marshalling Box for lightning purpose.

7.14 **RADIO INTERFERENCE AND NOISE LEVEL**

Transformers shall be designed with particular care to suppress at least the third and fifth harmonic voltages so as to minimise interference with communication circuits. Transformer noise level when energised at normal voltage and frequency shall be as per NEMA stipulations.

1. **INSPECTION AND TESTING**
2. The Contractor shall carry out a comprehensive inspection and testing programme during manufacture of the transformer. An indicative in inspection is given under Clause No. 4.1. This is, however, not intended to form a comprehensive programme as it is contractor’s responsibility to draw up and carry out such a programme duly approved by the Owner/PMC.
3. The contractor shall carry out type tests and routine tests on the transformers.
4. Only one no of transformer of each rating will be subjected to type test. The charges for conducting each of type tests shall be included in the tender and no separate type test charges shall be paid. The Owner/PMC reserves the right to conduct any or all type tests at CPRI/ National Govt. Approved Laboratory, if the type tests were not conducted earlier on transformers of the same rating and design.
5. The pre-shipment checks shall also be carried out by the contractor.
6. The requirements on site tests are as listed in the specifications.
7. Certified test report and oscillograms shall be furnished to the Owner/PMC for evaluation as per the schedule of distribution of documents. The Contractor shall also evaluate the test results and rectify the defects in the equipment based on his and the Owner/PMC’s evaluations of the tests without any extra charges. Manufacturer’s Test Certificates in respect of all associated auxiliary and ancillary equipment shall be furnished.
8. The Contractor shall state in his proposal the testing facilities available at his works. In case full testing facilities are not available, the Contractor shall state the method proposed to be adopted so as to ascertain the transformer characteristics corresponding to full capacity.

8.1 **INSPECTION**

1. Tank and Conservator
   1. Inspection of major weld.
   2. Crack detection of major strength weld seams by dye penetration test.
   3. Check correct dimensions between wheels, demonstrate turning of wheels, through 900 and further dimensional check.
   4. Leakage test of the conservator.
2. Core
   1. Sample testing of core materials for checking specific loss, properties, magnetization characteristics and thickness.
   2. Check on the quality of varnish if used on the stampings.
   3. Check on the amount of burrs.
   4. Visual and dimensional check during assembly stage.
   5. Check on completed core for measurement of iron loss, determination of maximum flux density,
   6. Visual and dimensional checks for straightness and roundness of core, thickness of limbs and suitability of clamps.
   7. High voltage DC test (2 KV for one minute) between core and clamps.
3. Insulating Material
   1. Sample check for physical properties of materials.
   2. Check for dielectric strength
   3. Check for the reaction of hot oil on insulating materials.
4. Winding
   1. Sample check on winding conductor for mechanical and electrical conductivity.
   2. Visual and dimensional checks on conductor for scratches, dent mark etc.
   3. Sample check on insulating paper for PH value, electric strength.
   4. Check for the bonding of the insulating paper with conductor.
   5. Check and ensure that physical condition of all materials taken for windings is satisfactory and free of dust.
   6. Check for absence of short circuit between parallel strands.
5. Checks Before Drying Process
   1. Check condition of insulation on the conductor and between the windings.
   2. Check insulation distance between high voltage connections, between high voltage connection cables and earth and other live parts.
   3. Check insulating distances between low voltage connections and earth and other parts.
   4. Insulating test for core earthing.
6. Check During Drying Process
   1. Measurement and recording of temperature and drying time during vacuum treatment.
   2. Check for completeness of drying

1. Assembled Transformer
   1. Check completed transformer against approved outline drawing, provision for all fittings, finish level etc.
   2. Jacking test on the assembled Transformer.
2. Oil

All standard tests in accordance with IS: 335 shall be carried out on Transformer oil sample before filling in the transformer.

1. Test Report for bought out items

The contractor shall submit the test reports for all bought out / sub contracted items for approval.

* 1. Buchholz relay
  2. Sudden pressure rise relay on Main Tank
  3. Winding temperature indicators (for TX capacity 6/8 MVA)
  4. Oil temperature indicators
  5. Bushings
  6. Bushing current transformers in neutral
  7. Marshalling box
  8. On Load Tap changer
  9. Any other item required to complete the works.
  10. Porcelain, bushings, bushing current transformers, wherever provided, winding coolers, control devices, insulating oil and other associated equipment shall be tested by the contractor in accordance with relevant IS . If such requirement is purchased by the contractor on a sub-contract, he shall have them tested to comply with these requirements.

8.2 **FACTORY TESTS**

1. All standards routine tests in accordance IS: 2026 with dielectric tests corresponding as per latest amendments to IS: 2026 shall be carried out.
2. All auxiliary equipment shall be tested as per the relevant IS. Test certificates shall be submitted for bought out items.
3. High voltage withstand test shall be performed on auxiliary equipment and wiring after complete assembly.
4. Following additional routine tests shall also be carried out on each transformer:

a) Magnetic Circuit Test

Each core shall be tested for 1 minute at 2000 Volt DC

b) Oil leakage test on transformer

**8.2.1** **Type Test**

The transformer shall be subjected to the following type tests particularly Short circuit and Impulse withstand tests at CPRI/ National Govt. approved Laboratory at the discretion of the Owner/PMC, if these tests were not conducted on the transformers of the submitted design and rating at the cost of the manufacturer.

1. Tan delta measurement and capacitance of each winding to earth (with all other windings earthed) & between all windings connected together to earth.
2. Measurement of Zero sequence impedance.
3. Temperature Rise Test
4. Short Circuit Test
5. Tank Vacuum test
6. Tank Pressure Test
7. Lightning impulse withstand test for line and neutral terminal.
8. Measurement of acoustic noise level.

The above type tests will be conducted by the contractor at their own cost, if the design/ test result of the type- tested transformer differs from those of the offered transformer as per their submittal.

**8.2.2** **STAGE INSPECTION**

The Contrator shall offer the core, windings and tank of each transformer for inspection by the Owner/PMC representative(s). During stage Inspection, all the measurements like diameter, window height, leg centre, stack width, stack thickness, thickness of laminations etc. for core assembly, conductor size, Insulation thickness, I.D., O.D, winding height, major and minor insulations for both H.V and L.V windings, length, breadth, height and thickness of plates of Transformer tank, the quality of fittings and accessories will be taken / determined. The Contractor shall offer for final inspection of the transformers subject to clearance of the stage Inspection report by the Owner/PMC.

**8.2.3** **Routine Tests**

Transformer routine tests shall include tests stated in latest issue of IS: 2026 (Part –1). These tests shall also include but shall not be limited to the following:

1. Measurement of winding DC resistance.
2. Voltage ratio on each tapping and check of voltage vector relationship.
3. Impedance voltage at all tappings.
4. Magnetic circuit test as per relevant ISS or CBIP manual or latest standard being followed.
5. Measurement of Load losses at normal tap and extreme taps.
6. No load losses and no load current at rated voltage and rated frequency, also at 25% to 112.5% of rated voltage in steps.
7. Absorption index i.e insulation resistance for 15 seconds and 60 seconds ( R 60/ R 15) and polarization index i.e Insulation Resistance for 10 minutes and one minute (R 10 mt / R 1 mt).
8. Induced over voltage withstand test.
9. Separate source voltage withstand test.
10. Ten delta measurement and capacitance of each winding to earth (with all other windings earthed) & between all windings connected together to earth.

1. Measurement of zero sequence impedance
2. Tests on on- load tap changer ( fully assembled on transformer ) as per IEC : 214/ 1976 and BS: 4571/ 1970.
3. Auxiliary circuit tests
4. Oil BDV tests
5. Measurement of neutral unbalance current which shall not exceed 2% of the full rated current of the transformer.
6. Magnetic balance test
7. Leakage test.

Six (6) set of certified test reports and oscillographs shall be submitted for evaluation prior to dispatch of the equipment. The contractor shall also evaluate the test results and shall correct any defect indicated by his and Owner/PMC evaluation of the tests without charge.

**TANK TESTS**

**Oil leakage Test :**

a) The tank and oil filled compartments shall be tested for oil tightness completely filled with air or oil of viscosity not greater than that of insulating oil conforming to IS : 335 at the ambient temperature and applying a pressure equal to the normal pressure plus 35 KN/ m2 measured at the base of the tank. The pressure shall be maintained for a period of not less than 12 hours of oil and one hour for air and during that time no leak shall occur.

1. **Pressure Test**

Where required by the Owner/PMC, one transformer tank of each size together with its radiator, conservator vessel and other fittings shall be subjected to a pressure corresponding to twice the normal head of oil or to the normal pressure plus 35 KN / m2 whichever is lower, measured at the base of the tank and maintained for one hour.

1. **Vacuum Test**

One transformer tank of each size shall be subjected to the vacuum pressure of 60 mm of mercury. The tanks designed for full vacuum shall be tested at an internal pressure of 3.33 KN/m2 (25 mm of mercury) for one hour. The permanent deflection of flat plates after the vacuum has been released shall not exceed the value specified in C.B.I.P. Manual on Transformers (Revised 1999) without affecting the performance of the transformer.

8.5 **PRE-SHIPMENT CHECK AT MANUFACTURERS WORKS**

1. Check for proper packing and preservation of accessories like radiators, bushings, explosions vent, dehydrating breather, rollers, buchholz relay, control cubicle connecting pipes and conservator etc.
2. Check for proper provision of bracing to arrest the movement of core and winding assembly inside the tank.
3. Gas tightness test to conform tightness.

8.6 **INSPECTION AND TESTING AT SITE**

Engineer-in-charge/Employer’s representative along with the contractor’s site engineer shall carry out detailed inspection covering areas right from the receipt of material up to commissioning stage. An indicative program of inspection as envisaged by the Owner/PMC is given below.

8.6.1 **Receipt and Storage Checks**

1. Check and record conditions of each package visible parts of the transformers etc for any damage.
2. Visual check of core and coils before filling up with oil and also check condition of core and winding in general.

8.6.2 **Installation Checks**

1. Inspection and performance testing of accessories like tap changers etc.
2. Check choking of the tubes of radiators
3. Test on oil samples taken from main tank top and bottom and cooling system. Samples should be taken only after the oil has been allowed to settle for 24 hours.
4. Check the whole assembly for tightness, general appearance etc.
5. Oil leakage tests.

8.6.3 **Pre-Commissioning Tests**

After the transformer is installed, the following pre-commissioning tests and checks shall be done before putting the transformer in service.

1. Dry out test
2. Megger Test
3. DC Resistance measurement of windings
4. Ratio test on all taps
5. Phase relationship test ( Vector grouping test )
6. Buchholz relay alarm & surge operation test
7. Low oil level ( in conservator ) alarm
8. Temperature Indicators
9. Marshalling kiosk
10. Protective relays
11. Magnetising current
12. Tests on OLTC

8.6.4 **The following additional checks shall be made :**

1. All oil valves are incorrect position closed or opened as required
2. All air pocket are cleared.
3. Thermometer pockets are filled with oil.
4. Oil is at correct level in the bushing, conservator, diverter switch & tank etc.
5. Earthing connections are made.
6. Colour of Silica gel is blue.
7. Bushing arcing horn is set correctly and gap distance is recorded.

Viii) C T polarity and ratio is correct.

8.7 **PERFORMANCE**

The performance of the transformer shall be measured on the following aspects.

1. The transformer shall be capable of being operated without danger on any tapping at the rated KVA with voltage variations and ± 10% corresponding to the voltage of the tapping
2. Radio interference and Noise Level
3. The transformer shall be designed with particular attention to the suppression of third and fifth harmonics so as to minimize interference with communication circuits.

8.8 **FAULT CONDITIONS**

1. The transformer shall be capable of withstanding for two(2) seconds without damages any external short circuit to earth
2. Transformer shall be capable of withstanding thermal and mechanical stresses conveyed by symmetrical or asymmetrical faults on any winding. This shall be demonstrated through calculation as per IS : 2026.
3. Transformer shall accept, without injurious heating, combined voltage and frequency fluctuation which produce the 125% over fluxing condition for one minute and 140% for 5 seconds.

Certified test report and oscillograms shall be furnished to the Owner/PMC for evaluation as per the schedule of distribution of documents. The Contractor shall also evaluate the test results and rectify the defects in the equipment based on his and the Owner/PMC evaluations of the tests without any extra charges. Manufacturer’s Test Certificates in respect of all associated auxiliary and ancillary equipment shall be furnished.

The Contractor shall state in his proposal the testing facilities available at his works. In case full testing facilities are not available, he shall sate the method proposed to be adopted so as to ascertain the transformer characteristics corresponding to full capacity testing.

8.9 **WITNESSING OF TESTS AND EXCESSIVE LOSSES**

1. The Owner/PMC and or his representative reserve the right to witness any or all test or to accord waiver at its sole discretion.
2. The Owner/PMC reserves the right to reject the Transformer if losses exceed the maximum specified as per **Clause No 2. SPECIFIC TECHNICAL REQUIREMENTS (STANDARDCONDITIONS), item-35 & 36** of this specification or if temperature rise of oil and winding exceed the values specified at item -26 of the above clause.
3. **CAPITALISATION O F LOSSES AND LIQUIDATED DAMAGES FOR EXCESSIVE LOSSES**

9.1 Losses:-

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No.** | **Transformer Rating** | **Maximum No. Load Loss in kW** | **Maximum Copper Loss in kW** |
| 1 | 33/11 KV, 6/8 MVA | 12 | 62 |

**N.B : There shall be no positive tolerance to above losses. Capitalization of losses shall not be factored in the comparative statement for selection of vendors.**

**SPARE PARTS**

10.1 In case the manufacturer goes out of production of spare parts, then he shall make available the drawings of spare parts and specification of materials at no extra cost to the Owner/PMC to fabricate or procure spare parts from other sources.

**Mandatory Spare Parts**

The Contractor shall provide the following mandatory spare s for each of Transformer supplied

1. H.V. & L.V. Bushing & Studs –Each 2 Nos
2. Bimetallic connector for H.V & L.V. Bushings – Each 2 sets

10.2 **INSTRUCTION MANUAL**

Eight sets of the instruction manuals shall be supplied at least four (4) weeks before the actual dispatch of equipment. The manuals shall be in bound volumes and shall contain all the drawings and information required for erection, operation and maintenance of the transformer. The manuals shall include amongst other, the following particular:

1. Marked erection prints identifying the components, parts of the transformer as dispatched with assembly drawings.
2. Detailed dimensions, assembly and description of all auxiliaries.
3. Detailed views of the core and winding assembly, winding connections and tapings tap changer construction etc. These drawings are required for carrying out overhauling operation at site.
4. Salient technical particulars of the transformer.
5. Copies of all final approved drawings.
6. Detailed O&M instructions with periodical check lists and Performa etc.

10.3 **COMPLETENESS OF EQUIPMENT**

All fittings and accessories, which may not be specifically mentioned in the specification but which are necessary for the satisfactory operation of the transformer, shall be deemed to be included in the specification and shall be furnished by the Contractor without extra charges. The equipment shall be complete in all details whether such details are mentioned in the specification or not, without any financial liability under any circumstances.

11.0 **TOOLS AND TACKLES**

All the necessary tools and tackles required for normal operation & maintenance of the transformers shall be supplied by the Contractor

12.0 **COMMISSIONING**

The equipments shall be commissioned as per CBIP manual, IS: 10028 and manufacturer‟s recommendations. All the related drawings and manuals shall be pre-requisite for release of final payment.

13.0 **NON COMPLIANCE SCHEDULE**

On this schedule the Vendor shall provide a list of non compliance with this specification, documenting the effects that such non compliance is likely to have on the equipment‟s life and operating characteristics. Each Non Compliance shall refer to the relevant clause of the specification.

Where there are no deviations from specifications, the Contractor shall so indicate by stating “No deviations” in this specifications.

**TEST CTEST CERTIFICATES SCHEDULE**

On this schedule a list of the test certificates included with the submittal shall be provided. The list should include type test certificates and sample routine test reports. Each certificate listed shall be referred to the relevant specification clause and item of equipment to which the test applies.

|  |  |
| --- | --- |
| Clause No. | Type Test Certificate or Routine test Report |
|  |  |
|  |  |

**TECHNICAL DATA SCHEDULE FOR  33/11kV, 6/8MVA ONAN/ONAF Transformer with OLTC (Tap settings -5 to +10%, 13steps) and RTCC – To be submitted with Submittal for Approval**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sl.** |  | **DESCRIPTION** | |  |  |  |  | **Unit** | | **As per Tender/Relevant Codes** | **Contractor Submittal** |
| **NO.** |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  | |  |  |
| **1** | **2** |  |  | **3** |  |  |  | **4** | | **5** | **6** |
|  |  |  |  |  |  |  |  |  |  |
| 1 | Name and address of the Manufacturer | | | | |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  | a) | Transformer |  |  |  |  |  |  |  |  |  |
|  |  |  | |  |  |  |  |  |  |  |  |
|  | b) | HV & LV Bushings | |  |  |  |  |  |  |  |  |
|  |  |  | | |  |  |  |  |  |  |  |
|  | c) | Bimetallic connectors | | |  |  |  |  |  |  |  |
|  |  |  | |  |  |  |  |  |  |  |  |
|  | d) | Transformer Oil | |  |  |  |  |  |  |  |  |
|  |  |  | | | |  |  |  |  |  |  |
|  | e) | Off Load/ On load tap changer | | | |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  | f) | Instruments |  |  |  |  |  |  |  |  |  |
|  |  |  | |  |  |  |  |  |  |  |  |
| 2 | Service ( Indoor / Outdoor ) | | |  |  |  |  |  |  |  |  |
|  |  | |  |  |  |  |  |  |  |  |  |
| 3 | Normal continuous | | rating | in | KVA | under | site | KVA | |  |  |
| conditions at all taps : | | |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | |  |  |  |  |  | |  |  |
|  | a) | HV winding (KVA) | |  |  |  |  | KVA | |  |  |
|  |  |  | |  |  |  |  |  | |  |  |
|  | b) | LV winding (KVA) | |  |  |  |  | KVA | |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 4 | Rated Voltage | |  |  |  |  |  |  |  |  |  |
|  |  |  | |  |  |  |  |  | |  |  |
|  | a) | HV winding (KV ) | |  |  |  |  | KV | |  |  |
|  |  |  | |  |  |  |  |  | |  |  |
|  | b) | LV winding (KV) | |  |  |  |  | KV | |  |  |
|  |  |  | |  |  |  |  |  | |  |  |
| 5 | Rated frequency (Hz) | | |  |  |  |  | Hz | |  |  |
|  |  | |  |  |  |  |  |  |  |  |  |
| 6 | No. of phases | |  |  |  |  |  |  |  |  |  |
|  |  | |  |  |  |  |  |  |  |  |  |
| 7 | Type of transformer | |  |  |  |  |  |  |  |  |  |
|  |  | |  |  |  |  |  |  |  |  |  |
| 8 | Connections | |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  | a) | HV winding |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  | b) | LV winding |  |  |  |  |  |  |  |  |  |
|  |  |  | |  |  |  |  |  |  |  |  |
| 9 | Connections symbols | | |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  | a) | HV – LV |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 10 | Tappings | |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  | a) | Range |  |  |  |  |  |  |  |  |  |
|  |  |  | |  |  |  |  |  |  |  |  |
|  | b) | Number of steps | |  |  |  |  |  |  |  |  |
|  |  |  | |  |  | |  |  |  |  |  |
|  | c) | Position of tapping | | on | HT winding | | for |  |  |  |  |
|  | high voltage variation | | |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | | |  |  |  |  |  |  |  |
| 11 | Reference ambient temperatures | | | |  |  |  |  |  |  |  |
|  |  |  | | | | | |  | |  |  |
|  | a) | Maximum ambient air temperature (0C) | | | | | | 0C | |  |  |
|  |  | Maximum | daily | average | | ambient | | 0 |  |  |  |
|  | b) | temperature (0C) | |  |  |  |  |  | C |  |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
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| **Sl.** |  |  | **DESCRIPTION** | | |  |  |  |  | **Unit** | |  | **As per Tender/Relevant Codes** | **Contractor Submittal** |  |
| **NO.** |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | c) |  | Minimum ambient air temperature (0C) | | | | | | | 0C | |  |  |  |  |
|  |  |  |  | |  |  | |  |  |  | |  |  |  |  |
|  | d) |  | Maximum | | yearly | 0weighted | |  | average | 0C | |  |  |  |  |
|  |  |  | ambient temperature ( C) | | | |  |  |  |  |  |  |  |  |  |
|  |  |  | |  | |  |  |  |  |  |  |  |  |  |  |
| 12 | Maximum | | | temperature | | rise | over |  | ambient |  |  |  |  |  |  |
| temperature | | |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | | | |  |  |  |  | |  |  |  |  |
|  | a) |  | In oil by thermometer (0C) | | | |  |  |  | 0C | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | b) |  | In winding | | by resistance measurement | | | | | 0 | C |  |  |  |  |
|  |  | (0C) |  |  |  |  |  |  |  |  |  |  |  |
|  | c) |  | Limit for hot spot temperature for which | | | | | | | 0C | |  | |  |  |
|  |  |  | the transformer is designed (º C) | | | | |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |
|  | d) |  | Type and details of winding hot spot | | | | | | | 0 | C |  | |  |  |
|  |  |  |  |  |  |
|  |  | temperature detector (0C) | | | |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |
|  | e) |  | Temperature | | gradient between | | | windings | | 0 | C |  |  |  |  |
|  |  | and oil (0C) | |  |  |  |  |  |  |  |  |  |  |
|  | f) |  | Type of maximum winding temperature | | | | | | |  |  |  | |  |  |
|  |  | indicator (0C) | | |  |  |  |  |  |  |  |  |  |  |
|  |  |  | | | | | | | |  |  |  |  |  |  |
| 13 | Voltage to earth for which the star point will be | | | | | | | | | KV | |  |  |  |  |
| insulated | | |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | | |  |  |  |  |  |  |  |  |  |  |  |  |
| 14 | Cooling type | | |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 15 | Losses | |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | Fixed | (Iron | ) | losses | of | 3 | phase |  |  |  |  |  |  |
|  | a) |  | Transformer | | (KW ) at rated voltage & | | | | | KW | |  | |  |  |
|  |  |  | rated frequency | | |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | | |  | |  |  |  |  |  |  |
|  | b) |  | Load | losses | at rated current at | | | principal | | KW | |  | |  |  |
|  |  | Tap at 750 C (KW ) | | |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| 16 | Max. Current density in winding at rated | | | | | | | | current |  |  |  |  |  |  |
| for normal tap position | | | | |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  | |  | | | | |  |  |  | |  | |  |  |
|  | a) |  | HV winding (Amps/ sq.mm.) | | | | |  |  | A/mm2 | |  | |  |  |
|  |  |  |  | | | | |  |  |  | |  | |  |  |
|  | b) |  | LV winding (Amps / sq.mm.) | | | | |  |  | A/mm2 | |  | |  |  |
|  |  |  | | | | | | | |  |  |  |  |  |  |
|  | Impedance voltage at rated current , frequency | | | | | | | | |  |  |  |  |  |  |
| 17 | and at 750 C expressed as percentage of rated | | | | | | | | |  |  |  |  |  |  |
|  | voltage at :- | | |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | |  |  | | | | |  |  | |  |  |  |  |
|  | a) |  |  | Principal (normal) tap (%) | | | | |  | % | |  |  |  |  |
|  |  |  |  | | |  |  |  |  |  | |  |  |  |  |
|  | b) |  | Highest tap (%) | | |  |  |  |  | % | |  |  |  |  |
|  |  |  |  | | |  |  |  |  |  | |  |  |  |  |
|  | c) |  | Lowest tap (%) | | |  |  |  |  | % | |  |  |  |  |
|  |  |  | | | | | | |  |  |  |  |  |  |  |
| 18 | Reactance at rated current & frequency as | | | | | | | |  |  |  |  |  |  |  |
| percentage of rated voltage at: | | | | | |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  | |  | | | |  |  |  |  | |  |  |  |  |
|  | a) |  | Principal (normal) tap | | | |  |  |  | % | |  |  |  |  |
|  |  |  |  | |  |  |  |  |  |  | |  |  |  |  |
|  | b) |  | Highest Tap | |  |  |  |  |  | % | |  |  |  |  |
|  |  |  |  | |  |  |  |  |  |  | |  |  |  |  |
|  | c) |  | Lowest Tap | |  |  |  |  |  | % | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |
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| **Sl.** |  |  | **DESCRIPTION** | **Unit** |  | **As per Tender/Relevant Codes** | **Contractor Submittal** |
| **NO.** | |  |  |  |
|  |  |  |  |  |
| 19 |  | Resistance at 75ºC | |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  | a) | H.V. winding at normal tap position | Ohms |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  | b) | L.V. winding | Ohms |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  | Resistance voltage drop at 75ºC winding |  |  |  |  |
|  |  | c) | temperature expressed as percent of rated |  |  |  |  |
|  |  |  | voltage (%) |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  | i) Principal/ normal tap | % |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  | ii) Highest tap | % |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  | iii) Lowest tap | % |  |  |  |
|  |  |  |  |  |  |  |  |
| 20 |  | Capacitance on open circuit conditions | |  |  |  |  |
|  |  |  |  |  |  |  |  |
| 21 |  | Insulation level | |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  | a) | Separate source power frequency voltage |  |  |  |  |
|  |  | withstand |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  | i) HV winding (KV rms) | KV |  |  |  |
|  |  |  | rms |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  | ii) LV winding (KV rms) | KV |  |  |  |
|  |  |  | rms |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  | b) | Induced over voltage withstand |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  | i) HV winding (KV rms) | KV | --- |  |  |
|  |  |  | rms |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  | ii) LV winding (KV rms) | KV | --- |  |  |
|  |  |  | rms |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  | c) | Full wave lightning impulsa withstand |  |  |  |  |
|  |  | voltage |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  | i) HV winding (KV peak) | KV |  |  |  |
|  |  |  | peak |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  | ii) LV winding (KV peak) | KV |  |  |  |
|  |  |  | peak |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  | d) | Power frequency high voltage tests |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  | i) | Test voltage for one minute withstand test | KV |  |  |  |
|  |  | on high voltage windings (induced) | rms |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  | ii) | Test voltage for one minute withstand test | KV |  |  |  |
|  |  | on low voltage windings | rms |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  | iii) | Test voltage for one minute withstand test | KV |  |  |  |
|  |  | on neutral end of low voltage windings | rms |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  | e) | Lightning impulse withstand tests |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  | Impulse test on high voltage winding | KV |  |  |  |
|  |  | i) | 1.2/50 µ sec full wave withstand (KV |  |  |  |
|  |  | peak |  |  |  |
|  |  |  | peak) |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  | Impulse test on low voltage winding | KV |  |  |  |
|  |  | ii) | 1.2/50 µ sec full wave withstand (KV |  |  |  |
|  |  | peak |  |  |  |
|  |  |  | peak) |  |  |  |
|  |  |  |  |  |  |  |
|  |  | iii) | Wave form for impulse test | KV |  |  |  |
|  |  | peak |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  | No load current, no load loss, no load power | | Amp/ |  |  |  |
| 22 | | factor at normal ratio and frequency (Amp/ KW/ | | KW/ |  |  |  |
|  |  | P.F.) |  | P.F |  |  |  |
|  |  |  |  |  |  |  |  |

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| **Sl.** |  | **DESCRIPTION** | **Unit** | **As per Tender/Relevant Codes** | **Contractor Submittal** |
| **NO.** |  |  |
|  |  |  |  |
|  | a) | 10 percent of rated voltage |  |  |  |
|  |  |  |  |  |  |
|  | b) | 25 percent of rated voltage |  |  |  |
|  |  |  |  |  |  |
|  | c) | 50 percent of rated voltage |  |  |  |
|  |  |  |  |  |  |
|  | d) | 85 percent of rated voltage |  |  |  |
|  |  |  |  |  |  |
|  | e) | 100 percent of rated voltage |  |  |  |
|  |  |  |  |  |  |
|  | f) | 105 percent of rated voltage |  |  |
|  |  |  |  |  |  |
|  | g) | 110 percent of rated voltage |  |  |  |
|  |  |  |  |  |  |
|  | h) | 112.5 percent of rated voltage |  |  |  |
|  |  |  |  |  |  |
|  | i) | 115 percent of rated voltage |  |  |  |
|  |  |  |  |  |  |
|  | j) | 120 percent of rated voltage |  |  |  |
|  |  |  |  |  |  |
|  | k) | 125 percent of rated voltage |  |  |  |
|  |  |  |  |  |  |
| 23 | Efficiency at 75ºC at unity power factor | |  |  |  |
|  |  |  |  |  |  |
|  | a) | Full load | % |  |  |
|  |  |  |  |  |  |
|  | b) | 75% load | % |  |  |
|  |  |  |  |  |  |
|  | c) | 50% load | % |  |  |
|  |  |  |  |  |  |
|  | d) | 25% load | % |  |  |
|  |  |  |  |  |  |
|  |  | The minimum % of load at which the |  |  |  |
| 24 | a) | transformer will run at maximum | % |  |  |
|  |  | efficiency (%) |  |  |  |
|  |  |  |  |  |  |
|  | b) | Maximum efficiency of the transformer | % |  |  |
|  |  |  |  |  |  |
| 25 | Regulation at full load at 75ºC | |  |  |  |
|  |  |  |  |  |  |
|  | a) | At unity power factor (%) | % |  |  |
|  |  |  |  |  |  |
|  | b) | At 0.8 power factor (lagging) (%) | % |  |  |
|  |  |  |  |  |  |
| 26 | Core data | |  |  |  |
|  |  |  |  |  |  |
|  | a) | Grade of core material used |  |  |  |
|  |  |  |  |  |  |
|  | b) | Thickness of core plate lamination (mm) | mm |  |  |
|  |  |  |
|  |  |  |  |  |
|  | c) | Whether core laminations are of cold |  |  |  |
|  | rolled grain oriented |  |  |
|  |  |  |  |  |
|  |  |  |  |  |  |
|  | d) | Details of oil ducts in core |  |  |  |
|  |  |  |  |  |  |
|  |  | i) Whether in the plane & at right angle to |  |  |  |
|  |  | the plane of winding |  |  |  |
|  |  |  |  |  |  |
|  |  | ii) Across the plane of lamination |  |  |  |
|  |  |  |  |  |  |
|  | e) | i) Insulation of core lamination |  |  |  |
|  |  |  |  |  |  |
|  |  | ii) Insulation of core plates |  |  |  |
|  |  |  |  |  |  |
|  |  | iii) Type of core joints |  |  |  |
|  |  |  |  |  |  |
| 27 | Flux density | |  |  |  |
|  |  |  |  |  |  |
|  |  | Designed maximum flux density at normal |  |  |  |
|  | a) | tap at rated voltage and rated frequency | Tesla |  |  |
|  |  | (Tesla) |  |  |  |
|  |  |  |  |  |  |

|  |  |  |  |  |  |  |
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| **Sl.** |  | **DESCRIPTION** | **Unit** | **As per Tender/Relevant Codes** | **Contractor Submittal** |  |
| **NO.** |  |  |  |
|  |  |  |  |  |
|  | b) | Operating continuous flux density(Tesla) | Tesla |  |  |  |
|  |  |  |  |  |  |  |
|  |  | i) at normal tap | Tesla |  |  |  |
|  |  |  |  |  |  |  |
|  |  | ii) at maximum tap | Tesla |  |  |  |
|  |  |  |  |  |  |  |
|  |  | iii) at minimum tap | Tesla |  |  |  |
|  |  |  |  |  |  |  |
|  |  | Designed maximum operating flux density |  |  |  |  |
|  | c) | which the transformer can withstand for | Tesla |  |  |  |
|  |  | one minute at normal tap(Tesla) |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  | Designed maximum operating flux density |  |  |  |  |
|  | d) | which the transformer can withstand for | Tesla |  |  |  |
|  |  | five seconds at normal tap(Tesla) |  |  |  |  |
|  |  |  |  |  |  |  |
| 28 | Inter-Tap insulation | |  |  |  |  |
|  |  | |  |  |  |  |
|  | a) | Extent of extreme end turns reinforcement |  |  |  |  |
|  |  |  |  |  |  |  |
|  | b) | Extent of end turns reinforcement |  |  |  |  |
|  |  |  |  |  |  |  |
|  | c) | Extent of turn adjacent to tapping |  |  |  |  |
|  | reinforced |  |  |  |  |
|  |  |  |  |  |  |
|  | d) | Test voltage for 10 seconds 50Hz inter- |  |  |  |  |
|  | turn insulation test on (a) |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | e) | Test voltage for 10 seconds 50Hz inter- |  |  |  |  |
|  | turn insulation test on (b) |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | f) | Test voltage for 10 seconds 50Hz inter- |  |  |  |  |
|  | turn insulation test on (c) |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| 29 | Windings: | |  |  |  |  |
|  |  |  |  |  |  |  |
|  | a) | Material |  |  |  |  |
|  |  |  |  |  |  |  |
|  | b) | Type of windings: |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  | i) HV windings |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  | ii) LV windings |  |  |  |  |
|  |  |  |  |  |  |  |
|  | c) | Insulation of HV windings |  |  |  |  |
|  |  |  |  |  |  |  |
|  | d) | Insulation of LV windings |  |  |  |  |
|  |  |  |  |  |  |  |
|  | e) | Insulation between HV & LV windings |  |  |  |  |
|  |  |  |  |  |  |  |
| 30 | Continuous rating under following conditions: | |  |  |  |  |
|  |  |  |  |  |  |  |
|  | a) | At 40ºC ambient air temp. at site | KVA |  |  |  |
|  |  |  |  |  |  |  |
|  | b) | At 30ºC ambient air temp. at site | KVA |  |  |  |
|  |  |  |  |  |  |  |
|  | c) | At 20ºC ambient air temp. at site | KVA |  |  |  |
|  |  |  |  |  |  |  |
| 31 | Transformer Tank | |  |  |  |  |
|  |  |  |  |  |  |  |
|  | a) | Material |  |  |  |  |
|  |  |  |  |  |  |  |
|  | b) | Thickness |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  | - Top | mm |  |  |  |
|  |  |  |  |  |  |  |
|  |  | - Sides | mm |  |  |  |
|  |  |  |  |  |  |  |
|  |  | - Bottom | mm |  |  |  |
|  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | | | | | | | |  | |
|  |  |  |  |  |  |  |  |  |  |  |  |
| **Sl.** |  | **DESCRIPTION** | | | |  |  |  | **Unit** | **As per Tender/Relevant Codes** | **Contractor Submittal** |
| **NO.** |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | c) | Details of painting (inner / outer surface) | | | | | | |  |  |  |
|  |  |  | | | | |  |  |  |  |  |
| 32 | Dimensions of 3 phase transformers: | | | | | |  |  |  |  |  |
|  |  |  | | | | | |  |  |  |  |
|  | a) | Max. Height to top of bushings (mm) | | | | | |  | mm |  |  |
|  |  |  | | | |  |  |  |  |  |  |
|  | b) | Over-all length (mm) | | | |  |  |  | mm |  |  |
|  |  |  | | | |  |  |  |  |  |  |
|  | c) | Over-all breadth (mm) | | | |  |  |  | mm |  |  |
|  |  |  |  |  |  |  | |  |  |  |  |
|  | Weight | | data | of | transformer | components | | : |  |  |  |
| 33 | (Tolerance + | | | 5% | ) ( approximate | | values | not |  |  |  |
|  | allowed ) | |  |  |  |  |  |  |  |  |  |
|  |  |  | | | | |  |  |  |  |  |
|  | a) | Core excluding clamping (Kg) | | | | |  |  | Kg |  |  |
|  |  |  | | | |  |  |  |  |  |  |
|  | b) | Core with clamping (Kg) | | | |  |  |  | Kg |  |  |
|  |  |  | | | | | |  |  |  |  |
|  | c) | HV winding insulated conductor (Kg) | | | | | |  | Kg |  |  |
|  |  |  | | | | | |  |  |  |  |
|  | d) | LV winding Insulated conductor (Kg) | | | | | |  | Kg |  |  |
|  |  |  | | | |  |  |  |  |  |  |
|  | e) | Coils with insulation (Kg.) | | | |  |  |  | Kg |  |  |
|  |  |  | | | |  |  |  |  |  |  |
|  | f) | Core and windings (Kg) | | | |  |  |  | Kg |  |  |
|  |  |  | | | |  |  |  |  |  |  |
|  | g) | Weight of steel (Kg) | | | |  |  |  | Kg |  |  |
|  |  |  | | | | |  |  |  |  |  |
|  | h) | Fittings and accessories (Kg) | | | | |  |  | Kg |  |  |
|  |  |  | | | | | | |  |  |  |
|  | i) | Oil required for first filling including 10% | | | | | | | Ltr/ |  |  |
|  | extra | |  |  |  |  |  | Kg |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  | | |  |  |  |  |  |  |
|  |  | 1. | Oil in main tank ( Ltrs) | | |  |  |  | Ltr |  |  |
|  |  |  |  | | | |  |  |  |  |  |
|  |  | 2. | Oil in the conservator (Ltrs) | | | |  |  | Ltr |  |  |
|  |  |  |  | | | |  |  |  |  |  |
|  |  | 3. | Oil in the radiators ( Ltrs ) | | | |  |  | Ltr |  |  |
|  |  |  |  | | |  |  |  |  |  |  |
|  |  | 4. | Oil in the OLTC (Ltrs ) | | |  |  |  | Ltr |  |  |
|  |  |  |  | | | | | |  |  |  |
|  |  | 5. | Overall total quantity of oil with 10% | | | | | | ltr/Kg |  |  |
|  |  | extra oil for first filling (ltrs / Kg) | | | | | |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  | | | |  | |  |  |  |
|  | j) | 1. | Transportation weight | | | | excluding | | Kg |  |  |
|  | accessories | | |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  | | |  |  |  |  |  |  |
|  |  | 2. | Shipping details | | |  |  |  |  |  |  |
|  |  |  | | | | | |  |  |  |  |
|  |  | i) Weight of heaviest package (Kg.) | | | | | |  | Kg |  |  |
|  |  |  | | | |  | | |  |  |  |
|  |  | ii) Dimension of largest | | | | package (L x W | | | mm |  |  |
|  |  | x H) (Mm) | | |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | | | |  |  |  |  |  |  |
|  | k) | Untanking weight (Kg) | | | |  |  |  | Kg |  |  |
|  |  |  | | |  | | | |  |  |  |
|  | l) | Total weight | | | of transformer with oil and | | | | Kg |  |  |
|  | fittings | |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  | |  |  |  |  |  |  |  |  |
| 34 | Bushing data : | | |  |  |  |  |  |  |  |  |
|  |  |  | | | |  |  |  |  |  |  |
|  | a) | Type of bushing insulator | | | |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | i) HV | |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  | ii) | LV |  |  |  |  |  |  |  |  |
|  |  |  | | |  |  |  |  |  |  |  |
|  |  | iii) Neutral | | |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |

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| **Sl.** |  | **DESCRIPTION** | |  | **Unit** | **As per Tender/Relevant Codes** | **Contractor Submittal** |
| **NO.** |  |  |  |
|  |  |  |  |  |  |
|  | b) | Material of bushing (inner part / | | outer |  |  |  |
|  | part) | |  |  |  |
|  |  |  |  |  |  |
|  |  |  | |  |  |  |  |
|  | c) | Weight of bushing insulator (Kg.) | |  |  |  |  |
|  |  |  | |  |  |  |  |
|  |  | i) HV | |  | Kg |  |  |
|  |  |  |  |  |  |  |  |
|  |  | ii) | LV |  | Kg |  |  |
|  |  |  |  |  |  |  |  |
|  |  | iii) | Neutral |  | Kg |  |  |
|  |  |  | |  |  |  |  |
|  | d) | Quantity of oil in one bushing (lt.) | |  |  |  |  |
|  |  |  | |  |  |  |  |
|  |  | i) HV | |  | ltr. |  |  |
|  |  |  |  |  |  |  |  |
|  |  | ii) | LV |  | ltr. |  |  |
|  |  |  |  |  |  |  |  |
|  |  | iii) | Neutral |  | ltr. |  |  |
|  |  |  | |  |  |  |  |
|  | e) | Minimum dry withstand & flash | | over | KV |  |  |
|  | power frequency voltage of bushing (KV) | | |  |  |
|  |  |  |  |  |
|  |  |  | |  |  |  |  |
|  | f) | Minimum wet withstand & flash | | over | KV |  |  |
|  | power frequency voltage of bushing (KV) | | |  |  |
|  |  |  |  |  |
|  |  |  | | |  |  |  |
|  | g) | Minimum withstand & flashover impulse | | | KV |  |  |
|  | level (KV) | |  |  |  |
|  |  |  |  |  |  |
|  |  |  | |  |  |  |  |
|  | h) | Voltage rating (KV) | |  |  |  |  |
|  |  |  | |  |  |  |  |
|  |  | i) HV | |  | KV |  |  |
|  |  |  | |  |  |  |  |
|  |  | ii) LV | |  | KV |  |  |
|  |  |  |  |  |  |  |  |
|  |  | iii) | Neutral |  | KV |  |  |
|  |  |  | |  |  |  |  |
|  | i) | Current rating (Amps.) | |  |  |  |  |
|  |  |  | |  |  |  |  |
|  |  | i) HV | |  | Amp |  |  |
|  |  |  | |  |  |  |  |
|  |  | ii) LV | |  | Amp |  |  |
|  |  |  |  |  |  |  |  |
|  |  | iii) | Neutral |  | Amp |  |  |
|  |  |  | | |  |  |  |
|  | j) | Thermal Short Time current & Duration | | | Sec |  |  |
|  |  |  | |  |  |  |  |
|  |  | i) HV | |  | KA |  |  |
|  |  |  | |  |  |  |  |
|  |  | ii) LV | |  | KA |  |  |
|  |  |  |  |  |  |  |  |
|  |  | iii) | Neutral |  | KA |  |  |
|  |  |  | |  |  |  |  |
|  | k) | Rated Dynamic current & its duration | |  | Sec |  |  |
|  |  |  | |  |  |  |  |
|  |  | i) HV | |  | KA |  |  |
|  |  |  | |  |  |  |  |
|  |  | ii) LV | |  | KA |  |  |
|  |  |  |  |  |  |  |  |
|  |  | iii) | Neutral |  | KA |  |  |
|  |  |  | |  |  |  |  |
|  | l) | Cantilever with stand loading | |  |  |  |  |
|  |  |  | |  |  |  |  |
|  | m) | Clearance in oil | |  |  |  |  |
|  |  |  | |  |  |  |  |
|  |  | -phase to phase (mm) | |  |  |  |  |
|  |  |  | |  |  |  |  |
|  |  | i) HV | |  | mm |  |  |
|  |  |  | |  |  |  |  |
|  |  | ii) LV | |  | mm |  |  |
|  |  |  |  |  |  |  |  |

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| **Sl.** |  | **DESCRIPTION** | | **Unit** | **As per Tender/Relevant Codes** | **Contractor Submittal** |
| **NO.** |  |  |
|  |  |  |  |  |
|  |  | iii) | Neutral | mm |  |  |
|  |  |  | |  |  |  |
|  |  | -phase to earth (mm) | |  |  |  |
|  |  |  | |  |  |  |
|  |  | i) HV | | mm |  |  |
|  |  |  | |  |  |  |
|  |  | ii) LV | | mm |  |  |
|  |  |  |  |  |  |  |
|  |  | iii) | Neutral | mm |  |  |
|  |  |  |  |  |  |  |
|  | n) | Creepage distance in oil & air (mm) | | mm/ |  |  |
|  | KV |  |  |
|  |  |  |  |  |  |
|  |  |  | |  |  |  |
|  |  | i) In oil | |  |  |  |
|  |  |  | |  |  |  |
|  |  | a) HV | | mm |  |  |
|  |  |  | |  |  |  |
|  |  | b) LV | | mm |  |  |
|  |  |  | |  |  |  |
|  |  | c) Neutral | | mm |  |  |
|  |  |  | |  |  |  |
|  |  | ii) In air | | mm |  |  |
|  |  |  | |  |  |  |
|  |  | a) HV | | mm |  |  |
|  |  |  | |  |  |  |
|  |  | b) LV | | mm |  |  |
|  |  |  | |  |  |  |
|  |  | c) Neutral | | mm |  |  |
|  |  |  | |  |  |  |
|  | o) | Minimum level of immersing / medium | | mm |  |  |
|  | (oil) (mm) | |  |  |
|  |  |  |  |  |
|  |  |  | |  |  |  |
|  | p) | Maximum pressure of immersing medium | | Kg/ |  |  |
|  | (oil) |  | cm2 |  |  |
|  | q) | Free space required at top for removal of | | mm |  |  |
|  | bushings | |  |  |
|  |  |  |  |  |
|  |  |  | |  |  |  |
|  | r) | Angle of mounting | |  |  |  |
|  |  |  | |  |  |  |
| 35 | Conservator (Main Transformer and OLTC ) | | |  |  |  |
|  |  |  | |  |  |  |
|  | a) | Total volume of the Conservator (Cub | | M3 |  |  |
|  |  | mtr) |  |  |  |  |
|  | b) | Volume of the conservator between the | | M3 |  |  |
|  |  | highest and lowest level (Cubic mtr. / Ltrs) | |  |  |  |
|  |  |  | |  |  |  |
| 36 | Calculated time constants for natural cooling | | | Hrs |  |  |
|  |  | | |  |  |  |
| 37 | Type of axial coil supports : | | |  |  |  |
|  |  |  | |  |  |  |
|  | a) | HV winding | |  |  |  |
|  |  |  | |  |  |  |
|  | b) | LV winding | |  |  |  |
|  |  |  | |  |  |  |
| 38 | Details of On load / off-circuit tap changer | | |  |  |  |
|  |  |  | |  |  |  |
|  | a) | Make | |  |  |  |
|  |  |  | |  |  |  |
|  | b) | Type | |  |  |  |
|  |  |  | |  |  |  |
|  | c) | Rating | |  |  |  |
|  |  |  |  |  |  |  |
|  |  | i) | Rated Voltage | KV |  |  |
|  |  |  |  |  |  |  |
|  |  | ii) | Rated current | Amp |  |  |
|  |  |  |  |  |  |  |
|  |  | iii) | Step voltage | V |  |  |
|  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
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|  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Sl.** |  |  | **DESCRIPTION** | | | |  |  |  | **Unit** | **As per Tender/Relevant Codes** | **Contractor Submittal** |
| **NO.** |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | iv) |  | Number of steps | | | |  |  |  |  |
|  |  |  |  | |  | |  | |  |  |  |  |
|  |  | d) | Whether | | Diverter | | switch provided | | with | Yes/ |  |  |
|  |  | gas vent and buchholz relay (Yes / No ) | | | | | | | No |  |  |
|  |  |  |  |  |
|  |  |  |  | |  |  | | |  |  |  |  |
|  |  | e) | Whether | | a | separate oil surge relay | | | with |  |  |  |
|  |  | trip contracts provided (Yes / No) | | | | | |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  | | | | | | |  |  |  |
|  |  |  | Whether Remote control panel provided | | | | | | |  |  |  |
|  |  |  | with Control scheme for simultaneous | | | | | | |  |  |  |
|  |  | f) | operation | |  | of | Tap | changer | when |  |  |  |
|  |  | transformers running in Parallel and | | | | | | |  |  |  |
|  |  |  |  |  |  |
|  |  |  | independent | | | control when in independent | | | |  |  |  |
|  |  |  | operation | |  |  |  |  |  |  |  |  |
|  |  |  |  | | |  |  |  | |  |  |  |
|  |  | g) | Details of | | | motor | device | unit housed in | |  |  |  |
|  |  | kiosk mounted on tap changer | | | | | |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  | | | | |  |  |  |  |  |
|  |  | h) | Pressure relief valve | | | | |  |  |  |  |  |
|  |  |  |  | | |  |  |  |  |  |  |  |
| 39 |  | Despatch details : | | | |  |  |  |  |  |  |  |
|  |  |  |  | | | | | | |  |  |  |
|  |  | a) | Approx. mass of heaviest Package (Kg) | | | | | | | Kg |  |  |
|  |  |  |  | | | | | | |  |  |  |
|  |  | b) | Approx. dimensions of largest Package | | | | | | |  |  |  |
|  |  |  |  |  |  | | |  |  |  |  |  |
|  |  |  | i) |  | Length (mm) | | |  |  | mm |  |  |
|  |  |  |  |  |  | | |  |  |  |  |  |
|  |  |  | ii) |  | Breadth (mm) | | |  |  | mm |  |  |
|  |  |  |  |  |  | |  |  |  |  |  |  |
|  |  |  | iii) |  | Height | | (mm) |  |  | mm |  |  |
|  |  |  |  | | | |  |  |  |  |  |  |
| 40 |  | Untanking height (mm) | | | | |  |  |  | mm |  |  |
|  |  |  | | | | |  | |  |  |  |  |
| 41 |  | Bimetallic connectors: | | | | | HV / LV | |  |  |  |  |
|  |  |  |  | | | | |  |  |  |  |  |
|  |  | a) | Normal current rating (A) | | | | |  |  | Amp |  |  |
|  |  |  |  | | | | | |  |  |  |  |
|  |  | b) | Short time current rating (A) | | | | | |  | Amp |  |  |
|  |  |  |  | | | | |  |  |  |  |  |
|  |  | c) | Tensile strength (Kg) | | | | |  |  |  |  |  |
|  |  |  |  | | | | | |  |  |  |  |
|  |  | d) | Maximum temperature limit | | | | | |  |  |  |  |
|  |  |  |  | | | | | | |  |  |  |
|  |  | e) | Dimensional sketch enclosed indicating | | | | | | |  |  |  |
|  |  | tolerances (Yes/No) | | | | |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  | | | | | |  |  |  |  |
|  |  | f) | Minimum clearance (mm) | | | | | |  |  |  |  |
|  |  |  |  |  | | | |  |  |  |  |  |
|  |  |  | - | Phase to phase | | | |  |  | mm |  |  |
|  |  |  |  |  | | | |  |  |  |  |  |
|  |  |  | - | Phase to Earth | | | |  |  | mm |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |

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| **Sl.** |  |  | **DESCRIPTION** | |  |  |  |  |  | **Unit** | **As per Tender/Relevant Codes** | **Contractor Submittal** |
| **NO.** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| 42 |  | CORE ASSEMBLY :- | | |  |  |  |  |  |  |  |  |
|  |  |  |  | | |  |  |  |  |  |  |  |
|  |  | a) | Core diameter (mm ) | | |  |  |  |  | mm |  |  |
|  |  |  |  | | | |  |  |  |  |  |  |
|  |  | b) | Core window height (mm ) | | | |  |  |  | mm |  |  |
|  |  |  |  | | |  |  |  |  |  |  |  |
|  |  | c) | Core leg centre (mm ) | | |  |  |  |  | mm |  |  |
|  |  |  |  | | | | | |  |  |  |  |
|  |  | d) | Gross core cross – sectional area (m2) | | | | | |  | M2 |  |  |
|  |  | e) | Total height of core (mm ) | | | |  |  |  | mm |  |  |
|  |  |  |  | | | |  |  |  |  |  |  |
|  |  | f) | Details of top end frame | | | |  |  |  |  |  |  |
|  |  |  |  | | | | |  |  |  |  |  |
|  |  | g) | Details of Bottom end frame | | | | |  |  |  |  |  |
|  |  |  |  | | | | | | |  |  |  |
|  |  | h) | Details of clamp plate (material, thickness, | | | | | | |  |  |  |
|  |  | insulation) | |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | | |  |  |  |  |  |  |  |
|  |  | i) | Total core weight (Kg ) | | |  |  |  |  | Kg |  |  |
|  |  |  |  | | | | | | |  |  |  |
|  |  |  | Core loss, basing on core loss graph at | | | | | | |  |  |  |
|  |  | j) | operating flux density (rated voltage | | | | | | and | W/Kg |  |  |
|  |  |  | rated frequency ) ( KW ) | | | |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | k) | Core stacking factor | | |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  | | |  |  |  |  |  |  |  |
|  |  | l) | Net core area (Sq.m) | | |  |  |  |  | M2 |  |  |
|  |  |  |  |  |  | |  |  | |  |  |  |
|  |  | m) | Margin | towards | corner | | joints, | cross- | | KW |  |  |
|  |  | fluxing, dielectric loss (KW) | | | | |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  | | | | | | |  |  |  |
|  |  | n) | Total core loss at rated voltage and rated | | | | | | | KW |  |  |
|  |  | frequency (KW ) | |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | | |  |  |  |  |
|  |  | o) | Describe | location | / | method of | | | core |  |  |  |
|  |  | grounding | |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | | |  |  |  |  |  |  |  |
|  |  | p) | Details of core- belting | | |  |  |  |  |  |  |  |
|  |  |  |  | | | |  |  |  |  |  |  |
|  |  |  | i) Material , grade and type | | | |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | ii) Width |  |  |  |  |  |  | mm |  |  |
|  |  |  |  | |  |  |  |  |  |  |  |  |
|  |  |  | iii) Thickness | |  |  |  |  |  | mm |  |  |
|  |  |  |  | |  |  |  |  |  |  |  |  |
|  |  |  | iv) Fixing method | |  |  |  |  |  |  |  |  |
|  |  |  |  | |  |  |  |  |  |  |  |  |
| 43 |  | DETAILS OF WINDING | | |  |  |  |  |  |  |  |  |
|  |  |  |  | |  |  |  |  |  |  |  |  |
|  |  | a) | Type of winding | |  |  |  |  |  |  |  |  |
|  |  |  |  | | | | |  |  |  |  |  |
|  |  | b) | Material of the winding conductor | | | | |  |  |  |  |  |
|  |  |  |  | | | | | | |  |  |  |
|  |  |  | Maximum current density of windings at | | | | | | | A/mm2 |  |  |
|  |  | c) | rated current and conductor area ( HV / | | | | | | |  |
|  |  |  | LV ) |  |  |  |  |  |  |  |  |  |
|  |  |  |  | | | | |  |  |  |  |  |
|  |  | d) | Whether windings are pre-shrunk ? | | | | |  |  |  |  |  |
|  |  |  |  |  | |  |  | |  |  |  |  |
|  |  | e) | Whether | adjustable | | coil | clamps | | are |  |  |  |
|  |  | provided for HV and LV windings ? | | | | | |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  | |  |  |  |  |  |  |  |
|  |  | f) | Whether | steel rings | | are | used | for | the |  |  |  |
|  |  | windings ? If so, whether these are split ? | | | | | | |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  | | | | | | |  |  |  |
|  |  |  | Whether electrostatic shields are provided | | | | | | |  |  |  |
|  |  | g) | to obtain uniform voltage distribution in | | | | | | |  |  |  |
|  |  |  | the windings ? | |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | | | | |  | |
|  |  |  |  |  |  |  |  |  |
| **Sl.** |  |  | **DESCRIPTION** | |  | **Unit** | **As per Tender/Relevant Codes** | **Contractor Submittal** |
| **NO.** |  |  |  |  |
|  |  |  |  |  |  |  |
|  | h) |  | Winding Insulation ( Type & Class ) | | |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  | i) |  | Insulating material , used for | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | i) H.V winding | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | ii) LV winding | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | iii) Tapping connection | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  | j) |  | Insulating material used between | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | i) L.V and H.V winding | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | ii) Core & L.V winding | |  |  |  |  |
|  |  |  |  |  | |  |  |  |
|  | k) |  | H.V to H.V winding between phases | | |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  | l) |  | Type of axial supports | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | i) H.V winding | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | ii) L.V winding | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  | m) |  | Type of radial supports | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | i) H.V winding | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | ii) L.V winding | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  | n) |  | Maximum allowable torque | | on coil |  |  |  |
|  |  | clamping bolts | |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  | o) |  | Clamping ring details | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | i) Thickness of ring mm | |  | mm |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | ii) Diameter of ring mm | |  | mm |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | iii) No. & size of pressure screw | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  | p) |  | Bare conductor size (mm2) | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | i) HV | |  | mm2 |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | ii) LV | |  | mm2 |  |  |
|  |  |  |  |  |  |  |  |  |
|  | w) |  | Inside diameter (mm ) | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | i) HV | |  | mm |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | ii) LV | |  | mm |  |  |
|  |  |  |  |  |  |  |  |  |
|  | x) |  | Outside diameter (mm ) | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | i) HV | |  | mm |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | ii) LV | |  | mm |  |  |
|  |  |  |  |  | |  |  |  |
|  | y) |  | Axial height after shrinkage (mm ) | | |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | i) HV | |  | mm |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  | ii) LV | |  | mm |  |  |
|  |  |  |  | |  |  |  |  |
|  | z) |  | D.C Resistance | |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  | i) |  | L.V winding at 750 C (Ohms ) | |  | Ohm |  |  |
|  |  |  |  | |  |  |  |  |
|  | ii) |  | H.V winding at normal tap at 750 | | C (Ohms | Ohm |  |  |
|  | ) | |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | | | | | |  | |
|  |  |  |  |  |  |  |  |  |  |
| **Sl.** |  |  | **DESCRIPTION** | |  |  | **Unit** | **As per Tender/Relevant Codes** | **Contractor Submittal** |
| **NO.** |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  | iii) | H.V winding at highest tap at 750 C | | | | Ohm |  |  |
|  |  | (Ohms ) | |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  | | |  |  |  |
|  |  | iv) | H.V winding at lowest tap at 750 C (Ohms | | | | Ohm |  |  |
|  |  | ) |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | |  |  |  |
|  |  | v) | Total I 2R losses at 750 | | C for normal tap | | KW |  |  |
|  |  | (KW ) | |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  | vi) | Total I2R losses at 750 | | C for highest | tap | KW |  |  |
|  |  | (KW ) | |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | |  |  |  |
|  |  | vii) | Total I2R losses at 750 | | C for lowest tap | | KW |  |  |
|  |  | (KW ) | |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  | | |  |  |  |
|  |  | viii) | Stray losses including eddy current losses | | | | KW |  |  |
|  |  | in winding at 750 C ( KW ) | | |  |  |  |
|  |  |  | a) Normal tap position | |  |  | KW |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  | b) Highest tap position | |  |  | KW |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  | c) Lowest tap position | |  |  | KW |  |  |
|  |  |  |  |  | | |  |  |  |
|  |  |  | d) Any special measures, taken to reduce | | | |  |  |  |
|  |  |  | eddy current losses and stray losses. | | | |  |  |  |
|  |  |  | Mention in details | |  |  |  |  |  |
|  |  |  |  |  | |  |  |  |  |
|  |  | ix) | Load losses at 750 C (I2 R + Stray ) | | |  |  |  |  |
|  |  |  |  |  | |  |  |  |  |
|  |  |  | a) Normal tap position (KW ) | | |  | KW |  |  |
|  |  |  |  |  | |  |  |  |  |
|  |  |  | b) Highest tap position (KW) | | |  | KW |  |  |
|  |  |  |  |  | |  |  |  |  |
|  |  |  | c) Lowest tap position (KW ) | | |  | KW |  |  |
|  |  |  |  |  | | |  |  |  |
|  |  |  | Details of special arrangement, provided | | | |  |  |  |
|  |  | x) | to improve surge voltage distribution in | | | |  |  |  |
|  |  |  | the windings. | |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| 44 |  | DETAILS OF TANK : | | |  |  |  |  |  |
|  |  |  |  |  | |  |  |  |  |
|  |  | a) | Material of Transformer tank | | |  |  |  |  |
|  |  |  |  | |  |  |  |  |  |
|  |  | b) | Type of tank | |  |  |  |  |  |
|  |  |  |  | | | |  |  |  |
|  |  | c) | Thickness of sheet (No approximate value | | | |  |  |  |
|  |  | to be mentioned) | |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  | |  |  |  |  |  |
|  |  |  | i) Sides (mm) | |  |  | mm |  |  |
|  |  |  |  | |  |  |  |  |  |
|  |  |  | ii) Bottom (mm ) | |  |  | mm |  |  |
|  |  |  |  | |  |  |  |  |  |
|  |  |  | iii) Cover (mm ) | |  |  | mm |  |  |
|  |  |  |  | |  |  |  |  |  |
|  |  |  | iv ) Radiators (mm) | |  |  | mm |  |  |
|  |  |  |  | |  |  |  |  |  |
|  |  | d) | Inside dimensions of | | main tank | (No |  |  |  |
|  |  | approximation in dimensions to be used ) | | | |  |  |
|  |  |  |  |  |  |
|  |  |  |  | |  |  |  |  |  |
|  |  |  | i) Length (mm) | |  |  | mm |  |  |
|  |  |  |  | |  |  |  |  |  |
|  |  |  | ii) Breadth (mm) | |  |  | mm |  |  |
|  |  |  |  | |  |  |  |  |  |
|  |  |  | iii) Height (mm ) | |  |  | mm |  |  |
|  |  |  |  | | |  |  |  |  |
|  |  | e) | Outside dimensions of main tank | | | (No |  |  |  |
|  |  | approximation in dimensions to be used ) | | | |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  | |  |  |  |  |  |
|  |  |  | i) Length (mm) | |  |  | mm |  |  |
|  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | | | | | | | | |  | | |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Sl.** |  |  | **DESCRIPTION** | | |  |  |  |  | **Unit** | **As per Tender/Relevant Codes** | **Contractor Submittal** |  |
| **NO.** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | ii) Breadth (mm) | | |  |  |  |  | mm |  |  |  |
|  |  |  |  | |  |  |  |  |  |  |  |  |  |
|  |  |  | iii) Height (mm) | | |  |  |  |  | mm |  |  |  |
|  |  |  |  |  |  | |  |  |  |  |  |  |  |
|  |  | f) | Vacuum | recommended | | | for | hot | oil | Kg/ |  |  |  |
|  |  | circulation (torr / mm of Hg) | | | | |  |  | cm2 |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  | g) | Vacuum to be maintained during oil filling | | | | | | | Kg/ |  |  |  |
|  |  | in transformer tank (torr / mm of Hg) | | | | | |  | cm2 |  |  |  |
|  |  |  | Vacuum | to which | | the | tank | can | be | Kg/ |  |  |  |
|  |  | h) | subjected without distortion ((torr / mm of | | | | | | |  |  |  |
|  |  | cm2 |  |  |  |
|  |  |  | Hg) |  |  |  |  |  |  |  |  |  |  |
|  |  | i) | No. of bi-directional wheels | | | | provided | |  |  |  |  |  |
|  |  |  |  | |  | | | |  |  |  |  |  |
|  |  | j) | Track gauge required for the wheels | | | | | |  |  |  |  |  |
|  |  |  |  | |  |  |  |  |  |  |  |  |  |
|  |  |  | i) Transverse axis | | |  |  |  |  | mm |  |  |  |
|  |  |  |  | |  |  |  |  |  |  |  |  |  |
|  |  |  | ii) Longitudinal axis | | |  |  |  |  | mm |  |  |  |
|  |  |  |  | |  | | | | |  |  |  |  |
|  |  |  | Type and make of pressure relief device | | | | | | |  |  |  |  |
|  |  | k) | and minimum pressure at which it operates | | | | | | |  |  |  |  |
|  |  |  | (Kpa ) |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | |  |  |  |  |  |  |  |  |  |
| 45 |  | CONSERVATOR :- | | |  |  |  |  |  |  |  |  |  |
|  |  |  |  | | | |  |  |  |  |  |  |  |
|  |  | a) | Thickness of sheet (mm) | | | |  |  |  | mm |  |  |  |
|  |  |  |  | | | |  |  |  |  |  |  |  |
|  |  | b) | Size (Dia x length ) (mm) | | | |  |  |  | mm |  |  |  |
|  |  |  |  | | |  |  |  |  |  |  |  |  |
|  |  | c) | Total volume (Litres) | | |  |  |  |  | Ltrs |  |  |  |
|  |  |  |  |  | |  | | | |  |  |  |  |
|  |  | d) | Volume | between the | | highest and lowest | | | | Ltrs |  |  |  |
|  |  | visible oil levels (Litres) | | | |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |

In addition to above, as per CEA guidelines following provision is to be inserted in the Technical Specifications

Signature of the Vendor/Contractor along with Company Seal.

**The above schedule is to be duly filled up & signed by the Vendor/Contractor along with their company seal on every page with the subittal.**

# 11 kV Substation and HT Power distribution system – C.13.12.111 kV HT Cable

**1. STANDARDS AND CODES**

All equipments, components, materials and entire work shall be carried out in conformity with applicable and relevant Bureau of Indian Standards and Codes of Practice, as amended upto date and as below. In addition, relevant clauses of the Indian Electricity Act 1910 and Indian Electricity Rules 1956 as amended upto date shall also apply. Wherever appropriate Indian Standards are not available, relevant British and /or IEC Standards shall be applicable.

Equipments certified by Bureau of Indian Standards shall be used in this contract in line with government regulations. Test certificates in support of this certification shall be submitted, as required.

It is to be noted that updated and current standards shall be applicable irrespective of dates mentioned along with ISS's in the tender documents.

The materials shall conform in all respects to the relevant International /Indian Standard Specifications with latest amendments thereto.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Title** | | | | **Indian Standard No.** | **International Standard** |
| Specification for Cross linked Polyethylene Insulated PVC Sheathed Cable for working voltages from 3.3 kV up to and including 33 kV | | | | IS:7098 Part II/1985 | IEC : 502 (1983) |
| PVC insulation electric cables. | and | sheath | of | IS:5831/1984 | IEC :502 (1983) |
| Conductors for insulated electric Cables and Flexible cords | | | | IS: 8130/1984 | IEC : 228 (1978) |
| Specification for cable drum | | | | IS : 10418/1982 |  |

Equipment conforming to other internationally accepted standards, which ensure equal or higher quality than the standards mentioned above, would also be acceptable.

**2. CABLES**

**2.1 HT Cables**

11 kV cable shall be aluminium conductor with cross linked polyethylene (XLPE) insulation, galvanized steel armouring and PVC sheathing conforming to IS 7098. Conductors shall be sector shaped, made from electrical purely aluminium of 3 x 4 H or H temper conforming to IS 8130 XLPE insulation of high purity shall be extruded on the conductors with screen a layer of semi-conducting material shall be applied over the XLPE insulation to prevent partial discharge at insulation surface. This shall be followed up by metallic aluminium tape screen the cores shall be discharged tested. Built up cores shall then be laid up and filler codes added. Combined core shall be provided with extruded PVC sheathing. Galvanized steel wire of strip armouring shall then be provided protected by an overall extruded black PVC sheet. The outer sheath shall bear the manufacturer's name and trade mark at every meter length.

GTP to be approved during submittal before procurement of the cables. IS is for reference, Minimum approved GTP to be given.

**2.2 PRINCIPAL PARAMTERS:**

The material shall conform to the following specific parameters.

|  |  |  |
| --- | --- | --- |
| **S.I. No.** | **Item** | **Specification** |
| 1. | Type of Installation | Outdoor |
| 2 | System Voltage | 11 kV (+10% - 15%) |
| 3 | System Frequency | 50 Hz. + 5% |
| 4 | No. of Phases | Three |
| 5 | System of earthing | Solidly grounded |

**2.3 TECHNICAL REQUIREMENT**

The cable shall be 11 kV Grade, high conductivity stranded compacted circular conductor, electrolytic grade Aluminium, tapped with semi conducting, 3 core, XLPE insulated, inner PVC sheathed, galvanized steel strip armoured with overall separate extruded PVC outer sheath, conforming generally to IEC-60502/IS: 7098 (Part-II) - 1985 and amendment thereof suitable for 11 kV 3 phase 50 Hz earthed system.

Two distinct sheaths i.e. inner and outer shall be provided. Outer sheathing shall be designed to afford high degree of mechanical protection and shall also be heat, oil, chemicals and weather resistant, common acids, alkalies and saline solution shall not have adverse effect on the material used for PVC outer sheathing.

The cable should be suitable for lying in covered trenches and/or buried direct underground.

**2.3.1 CONDUCTOR**

The conductor shall be made from stranded very well compacted, round conductor shall be made of annealed plain copper wires complying the requirement as specified in Table-2 of IS: 8130 /1984 and any amendment thereof.

**2.3.2 CONDUCTOR SHIELD**

The conductor shall have a semi-conducting screen, which will ensure perfectly smooth profile to avoid stress concentration. The conductor screen shall be extruded in the same operation as the insulation.

**2.3.3 INSULATION**

The XLPE insulation shall be suitable for specified 11 kV system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method shall give very smooth interface between semi-conducting screen and insulation. The insulation of the cables shall be of high standard quality and conform to Clause-11 of IS: 7098 (Part-II)/1985 or latest amendment thereof.

**2.3.4 INSULATON SHIELD**

To confine electrical field to the insulation, insulation screening consisting of two parts, namely metallic (non-magnetic) and non-metallic (semi conducting) shall be provided. The non-metallic semi-conducting shield shall be put over the insulation of each core. The insulation shield shall be extruded in the same operation as the conductor shield and the insulation by triple extrusion process. The insulation shield shall be bonded and Strippable, on adequate heat treatment. Metallic shield shall be provided over non- metallic portion as per provision of clause 12.4 of IS: 7098 (Part-II)/1985 and amendment thereof.

* + 1. **INNER SHEATH**

The sheath shall be suitable to withstand the operating conditions and the desired temperature rating of the cable. It shall be of adequate thickness, consistent quality and free from all defects.

* + 1. **ARMOUR**

Galvanized steel strip armouring shall be provided. The dimensions of steel strip shall be as per table 4 of IS: 7098 (Part-II)/1985 and its latest amendment and strip shall conform to latest provisions of IS: 3975 - 1988 and amendment thereof.

* + 1. **OUTER SHEATH**

Extruded PVC outer sheath of type ST-2 as per IS: 5831/1984 and its latest amendment shall be applied over armouring with suitable additives to prevent attack by rodent and termite and its thickness shall be in accordance with Clause -17.32 of IS:7098 (Part-III)/1985 and latest amendment thereof.

* + 1. **CONSTRUCTION**

The cable shall have suitable PVC fillers laid up with insulated cores to provide substantially circular cross section before the inner sheath is applied. The fillers shall be suitable for operating temperature of the cable and compatible with the insulating material.

All materials used in the manufacture of cable shall be new, unused and of finest quality. All materials shall comply with the applicable provisions of the tests of the specification, IS, Indian Electricity Rules, Indian Elect. Act and any other applicable statutory provisions, rules and regulations.

The PVC material used in the manufacture of cable shall be of reputed make. No recycling of the PVC is permitted. The Owner/PMC reserves the right to ask for documentary proof of the purchase of various materials to be used for the manufacture of cable and to check that manufacturer is complying with quality control.

**3. DELIVERY, STORAGE AND HANDLING**

Cable drum shall be stored on a well-drained, hard surface, preferably of concrete, so that the drums do not sink in ground causing rot and damage to the cable drum. The cable drum shall conform to IS 10418. During storage, periodical rolling of drums, in the direction of arrow marked on the drum, shall be done once in 3 months through 900 C both ends of cables shall be properly sealed to prevent moisture ingress Drums shall be stored in well ventilated area protected from sun and rain. Drums shall always be rested on the flanges and not on flat sides. Damaged battens of drums etc. shall be replaced. Movement of drums shall always be in direction of the arrow marked on the drum. For transportation over long distance, the drums shall either be mounted on drum wheels and pulled by ropes or they shall be mounted on trailers etc. drums shall be unloaded preferably by crane otherwise they shall be rolled down carefully on suitable ramps. While transferring cable form 1 drum to another, the barrel of the new drum shall have diameter not less than the original drum. Cables with kinks or similar visible defects like defective armouring etc shall be rejected. Cables shall be supplied at site in cut pieces as per actual requirements.

**4. LAYING OF CABLES**

Cables shall be so laid that the maximum bending radius is 20 times the overall diameter for 11 kV cables. Cables shall be laid in masonry trenches, directly on walls/cable trays, directly buried in ground or in pipes/ducts as elaborated below. Cables of different voltages and also power and control cables shall be laid in different trenches with adequate separation. Wherever available space is restricted such that this requirement cannot be met, medium voltage cables shall be laid above HT cables.

**4.1 In Masonry Trenches**

Wherever so specified, cables shall be laid in indoor/outdoor masonry/RCC trenches to as per approval of Owner/PMC. Cables shall be laid on MS supports fabricated from minimum 38mm x 38mm x 6mm painted / galvanized angle iron supports grouted in trench walls at intervals not exceeding 600 mm. If required, cables shall be arranged in tier formation inside the trench. Suitable clamps, hooks and saddles shall be used for securing the cables in position and dressing properly so that the clear spacing between the cables shall not be less then the diameter of the cable. Trenches shall be provided with chaquered plate/RCC covers. Wherever so specified, trenches shall be filled with fine sand.

**4.2 On Trays/Walls**

Wherever so specified, cables shall be laid along walls/ceiling or on cable trays. Cable shall be secured in position and dressed properly by means of suitable clamps, hooks, saddles etc. such that the minimum clear spacing between cables is diameter of the cable. Clamping of cables shall be at minimum intervals as below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Type of cables** | **Size** | **Clamping by** | **Fixing intervals** |
| MV & HV | 150 sq mm and above | Clamps 3 mm thick 40 mm wide | 45 cm |

**Note:** The fixing intervals specified apply to straight runs. In the case of bends, additional clamping shall be provided at 30 cm from the center of the bend on both sides.

Cable trays, of sizes as per schedule of quantities and drawings shall be of perforated doubled bend channel/ladder design unless otherwise stated. Cable trays shall be fabricated from minimum 2 mm thick sheet steel and shall be complete with tees, elbows, risers, and all necessary hardware. Cable trays shall comply with the following:

Trays shall have suitable strength and rigidity to provide proper support for all contained cables. Trays shall not have sharp edges, burrs or projections injurious to cable insulation. Trays shall include fittings for changes in direction and elevation. Cable trays and accessories shall be painted with one shop coated of red oxide zinc chromate primer and two side coats of aluminium alkyd paint or approved equivalent. Cable trays shall not have sharp edges, burrs or projection that may damage the insulation jackets of the wiring. Cable trays shall have side rails or equivalent structural members.

Unless otherwise specifically noted on the relevant layout drawing, all cable tray mounting works to be carried out ensuring the following:

Cable tray mounting arrangement type to be as marked on layout drawing. Assembly of tray mounting structure shall be supplied fabricated, erected & painted by the electrical contractor. Tray mounting structures shall be welded to plate inserts or to structural beams as approved by the Owner/PMC. Wherever embedded plates & structural beams are not available for welding the tray mounting structure electrical contractor to supply the MS plates & fix them to floor slab by four anchor fasteners of minimum 16 mm dia having minimum holding power of 5000 Kg at no extra cost. Maximum loading on a horizontal support arm to be 120 Kg. meter of cable run. Width of the horizontal arms of the tray supporting structures to be same as the tray widths specified in tray layout drawings, plus length required, for welding to the vertical supports. The length of vertical supporting members for horizontal tray runs shall be to suit the number of tray tiers shown in tray layout drawings. Spacing between horizontal supports arms of vertical tray runs to be 300 mm. Cable trays will be welded to their mounting supports. Minimum clearance between the top most tray tier and structural member to be 300 mm. Cables in vertical race ways to be clamped by saddle type clamps to the horizontal slotted angels. Clamps to be fabricated from 3 mm thick aluminium strip at site by the electrical contractor to suit cable groups. The structural steel (standard quality) shall be according to latest revision of IS: 226 & 808. Welding shall be as per latest revisions of IS: 816. All structural steel to be painted with one shop coat of red oxide and oil primer followed by a finishing coat of aluminium alkyd paint where any cuts or holes are made on finished steel work these shall be sealed against oxidation by red oxide followed by the same finishing paint. Steel sheet covers wherever indicated to be similarly painted. Trays shall be erected properly to present a neat and clean appearance. Trays shall be installed as a complete system. Trays shall be supported adequately by means of painted MS structural members secured to the structure by dash fasteners or by grouting. The entire cable tray system shall be rigid. Each run of cable tray shall be completed before laying of cables. Cable trays shall be erected so as to be exposed and accessible.

**4.3 Buried Directly in Ground**

**4.3.1 General**

Cables shall be so laid that they will not interfere with under ground structures. All water pipes, sewage lines or other structures which become exposed by excavation shall be properly supported and protected from injury until the filling has been rammed solidly in places under and around them. Any telephone or other cables coming in the way are to be properly shielded as directed by Engineer in charge. Surface of the ground shall be made good so as to conform in all respects to the surrounding ground to the satisfaction of Engineer in charge.

**4.3.2 Routing of cables**

Before cable laying work is undertaken, the route of the cables shall be decided with the Engineer in charge. While shortest practicable route shall be preferred, cable runs shall follow fixed development such as roads, footpaths etc with proper off-sets so that future maintenance and identification are rendered easy. Whenever cables are laid along well demarcated or established roads, the LV/MV cables shall be laid further from the kerb line than HV cables. Cables of different voltages and also power and control cables shall be kept in different trenches with adequate separation. Where available space is restricted, LV/MV cables shall be laid above HV cables. Where cables cross one another, the cables of higher voltage shall be laid at a lower level than the cables of lower voltage. Power and communication cables shall as far as possible cross at right angles. Where power cables are laid in proximity to communications cables the horizontal and vertical clearances shall not normally be less than 60 cm.

**4.3.3 Width of Trench**

The width of trench shall be determined on the following basis. The minimum width of trench for laying single cables shall be 350 mm. Where more than one cable is to be laid in the same trench in horizontal formation, the width of trench shall be increased such that the inter-axial spacing between the cables except where otherwise specified shall be at least 200 mm. There shall be a clearance of at least 150 mm between axis of the end cables and the sides of the trench.

**4.3.4 Depth of Trench**

The depth of trench shall be determined on the following basis:

• Where cables are laid in single tier formation, the total depth of the trench shall not be less than 750 mm for cables upto 1.1 kV and 1000 mm for cables above 1.1 kV.

• When more than one tier of cables is unavoidable and vertical formation of laying is adopted, the depth of trench shall be increased by 300 mm for each additional tier to be formed.

**4.3.5 Excavation of Trenches**

The trenches shall be excavated in reasonably straight lines. Wherever there is a change in direction, suitable curvature of 12 times the overall diameter of the largest cable shall be provided. Where gradients and changes in depths are unavoidable these shall be gradual. Excavation should be done by any suitable manual or mechanical means. Excavated soil shall be stacked firmly by the side of the trench such that it may not fall back into the trench. Adequate precautions shall be taken not to damage any existing cables, pipes or other such installations during excavation. Wherever bricks, tiles or protected covers or bare cables are encountered, further excavation shall not be carried out without the approval of the Owner/PMC. Existing property exposed during trenching shall be temporarily supported or propped adequately as directed by the Engineer in charge. The trenching in such cases shall be done in short lengths, necessary pipes laid for passing cables therein and the trench refilled as required. If there is any danger of a trench collapsing or endangering adjacent structures the sides shall be well shored up with timbering and/or sheathing as the excavation proceeds. Where necessary these may even be left in place when back filling the trench. Excavation through lawns shall be done in consultation with the Engineer in charge. Bottom of the trench shall be level and free from stone, brick, etc. The trench shall then be provided with a layer of clean dry sand cushion of not less than 170 mm.

**4.3.6 Laying of Cable in Trench**

The cable drum shall be properly mounted on jacks or on a cable wheel at a suitable location. It should be ensured that the spindle, jack etc are strong enough to carry the weight of the drum without failure and that the spindle is horizontal in the bearings so as to prevent the drum creeping to one side while rotating. The cable shall be pulled over rollers in the trench steadily and uniformly without jerks or strains. The entire cable length shall, as far as possible, be laid in one stretch. However when this is not possible the remainder of the cable shall be removed by flaking i.e. making one long loop in the reverse direction.

After the cable is uncoiled and laid over the rollers, the cable shall be lifted slightly over the rollers beginning from one end by helpers standing about 10 meters apart and drawn straight. The cable should then be taken off the rollers by additional helpers lifting the cables and then laid in the trench in a reasonably straight line. For short runs and cable sizes upto 50 sq mm 1.1 kV grade the alternative method of direct handling can be adopted with the prior approval of the Owner/PMC. If two or more cables are laid in the same trench care should be taken to preserve relative position. All the cables following the same routes shall be laid in the same trench. Cables shall not cross each other as far as possible. When the cable has been properly straightened the cores shall be tested for continuity and insulation resistance. The cable shall be measured thereafter.

Suitable moisture sealing compound/tape shall be used for sealing of the ends. Cable laid in trenches in a single tier formation shall have a covering of clean dry sand of not less than 170 mm above the base cushion of sand before the protective cover is laid. In the case of vertical multi-tier formation after the first cable has been laid a sand cushion of 300 mm shall be provided over the initial bed before the second tier is laid. If additional tiers are formed each of the subsequent tiers also shall have a sand cushion of 300 mm. The top most cable shall have final sand covering not less than 170 mm before the protective cover is laid. A final protection to cables shall be laid to provide warning to future excavators of the presence of the cable and also to protect the cables against accidental mechanical damage. Such protection shall be with second class bricks of not less than 200 mm x 100 mm x 100 mm (normal size) laid breadth wise for the full length of the cable to the satisfaction of the Engineer in charge. Where more than one cable is to be laid in the same trench this protective covering shall cover all the cables and project at least 50 mm over the sides of the end cables. In addition bricks on edge shall be placed along the entire run on either side of the cable run. The trenches shall then be back filled with excavated earth free from stones or other sharp edged debris and shall be rammed and watered in successive layers not exceeding 300 mm. Unless otherwise specified a crown of earth not less than 50 mm in the centre and tapering towards the side of the trench shall be left to allow for subsidence. The crown of earth should however not exceed to 100 mm so as not to be a hazard to vehicular traffic. Where road berms or lawns have been cut or kerb stones displaced the same shall be repaired and made good to the satisfaction of the Owner/PMC and all surplus earth and rocks removed to places as specified.

Sand filling to be done on both sides 150mm and below and upto 170 height and then brick protection and back filling after that. Check.

All glands should be double compression

**4.3.7 Laying In Pipes/Closed Ducts**

In locations such as road crossings, entry to buildings/poles in paved areas etc., cables shall be laid in pipes or closed ducts. Spun reinforced concrete pipes shall be used for such purposes and the pipe shall not be less than 100 mm in diameter for a single cable and not less than 150 mm for more than one cable. These pipes shall be laid directly in ground without any special bed. Sand cushioning and/or brick tiles need not be used in such installations. Unless otherwise specified the top surface of pipes shall be at a minimum depth of 1000 mm from the ground level when laid under roads, pavements etc.

The pipes for road crossings shall preferably be on the skew to reduce the angle of bend as the cable enters and leaves the crossing. Pipes shall be continuous and clear of debris or concrete before cable is drawn. Sharp edges at ends shall be smoothened to prevent injury to cable insulation or sheathing. No deduction shall be made for sand and bricks not used for cables passing through RCC Hume pipes or for parts of vertical cables at the lighting poles. Wherever so required, cables shall be laid at the bed of the lake through existing PVC pipe as itemized in bill of quantities.

**4.3.8 Laying Of Cables in Floors**

Laying of cables directly in floors shall be avoided and GI pipes of adequate size shall be used wherever necessary. However if the cables have to be laid direct in the floor specific written approval of Owner/PMC shall be obtained and the Contractor shall cut chases, lay the cables and make good the chases to original finish.

**4.3.9 Cable Entry into Buildings**

Cable entry into buildings shall be made through RCC pipes recessed in the floor. RCC Hume pipes shall be provided well in advance for service cable entries. The pipe shall be filled with sand and sealed at both ends with bitumen mastic to avoid entry of water. Suitable size manholes shall be provided wherever required to facilitate drawing of cables as per requirements.

**5 TERMINATION/JOINTING OF CABLES**

Soldered jointing/termination shall be totally avoided. Solder less terminations by using Dowel crimping tools and suitable legs shall be adopted for all cable terminations. Any terminations without use of proper crimping tool shall be liable to be rejected. In the case of aluminium conductors, it is to be ensured that the conductor oxidation is cleaned by means of emery paper and then a thin coat of tin is applied before pinching into any equipment. Heat shrinkable Raychem type or approved equivalent terminations shall be provided for High Voltage cables and Siemens make or approved equivalent make brass double compression glands shall be provided for Medium Voltage cable terminations. Straight through jointing of Medium Voltage or High Voltage cable shall normally be totally avoided. If absolutely unavoidable, such jointing shall be carried out as per procedure to be got specifically approved from Engineer in charge.

**7. CABLE LOOPS**

At the time of the installation approximately 3 meters of surplus cable shall be left

- at each end of the cable.

- on each side of underground straight through/tee/termination joints.

- at entries to buildings.

- and such other places as may be decided by the Engineer in charge.

This cable shall be left in the form of a loop.

Wherever long runs of cable length are installed cable loops shall be left at suitable intervals as specified by the Engineer in charge.

**8. BONDING OF CABLES.**

Where a cable enters any piece of apparatus it shall be connected to the casting by means of an approved type of armoured clamp or gland. The clamps must grip the armouring firmly to the gland or casting, so that in the event of ground movement no undue stress is placed on to the cable conductors.

**9. TESTING**

**9.1 Tests at Manufacturer's Work**

The cables shall be subjected to shop test in accordance with relevant standards to prove the design and general qualities to the cables as below (as per IS 10810) and as per approved GTP:

• Routine test on each drum of cables.

• Acceptance tests on drums chosen at random for acceptance of the lot.

• Type test on each type of cables, inclusive of measurement of armour DC resistance of power cables.

**9.2 Site Testing**

• All cables before laying shall be tested with a 500 V megger for 1.1 KV grade or with a 2,500/5,000 V megger for cables of higher voltages. The cables cores shall be tested for continuity, absence of cross phasing, insulation resistance to earth/sheath/armour and insulation resistance between conductors.

• All cables shall be subject to above mentioned test during laying, before covering the cables by protective covers and back filling and also before the jointing operations.

• After laying and jointing, the cable shall be subjected to a 1.5 minutes AC/DC pressure test.

• In the absence of facilities for pressure testing in accordance with clause above it is sufficient to test for one minute with 1000 V megger for cables of 1.1 kV grade and with 2,500/5,00 V megger for cables of higher voltages.

**9.3 Test Witness**

Tests shall be performed in presence of representative of Engineer in charge. The Contractor shall give at least fifteen (15) days advance notice of the date when the tests are to be carried out.

# 11kV HT VCB PANEL

**Design Criteria**

1.1 Switchgear shall be located in a clean but hot, humid and tropical atmosphere.

1.2 For continuous operation at specified ratings. temperature rise of the various switchgears components shall be limited to the permissible values stipulated in the relevant standards.

1.3 The switchgears and components thereof shall be capable of withstanding the mechanical forces and thermal stresses of the short circuit current listed in the annexure without any damage or deterioration material.

1.4 Circuit breakers, instrument transformers, bus-bars cable compartment etc. shall be housed in separate compartment within the cubicle. The design shall be such that failure of one equipment shall not affect the adjacent units.

1.5 Circuit breakers of identical rating shall be physically and electrically interchangeable.

2.0 **SPECIFIC REQUIREMENTS**

2.1 **CONSTRUCTION FEATURES**

1. The Switchgear shall be indoor, metal-clad, floor mounted, drawout type.
2. The Switchgear shall be such as to allow extension at either end.
3. The Switchgear enclosure shall conform to the degree of protection IP-4X.
4. The minimum thickness of sheet steel used shall be 2 mm.
5. The switchgear shall be dead-front, free standing type vertical cubicle.
6. Switchgear shall have a front hinged door with latches and a removable back cover.
7. All covers and doors shall be provided with neoprene gaskets.
8. All relays, meters, switches and lamps shall be flush mounted on the respective cubicle door or on control cabinet built on the front of the cubicle.
9. The complete structure shall be free, rigid, self supporting, free from twist and bends etc.

2.2 **BUS AND BUS TAPS**

a) The main buses and connection shall be of high grade of aluminium bus bars conductivity aluminium/ aluminium alloy (Grade EC-91E) sized for specified current ratings with max. temp. limited to 85 deg.C (35 deg. above 50 deg. ambient temp.).

b) Busbars and connection shall be fully insulated for working voltage with adequate phase/ ground clearances. Insulating sleeves for busbars and cast-resin shrouds for joints shall be provided.

c) All buses and connections shall be supported and braced to withstand stresses due to maximum short circuit current and also to take care of any thermal expansion.

d) Busbars shall be colour coded for easy identification and so located that the sequence R-Y-B shall be from left to right, top to bottom or front to rear, when viewed from front of the switchgear assembly.

2.3 **CIRCUIT BREAKERS**

1. Circuit breakers shall be triple pole, single throw and shall be Vacuum/SF6 type.
2. Circuit breakers shall be horizontal draw out type with horizontal isolation system, having SERVICE, TEST and DISCONNECTED position with positive indication for each position.
3. The operating time (break time) of the breaker shall be maximum of 3 cycles.
4. Circuit breaker shall have motor wound spring charged trip free mechanism with anti-pumping feature and shunt trip. In addition, facility for manual charging of spring shall be provided.
5. For motor wound mechanism, spring charging shall take place automatically after each breaker closing operation. One open-close-open operation of the circuit breaker shall be possible after failure of power supply to the motor.
6. Mechanical safety interlock shall be provided to prevent :
   1. The circuit breaker from being racked in or out of the service position when the breaker is closed.
   2. Racking in the circuit breaker unless the control plug is fully engaged.
7. Automatic safety shutters shall be provided to fully cover the female primary disconnects when the breaker is withdrawn.
8. Each breaker shall be provided with an emergency manual trip, mechanical ON-OFF indication, an operation counter and mechanism charge/ discharge indicator.
9. Each breaker shall be provided with following :
   1. Auxiliary switch, with 6 NO + 6 NC contacts, mounted on the drawout portion of the switchgear.
   2. Position/cell switch with 3NO + 1 NC contacts, on each for TEST and SERVICE position.
10. Control & Indication :

Breaker cubicle shall be equipped with following :

* 1. One (1) No. spring return type TNC switch for closing and tripping of the breaker.

1. One (1) No. Push button operated mechanical mechanism for tripping.
2. Three (5) Nos. indicating lamps on front of compartment

GREEN Breaker Open and Spring charged

RED Breaker closed

AMBER Trip/ trip circuit trouble

1. Lamps shall be of LED type. Lamps and lens shall be replaceable from the front.
2. Each circuit breaker shall be provided with a anti-pumping relay. Trip coil supervision relay and fast trip relay in addition to those shown in the drawing.
3. Metering device and protective relays for switchgear shall be provided as shown in the attached drawings.

2.4 **CURRENT TRANSFORMERS:**

i) Current transformer shall be cast resin type. All secondary connections shall be brought out to terminal blocks where wye or delta connections will be made.

ii) Accuracy class of Current Transformers shall be :

* + Class PS for differential Protection
  + Class 5P20 for relaying
  + Class 1.0/0.5 as specified and ISF<5 for metering.

2.5 **VOLTAGE TRANSFORMERS:**

i) Voltage Transformers shall be of cast-resin type having accuracy class of 1.0/ 0.5 and shall be mounted on drawout trolly.

ii) High voltage winding of voltage transformer shall be protected by current limiting fuse. The voltage transformer and fuse shall be completely disconnected and visibly grounded in fully draw-out position.

iii) Low voltage fuses, sized to prevent overload, shall be installed in all ungrounded secondary leads. Fuse shall be suitably located to permit easy replacement while the switchgear is energised.

2.6 **RELAYS :**

i) Relay shall be of drawout design with built – in testing facilities. Small auxiliary relays may be in non-drawout execution and mounted with in the cubicle.

ii) Relays shall be rated for operation on secondary voltage and secondary currents as shown on drawings. Number and rating of relay contacts shall suit the job requirements.

2.7 **METERS :**

Indicating instruments (96 x 96 mm) shall be digital / Analog meter ( as per requirement), switch board type and accuracy class of + (1% full scale + 1 count).

2.8 **SIGNAL BUS**

A Bus for RS 485 Signal shall be provided to connect all instruments having RS 485 port on the bus. One port of the bus shall be left for the use of consumer.

2.9 **SECONDARY WIRING**

1. The switchgear shall be fully wired at the factory to ensure proper functioning of control, protection, transfer and interlocking schemes.
2. Inter panel wiring shall be carried out through Male/Female connectors and not by loose wires. In case any loose wire is found at site it will be responsibility of the Contractor to connect the the same at site without any kind of commercial implication (Travelling / lodging / boarding / man-hours Etc.)
3. Fuse and links shall be provided to permit individual circuit isolation from bus wires without disturbing other circuits. All spare contacts of relays, switches and other devices shall be wired upto terminal blocks.
4. Wiring shall be done with flexible, 650V grade, PVC insulated switchboard wires with stranded copper conductors of 2.5 sq. mm for control and current circuits and 1.5 sq. mm for voltage circuits.
5. Each wire shall be identified, at both ends, with permanent markers bearing wire numbers as per contractor`s Wiring Diagram.
6. Wire terminations shall be made with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals.
   1. **TERMINAL BLOCKS**

i) Terminal blocks shall be 660 V grade box-clamp type with marking strips similar to ELMEX 10 Sq. mm or equal. Terminals for C.T. secondary leads shall have provision for shorting.

ii) Not more than two wires shall be connected to any terminal. Spare terminals equal in number to 20% active terminals shall be furnished.

6.2.11 **CABLE TERMINATION**

1. Switch gear shall be designed for cable entry from the bottom. Sufficient space shall be provided for ease of termination and connection.
2. Power cables shall be XLPE insulated, armoured, overall PVC sheathed with stranded Aluminium conductor.
3. Control cables shall be PVC insulated, armoured, overall PVC sheathed with 2.5 Sq. mm stranded copper conductor.
4. The gland plates shall be minimum 4 mm thick. The gland plate and supporting arrangement for I/C power cables shall be such as to minimise flow of eddy current. In such case, gland plate shall be non ferrous metal.
5. Sufficient space shall be provided between the power cable termination (end-boxes) and gland plate. Core accommodated within this space.

2.12 **GROUND BUS**

1. A ground bus, rated to carry maximum fault current, shall extend to full length of the switchgear.
2. The ground bus shall be provided with two- bolt drilling with G.I. bolts and nuts at each end to receive 75 x 10 mm G.I flat.
3. Each stationary unit shall be connected directly to the ground bus. The frame of each circuit breaker and drawout V.T. unit shall be grounded through heavy multiple contacts at all times.
4. Wherever the schematic diagrams indicate a definite ground at the switchgear, a single wire for each circuit thus grounded shall be run independently to the ground bus and connected thereto.
5. C.T. and P.T. secondary neutrals shall be earthed through removable links so that earth of one circuit may be removed without disturbing other.

2.13 **NAMEPLATES**

i) Nameplates of anodised aluminium shall be furnished at each cubicle and at each instrument, device mounted on or inside the cubicle.

ii) Caution notice on suitable metal plate shall be affixed at the back of each vertical panel.

2.14 **SPACE HEATERS :**

Cubicle shall be provided with thermostat controlled space heaters.

2.15 **A.C/ D.C POWER SUPPLY:**

The following power supplies shall be made available at each switchgear by the, contractor:

A.C. supply : Single Feeder

D.C supply : Double Feeder

1. Isolating switch fuse units shall be provided at each switchgear for the incoming supplies, 4- pole, single throw for A.C. and 2-pole, double throw for D.C.
2. Bus-wires of adequate capacity shall be provided to distribute the incoming supplies to different cubicles. Isolating switchfuse units shall be provided at each cubicle for A.C/ D.C. supplies.
3. A.C. load shall be so distributed as to present a balance loading on three-phase supply system.

2.16 **TROPICAL PROTECTION**

1. All equipment, accessories and wiring shall have fungus protection, involving special treatment of insulation and metal against fungus, insects & corrosion.
2. Screen of corrosion resistant material shall be furnished on all ventilating louvers to prevent the entrance of insects.

2.17 **PAINTING**

1. All surfaces shall be sand blasted, pickled and grounded as required to produce a smooth, clean surface free of scale, grease and rust.
2. After cleaning, the surfaces shall be given a phosphate coating followed by 2 coats of high quality primer and stoved after each coat.
3. The panels shall be finished in Siemens Grey, RAL7032 with synthetic enamel paint.

3.0 **TESTS**

3.1 The switchgear shall be completely assembled, wired, adjusted and tested at the factory as per the relevant standards.

1. **ROUTINE TEST**

The tests shall include but not necessarily limited to the following :

* 1. Operation under simulated service condition to ensure accuracy of wiring, correctness of control scheme & proper functioning of the equipment.
  2. All wiring and current carrying part shall be given appropriate High Voltage test.
  3. Primary current and voltage shall be applied to all instrument transformers.
  + Routine test shall be carried out on all equipment such as circuit breakers, instrument transformers, relays, meters etc.

1. **TYPE TEST**

Type test reports of similar switchgear shall be furnished.

1. **TEST WITNESS**

All tests shall be performed in presence of Owner/PMC, if so desired by the Owner/PMC. The Contractor shall give at least fifteen (15) days advance notice of the date when tests are to be carried out.

4.0 **SYSTEM DESCRIPTION & REQUIREMENTS**

1. **11KV PANELS SYSTEM DESCRIPTION**
   1. **System Details**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| a) | Voltage | : | 11/12 KV (Nom./Max.) | | |
| b) | Nos. of Phase | : | 3 |  |  |
| c) | Frequency | : | 50 Hz + 5% | | |
|  |  |  |  |  |  |
| d) | System Neutral | : | Non effectively earthed | | |

**ii) Insulation Level**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| a) | 1 minute 50 Hz withstand | : | 28 | KV rms. |
| b) | Impulse withstand | : | 75 | KV peak |

**iii) Short Circuit Rating**

a) Interrupting : 25KA

b) Withstand time : 1Sec.

**iv) Circuit Breaker**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | a) | Duty Cycle | : | O-3 min - CO- 3min- CO |
|  | b) | Breaking Current | : | 25kA |
| (v) | Auxiliary Power supply available | | : | 110V,DC |
| (vi) | Heater/Lamp/Socket | | : | 415V/240V + 10% |
|  |  | | : | 50 Hz + 5% 3Ph./1 Ph. |
| (vii) | Spring wound motor for circuit breaker | | : | 230V 1 Ph. 50 Hz/ 110V DC |
| (viii) | Shunt trip coil & Closing coil | | : | 110V,DC |

# STAND BY SOURCE OF SUPPLY – 11kV DG SETS

1.0 **GENERAL INFORMATION**

Any material or accessories which may not have been specifically mentioned here but which is necessary for satisfactory and trouble free operation and maintenance of the equipment, shall be furnished by the contractor without any extra charge.

2.0 **SCOPE OF WORK**

Design, manufacture, assembly, packaging, dispatch, transportation to site, supply, testing, delivery, loading, unloading, erection & commissioning of followings on Turnkey Basis: -

2.1 DG Sets (Prime Power), 11KV Alternator in weather proof acoustic enclosure and suitable for parallel operation **The system shall be provided with Auto as well manual PLC based synchronisation with SCADA.**

2.2 DG Local/Remote control panel

2.3 Set of Batteries complete with all accessories.

2.4 Exhaust System with Hospital type silencer, chimney including thermal logging, cladding etc. Common supporting structure suitable for chimneys of all the three (3) Nos. DG Sets.

2.4 Fuel System from HSD Tank onwards (including day tank & piping) with Flameproof Motor and pumps, Diesel Flow meter and Level controller.

2.5 Cooling System (Radiator Cooled System).

2.6 All Statutory Approvals including Environmental Compliance

2.7 Anti Vibration Mountings.

2.8 Connectors (if required).

2.9 All piping between equipment including exhaust piping, its lagging supports, etc.

2.10 Erection & commissioning of above equipment including piping.

* 1. All Electrical system including the followings:
  2. 11KV DG Synchronization Panel / NGR Panel / Auxiliary panels as required.
  3. HT/ LT / Control Cable/ Special cables & Terminations as required.
  4. Cable Trays with supports as required.
  5. Earthing system as required.
  6. All Civil works like chasing, grouting etc. for erection of jobs.

3.0 Submission: -

3.1 Following documents shall be furnished after award of work.

a) Plan and sectional layout of DG sets showing various auxiliaries and panels.

b) GA of panels showing arrangement of various devices on panels.

c) P&I Diagrams for the following: -

1. Lube oil system
2. Fuel oil system
3. Cooling water system
4. Guaranteed Technical Particulars (GTPs)
   1. Following documents shall be furnished in quadruplicate for comments/approval.. Contractor shall incorporate Owner/PMC comments on these drawings and furnish revised/final drawings in six set. All documents shall be in English.

a) Guaranteed Technical Particulars (GTPs)

b) Layout of DG room with all accessories, weight of equipments, maintenance space etc. clearly indicated.

c) Wiring & scheme diagram for HT, LT system and control system of DG set.

d) P&I Diagrams for the following system.

i) Lube oil system

ii) Fuel oil system

iii) Cooling water system

e) Foundation drawing of DG set with static and dynamic loading/centre of gravity of loads and location of all loads.

f) Foundation requirement of all auxiliaries like compressors, heat exchangers, tanks etc.

g) Bill of material for DG set, fuel oil system, ventilation system, cooling system, lube oil system, electrical system (including cables) engine and alternator control system (including cables).

h) GA of panels showing arrangement of various devices on panel and foundation details.

i) Test Certificates

j) Installation and operational Manual.

k) Maintenance Schedule.

l) Terminal Box drawing of Alternator.

m) Air quantity required for cooling & combustion

n) Coil cooler size alongwith water temperature at inlet/ outlet.

o) GA & Control Schematic Diagram of Electrical Panels, Cable list/schedule & interconnection diagram

p) Cabling & Earthing Layout

q) Test certificates of equipment.

r) Complete SLD with protection, cable size, power / control cable schedule, interconnection chart, equipment layout.

4.0 **COMPLETENESS**

1. It is not the intent to specify completely herein all details of the equipment. Nevertheless, the equipment shall be complete and operative in all aspects.
2. Any material or accessories which may not have been specifically mentioned but which is necessary usual for satisfactory and trouble free operation and maintenance of the equipment, shall be furnished by the contractor without any extra charge.

5.0 **PROVISIONS AGAINST ACCIDENTS AND SAFETY MEASURES**

1. All safety rules and codes as applicable to work including rules applicable as per factory inspector shall be followed during execution of above work.
2. All safety appliances and protective devices including hand gloves, aprons, helmets, shields, goggles, belts etc. shall be provided by Contractor for his personnel.
3. The Contractor shall arrange to provide guards and prominent display caution notices if access to any equipment / area is considered unsafe and hazardous.
4. The Contractor shall undertake to provide compensation cover to work force employed by them / taken on contract / work force of their sub-contractor

6.0 **SPECIFICATIONS**

In the absence of specifications for any work or materials, relevant Indian Standard Specifications shall be applicable. If such codes for a particular subject have not been framed, the decision of the Owner/PMC will be final and binding.

7.0 **CODES AND STANDARDS**

7.1 All equipment and materials specified herein or not, shall be designed, manufactured and tested with the latest applicable standards & bureau of Indian standards.

7.2 All electrical equipment shall also conform to the latest electricity rules as regards safety and other essential provisions.

7.3 All electrical installation work shall comply with the requirements of the following Act /rules /codes as amended upto date :

1. Indian electricity act.
2. Indian electricity rules.
3. National electric code published by BIS.
4. All relevant Is codes of practice.
5. Regulations published by tariff advisory committee.

BS:5514 : Specification for reciprocating internal combustion engine.

BS:649 : Diesel Engine for General purpose

BS:5000 : Rotating electrical machines of particular type or for particular applications.

IS:1239 (Part-I & II) :Mild steel tubes and fittings.

ISO:3046 : Internal Combustion Engines

IS:1651 : Stationary cells and batteries VRL/SMF (Sealed Maintenance free) type (with tubular positive plates).

BS:2613 : Rotating Electrical Machinery

IS:9224 : Specification of low voltage fuses, General Purpose.

IS:4540 : Mono-crystalline semi-conductor rectifier assemblies and equipment.

IS:13018 : IC Engines – Method of test for pressure charged Engine.

IS:5 : Colours for ready mixed paints.

IS:4722 : Electrical Performance of Rotating electrical machines

ISO:8528 : Rating of Generator Set

IEC:60947 : Low Voltage Switchgear & Controlgears

IS:1248 : Specification for electrical indicating instruments.

IS:10000 : Methods of tests for internal combustion engines.

IS:10002 : Specifications for performance requirements for constant speed   
compression ignition (Diesel) engine for general purposes (above 20 KW).

IS:4728 : Terminal markings for rotating electrical Machines.

IS:2147 : Degree of protection provided by enclosure for low voltage switchgear and control gear.

ISO:8528 Part 1to10 : Reciprocating Internal Combustion Engine Driven AC Genset

IS:1600 : Code for type testing of constant speed IC engines for general purposes.

IS:4729 : Measurement of Vibrations rotating electrical Machines

IS:1601 : Performance of constant speed IC engines for general purposes.

IEC:60034.1 : Rotating electrical Machines Part 1 Rating & Performance

ASME Power : Internal combustion engines.

Test Code PTC-17

Codes of Diesel Engine Manufacturer’s Association U.S.A.

In case of contradiction between the specifications of any standards the most stringent shall be applicable.

7.4 The installation work shall conform to Indian Electricity act and Indian Electricity Rules as amended upto the date of installation.

The fuel oil installation shall meet all statutory requirements of Govt. of India as amended upto the date of installation. Any approval required from statutory authorities shall be obtained by the Contractor. Nothing in this specification shall be construed to relieve the contractor of these responsibilities. All fuel pipes should be made of double jacketed from underground tank to day tank and day tank to fuel filter.

8.0 **DESIGN CRITERIA**

1. DG Sets shall run in following condition

Black Start – DG Sets shall be started in Black Start mode in case of SEB Power Failure means there shall be no power to start auxiliary system of DG Sets. DG Sets shall be started automatically and shall get synchronized in “NO Load Condition “and shall resume power to load in less than 60 second time.

1. DG Sets shall be provided with acoustic enclosure.
2. DG Sets shall be provided with Electronics governor and shall be suitable for parallel operation.
3. DG set rating shall be prime power
4. DG Sets shall be started/ stopped from Engine / DG Panel/ Remote.
5. The height of exhaust pipes shall be in line with requirements of pollution control rules.
6. Critical Plant Load shall be fed through UPS.
7. Main features of DG sets shall be as follows:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| i. | Rating | 3x2000 kVA at 0.8 | | PF, 11KV, |
|  |  | 3 Ph, 50 Hz. | |  |
| ii. | Duty | Primes duty suitable for continuous operation | |  |
| iii. | Diesel Engine | 4 stroke, multi Cylinders, turbo- charged after cooled. | | |
| iv. | Speed | 1500 rpm | |  |
| v. | Type of cooling | Coil Coolers | |  |
| vi. | Type of alternator | 11KV, | Brushless, | separately- |
|  |  | excited (PMG), self-regulated | | |
| vii. | Starting | Electrical Self-Starting | |  |
| viii. | Batteries | VRL /SMF (Sealed Maintenance free) type | |  |

1. DG set system shall have facility to start system automatically including the following:-
2. DG sets shall get paralleled and shall be ready to deliver the load within 60 Seconds on receipt of start command.

xi) Auto Load Sharing/ Additional Auto DG Start and paralleling on increase of load / Stopping DG set on load reduction automatically.

xii) One set of back up protection relay to be provided for over current / Earth Fault, in case a composite relay is provided for DG Protection.

xiii) Necessary Controller to be provided for control / parallel operations / fault annunciation / load sharing etc. for DG sets.

9.0 **ENGINE**

9.1 **GENERAL**

1. Engine shall be internal combustion type, multi-stroke, multi-cylinder, V type, turbo charged after cooled, suitable for High Speed Diesel Fuel
2. The engine shall be capable to run on 10% overload for 1hour duration in every 12 hours of service as per ISO regulations.
3. The engine shall be directly coupled with the generator set.
4. The engine shall be designed to have provision for easy maintenance, overhaul, cleaning, inspection & replacement of parts.
5. The engine shall be of similar design and shall permit interchangeability of parts among various units.
6. All parts subjected to substantial temperature variations shall be designed & supported to permit free expansion and contraction without resulting in leakage, excess of clearance, harmful distortion or misalignment.
7. Vibration, noise, mechanical, thermal stresses & exhaust gas conditions shall be

not exceed the permissible or acceptable limits of the guiding standards / codes.

1. DG Sets and its governor / AVR shall be suitable for auto parallel operation. However **Governor** shall be electronics type

9.2 **COOLING**

DG set cooling system shall be radiator cooled.

9.3 **LUBRICATION**

1. The engine lubricating oil system shall comprise an engine driven pump complete with oil coolers, duplex oil filters, strainers etc. Priming pump if required shall also be provided.
2. Lubricating system shall also consist of pressure gauge, temperature and oil level indicators, pressure switch for “oil pressure low” alarm for interlock and alarm along with necessary piping, fittings, valves etc.

9.4 **FUEL SYSTEM**

1. Engine shall be suitable to run on High-Speed Diesel fuel.
2. The fuel oil system of the engine shall be direct injection type provided with fuel piping, governor injectors, shutdown valve with fuel strainer and filters.
3. Fuel day tank of suitable capacity for each DG set shall be provided with stand , level gauge , valve and complete piping up to engine.
4. Flow meter and Level controller to be provided on each day tank. Secondary containment to be provided below each day tank with provision of over flow to be directed to main diesel tank.

9.5 **ASPIRATION AND EXHAUST**

1. Engine shall be turbo-charged after cooled. Air intake shall be provided either with dry type replaceable filters or oil bath type filters. Air cleaner assembly shall also have service indicator.
2. Exhaust manifold and exhaust pipe shall be suitably legged with asbestos rope. Exhaust system shall be insulated with AL cladding and shall be fitted with bellows type coupling and supported suitably with anti-vibration spring mountings.
3. Silencer shall be of the Hospital type.
4. The height and size of the exhaust hooks shall be fixed considering the emission of gases and the environmental law of Government of India and the local authorities.
5. The noise level and gas emission temperature and volume shall be as per relevant standards.

9.6 **STARTING SYSTEM**

1. Engines shall be started with 24 volts DC starter motors. Charging of battery shall be through panel mounted static Battery charger. AH rating of Battery shall be suitable for three successive starts of DG Set, and control supply of DG panel completes with battery leads etc.

9.7 **LIST OF FITTINGS & ACCESSORIES**

Following minimum accessories shall be provided with DG Set.

1. **WITH ENGINE**
   1. Tachometer with hour meter
   2. Flywheel
   3. Flexible coupling with guard
   4. Electronics Governor
   5. Electronic control panel( ECP)
   6. Corrosion resistor
   7. Air cleaner
   8. Turbo charger
   9. Fuel pump
   10. Fuel Tank for 990 lts. with low level alarm switch
   11. Fuel / lube oil filter
   12. Air intake manifold
   13. Hospital type silencer
   14. Exhaust pipe with asbestos, vibration isolators (if required), rain water hood
   15. Exhaust manifold
   16. Anti vibration pads
   17. Engine mounted instrument panel with control key switch and gauges for:-
2. Lube oil pressure
3. Cooling water temperature Starter Motor
4. Speed switch
5. Lube oil pressure switch for low pressure
6. Oil heater in sump with manual switch control

9.8 **ACOUSTIC ENCLOSURE**

1. The complete DG Set shall be housed in a sheet steel enclosure with suitable acoustic system.
2. The enclosure shall also be provided with Air Cooling System to maintain the temperature of the Engine.
3. Enclosure shall have necessary doors for maintenance of Engine / Alternator.
4. Enclosure shall also be provided with in built Fuel Tank & Separate 990 Litre day oil tank .
5. Side walls of enclosure shall be fabricated from 2 mm CRCA sheet and shall be filled with 100mm thick acoustic material having 96 Kg/m3 density which should be then be covered with fiber cloth/ tissue paper and finally with perforated MS Sheets.
6. The DG chamber shall be fitted with internal lighting system for ease of maintenance.
7. Hospital type silencer shall be provided and shall be isolated from main D.G. chamber to avoid excess heat in genset operational area.
8. Air inlet and outlet space should be provided with sound dampers.
9. Enclosure shall level the Noise to 68-72 dBA with in 1 Mtr. or as per DPCC norms ( what ever is lower).

9.9 **ALTERNATOR**

9.9.1 General features of the alternators shall be as follows :

|  |  |  |
| --- | --- | --- |
| Rating | : | 2000kVA at 0.8 PF |
| Voltage | : | 11kV, 3 Phase, 3 wire, 50 Hz. |
| Speed | : | 1500 rpm |
| Enclosure | : | IP23 |
| Insulation | : | “H” |
| Temp. Rise | : | “F” |

9.9.2 Alternator winding shall have 2/3 Pole pitch winding to take care of heating due to “Harmonics” in the system.

9.9.3 Damper winding shall be provided to assist parallel operation of Alternators. The damper bars of copper brazed to heavy copper and connector shall be located in semi-closed circular slots situated in the pole faces.

9.9.4 The generator shall be capable of delivering rated output at rated p.f. with: -

* + The terminal voltage shall not differ by more than + 0.5% of set value of terminal voltage.
  + The frequency shall not differ by more than + 4% of rated value.

9.9.5 The Generator shall withstand 10% overload for 1 hour at every 12 hours.

9.9.6 Transient Voltage Dip shall not be more than 14% on application of full load at rated power factor.

9.9.7 The Generator shall be capable of withstand minimum 25% unbalance load of its rated load without exceeding the current in any of the phases beyond full load current.

9.9.8 Alternator winding shall be suitable to take minimum 70% Thyristor load of rated capacity.

9.9.9 The alternator shall be provided with six numbers of RTDs in stator winding and four nos. in both ends bearing

9.9.10 Anti Condensation heater of 240V, 1Ph, 50Hz shall be provided with thermostat control switch.

9.9.11 All alternators shall be provided with Droop CT for paralleling operation.

9.9.12 Six terminals shall be brought from alternator terminal for connection.

9.9.13 AVR shall have motorised protection meter and shall be suitable for remote operation.

9.9.14 **LIST OF FITTINGS & ACCESSORIES**

Following minimum accessories shall be provided with DG Set.

**WITH ALTERNATOR**

* Terminal box suitable for cable 3C-185 Sq. mm 11kV Al ( (Arm) XLPE cable connection.
* Necessary CT & PT shall be provided to provide signal to DG Controller for parallel operation
* Space Heater
* Nos. Termination to be brought out.
* Nos. Duplex Type RTDs in winding and 2Nos. Duplex Type RTDs in each bearing.

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9.10 **OTHER ACCESSORIES**

* 24V VRL/SMF (Sealed Maintenance free) batteries suitable for 3 starts of engine and for control of DG Set with rating of static battery charger
* Controller (EMCP with Woodward controller or PC3i of Cummins or approved equivalent)
* Temp. scanner.
* Engine Running Hour Meter & Engine operation counter
* Master Engine control Switch
* Rubber foot mat ( as per IS :15652, make : Premier Polyfilm) to be provided in full length for HT as well LT panels.

9.11 **TROPICAL PROTECTION**

All equipment, accessories & wiring shall have fungus protection, involving special treatment of insulation & metal against fungus, insects and corrosion.

Screens of corrosion resistant material shall be furnished on all ventilating louvers to prevent the entrance of insects.

10.0 **TESTS**

1. All equipment shall be subjected to routine and acceptance tests laid down in relevant standards.
2. All tests shall be performed in the presence of Owner/PMC, if so desired by them. The contractor shall give at least 5 days in advance of the date when tests are to be carried out.

**10.1 Period of Operation/Duty Cycle:**

The sets are intended to supply power only during an emergency for all services and may be idle for long periods except for periodic routine tests once in a week. When there is a total failure of main power supply, the sets shall be required to operate continuously at full load for a period which at times may exceed even 24 hours.

11.0 ENGINE:

**11.1 Type:**

The diesel engine shall be heavy duty stationary type four stroke prime rating, multi-cylinder electronic injection, with vertical in line or (V) type cylinder arrangement, Turbo-charged, HE cooled suitable for cold weather starting, heavy duty industrial design, prime continuous rating, low noise complete with all accessories as specified mounted on common base frame, suitable for erection of AVMs.

**11.2 Rating:**

a) **Prime power BHP rating** of the engine shall be such that the DG set deliver the specified net electrical output while supplying power/driving all electrical and mechanical auxiliaries connected to alternator terminals and engine shaft at specified site conditions and ambient temperature of 45OC. The Contractor shall submit the deration calculations if the engine is not designed for 45 deg C. ambient temperature.

b) It shall also be capable of satisfactorily driving the alternator at 10% over load at the rated speed for one hour in any period of 12 hours of continuous running.

**The** Contractor **shall have to furnish copy of deration chart from the original manual of the engine manufacturer and supporting calculations to arrive at diesel engine rating.**

**11.3 Speed and Vibration Levels:**

a) Speed shall be 1500 revolutions per minute. Speed governor/over speed protection shall be provided.

At due running conditions, speed shall be stabilized at plus or minus 2% nominal speed, regardless of load. At transient condition, engine speed shall vary not more than 10% plus or minus. Governor class shall be A1 (4% drop) for normal application unless otherwise specified.

b) The engine vibration level shall not exceed 100 microns.

**11.4 Lubrications:**

a) The engine shall have a closed cycle forced & splash lubricating system with positive oil pressure and a crank chamber for collection/storage of the lubricating oil during circulation. Lubricating oil shall be circulated in the engine by an engine driven pump.

b) A lubricating oil filter of an efficient full flow type of ample capacity shall be provided for operation under normal conditions for a period of 300 hours without the necessity of its replacement or cleaning. Filters shall be capable of removing all foreign matter above a particle size of 5 microns.

c) In case lubricating oil coolers are required it shall be supplied as an integral part of the Diesel Generator Set.

d) Necessary temperature and pressure gauges and other instruments shall be supplied and fitted on the lubrication system.

e) A lubricating oil level dipstick suitably graduated shall be provided and located in the accessible position.

f) The tenderers shall state the guaranteed lubricating oil consumption in litres per hour.

**11.5 Fuel System:**

a) The engine shall be capable of satisfactory running on all types of diesel fuel oil normally available locally/ in India.

b) The fuel consumption of the engine shall be expressed by the Contractor in litres per gross/nett kWh output from the alternator (after supplying the requirements of auxiliaries) at full, three quarters and half of its rated power output and at 0.8 and unitary power factor.

If guaranteed fuel consumption is exceeded, the contractor shall make such amendments or alterations as are necessary to bring the consumption to within the guaranteed figures. Tolerance of +5% as defined in BSS-649-1985 shall be allowed.

c) A fuel service tank of 990 litres capacity with each D.G. Set shall be provided on a suitably fabricated steel platform. The tank shall be complete with level indicator marked in litres, filling inlet with removable screen, an outlet, a drain plug, an air vent and necessary piping. The fuel tank shall be painted with oil resistant paint. All pipe joints should be brazed/welded.

**11.6 Air Intake System:**

The diesel engine shall be provided with special dry type air filters having low resistance to air passage, high dust retaining efficiency and provision for easy cleaning. Filters shall be suitable for achieving satisfactory engine operation and ensuring the engine life under tropical humid conditions, with sulphur dioxide fumes, abrasive dust and coal particles of 5 to 100 microns present in the atmosphere. The minimum efficiency of filters shall be 90% down to 5-micron size.

**11.7 Cooling:**

The diesel engine should be radiator cooled

**11.8 Engine Governor:**

The governor shall be Electronic ISO-Chronous type to maintain zero speed rate or regulation and shall be Al type as per BS:5514 in order to take care of heavy motor starting. It shall have necessary characteristics to maintain the speed substantially constant even with sudden variation in load. However, a tripping shall be provided if speed exceeds maximum permissible limit. The governor shall be suitable for operation without external power supply.

**11.9 Turbo Charger:**

It shall be of a robust construction, suitable of being driven by engine exhaust having a common shaft for the turbine and blower. It shall draw air from filter of adequate capacity to suit the requirements of the engine.

**11.10 Quietness of Operation:**

a) The engine shall be designed to achieve maximum quietness of operation.

b) Efficient residential silencer shall be provided as per engine manufacturer’s approved make only for the exhaust.

c) Noise level of the set shall not exceed 75 dbA at one meter distance from the enclosure surface.

**11.11 Engine Starting:**

a) Engine starting shall be by electric starting motor complete with manual/automatic starting arrangement. The starter motor shall conform to IS:4722 and shall be of adequate power for its duty and be of inertia or pre-engaged type. The pinion shall positively disengage when the engine starts up or when the motor is de-energized. The engine cranking shall be only from the panel both for AMF & DG sets (Manual) and any engine starting devices etc. that are given as original fitment on the engine by engine manufacturers shall be either removed or padlocking arrangement given for this so that all normal start/stop operations could be done only from panel whether the set is AMF or manual.

The engine wiring shall be appropriately modified, ferruled to totally match with schematic drawings of the panel.

b) Time for Run-up to Speed:

From the initial operation of the starting device, the engine shall start, run up to normal speed and be capable of accepting 60% of full load within a maximum time of 20 seconds, and full load within a further 20 second.

**11.12 Starter Battery:**

a) The battery shall conform to the requirement of IS:1651. Starting battery each of 12 V, heavy duty high performance approved make/quality shall be provided to enable crank & start the engine even in cold/winter morning conditions. Type/voltage/AH capacity of same on 20 hour rated discharge period shall be indicated in the offer. The battery set shall be capable of performing at least (5) five normal starts without recharging.

b) The battery shall be provided with good quality iron battery stand painted with acid proof black paint with min 3mm thick rubber mat below the battery.

c) Batteries shall be of load container type only and not with PVC moulded sealed container so that each individual cells are available for individual monitoring during its life span. Each cell shall be provided with electrolyte filling cap with level floats for easy monitoring of electrolytic level.

d) The battery shall be provided with 2 Nos. cables, minimum 1.5m long heavy duty rubber/PVC insulated cabling with brazed tinned lug at one end and with brazed tinned brass terminal lug at battery end - for connecting batteries to cranking system - with 0.25 m long inter battery connecting cable.

e) The lugs shall be clearly stamped (+) or (-) and positive cable also red sleeved for easy identification.

f) The batteries Set shall be supplied fully filled and first charged ready to use.

g) Batteries set shall be supplied with spring type hydrometer, thermometer with specific gravity correction scale and cell testing voltmeter etc.

**11.13 Battery Charging System:**

a) Float rate charging and quick rate charging system shall be provided at the generator panel with appropriate bridge charger system, LC network, rate selector switch and generously rated charging transformer and silicon one rectifier bridge, so that the cranking battery system can be kept fully charged at all times from E.B. supply network with quick charging rate limited to 0.8 times rated discharge current with provision in control transformer and Si rectifier present to enable boost charging the battery at 2 times rated discharge current in case of emergencies. To this and in the mode selector switch boost charge position shall be present which however shall be kept disconnected at mode selector switch normally.

b) DC ammeters to clearly indicate float charging current and quick/boost charging current shall be provided.

c) Dropper resistor network on the load side of battery charger system shall be provided so that higher charger voltages in quick or boost conditions does not get impressed on the I/L and Contactor coils, which voltage shall remain well within +10% of rated voltage.

d) Battery charging subsystem shall be designed for continuous operation at cubicle ambient of 50OC corresponding to 45OC ambient outside and should be designed to operate at 1.5 times rated maximum current corresponding to boost charge current which can reach in practice as high as 2.5 times or 3 times rated discharge current.

e) Any charger dynamo and dynamo charging current network present on the set shall be made in operative so that both for AMF and manual application the cranking battery system is kept charged from the charger at the panels at all times during or shut down periods of the set.

f) To the above and in case of manual DG sets, the input to charger subsystem viz., 240 V AC is foreseen to be provided from customer network from the portion that is normally supplied by manual DG Set during DG operation or being fed by E.B. System.

g) Battery charger shall form part of D. G. protection and PLC panel.

**11.14 Engine Fitments:**

The engine shall be provided with but not limited to following essential basic fitments:

1. Crank case breather - Dry type element (Breather outlet shall be fitted with a filter cap capable of preventing entry of dust).
2. Air Cleaner - Dry type mounted.
3. Corrosion resistor - to control acidity and impurities from

coolant.

1. Lubricating Oil Cooler -
2. Filters - Lub oil & fuel oil, paper element type.
3. Coolant Pump - Gear Driven.
4. Fuel Pumps - Priming & Transfer
5. Governor - Electronic Class A1.
6. Turbo Charger - Exhaust gas driven in case of turbo

charged engines.

1. Flywheel with flywheel housing - SAE Type
2. Vibration dampers - One Set
3. Exhaust/Intake manifolds -
4. Oil Sump (crank case) with dip stick
5. Engine Supports
6. Residential type silencer in exhaust system
7. Electrical starter 12 V or 24 V
8. Safety controls & instruments
9. Flexible coupling with guard

**11.15 Engine Instrumentation:**

The following instruments mounted on instrument panel shall be essentially present as minimum:

1. Engine speed tachometer with service hour counter
2. Lub oil pressure gauge
3. Coolant water temperature gauge

The instrument panel shall be mounted on engine using rubber dampers for vibration isolation.

The gauges shall have clear red marking to identify the limiting dangerous levels, `Zone Markings’ on the scale to indicate the normal healthy & abnormal operating zones for the parameters concerned.

The metering could be either normal electro-mechanical analogue type or electronic digital type, latter being preferred as manufacturers fitment only.

The engine control panel must be supplied by the engine manufacturer only.

**11.16 Mountings and Foundations:**

The engine and direct coupled attenuator shall be rigidly secured to a common rigid base frame fabricated from MS section.

The DG set shall be placed on the RCC floor with approved make anti-vibration mountings. A lifting hook of required capacity shall be provided above the finalized location of the DG set to facilitate installation and subsequent maintenance of the DG Sets.

The design of mounting arrangement with anti-vibration mountings shall be as recommended by the DG manufacturers and shall be such that a maximum of 2% vibration are transmitted to the structure.

The tenderer shall confirm the type & design of mountings provided and the vibration isolation efficiency in the tender.

**11.17 Exhaust Piping:**

The engine shall be fitted with a residential type silencer (design approved by manufacturer) to reduce the noise level. Silencer outlet shall be connected to exhaust piping carried to the top of the building through shafts provided for the purpose. Exhaust piping shall be fabricated from class ‘B’ MS pipes of size suitable to limit back pressure to within permissible limit (2.5” of Hg.). Tenderer shall submit design calculation in support of the back pressure being within limits along with the tender.

It is important to ensure that the surface temperature of the exhaust piping does not exceed 50OC. For this purpose, the entire length of exhaust piping shall be insulated with minimum 50mm thick layer of LRB rock wool (48 kg./m3 density covered with 26 SWG aluminium sheet cladding. Flanged joints in the exhaust piping shall be covered with removable insulation at suitable intervals for permitting access to the joint if and when required.

Exhaust piping shall connected to the engine by means of flexible section or an expansion joint and shall also be graded to a drain pocket inside the building. The pocket shall be fitted with a drain cock.

Surface preparation has to be done for primer application in pipes.

**11.18 Tools:**

Two sets of standard tools kit for maintenance shall be provided by Contractor. Tenderer shall submit a list of the tools along with the tender. (Cost shall be inclusive in the tender)

**11.19 Safety Controls:**

**Low Lubricating Oil Pressure:**

Pressure sensors shall be fitted such that in the event of a fall in the lub oil pressure, an alarm and indication shall be actuated. In addition, the engine shall be automatically shut down in the event of lub oil pressure dropping to a predetermined low value.

**High Water Temperature:**

An alarm shall be given if the close loop engine jacket cooling water temperature exceeds safe limits stipulated by the engine manufacturer due to any. The engine shall be shut down when a pre-determined set water temperature is reached.

**Over Seed:**

Speed control shall be so arranged that a 12 ½% increase over normal rated speed shall cut off fuel supply, thus stopping.

**Overload Protection:**

The engine shall be adequately protected against operating under overload conditions. The requirements shall be met by the provision of a fixed overload limit stop on the fuel pump rack control rod to prevent the set being subject to a load exceeding the site rating plus 10%.

**Excess Starting Time:**

The starting circuit for the automatic mains failure diesel generator sets shall be arranged to attempt upto three starting cycles, each not exceeding 10 seconds duration with a similar OFF period between each cycle. If the set fails to start upon completion of the third attempt the starting circuit shall be locked out until it is restored manually. An alarm shall be given and “Set failed to start” indication given on the panel.

**Fuel Level Protection:**

A level sensor shall be provided in the day fuel tanks to give visual and audible alarms if the level in the tank falls to below ¼ of full.

12.0 INTEGRATED DG SET CONTROLLER

|  |  |  |
| --- | --- | --- |
| The Power Command Control is a microprocessor-based generator set monitoring, metering, and control system. The control provides an operator interface to the genset; digital voltage regulation, digital governing, and generator set protective functions. The integration of all the functions into a single control system provides enhanced reliability and performance compared to conventional control systems. | |  |
| **CONTROL** | * Run/ Off / Auto switch * Emergency stop * Manual Run / Stop Control switch * Idle / Run mode control | |
| **METERING**  **ENGINE** | * Starting Battery Voltage * Lube Oil Temperature & Pressure * Engine Coolant Temperature * Coolant Pressure * Engine Rpm. * Operating Hours. * Number of Starts. | |
| **ELECTRICAL** | * Current * Voltage * Frequency * KW * KWH * Pf * KVA | |
| **PROTECTION / WARNING**  **ENGINE** | * Over Speed Shutdown * Low Lube Oil Pressure Warning /Shutdown * High Coolant Temperature Warning / Shutdown * Low Coolant Temperature Warning * Low Coolant Level Warning./ Shut Down * Low And High Battery Voltage Warning * Weak Battery Warning * Over Crank Shutdown * Fail To Crank Shutdown * Magnetic Pickup Failure Shut Down | |
| **ALTERNATOR** | * Over Current * High Voltage * Low Voltage * Under / Over Frequency * Reverse Power (KVA & KVAr) * Phase Sequence | |
| **SPECIAL FEATURE** | * Digital AVR * Amp Sentry Protection * Sensor Failure Indication * Programmable Idle Speed Control * Digital Synchronizing Function * Sync Check * Synchronoscope * Auto Load Sharing * Compatibility to Remote Monitoring. * Smart Starting | |

13.0 Technical Specification Of Acoustic Enclosure

* The enclosure is fabricated out of CRCA sheet.
* The sheet metal components are hot dipped in NINE TANKS pre-treated before powder coating.
* Enclosure is powder coated (inside as well outside) with a special pure polyester based powder. All Nuts and, bolt/external hardware are made from stainless steel.
* The doors are gasket with high quality EPDM gaskets to avoid leakage of sound.
* The door handles are lockable type.
* Sound proofing of enclosure is done with high quality rock wool/mineral wool confirming to IS 8183.
* The rock wool is further covered with fiber glass cloth and perforated powder coated ms sheet.
* Specially designed attenuators are provided to control sound at air entry to the container and exit from the container.
* Adequate ventilation is provided to meet air requirement for combustion and heat removal.
* As per CPCB norms with acoustic enclosure the noise insertion loss shall be 25 dBA at one meter under free field condition for DG set.

14.0 TESTS:

14.1 The alternator of each type and rating shall be type tested for the following tests as per IS:4722, IEEE 115 & BS:5000. Test certificates to be provided for routine and type tests from the manufacturers.

Witness testing for DG Sets shall be done before dispatch of material by two representatives including all boarding lodging travel etc. as required.

15.0 ERECTION, TESTING, COMMISSIONING AND PERFORMANCE & GUARANTEE TESTS/PROCEDURE AT SITE:

The entire work of erection, testing and commissioning of equipment supplied under this package shall be carried out by contractor and performance and guarantee tests to be conducted at site are also included under the scope of this specification. For this purpose, the contractor shall depute suitable qualified technical supervisor to site on advance intimation to the Owner/PMC along with all special testing equipment required for testing and performance and guarantee tests. The supervisor(s) shall be responsible for the installation, testing, commissioning checks and performance & guarantee tests mentioned in relevant clauses of this volume and the checks recommend by the contractor.

The contractor shall ensure that the equipment supplied by him are installed in a neat workman like manner such that they are leveled, properly aligned and well oriented. The tolerances shall be established in Contractors drawings and/or as stipulated by the Owner/PMC. All special tools and tackles and spares required for erection, testing and commissioning of equipment shall be supplied by the contractor.

Erection, testing and commissioning manuals and procedures shall be supplied, prior to dispatch of the equipment.

The contractor shall ensure that the drawings, instruction and recommendations are correctly followed while handling, setting, testing and commissioning the equipment.

**15.1 Commissioning Check Tests/Performance and Guarantee Test:**

In addition to the checks and test recommended by the manufacturer, the contractor shall supervise the following acceptance tests to be carried out on each test at site.

**i. Load Test:**

The DG Set shall be given load test at site for a period of at least 6 hours depending upon the actual power factor of the load and set shall be subjected to the maximum achievable load without exceeding the engine or alternator capacity.

This full load test is to be followed immediately by a 10% overload run for one hour. The performance of the engine, alternator shall be satisfactory at the end of this overload run.

During the load test half hourly records of the following shall be taken:

a) Ambient temperature

b) Cooling water temp.

c) Lubricating oil pressure.

d) Speed

e) Voltage, wattage and current output.

f) Oil tank level

**ii. Speed and Governing:**

The speed of the engine shall be verified to ensure that it conforms to the requirement of BS:5514.

**iii. Test report of engine vibration shall be provided at the time of commissioning.**

**iv. Check of Fuel Consumption:**

A check of the fuel consumption shall be made through out the test run of full load and overload.

**v. Noise Level:**

The noise level shall not increase beyond 75 dBA at 1 metre distance from DG Set enclosure surface.

16.0 EARTHING

**16.1 General**

This section covers the general arrangement of the earthing, i.e. all non-current carrying metal parts of the electrical installation shall be earthed as per IS 3043(1987) and general specifications for electrical works (part-1, internal) of CPWD specifications. All metal conduits, trunkings, cable sheaths, switchgear, distribution boards, meters, light fixtures, fans and all other metal parts forming part of the work shall be bonded together and connected by two separate and distinct conductors to earth electrodes. Earthing shall also be in conformity with the provisions of Rule 32, 61, 62, 67 and 88 of IER 1956. The earth electrode shall not be situated less than 1.5 mtr.

**16.2 Earthing Systems**

It shall comprise of earth electrodes, earth strips, earth continuity conductor and all earthing conductors shall be of high conductivity copper, GI or aluminium and shall be protected against mechanical damage and corrosion. The size of earth conductors shall not be less than half that of the largest current carrying conductor. The connection of earth continuity conductors of earth bus and earth electrodes shall be strong and sound and shall be rigidly fixed to the walls, cable trenches, cable trays or conduits and cable by using suitable clamps made of non ferrous metals.

**16.3 Earthing Electrodes**

Earthing electrodes shall be designed as per the requirement of IS 3043 (1987). The number and size of earth electrodes shall be calculated so that under fault conditions no electrode is loaded above its maximum permissible current density. The resistance of earth electrode shall be as low as possible, the maximum allowable value being one ohm.

Earthing electrodes of either plate type or pipe type may be adopted. The choice of plate or pipe electrode shall be decided according to the anticipated fault level of the network and local soil conditions. Generally, plate electrodes shall be used for substations and large medium voltage network and pipe electrodes for small medium voltage network and installations.

**16.3.1 Location of Earth Electrodes**

Normally on earth electrode shall not be situated less than 1.5 m from any building. Care shall be taken that the excavation for earth electrode may not effect the column footings or foundation of the buildings. In such cases electrodes may be further away from the building.

The location of the earth electrode will be such where the soil has reasonable chance of remaining moist. As far as possible, entrances, pavements and road ways, are to be definitely avoided for locating earth electrode.

**16.3.2 Water Arrangement**

Method of watering arrangement shall comply with CPWD General Specifications.

**16.3.3 Plate Electrode**

Plate electrodes shall be made of GI plate of 6 mm thick and 60x60 cm. size. The plate shall be buried vertically in ground at depth of not less than 3.5 metres to the top of the plate, the plate being encased in charcoal to a thickness of 15 cm. all round. It is preferable to bury the electrode to a depth where sub-soil water is present. Earth leads to the electrode shall be laid in a GI pipe and connected to the plate electrode with GI bolts, nuts and washers. A GI pipe of not less than 19 mm dia shall be placed vertically over the plate and terminated in a funnel at 5 cm. above ground. The funnel shall be provided with a wire mesh. The funnel shall be enclosed in masonry chamber of not less than 300 x 300 x 300mm dimensions. The chamber shall be provided with CI frame cover of 300 x 300mm size & thickness not less than 10mm. The earth station shall also be provided with a suitable permanent identification label/tag. A suitable test link shall be provided in the earth chamber.

Note : If copper plate is used it shall be of 3mm thickness.

16.3.4 Pipe electrode shall comprise of a 2.5 Mtr. long 40 mm dia GI pipe buried vertically in a pit of 35 x 35 cm size and filled with alternate layers of charcoal, salt and river sand and connected at the top to a GI pipe of 19 mm, 1 Mtr. long with a funnel at the other end, 5 cm above the ground. The earth lead shall be properly fixed to the pipe electrode with brass bolts, nuts and washers. The funnel and earth lead connections shall be enclosed in a masonry chamber of 30 x 30 x 30 cm. dimensions. The chamber shall be provided with a CI frame and CI cover. Proper permanent identification tag/label shall be provided for each electrode.

**16.4 Installation**

16.4.1 All joints shall be reverted and sweated. Joints in the earth bar shall be bolted and the joints faces tinned. Where the diameter of the bolt for connecting earth bar to aparatus exceeds one quarter of the width of the earth bar, the connection to the bolt shall be made with a wider piece of flange of copper jointed to earth bar. These shall be tinned at the point of connection and special care taken to ensure a permanent low resistance contact to iron or steel. All steel bolts, nuts, washers, etc shall be cadmium plated. Main earth bars shall be spaced sufficiently away from the surface to which they are fixed, such as walls or the side of trenches to allow for easy connections. Copper earth bars shall not be fixed by ferrous fittings. The earthing shall be suitably protected from mechanical injury by galvanized iron within ground shall be buried at least 60 cm deep. The earthing lead shall be securely bolted and soldered to the plate or pipe as the case may be. In the case of the plate, the lead shall be connected by means of cable socket with two bolts and nuts. All washers shall be of the same materials as the plate or pipe. All iron bolts, nuts and washers shall be galvanized.

**16.4.2 Method of Installation of watering arrangement**

In the case of plate earth electrode a watering pipe of 20 mm dia of medium class GI pipe shall be provided and attached to the electrode. A funnel with mesh shall be provided on the top for watering the pit. In case of pipe earth electrode a 40 mm x 20 mm reducer shall be used for accessing the funnel. The watering funnel attachment shall be housed in masonary enclosure of not less than 30 cm x 30 cm x 30 cm. A cast iron cover having locking arrangement shall be suitably embedded in the masonary enclosure.

**16.5 Precautions**

16.5.1 Earthing system shall be mechanically robust and the joints shall be capable of retaining low resistance even after passages of fault currents.

16.5.2 Joints shall be soldered, tinned and double riveted. All the joints shall be mechanically and electrically continuous and effective. Joints shall be provided against corrosion.

16.5.3 The earthing lead from electrode onwards shall be suitably protected from mechanical injury by a 15 mm dia GI pipe in case of wire and by 40/80 mm dia medium class GI pipe in case of strips. Portion of this protection pipe within the ground shall be buried at least 30 cm deep (to be increased to 60 cm in case of road crossing and pavements). The portion within the building shall be recessed in walls and floor to adequate depth.

**16.6 Testing**

16.6.1 On the completion of the entire installation, the following tests shall be conducted and no earth electrode shall have ohmic resistance of more than 2 ohm and in rocky soil not more than 3 ohms.

1. Earth resistance of electrodes
2. Impedance of earth continuity conductors as per E-3 of IEE regulations.
3. Effectiveness of earthing as per E-4 & E-5 of IEE regulations.

16.6.2 All meters, instruments and labour required for the tests shall be provided by the contractor. The test results shall be submitted in triplicate to the Owner/PMC for approval.

17.0 RADIO INTERFERENCE:

All equipment provided under this specification shall be so designed that it will not cause interference with radio equipment. In the event of the inherent characteristics of the equipment being such that radio interference is possible, efficient devices to nullify the same shall provided. Suppressers shall be as per the relevant IS/BS Standards. Nothing extra shall be paid to the contractor on this account.

18.0 PRE-COMMISSIONING CHECKS:

All standards checks including the ones elaborated in the specifications to ensure that the installation of the DG sets and associated systems has been carried out satisfactorily shall be done on completion of installation. These shall include:

a) DG Sets:

Checking of piping interconnections

Checking of electrical interconnections

Checking of insulation resistance

Checking of earthing

Checking of instruments and controls

Checking of alignment

Checking of vibration transmission to building a structure

Checking of expansion joints

c) Exhaust System:

Checking of silencer operation

Checking of surface temperature of exhaust piping

d) Fuel System:

Checking of automatic operation of fuel transfer pumps

19.0 PERFORMANCE TESTING AND TYPE TESTS:

**19.1 Performance Testing:**

DG sets shall be tested at varying loads at manufacturers works prior to dispatch of the sets to site. The performance tests at the works shall be carried out in presence of authorized representative from the Owner/PMC to enable them to arrange for their representatives for his inspection to be at manufacturers works for this inspection and testing. The costs for the shall be same shall be included.

The performance test on each DG sets shall be of minimum 8 hours duration.

All instruments, materials, consumables (fuel oil, lube oil etc.) load and labour required for carrying out of the test shall be provided by the Contractor.

Following test acceptance criteria shall be applicable:

|  |  |  |
| --- | --- | --- |
| 1. | Fuel consumption at 50%, 75%, 100% and 110% load | ±5% of guaranteed performance. Actual alternator efficiencies as determined in the manufacturers works tests shall be used as the basis of calculation of specific fuel consumption ratio. |
| 2. | Voltage regulation from no load to full load | ±1% |
| 3. | Frequency regulation from no load to full load | ±0.5% |
| 4. | Maximum water temperature | ±5% of guaranteed performance |
| 5. | Maximum Lub Oil temperature | ±5% of guaranteed performance |
| 6. | Minimum Lub Oil pressure | ±5% of guaranteed performance |
| 7. | Lub Oil Consumption | ±5% of guaranteed performance |

**19.2 Type Test:**

Copies of manufacturers type test for the engine and the alternator of all ratings shall be enclosed along with the dispatch of the DG sets.

20.0 EXHAUST BLOWER:

20.1 The exhaust fans shall be propeller type with steel hub and blades, mounted directly on the shaft of a totally enclosed motor.

20.2 The fan blades shall be of pressed steel of aerofoil design for high efficiency and static pressure.

20.3 The mounting frame shall be of cast /sheet steel brackets to connect the frame, with the fan/motor assembly. Rubber mounts shall be provided between the mounting frame and the mounting brackets.

20.4 The fan motor shall be totally enclosed squirrel cage type.

21.0 DG CONTROL AND OPERATION:

Operation of DG Sets shall be monitored and controlled by Engine Control Module & DG Synchronization Panel.

# HSD OIL STORAGE TANK

1. **Scope**

The contractor shall design supply, install, test and commissioning of the HSD tank, fittings and accessories as per requirements of the following BIS codes:

i. IS : 10987 / IS : 823 / IS : 1239

ii. Rules and regulations of the Chief Inspector of Explosives India.

iii. Petroleum Rules 1936

iv. All site welding shall be carried out by fusion welding as per IS:823. For all butt welds, the roof run and final run shall be carried out.

The tank design shall be as per the above codes and contractor shall submit criteria of design adopted by them along with the tender.

1. **CONSTRUCTION**

The tank shall be fabricated from MS Sheet of min. 6mm thick for shell & 8mm thick plain ends.

The fuel tank top shall be fully bolted type and shall have a bolted type inspection manhole cover with a handle, so that ordinary inspection and minor cleaning of tank can be carried out.

The top cover & inspection cover fitting shall be so as to make it water proof, fitted with minimum 5 mm thick neoprene rubber gasket.

In case of floor mounted tanks the tank shall have fabricated footing on four corners so that the bottom of fuel tank is atleast 150 mm above resting level or floor level, to enable cleaning of space below, drain the tank etc.

In case of structure mounted high level day tank, instead of footings an appropriate channel base shall be provided.

1. **PAINTING**

The day tanks, after fabrication & calibration shall be thoroughly cleaned & spray painted with two base coats plus two finish coats of special diesel resistant paint.

The supporting structure also should be cleaned & painted with two coats of base primer and two coats of enamel paint.

1. **INSPECTIONS, APPROVAL & LICENCE**

The contractor shall arrange the inspection, approval and license for the proposed HSD oil installation by the Chief Inspector of Explosives as given below:

**4.1 Pre-installation Approval**

The contractor shall upon the award of the work, prepare working drawings for the HSD installation and submit the drawings to the consultants for their provisional approval. The drawings so approved by the consultants shall be submitted to the Chief Inspector of Explosives for his scrutiny and approval.

**4.2 Test & Safety Certificates**

It shall be the responsibility of the contractor to arrange test and safety certificates under rules 126 after the installation is commissioned.

**4.3 Inspection / Storage License**

It shall be the responsibility of the contractor to arrange for inspection of the installation by the Chief Inspector of Explosives and carry out any modifications / additions if required by the Chief Inspector of Explosives and obtain storage license and submit the same to the Owner/PMC. Also drawing approval from CCOE Nagpur shall be considered.

1. **FUEL OIL PIPING**
   1. **Scope**

The scope of this section comprises the supply and laying of pipes, pie fittings and valves testing and balancing of all HSD piping required for the complete installation as shown on the drawings. All piping inclusive of fittings and valves shall follow the applicable BIS Codes.

1. Pipes shall be MS class ‘C’ & fittings shall be welded type fittings conforming to relevant BIS codes. All jointing in the pipe system shall generally be by welding / flanges, unless otherwise mentioned or directed at site. All welding shall be done by qualified welders and shall strictly conform to BIS code of procedure for manual metalarc welding of mild steel.
2. All pipes and their steel supports shall be thoroughly cleaned and given on primary coat of red oxide paint before being installed. All welded piping shall be subject to the approval at site.
3. Thread joint fittings shall be malleable casting of pressure rating suitable for the piping system. Fittings used on welded piping shall be of the weldable type.
4. Tee-off connections shall be through equal or reducing tees other-wise ferrules welded to the main pipe shall be used. Drilling and tapping of the walls of the main pipe shall not be resorted to.
5. Valves, conforming to the following specifications, shall be provided as shown on drawings.

**Size Construction Ends**

15 to 65 mm Gun Metal Flanged

75 mm over Body cast iron spindle and valve seat

of bronze or gun metal Flanged

All valves shall be heavy duty.

1. Flanges shall be approved make. The supply of flanges shall also include supply of bolts and nuts and suitable asbestos fibre / rubber insertion gaskets (minimum 3 mm thick).
2. Non-return (check) valves shall be provided as shown on the drawings, conforming to relevant BIS codes and in accordance with the following specifications:

**Size Construction Ends**

15 to 65 mm Gun Metal Flanged

75 mm over Cast Iron / Gun Metal Flanged

Swing check valves shall normally be used in all services. Lifts type valves may be used in horizontal runs.

1. The strainers shall be of cast iron body with gunmetal or bronze mesh for fine filtration of the oil.
2. All piping and fitting shall be pressure tested, then painted and shall be provided with additional weather proof treatment for buried pipes.
3. All piping shall be painted as specified herein. After piping has been installed, tested and run for atleast three days of eight hours each, all exposed piping and pipe supports shall be given two finish coats, 3 mils each, of approved paint, conforming to relevant BIS codes. The direction of flow of fluid in the pipes shall be visibly marked with identifying arrows.

The specifications given above are minimum requirement only. The Contractor should supply, erect and commission the equipment’s/ system according to latest amended BS/IEC/IS Standards.

# NGR PANEL

7.1 **DESIGN CRITERIA**

The design basis for neutral grounding resistor shall be as follows:

1. The Neutral Grounding Resistor (NGR) shall be used for non-effective grounding of 11KV side neutral of 11KV, 1500KVA DG Set. NGR and Contactor shall be connected between the DG winding neutral point and earth.
2. Neutral Grounding Resistor shall be used to limit the magnitude of earth fault current so that damage of Electrical equipment is reduced, safety of personnel is increased and sensitive, selective earth fault protection can be provided.
3. The NGR box shall be installed indoor in hot, humid and tropical finish shall be provided to prevent fungus growth.
4. The rated time for the earth fault current or specified thermal current withstand time shall be 10 seconds. The Resistor unit shall be natural air-cooled type suitable for installation at indoor location.

7.2 **SPECIFIC REQUIREMENTS FOR NGR**

The following specific requirements shall be complied with:

* 1. The resistor element shall be Non Inductive made up of non-aging formed stainless steel grid of uniform thickness and cross-section having high electrical resistivity and low temperature co-efficient of resistance.
  2. The resistor unit shall consist of number of elements. All the elements shall be mounted inside a cubicle with ease of inspection and replacement of individual element.
  3. Resistors shall be able to carry the specified current for 10 seconds with temperature rise not exceeding 3500C over the maximum specified ambient temp. The resistors shall also be able to carry at least 5% of the rated current continuously with the enclosure surface temperature not more than 550C over the ambient temperature specified. It is also required that while carrying 5% continuous current, NGR shall be able to carry rated current for 10 seconds without its temperature rise exceeding the 3500C limit.
  4. Each Resistor element shall possess a balanced combination of both Mechanical and Electrical properties over the entire intended operating temperature range without any harmful effect on the elements and their accessories.
  5. All the resistor elements constituting the NGR shall be assembled and supported inside the cubicle in such a way that no distortion or breakage occur during the passage of through fault current to earth.
  6. Current density of resistor element shall be as per IEEE-32 or better for short time rating.
  7. All elements connections shall be bolted type to ensure stable resistance value throughout the working life of the unit.
  8. Wet process type white glaze porcelain insulators shall be used for supporting resistor elements. Porcelain insulators shall have high creepage value suitable for heavily polluted atmosphere.
  9. Neutral grounding resistor box shall have structural steel work enclosed on all sides and also on top by sheet steel having a minimum thickness of 2 mm.
  10. Cubicle shall be complete with a front access door with handles, lock and also a removable bolted cover. All doors and removable covers shall be properly gasketted with neoprene rubber gaskets.
  11. All cubicle door hinges shall be concealed type. Cubicle shall be complete with a suitably mounted cable end box fitted with removable gland plate for fixing cable gland.
  12. Cubicle shall be provided with suitable base channels for direct bolting to the foundation at site.
  13. Resistance box shall be provided with Porcelain insulated through terminal for connection with incoming cable from Isolator Panel and outgoing terminal connection between NGR and earth pit by 75x10 mm Cu flat.

7.3 **WIRING**

All internal wiring between auxiliary equipment and terminal block shall be carried out by PVC insulated 1100V grade 2.5 sq. mm stranded copper conductor wires. All wiring shall be suitably ferruled with corresponding wiring identification marks used in the schematic/ wiring diagrams. All devices and terminal blocks within the terminal box shall be clearly identified by symbol corresponding to those used on applicable schematic/ wiring diagram.

7.4 **GROUNDING**

All parts of enclosure, supporting structures, equipment frames etc. shall be properly grounded at two points. NGR cubicle shall be complete with two (2) Nos. ground pads, tapped holes and bolts suitable for connection with station earthing grid.

7.5 **PAINTING**

1. All steel surfaces shall be thoroughly cleaned by sand blasting or chemical agents, as required, to produce a smooth surface free of scales, grease and rust.
2. The internal surfaces in contact with insulating oil shall be painted with heat resistant insulating varnish, which shall not react with and be soluble in the insulating liquid used.
3. The external surfaces, after cleaning, shall be given a coat of high quality red oxide or yellow chromate primer followed by filler coats.

7.6 **TESTS**

**ROUTINE TESTS :**

During manufacture and on completion, NGR shall be subjected to the IS routine tests including measurement of resistance.

**TYPE TESTS:**

Following type tests shall be performed on specific instruction on one NGR in accordance with relevant Indian Standard with the approval of the Owner/PMC.

* Temperature rise test.

Cost of such tests, shall be included in the tender.

**TEST WITNESS** :

Tests shall be performed in presence of Owner/PMC if so desired by them. The Contractor shall give at least fifteen (15) days’ advance notice of the date when the tests are to be carried out.

**8.0** **SYSTEM REQUIREMENTS**

8.1 **ENCLOSURE**

|  |  |  |  |
| --- | --- | --- | --- |
| a) | Type | : | Metal enclosed, free standing |
| b) | Service | : | Indoor |
| c) | Protection Class | : | IP-31 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 8.2 | **RESISTOR ELEMENT** | |  |  |
|  | a) | Material | : | Non-aging, corrosion proof, formed |
|  |  |  |  | stainless steel |
|  | b) | Rated Voltage | : | 11KV |
|  | c) | Rated Current | : | To be decided by vendor depending |
|  |  |  |  | upon Alternator capacity to carry |
|  |  |  |  | earth fault current & approval from consultant |
|  | d) | Short time duration | : | 10Sec |
|  | e) | Ohmic value of Resistor | : | To be decided by vendor depending |
|  |  |  |  | upon Alternator capacity to carry |
|  |  |  |  | earth fault current & approval from consultant |
|  | f) | Limit of maximum temperature | : | 3500 C above ambient |
|  |  | attained at any part of the Resistor |  | (short time) |
|  |  | assembly |  | 550 C above ambient |
|  |  |  |  | continuous |
| 8.3 | **CONTACTOR** | |  |  |
|  | a) | Type | : | Single Pole , Vaccum Type |
|  | b) | Voltage | : | 11KV |
|  | c) | Current Rating | : | 200A |
|  | d) | Contactor Aux. Contact | : | 4NO + 4NC |
|  | e) | Indication | : | ON/OFF |

# 11/0.433kV Oil Cooled Transformer

**SCOPE**

This specification generally describes the power transform­ers and associated auxiliary equipment for use on the electrical power distribution system and covers the design, manufacture, testing at works, supply and delivery, testing and commissioning aspects of the same. The losses should be as per ECBC (Level-5).

1. GENERAL DESIGN AND CONSTRUCTIONAL FEATURES:
   1. All materials used shall be of best quality and of the class most suitable for working under the site conditions and shall withstand the variations of temperature and atmospheric conditions, overloads, over-excitation, short circuits as per applicable standards, without distortion or deterioration or the setting up of undue stresses in any part, and also without affecting the strength and suitabil­ity of the various parts for the work which they have to perform.
   2. The design shall be such that the risk of accidental short‑circuit due to birds or vermin’s are obviated. All apparatus, including bushing insulators and fittings shall be so designed that water cannot collect at any point. Marshaling kiosks, boxes etc. shall be adequately ventilat­ed to prevent condensation of moisture and so treated internally as to prevent growth of fungi on any coils, wires and insulating materials used.
   3. The transformers shall operate with minimum noise and vibration. The cores, tank and other structural parts shall be properly constructed so that the mechanical vibrations are kept to the minimum, thus reducing the noise.
   4. The design of the transformer shall be such that changes in transformer connection can be made by a simple change of link connection inside the tank. The transformers shall be designed to suppress harmonic voltages, specially the third and fifth, so as to eliminate distortion in wave form, and the possibility of circulating currents between the neu­trals at different transformer stations.
   5. All transformers shall be of the latest design, oil filled as called for in the main specification. Unless otherwise specified, all transformers shall be suitable for indoor installation. The type of cooling and the corresponding ratings for each transformer shall be as indicated in the main specification.
   6. The magnetic circuit of each transformer shall be so de­signed as to minimise eddy‑current and hysteresis losses in the core.
   7. All electrical connections and contacts shall be of ample section for carrying the rated current without excessive heating.
   8. All mechanisms shall be of stainless steel, brass, gunmet­al, or other suitable material to prevent sticking due to rust or corrosion.
   9. **TANK:**
      1. The transformer tank shall be made of steel plate, shaped in such a way that minimum of welding is required. The tank shall be electrically welded and all welding stresses shall be properly relieved. Tank walls shall be reinforced by adequate stiffeners to ensure mechanical rigidity permit­ting hoisting of complete transformers filled with oil and also to damp transformer‑noise. The tank shall be suffi­ciently strong to withstand shocks likely to be encountered during transport of the transformer without any deformation or weakening of joints. The joints shall be oil‑tight. Guides shall be welded on the inner side of the tank to facilitate tanking and untanking of the transformer core and coil assembly.
      2. Tank cover shall be bolted on to the flanged rim of the tank with a suitable weather‑proof, hot‑oil‑resistant gasket in between for oil‑tightness. The bolted tank cover shall be so arranged that it can be removed and the core inspected without removal of the radiators. All requisite access and inspection holes shall be provided with bolted oil‑tight, gasket‑seated cover‑plates. Bushing‑turrets, covers of access holes, covers of pockets to prevent leakage of water into the tank shall be provided.
      3. The exterior of tank and other steel surface exposed to the weather shall be thoroughly cleaned and have a priming coat of zinc chromate applied. The second coat shall be of an oil and weather resistant nature preferably of distinct colour from the prime and finish coats. The final coat shall be of a glossy, oil and weather resisting non‑fading paint of specified shade. The interior of the tank shall be cleaned by shot blasting and painted with two coats of heat resistant and oil insoluble paint.
      4. Steel bolts and nuts exposed to atmosphere shall be galva­nised however, surfaces of the transformer or other parts of the transformer or auxiliary equipment which are in contact with oil shall not be galvanised.
      5. The transformer tank, auxiliary equipment and fittings shall be provided with necessary devices for lifting and haulage facilities. The tank shall be mounted on a substan­tial under‑carriage.
      6. Unless otherwise stated the tank together with radiators, conservator, bushings and other fittings shall be designed to withstand without permanent distortion the following conditions.
2. Full vacuum of 760mm of Hg for filling oil by vacuum.
3. Internal gas pressure of 0.35 Kg/Sq.cm. with oil at operating level.

Valves shall not leak nor any welded joints sweat under above conditions.

* + 1. Adequate space shall be provided at the bottom of the tank for collection of sediments.

1. CORE:
   1. The magnetic circuit shall be built of transformer grade cold rolled grain oriented low loss steel stampings having high permeability and conforming to adopted standards. Stampings shall be insulated from each other with material having high inter-lamination insulation resistance and rust inhibiting property and also capable of withstanding pres­sure, mechanical vibration and action of heat and oil, thus reducing the possibility of sludge formation to a minimum.
   2. The framework, clamping arrangement and general structure of the cores of each transformer shall be of robust con­struction and shall be capable of withstanding any shock to which they may be subjected during transport, installation and service. The assembled core shall be securely clamped, on the limbs and the yoke, to build up a rigid structure. The clamping pressure shall be uniform over the whole of the core and so adjusted as to minimize noise and vibration in the core when the transformer is in service. The frame­work and the core bolts shall be efficiently insulated from the core so as to reduce the circulating currents to a minimum.
   3. The core clamping frame shall be provided with lifting eyes for the purpose of tanking and untanking the core with winding mounted thereon and shall have ample strength to take the full weight of the core and winding assembly.
   4. An approved type of core grounding system shall be used; the grounding connections being located at the top of the core for easy access from the inspection hole.
   5. **WINDING:**
      1. The coils used for transformer winding shall be circular in shape, made of paper insulated, continuous and smooth, tinned or enameled electrolytic copper conductors of high conductivity.
      2. The transformer winding shall be designed for basic impulse insulation level not lower than that specified in the main specification.
      3. Liberal ducts shall be provided to prevent any hot spot temperature in the winding that may adversely affect the life of the transformer. Adequate supports, wedges and spacers of hard insulating material shall be so fitted that they will neither move nor permit relative movement of any part of winding during transit of normal service or under terminal short‑circuit, nor damage the winding insulation in any way. All leads and connections shall be robust, adequately insulated, protected and clamped. The winding assembly shall be dried in vacuum with tested insulating oil of approved standard. The windings shall be subjected to a thorough shrinking and seasoning process so that no further shrinkage of windings occur during service at site. However adjustable devices shall be provided for taking up any possible shrinkage of coils in service. The assembly shall be held in position under adequate axial compression to withstand the axial thrust likely to occur under termi­nal short‑circuit.
      4. The end turns on the high voltage winding shall have rein­forced insulation to take care of the voltage surges likely to occur during switching or any other abnormal system condition.
      5. The transformers shall be suitable for operation at full rated power on all tappings without exceeding the specified temperature rise as indicated in the applicable standards.
   6. **INSULATING MATERIALS:**
      1. The insulating oil shall conform to British standard or IEC and shall be suitable in all respects for operating the transformer at the rating and under conditions specified in the main equipment specification. Sufficient oil shall be supplied for the first filling of transformer, the oil circulating equipment and the tank containing tap‑changing mechanism and an extra 10% shall be supplied in non‑returnable drums. The tender shall contain information about the grades of oil recommended by the transformer manufacturer for use in the transformer. Test certificates for the oil shall be furnished before dispatch of transformer and acceptance by Owner/PMC.
      2. Class F insulating materials specified in latest IEC shall be used. Paper insulation shall be new and free from punc­tures. Wood insulation, where used shall be well seasoned and treated.
   7. **TRANSFORMER TAPPINGS:**

Transformer shall be provided with Off Circuit Tap Changer arrangement in steps of 2.5% with range from + 5% to – 5%.

* 1. **COOLING EQUIPMENT:**
     1. Natural cooling by means of banks of detachable type radia­tors made from pressed/round tubes around transformer tank shall be provided. The tubes shall be of seamless mild steel sheet with clean bright internal surface and shall be suitably braced to protect them from shock.
     2. The radiators shall be provided with butterfly type of shut off valves.
     3. Cooling tubes/radiators shall permit every part of the cooling surface to be cleaned by hand.
  2. **TERMINAL ARRANGEMENT**
     1. **High Voltage Side (11 kV)**

Cable box shall be provided suitable for terminating Al conductor, XLPE insulated armoured, 11 kV cable complete with disconnecting chamber, compression glands, lugs, Armoured, earth clamp and body earth terminal.

Cable box shall be fitted with bushing insulators for H.T. cable termination side.

* + 1. **Low Voltage Side (433 V)**

LT Termination shall be suitable for 1.1kV, Al conductor, XLPE insulated, armoured cable.

* + 1. **Disconnecting Chamber**

The disconnecting chamber shall be air insulated and complete with seal off bushing, removable flexible connectors / links and removable covers. It shall be possible to trail out the transformer without having disconnecting the bus duct.

Phase to phase and phase to ground clearances with in the chamber shall be such as to enable either the transformer or cable to be subjected separately to H.V. test.

* + 1. **Bushing :**

Bushings shall confirm to latest IEC and other relevant standards.

Bushings shall be supplied with terminal connector clamp suitable for connecting the bushing terminal to the Owner/PMC.

Creepage distance of bushing shall be (41mm/kv phase ground) adequately,

* 1. **MARSHALLING BOX**
     1. Whenever optional fittings, temperature indicators, with auxiliary contacts, Buchholtz Relay and Bushing CT's are specified, then the Contractor shall provide a Marshalling box and Marshall to it all the contact terminals of electrical devices mounted on the transformer. It shall be in the contractor's scope to provide:

1. The interconnection cabling between the Marshalling box and the accessory devices either by PVC insulated copper wire in G.I. conduits or PVC insulated copper conductor armoured cables.
2. Necessary compression type brass cable glands at the Marshalling box for above cables.
   * 1. The Marshalling box shall be tank mounted, water/dust tight sheet steel (2mm thick) enclosed with hinged door having padlocking facility. All doors, covers and plates shall be fitted with neoprene gaskets. Top surface shall be sloped and bottom shall be atleast 600mm from floor and provided with gland plate and cable glands as required.
     2. Terminals shall be clipon type rated for 10A. All contacts for alarm/trip indication shall be potential free, wired up to the terminal block. Wiring shall be done with stranded copper conductor wires of sizes not less than 1.5 sq.mm for control and 2.5 sq.mm for CT circuits. C.T. terminals shall be provided with shorting facility.
3. ELECTRICAL & PERFORMANCE REQUIREMENT :
4. Transformer shall operate without injurious heating at the rated KVA at any voltage within +/‑ 10% of the rated voltage of that particular tap.
5. Transformer shall be designed for 110% continuous over fluxing withstand capability.
6. The neutral terminals of the winding with star connec­tion shall be designed for the highest over current that can flow through the winding.
7. Overloads shall be allowed with in the conditions defined in the loading guide of the applicable stand­ard. Under these conditions, no limitations by termi­nal bushings, tapchangers or other auxiliary equipment shall apply.
8. Temperature Rise shall be continuously rated for full load. The temperature rise shall not exceed 50 degree C by thermometer in oil or 55 degree centigrade by resistance over an ambient of 38 degree C.
9. EARTHING :
   1. Two separate earthing terminals to be provided at the bottom of the tank on opposite sides. The terminals shall be of clamp type suitable for connection to Employer’s ground­ing strip (50x6mm copper).
   2. **Internal Earthing :**

The frame work and clamping arrangements of core and oil shall be securely earthed inside the tank by adequately sized copper strip connections to the tank.

1. FITTINGS AND ACCESSORIES :

The transformer shall be provided with all standard fit­tings and accessories specified in the applicable standard for the size and type of transformer concerned. The accessories and fittings shall generally be as specified below:

* 1. **Oil Conservator :**

The transformer to be provided with an oil conservator with welded end plates. It is to be bolted to the cover and can be dismounted for purpose of transport. It shall be provided with plain oil level gauge with marking for minimum level and an oil filling hole with a cap which can be used for filling oil. For draining purpose a plug shall be provided. An equiliser pipe between the conservator and the main tank is to be provided, which projects inside conser­vator.

* 1. **Breather:**

The transformer shall be provided with an indicating dehydrating silica‑gel breather with glass window for inspection of sufficient capacity.

* 1. **Explosion Vent.**

An explosion vent with diaphragm shall be provided for relieving the pressure within the transformer.

* 1. **Diagram and Rating Plate:**

Diagram and rating plate of stainless steel shall be provided indicating the details of transformer, connecting diagram, vector group, tap changing diagram etc.

* 1. **Earthing Terminals**

Two earth terminals of adequate mechanical and elec­trical capacity shall be provided. One separate earthing terminal shall also be provided on each separate radiator banks.

* 1. **Buchholtz Relay**

Double float Buchholtz relay where specified shall have two separate sets of contacts, one for alarm and other for circuit breaker trip. The relay shall have a test cock. A small window in the wall of the relay shall be provided to show the amount of the trapped gas, it any. The construction of the transformers shall be such that all rising gas will be readily reach the Buchholtz relay. Gas sampling device at an accessible height and an air release cock for Buchholtz relay shall be provided.

* 1. **Dial type Thermometer (OTI)**

Dial type thermometer (150mm dia) with maximum set pointer at 75 degrees c and electrical contacts for electrical alarm at high temperature with thermometer pocket shall be provided.

* 1. **Winding Temperature Indicator (WTI)**

Shall comprise of :

1. Temperature sensing element
2. Image coil
3. Bushing or turret mounted
4. C.T. Local indicating instrument with electrically independent trip/alarm contact brought out to separate terminals.
   1. **Lifting Lugs :**

The arrangement for lifting the active part out of the transformer tank along with cover by means of lifting lugs without disturbing the connections shall be provided.

* 1. **Swivel Type Rollers :**

The transformer to be provided with 4 Nos. bi-directional rollers fitted on cross channels to facilitate the movement of transformer in both directions.

* 1. **Air Release Plugs :**

An air release plug shall be provided on the top of the tank cover/radiators to facilitate the release of the entrapped air and filling of oil.

* 1. **Drain‑cum‑oil Filter Valves with Plug on Cover Plate:**

The transformer shall be provided with a drain‑cum‑oil filter valve with blanking plate & locking arrangement of 1 1/2"BSP size at the bottom of the tank.

Filter valve of 1 1/4" BSP at top with blanking plate.

Sample valve with blanking plate ( ½").

Inspection cover.

Oil filling hole with cap.

* 1. **Jacking Pads**

**Skids**

Neutral bushing terminals complete with connector for earth conductor.

1. DRAWINGS AND O & MANUALS:
   1. Four copies of manual of complete instructions for the installation, operation, maintenance and repairs circuit diagrams, foundation and trenching details shall be provid­ed with the transformers. List of spare parts shall also be indicated.
   2. Two copies of the drawings incorporating the following particulars shall be submitted with the offer for prelimi­nary study.
2. GA drawing showing dimension, net weight and shipping weight, quantity of insulating oil etc.
3. Crane requirements for assembly and dismantling of the transformer.
4. Drawing indicating GA of cable box and its dimension for cable entry cut out requirements etc.
   1. The drawings in (four sets) to be furnished by the Contractor for approval after acceptance of his order shall include the following.
5. GA showing front and side elevations and plan of transformer and all accessories and external features, detailed dimensions, crane lift for untanking, oil quantity, H.T./L.T. clearances etc.
6. Drawings of Bus duct/cables termination arrangement.
7. HV cable box arrangement & disconnecting chamber GA & details drawings.
8. Drawing of each type of bushing.
9. Name plate and terminal making and connection diagram.
10. Control wiring & schematic diagram showing polarity and vector group of windings, CTs and OTI, WTI, cir­cuits, Alarm/trip circuits etc.
11. Assembly of ON Load Tap Changing gear mechanism & details of mechanism parts, limits, contours of wearing parts, timing gear adjustments etc.
    1. Reproducible copy of the above drawings for records
12. TESTING:

The transformer shall be subjected to all routine tests in accordance with latest IEC latest version at the factory before dispatching the same and test certificates shall be furnished.

1. Measurement of winding resistance.
2. Ratio polarity and phase relationships.
3. Impedance voltage.
4. Load losses
5. No‑load losses and No load current
6. Insulation resistance (Before & after carrying out all tests)
7. Induced over voltage withstand test
8. Separate source voltage withstand test
9. Contractor shall get the HV impulse test done. Alterna­tively they may submit the test certificate for the test conducted on the similar transformer.
10. TEST REPORTS

Four copies of the test reports in bound volume shall be submitted for approval.

1. SPARES

The Contractor shall provide his recommended spares for the period of operation of transformer upto DLP.

1. TRANSFORMER DATA SHEET
   1. **GENERAL**

Application : Distribution Transformer

Quantity Required : As mentioned in BOQ

Installation : Outdoor type

* 1. **RATINGS**

Rating KVA : 1 No. 2000kVA & 1 No. 315kVA

Number of phases &

Frequency : 3 Phase, 50Hz

Type of cooling : ONAN

No Load Voltage

HV : 11000 V

LV : 433 V

Vector Group : Dyn11

Percentage Impedance :As per B.S. (without negative tolerance)

* 1. **VOLTAGE**

Nominal System Voltage

HV : 11000 V

LV : 433 V

Highest System Voltage

HV : 11000 V

LV : 433 V

* 1. **TAPCHANGING GEAR**

TAPS ON/OFF LOAD : OFF LOAD

Tapping on windings HV/LV : HV

Total tapping range : +5% to – 5%

Steps : 2.5%

* 1. **TEMPERATURE RISE**

Ref. Ambient oC : 50OC

Oil by thermometer oC : 45OC

Winding by Resistance oC : 55OC

* 1. **INSULATION WITHSTAND**

Impulse (1.2x50 micro second wave) : 75 kV

Power Frequency (Dry & Wet)

HV : 28 kV

LV : 3 kV

* 1. **NEUTRAL EARTHING**

SYSTEM NEUTRAL

Effectively Earthed/Resonant

Non effectively Earthed/

Isolated : Effectively Earthed

TRANSFORMER NEUTRAL : Effectively Earthed

* 1. **VACUUM WITHSTAND CAPABILITY**

Main Tank with bushing, Radiator, fittings & accessories : Full Vacuum

* 1. **ACCESSORIES**

Dial type thermometer with Alarm and trip contacts : Yes

Magnetic Oil gauge with Alarm contact : Yes

Buchholtz Relay (Double float) : Yes

Winding Temperature Indicator : Yes

Wheels Plain/Flanged/bi-directional/unidirectional : Plain, Bi-directional

Explosion Vent diaphragm : Yes

Silicagel Breather : Yes

Valves : Drain valve, Filter valve, Sampling

* 1. **TERMINATION ARRANGEMENT**

H.V. SIDE (CABLE BOX) : Cable box and disconnecting chamber suitable for 11kV, Al conductor, XLPE insulated, Armoured cable.

L.V. SIDE (CABLE BOX) : 1. 2000kVA : 3200A Bus Duct

2.315kVA : Cable box and disconnecting chamber suitable for 1.1kV, Al conductor, XLPE insulated, Armoured cable .

1. DATA TO BE FURNISHED BY VENDOR/CONTRACTOR:
   1. **POWER TRANSFORMER:**
2. Name of Manufacturer
3. Standards followed in design manufacture and testing
4. Continuous maximum rating in KVA
5. Transformer no‑load voltage

* High voltage
* Low voltage

1. Vector group reference
2. Temperature rise over specified ambient temperature in degree C

* In oil by thermometer
* In winding by resistance
* Maximum hot spot temperature in degree C

1. Terminal Arrangement.

* H.V. Side
* L.V. Side

1. One‑ninute dry power frequency test withstand voltage in KV

* High voltage
* Low voltage

1. Impulse test withstand voltage with 1.2 x 50 microseconds wave in KV
2. Type of tap changer

* No. of plus taps
* No. of minus taps

1. Iron losses in KW at rated voltage and frequency
2. Copper losses in KW at rated full load current and frequency at 75 degree C
3. Reactance voltage with guaranteed tolerance in percent at rated full load current and frequency75 Deg C
4. Impedance voltage with guaranteed tolerance in percent at rated full load current and frequency at 75 Deg C
5. 1.15 Regulation in percent of no‑load voltage at full load current at 75 degree C and with power factors of

* Unity
* 0.8 lagging

1. Efficiency in percent at 75 degree C and unity power factor for

* 100 percent load
* 75 percent load
* 50 percent load

1. No‑load current in amperes at rated voltage and frequency
2. Inrush magnetizing current in percent of normal full load current.
3. Details of winding insulation

* Class of insulation materials
* Turns insulation high voltage in meg ohm
* Turns insulation low voltage in meg ohms
* Insulation core to low voltage in meg ohms
* Insulation high voltage to low voltage in mega ohms

1. Details of 415 V neutral current transformer

* Name of manufacturer
* Current ratio
* VA capacity
* Accuracy &performance characteristics

1. Quantity in liters and grade of oil
2. WEIGHTS :

* Core and windings in kg
* Tank and fittings in kg
* Oil
* Complete transformer filled with oil

1. OVERALL DIMENSIONS :

* Length in mm
* Breadth in mm
* Height in mm
  1. **TESTS:**

1. List of tests proposed to be carried out at the factory
2. List of tests proposed to be carried out at the site before commissioning.

:

1. INFORMATION TO BE FURNISHED BY THE VENDOR/CONTRACTOR AFTER AWARD OF CONTRACT

Information to be furnished after award of contract.

1. Positive sequence impedance at maximum voltage tap.
2. Positive sequence impedance at maximum voltage cap.
3. Zero sequence impedance at principal tap.
4. Efficiency at 75oC winding temperature:

* At full load
* At 75% full load
* At 50% full load

1. Maximum efficiency and load at which it occurs.
2. Regulation at full load at 75oC winding temperature at:

* Unity power factor
* 0.85 power factor lag.

1. Resistance per phase of :

* H.V. winding : Ohms
* L.V. winding : Ohms

1. Conductor area (sq.cm) and current density (Amps/cm2)

* HV winding
* LV winding

1. Type of windings

* HV
* LV

1. Insulating materials for interterm insulation

* HV winding
* LV winding

1. Insulating materials for winding insulation
2. Insulating materials

* Winding and core
* Laminations of the core.

1. Make, type, dial rise, number of contacts and contact ratings (current following items, if provided).

* Magnetic oil level gauge.
* Dial type thermometer.
* Winding temperature indicator.
* Gas and oil actuated relay.

1. Thermal withstand capability under full short circuit conditions in terms of number of times of calculation of short circuit and corresponding anticipation percentage reduction in transformer life. Relevant calculations shall be submitted.
2. DRAWINGS

The following drawings shall be submitted for the Owner/PMC approval in the stipulated time.

Weeks after award of contract

* 1. General outline drawings show­ing plan, front elevation, rear elevation, cable boxes/discon­necting chamber section views, locating dimensions of cable entries, terminals foundation floor fixing details and weights.
  2. Bushings: Plan, elevation terminals details, mounting details make and type number, current and voltage rating, Creepage distances and princi­pal characteristics.
  3. Rating and diagram plate
  4. Marshalling box terminal con­nections, wiring diagram

1. TEST REPORTS

Test results shall be corrected to a reference temperature of 75 Deg C.

* 1. Two copies of test results shall be submitted for the Owner/PMC approval before dispatch of transform­er.
  2. Additional bound copies, as required by the Owner/PMC, of complete test results including all tests on transformer, bushing, current transformer (if provided), shall be furnished with the transformer.

# LT BUS DUCT

**BUSDUCT (SANDWICH CONSTRUCTION)**

**1.** **Scope**:

The specification covers design, manufacturing, supply, installation, testing and commissioning of Sandwich type busbar trunking for use as feeder busbars for interconnection between separate electrical equipment / load centers, and for use as plug-in busbar risers.

**2.** **System details:**

The busbar shall be suitable for operation in a 1000V system, with frequency of 50 Hz having 100% neutral and internal earth.

**3.** **Standards & Type Test Certification.**

The busbar shall be designed and manufactured in accordance with the following international standards for busbar trunking:

* IS 8623 Part 2 : Particular requirements of busbar trunking systems
* IEC 61439 –6 : Particular requirements of busbar trunking systems
* IEC 60529 : Degree of protection

The bus duct shall be type tested in confirmation to above standards from a independent national recognized test house within last Five years for Short circuit , temperature rise & Degree of Protection & Resonance , Seismic withstand test for Zone V as per Latest IS/ IEC.

**4. Design & Construction requirements – Sandwich busbars**

**General:** The busbars shall be of sandwich construction, non-ventilated design. It shall be possible to mount the busbar system in any orientation, without affecting the current rating.

**Busbars::** The busbars shall of high conductivity Aluminum bars with conductivity > 60%.

The maximum hotspot temperature rise at any point in the bus duct at continuous rated load shall not exceed 45 deg.C above a maximum ambient temperature of 45 deg.C in any position.

Busduct system shall be terminated by end enclosure.

Unless otherwise highlighted, full size neutral of the same cross-sectional area as the phase conductor shall be provided for all rating of the busbar system.

Where an earth conductor is required, it shall be a separate, integral earth conductor, of the same high conductivity material as the phase conductors.

**Insulation:**

The busbars shall be insulated throughout their length by epoxy coating / Polyester / Mylar. The insulation material used shall be of Class F / Class H . The insulation must comply to UL 94 V-O.It shall be Halogen Free.

**Housing:**

The housing shall be made of 1.6 mm galvanized sheet steel/Aluminium , with an epoxy powder coated paint finish. The housing shall be profiled, to provide higher strength and efficient heat dissipation. The width of the housing shall preferably be the same for all ratings of busbars, in order to provide interchangeability of tap off boxes.

**Joints:**

The joints between sections shall be made so as to provide flexibility during installation and expansion / contraction of busbar during operation. The joints shall be of the single bolt type

The joint construction must have the following features.

* Heat expansion of at least 3mm per joint.
* The joint insulation must be of one piece molded design and not have any cut edges which can absorb moisture.
* The joint construction must allow a +/- 14mm adjustment at the time of installation, for ease of adjusting to site measurement variations.
* The joint bolt must be insulated with a bolt insulator. The bolt insulator must be of molded one piece.
* The joint system must be designed in a way that the installer cannot insert the busduct length too far and damage the bolt insulator.
* The busbar ends shall not have holes or slots at the joints – the electrical continuity shall be through pressure plates, achieving a high area of joint cross section and expansion capability.
* It shall be possible to install and remove the joints without disturbing the busbar run.

**Tap off units:**

Where specified, tap off locations shall be provided for insertion of plug in tap off units. The tap off locations shall be covered by hinged plates.

Tap off unit’s safety features:

* When the door cover is open, it should not be possible to turn the MCCB “ON”.
* The door shall be provided with a lock and keys.
* When the lever is in ‘on’ position, even with the key unlocked, the operator should not be able to remove the box or open the tap off location cover.
* During insertion, the earth conductor shall make contact first before the phase conductors. This should follow the sequence of first in last out concept.
* The tap off unit handle can be attached to at the front or left or right side of the box, depending on the site situation and as per approved drawings.
* When the box is open the live conductors shall be safe guarded by a transparent insulator plate which allows for visible inspection but does not allow touching of the live conductors.
* In the event of a MCCB requiring maintenance or changing, the mechanical interlocking must allow easy access by removing only the front plate and not interrupting the adjacent linkages.
* For IP65 bus-trunking, the tap off unit arrangement also must be covered through 1.6 mm thick GI Sheet canopy.
* The tap off boxes will be suitable for accommodating MCCBs or other accessories, as required. The tap off units should allow the flexibility of accommodating different, reputed MCCB makes, to be mutually agreed depending on the tender requirements.

**Accessories:**

Bus trunking system shall be complete with all accessories like bends, busduct, expansion joints, flexible connections etc to suit site requirements. Rising main in addition shall be complete with tap off points, end feed units, end covers, thrust pads and spring hangers at each floor. Bus trunking systems shall be complete in all respects. All accessories shall be quoted along with the unit rate of straight length of the busduct and rising mains.

**Thrust Pads**

Thrust Pads shall be provided in the raising main systems for necessary support to the rising mains and to prevent busbar expansion in down ward direction.

**5. INSTALLATION**

* Installation of the Rising Main shall be carried out as per manufacturers instruction.
* For Bus Duct horizontal runs, a horizontal expansion units shall be provided at every 40 m if required by design and at expansion joints of the building structure and the system shall be supported at every 1.5 m or as per the site conditions.
* Annular space around Rising Mains and/or Bus Ducts while crossing floors and walls shall be filled up by sealing material made available by Engineer-in-charge in accordance with manufacturer’s instructions.

**6. TESTING AT SITE**

* Physical check including checking damage/crake in any components, tightness of bolts and connections etc.
* Insulation test after installation according to manufacturers test procedures.
* Testing earth continuity.

**7. DATA SHEET FOR BUS DUCTS**



|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S.No.** | **Rated** | **3200 A** | **4000 A** | **5000 A** |
| **Current** |
|  |  |  |  |
| 1 | Type | Compact sandwich | Compact sandwich | Compact sandwich |
| 2 | Supply system | 3 Phase, 4 wire, AC, | 3 Phase, 4 wire, AC, | 3 Phase, 4 wire, AC, |
|  |
|  |  | 415 Volts, 50 HZ | 415 Volts, 50 HZ | 415 Volts, 50 HZ |
| 3 | Bus Bar | Aluminium | Aluminium | Aluminium |
| Conductor |
|  |  |  |  |
| 4 | Insulation | Class F | Class F | Class F |
|  |  |  |  |  |
|  | Rated |  |  |  |
| 5 | Insulation | 1000 V | 1000 V | 1000 V |
|  | Voltage |  |  |  |
|  | Power |  |  |  |
| 6 | frequency | 3 kV | 3.0 kV | 3.0 kV |
|  | withstand |  |  |  |



|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 7 | Short Circuit | 65 kA for 1 sec | | 65 kA for 1 sec |  |
| Rating | 70 kA for 1 sec |
|  |  |  |  |  |
|  |  | 3200 A, 3P, + 100% | | 4000 A, 3P, + 100% |  |
| 8 | Current Rating | N, + 50% integral | | N, + 50% integral | 5000 A, 3P, + 100% N, + 50% integral earth |
|  |  | earth | | earth |  |
|  | Temperature | As per IEC |  | As per IEC | As per IEC |
| 9 | standards | | standards |  |  |
| Rise \* | standards |  |
|  |  |  |  |  |
|  |  |  |  |  |  |
|  | Degree of | IP 65 for outdoor | | IP 65 for outdoor | IP 65 for outdoor |
| 10 | use, IP 54 for indoor | | use, IP 54 for indoor | use, IP 54 for indoor |
| Protection |  |
|  | use |  | use |  |
|  |  |  |



# 433V LT Power Supply and distribution system –

1.0 LOW VOLTAGE PANELS ( L T Panels)

1.1 GENERAL

1.1.1 This Specification covers the general requirements for design, manufacture, testing and supply of Main Distribution Boards (MDB / L.V. Panel). The specific requirements and details of the main distribution board(s) or L.V. Panel(s) required are given on the drawings.

1.1.2 The Contractor shall install the Main Distribution Boards (MDB / L.V. Panel) as shown in the drawings and in full compliance to this specification, the international standards specified in the following section & the local authority regulations. In case of difference between this specification, the specified international standards and the local authority regulations, the more stringent requirements in compliance with local authority regulations shall prevail.

1.2 MANUFACTURER & PANEL BUILDER / ASSEMBLER: PRE-QUALIFICATIONS

1.2.1 Main distribution boards shall be assembled only by the original manufacturer and approved by the consultant. The certificate copy issued by original manufacturer shall be attached with quotation document for review & acceptance.

1.2.2 Panel builder shall have a minimum experience of 10years in the field of manufacturing of TTA /IEC 61439 Design LT Panels.

1.3 APPLICABLE STANDARDS

1.3.1 Unless specified otherwise Main Distribution board / L.V. Panel shall conform in design, material, construction and performance to the latest editions of the International recommendations (IEC standards) and its corresponding British / European standards (BSEN standards) and in particular to the following publications:

- Low Voltage Switchboard IEC 61439-1 & 2

- Degree of protection IEC 60529

In addition to the above listed standards, the local authority regulations shall also be adhered to.

1.4 SITE CONDITIONS

1.4.1 For general climatic conditions, refer and comply the specified project site conditions. The main distribution boards shall comply and perform satisfactorily at the below listed special design conditions as minimum:

Ambient temperature : 45ºC

Relative humidity : 95% (at 55ºC)

1.5 DESIGN CONSIDERATIONS

1.5.1 The main distribution boards shall be of standard, natural air cooled, well tested and proven design which ensures maximum safety to personnel, maximum service reliability and economic operations. Design and construction shall be simple, well laid-out and shall provide good accessibility to components and parts.

1.5.2 Unless specified otherwise, the form of construction for the main distribution board shall comply with Form 3/4 requirements of IEC 61439.

1.5.3 Unless specified otherwise, the main distribution board shall be fixed version with main incoming Air Circuit Breaker shall be withdrawable type and the outgoing MCCB shall be fixed type.

1.5.4 Main distribution boards shall be rated on the basis of voltage, current, frequency and the symmetrical breaking capacity of incorporated switching devices.

1.5.5 The electrical system for all main distribution boards shall be 415V, 50 Hz 3phase and neutral, 4-wire solidly earthed. The main distribution boards shall be suitable for operating voltage up to 690 V and Insulation voltage of 1000V.

1.5.6 Unless specified otherwise, the fault level withstand capacity of the main distribution board bus bar system shall be as mentioned in SLD/BOQ. The type test certificate shall be submitted for consultant engineer verification, to prove the fault level withstand capacity of the main distribution boards. Even under extreme conditions of short circuit or mal-operation there shall be no danger to persons in the vicinity of the assembly.

1.5.7 All equipment and components of the main distribution boards shall be capable of continuous operation at their full current and voltage ratings and without detriment or malfunction at system continuous deviation of up to and including the following percentages of the normal values.

- Voltages ± 10%

- Frequency ± 5%

All components shall be capable of withstanding the dynamic, thermal and dielectric stresses resulting from prospective short circuit currents without damage or injury to personnel.

1.6 CONSTRUCTION REQUIREMENTS

1.6.1 General

1.6.1.1 The main distribution boards shall be assembled by an approved panel builder, who shall pre-qualify and comply with requirements specified under panel assembler pre-qualification of this specification. The main distribution boards shall be assembled by the same panel builder / assembler, who shall also assemble the sub-main, motor control centre and SUB distribution boards.

1.6.1.2 Unless specified / approved otherwise, enclosure system, the switching devices and other components used for assembly of the main distribution boards shall be from original manufacturer.

1.6.1.3 Unless specified otherwise, the main distribution board shall be of fixed version with cable access at rear/front to have optimal solution.

1.6.1.4 Type test certificates shall be available for the proposed type of enclosure and the busbar system. The type test certificates shall be clearly state type, model and main characteristics of the assembly, references of the standards applied for the tests, results obtained and the observations made during & after the tests..

1.6.1.5 Components shall be as per approved makes.

1.6.1.6 Design drawings, component catalogues and type test certificates shall be submitted for Owner/PMC approval prior to placement of order for the main distribution boards.

1.6.1.7 Contractor shall ensure components like ACB’s, MCCB’s selected shall have both current and time discrimination. Published coordination chart or coordination study done using switchgear manufacturer’s software shall be furnished along with drawing for approval.

1.6.2 General Arrangement & Assembly

1.6.2.1 L.V Panel shall comprise of free standing enclosure, bus bar system, switching devices such as ACB/MCCB, metering equipments, all necessary current transformers and the like as required. Panel shall be assembled in a systematic manner such as Transformer Incomer section, Generator Incomer section (if applicable), Bus coupler section (if applicable), Incomer Metering / Indication section and Outgoing section.

1.6.2.2 Unless otherwise specified the panels shall be designed to accept bottom/top entry of cables and shall be of rear access type. The rear access shall only be provided for access for termination of cables, all other equipments shall be accessible / operable from the front of panel. Where front access type is specified, the panel shall be designed completely for front access only.

1.6.2.3 Each panel section (cable compartment) shall be provided with thermostatically controlled panel heater in Main Distribution Board.

1.6.2.4 Each section shall be arranged typically as described below and as per the details shown in the drawings:

1.6.2.4a Incomer section (Transformer Incoming)

Transformer Incomer panel shall be a 3 compartment enclosure with Top & Bottom compartment dedicated for metering / controls and the Middle compartment shall be dedicated for the circuit breaker. It shall comprise of but not limited to the following:

Bottom Compartment

Incomer supply cables / bus duct

Middle Compartment

Main Incoming circuit breakers with rating and type as per the drawing.

Top Compartment

- Any control component for Incoming circuit breaker.

- Digital power meter to indicate various electrical parameters

- Phase indication lamps wired to the line side of the circuit breaker.

- Power factor meter (If required as per local authority requirement).

- KWH energy meter (If location of KWh is approved by local authority).

1.6.2.4b Incomer section (Generator Incoming) – (If applicable)

Generator Incomer panel shall be a 3 compartment enclosure with Top & Bottom compartment dedicated for metering / controls and the Middle compartment shall be dedicated for the circuit breaker. It shall comprise of but not limited to the following:

Bottom Compartment

Incomer supply cables / bus duct

Middle Compartment

Main Incoming circuit breakers with rating and type as per the drawing.

Top Compartment

- Any control component for Incoming circuit breaker.

- Digital power meter to indicate various electrical parameters

- Phase indication lamps wired to the line side of the circuit breaker.

- Power factor meter (If required as per local authority requirement).

- KWH energy meter (If location of KWh is approved by local authority).

1.6.2.4c Bus coupler / Bus Tie section – (If applicable)

The Bus Tie / Bus Coupler Panel shall be a 3 compartment enclosure to match with the incomer panels. The Top & Bottom compartment can be used for accommodating the common controls of the incoming and the bus tie circuit breakers. The Middle compartment shall be dedicated for the circuit breaker. It shall comprise of but not limited to the following:

**Notes:**

- Where ACB’s are used as incoming or bus coupler, the front face of the ACB shall be accessible for operation from the front without opening the feeder door.

- Where MCCB’s are used as incoming or bus coupler circuit breakers an Direct Rotary handle shall be provided at the front face of the MCCB which is operated from front door. All such handles shall be door interlocked to ensure safety for operating personnel.

1.6.2.4d Outgoing section(s)

The outgoing section(s) enclosure shall accommodate the outgoing circuit breakers which shall be arranged in a systematic and symmetrical manner. It shall comprise of but not limited to the following:

Each panel shall have various fixed compartments with individual doors for each compartment and each compartment shall accommodate the following:

- Circuit breakers with rating and type as specified in the drawings.

- Any other controls, which may be part of the outgoing circuit breakers along with Indication Lamps & metering as specified in SLD/BOQ.

Notes:

- All circuit breakers and other controls pertaining to a feeder shall be accommodated in its own compartment, which shall have its own feeder doors. Keys for all such external door shall be common.

- Moulded case circuit breaker in each compartment shall be equipped with a operating handle extended to the front face of the door for operation. All such door handles shall be door interlocked to ensure safety for operating personnel.

- Air circuit breaker front face shall be accessible without opening the door.

- Circuit breakers and other control components shall be fully accessible after opening the panel door; however no live parts shall be exposed.

- All the bus bar connections / terminations to the outgoing circuit breakers shall be taken from the rear side of the circuit breaker, which shall be shrouded properly using metallic / poly carbonate sheets. All the MCCB terminals shall be fully shrouded with original terminal shrouds from the MCCB manufacturer, in such a way that no live parts are exposed, when the front door is opened.

- Opening of the front door shall give access to the circuit breaker for rating adjustments etc.

- Maximum 2 nos. air circuit breakers shall be installed in one vertical, provided that sufficient space for cable termination is provided and de-rating of circuit breaker is carried out as per manufacturer recommendations.

- Maximum 2 nos. moulded case circuit breakers, rated at 800Amps shall be installed in one vertical, provided that sufficient space for cable termination is provided.

- Maximum 9 nos. of moulded case circuit breakers (rated less than 250Amps) shall be installed in one vertical, provided that sufficient cable termination is provided.

- All Partitioning and shrouding shall comply the requirements of Form-3/4, construction as per IEC standards.

1.6.3 Enclosure manufacturing

1.6.3.1 Main distribution board enclosure shall be product from approved manufacturer. The sheets have a fine surface finish, which gives good presentation to the painted/ Powder Coated components of the enclosure.

1.6.3.2 The enclosure system shall be Modular in nature. Enclosure parts/kits shall be interchangeable to reduce downtime during modification or maintenance work.

1.6.3.3 The enclosure shall be powder coated with paint shade as specified. The painting process shall include removal of moisture on the sheet steel surface using and applying thermosetting polyester powder using Powder Coating guns. Polymerization of the powder shall take place when the components are cured at about 180ºC, forming a continuous integrated coating. A uniform coating of atleast 70-80 microns shall be provided.

1.6.3.4 The pretreated and powder coated sheet steel components shall be atleast tested randomly at regular intervals for coating thickness measurement, adhesion test, bend test, impact test, hardness test, salt spray test etc & manufacturer must posses the In – House test facilities for the same.

1.6.4 Enclosure construction

1.6.4.1 Main distribution board manufacturer shall fabricate & assemble the fabricated elements of the enclosure system, busbar system, switching devices and other equipment to complete the main distribution board all the facility shall be IN-HOUSE.

1.6.4.2 Main distribution board enclosure shall be fabricated of minimum 2mm for load bearing members and 1.5mm non-load bearing members with thick electro-galvanized sheet steel folded construction. The enclosure shall be of simple and robust construction designed for a variety of dimensions obtainable by means of standardized basic elements.

1.6.4.3 The complete assembly shall be rigid self-supporting structure which is deformable and unaffected by vibration/shocks. The structure shall be completed by a metal partition made of one or more pieces between two sections depending on the depth of the compartment. The lower part of structure shall be closed by means of bolted plates that can be removed whenever the assembly of cable glands is required. The switchgear components contained in sections shall be installed on mounting plates. Each door panel shall be equipped with door interlock with MCCB operating handle. All door hinges to be of concealed type and it shall be possible to remove the door panel whenever required. All doors, bolted cover, partitions, mounting plates and metallic shrouds shall be effectively connected to earth. Flexible earth wires shall be used for removable covers and hinged doors. Each vertical shall be provided with common lockable door to prevent unauthorised operation.

1.6.4.4 The structure and the partitions shall be protected by a durable scratch resistant textured paint finish, epoxy powder polymerized at high temperatures to an approved paint shade.

1.6.4.5 Unless specified otherwise, the main distribution board shall be with ingress protection rating of IP as per IEC standards as minimum.

1.6.4.6 Unless specified otherwise, Main distribution boards shall be designed for front access for the purpose of operation and access to all components and shall suit front or rear access for cable connections and top or bottom for cable entries. Wherever required, enclosure shall be suitable for busduct entry at the top. The access and entries shall be provided as per site requirements.

1.6.4.7 Adequate care shall be taken while designing the main distribution board connection spaces for the external cables. Sufficient cable supports shall be provided for routing the cables inside the enclosure.

1.6.4.8 Enclosure system shall effectively dispose the heat produced by the main circuits and shall integrate a high performance natural ventilation system which shall be aimed at regulating the internal temperature based on the actual capacities of the components.

1.6.4.9 Enclosure shall be readily suitable for future extension on either side without any modifications (after installation at site).

1.6.4.10 Form-3/4 construction assembly shall provide protection against contact with internal live parts and components. Bus bar, functional units and cable termination shall be segregated from each other as given below:

- Bus bar shall be separated from functional units;

- Functional units/switching devices shall be separated from each other;

- Cable termination and functional units/switching devices shall be separated from each other;

- Incoming and outgoing terminals shall be separated from each other.

Bus bars shall be accommodated in a separate chamber/alley with metallic/poly carbonate shrouds and partitions to avoid accidental external contacts.

Incoming switching device shall be located in separate section and outgoing switching devices in other sections, wherever applicable. Each switching device shall be segregated from each other and located in individual compartment with hinged door.

External cable termination to the switching device terminals shall be outside the functional unit / switching device compartment. Segregation shall be made between the switching device terminal and the switching device within its compartment by means of rigid barriers and partitions.

All segregation shall be achieved by means of rigid metallic sheet partitions. Segregation and partition shall ensure protection against contact with live parts and limitation of the faults within each of the functional unit compartment.

A cable alley shall be provided either at rear or at the side of each section as per site conditions and requirements to facilitate termination of cables.

Cables shall be glanded on the bottom/top plate of common cable alley/chamber. Supports shall be provided to fasten the power and control cables inside cable alley/chamber.

1.6.5 Bus bars

1.6.5.1 The bus bar system shall be designed as per the pre-defined guidelines provided by the original manufacturer. The bus bar system shall be type tested by the manufacturer at reputed laboratory for short circuit withstand capacity. The neutral and earth bus bars shall also be type tested for the short circuit withstand capacity. The fault level rating of the bus bar system shall be as per the drawings however the minimum short circuit withstand capacity shall be 50KA RMS for 1second.

1.6.5.2 The bus bars shall be of electrolytic grade (E91E or better) aluminium or copper of rectangular shape. The phase bus bars and neutral bus bars shall be arranged systematically in a bus bar chamber/ alley. The bus bars shall be shrouded completely using metallic partitions and/or polycarbonate shrouds as applicable. The bus bar assembly shall be shrouded (at least IP20) by shrouds so that no live parts are accessible.

1.6.5.3 The busbar system shall be supported adequately at regular intervals as per manufacturer guidelines based on the type test results on a specially designed busbar supports. The supports shall be independently fixed to structure to strengthen the busbar arrangement. Wherever required additional intermediate supports shall be provided between the busbars. All vertical droppers shall also be adequately supported as per the manufacturer guidelines and the test results. The distribution busbars shall be connected to the main busbars by suitable sized and graded bolt & nut and contact washers.

1.6.5.4 Distance between the busbar supports for busbar system and the distance between different phases of busbar system shall be as per original manufacturer guidelines based on the type test results.

1.6.5.5 The main busbars shall be accommodated in a separate busbar chamber running horizontally at top or bottom.

1.6.5.6 The dimensioning of the busbar system shall be as per the rated current of the main switching device, the short circuit current, the maximum rated permissible temperature and the ambient temperature around the busbars. The selection of busbars shall be supported by calculations and recommendations from the original manufacturer.

1.6.5.7 The neutral busbar shall run along with the phase busbars and neutral termination for outgoing switching devices shall be provided with bolted link for isolation purpose.

1.6.5.8 Earth busbar shall be running throughout the panel fitted directly on to the structure for connection of the protective conductors to provide equipotential bonding of exposed conductive parts. Earth busbar shall be located at the bottom of the panel and in the cable chamber/ alley to facilitate easy connection of protective conductor.

1.6.5.9 The busbar joints shall be plated or provided with bimetallic washers for dissimilar material. The hardware used at joints shall be as per original manufacturer’s recommendation.

1.6.8 Testing

1.6.8.1 Type test

The main distribution board and the components as applicable preferably highest rating shall be type tested in accordance with the IEC standards to verify the specified fault level withstand capacity from a reputed and approved type testing laboratory.

The following type tests as specified in IEC 61439-1standards shall be carried out on assembly at recognized test laboratories CPRI /ERDA and certificates shall be provided for following test:

1. Verification of temperature-rise limits (IEC Cl. 10.10);

2. Verification of the dielectric properties (IEC Cl. 10.9);

3. Verification of short-circuit withstand strength (IEC Cl. 10.11);

4. Verification of the effectiveness of the protective circuit (IEC Cl.10.5)

5. Verification of clearances and creep age distances (IEC C. 10.4)

Type test certificates shall be submitted to the consultant engineer for verification.

1.6.8.2 Routine test

The panel assembler shall perform the routine test and provide the test certificates as defined in IEC standards. The routine test shall include but not limited to the following:

1. Inspection of the assembly including inspection of wiring and electrical operational test

2. Dielectric test & Insulation resistance test

3. Checking of protective measures and of the electrical continuity of the protective circuits

4. Functional test as per the approved test procedure.

Routine test certificates and test readings shall be submitted to the consultant engineer for verification.

CONTACTORS:-

a) Contactors shall be of double break, single throw and electromagnetic and non- gravity type.

b) Contactors shall be suitable for interrupted duty and shall be rated for class AC-3 duty.

c) Main contacts of contactors shall be silver faced.

d) Operating coils of contactors shall be suitable for operation on 220/240VAC, 1 phase, 50 Hz supply.

e) Contactors shall be provided with at least two pairs of 'NO' and 'NC auxiliary contact.

f) Contactors shall not drop out at voltages down to 70% of coil rated voltages min pick up voltage 85%.

**OVER LOAD RELAYS:-**

Over load protection for each motor feeder(wherever required) shall be provided by thermal over load relay on each of the three phases.

The relay shall be duly compensated against fluctuation so ambient temp. and frequency and shall have single phasing preventer feature.

Relay shall be hand reset type from the front of the cubicle door.

Overload relay for fan applications shall be of heavy duty type with provision of by passing the same during starting of the fan.

Moulded Case Circuit Breakers:-

The MCCB’s shall comply with International Standards as per IEC60947-1 and IEC60947-2. All MCCB’s in the Main Distribution Board shall have ultimate short circuit breaking capacity of 50KA at 415 volts. The circuit breakers shall have service short circuit breaking capacity equal to ultimate short circuit breaking capacity.

The short circuit breaking capacity of MCCB’s shall be inline with busbar fault current of the low voltage switchboards. If Switchboard fault current is 50KA, All MCCB’s used in the switchboard shall be of 50KA minimum.

The moulded circuit breakers offered shall strictly comply with environmental protection. The circuit breakers shall be free from hazardous substances like Lead, Mercury, Cadmium, Chrome etc. The materials shall be suitable for recyclability.

Manufacturer shall furnish discrimination chart for coordination between upstream and downstream devices. The MCCB’s shall be from one manufacturer and shall be from one range.

The MCCB’s shall be Line/Load Interchangeable. The MCCB’s shall have adjustable over load settings & adjustable short circuit settings for discrimination. The rated impulse withstand capability shall be minimum of 8kV. The circuit breaker shall comply with the requirement of isolation function in accordance with IEC 60947

The circuit-breakers shall be tropicalized to make them suitable for use in hot-humid places, in compliance with the International IEC 60068-2-30 Standards.

MCCB’s up to 100A shall be of Thermo-magnetic release. MCCB 125A and above shall be Microprocessor based release. The ground fault protection shall be inbuilt and external module for ground fault is not acceptable.

Thermo-magnetic trip unit should have:-

1-) Adjustable thermal protection from 70– 100% times the current rating in.

2-) Fixed magnetic protection for current ratings up to100A.

Electronic trip units should have:-

1-) Adjustable overload protection from 40-100% times the current rating and with time setting.

2-) Variable short circuit protection setting from1 to10 In and with time setting.

3-) Instantaneous protection setting from 1 to 10 In and time setting will be instantaneous trip take place.

4-) Earth Fault protection variable setting and with time setting.

5-) Incase of4 pole MCCB neutral should be adjustable as a Neutral unprotected or neutral.

The MCCB’s offered shall have trip free mechanism. Circuit-breakers fitted with electronic trip units shall comply with International Standards on electromagnetic compatibility.

The moulded-case circuit breakers shall be designed for both vertical and horizontal mounting, without any adverse effect on electrical performance.

The operating mechanism of the moulded-case circuit breakers shall be of the quick-make, quick-break type with fault tripping overriding manual operation. All poles shall operate simultaneously for circuit breaker opening, closing and tripping.

COMPONENTS SPECIFICATION

Air Circuit Breakers:-

The Air Circuit Breakers shall be rated Service voltage of 690V AC and Insulation Voltage of 1000V AC. The Air Circuit Breaker shall comply with latest international standards IEC60947-2. The Air circuit Breaker shall be 3/4 Pole Motorised Draw out type capable of handling rated current up to in ambient temperature of 45 deg Celsius.

Air circuit breakers(ACB) shall comply with standards IS/IEC60947-1 &2. The breakers shall be tested & certified at ERDA /CPRI/International Laboratories.

Draw out Circuit Breakers shall have three discrete positions Isolate/Test/Service positions. It shall have visual indication to show position. The Circuit Breaker shall have clear visual indication to show whether it is in closed or open condition. The closing mechanism shall be spring charged mechanism. It shall be possible to visualize whether spring is charged or discharged condition. The stored energy in the spring charged mechanism shall be sufficient to ensure that, it shall be possible to open a circuit breaker, reclose & open again.

CircuitbreakersshallconformtoElectromagneticcompatibilitytests(EMC)asspecifiedin

IEC60947-2.

All ACB’s irrespective incoming or outgoing feeders shall have neutral protection. In case 3Pole ACB are offered based on application, it shall still be possible to protect the neutral by providing an external CT as per BOQ

The Air Circuit Breaker shall have Service Short Breaking capacity of 50ka (Ics) at 440volts AC. Circuit Breakers with less than 50ka (Ics) is not acceptable.

All ACB shall have Icu=Ics=Icw=50KA or 1sec minimum.

The operating mechanism shall be of the Open/Closed/Open stored-energy spring type.

All 4Pole ACBs shall have fully rated neutral equal to rating of the breaker & shall be protected again stover-load & short-circuit with provisions for settings at neutral for protection, half protection or no protection.

Protection Release:-

The Circuit breaker protection shall be through micro-processor based trip units.

The micro-processor release should be self-powered type without any auxiliary power supply during normal operation of the breaker.

The circuit breaker control unit shall measure the true r.m.s value of the current.

I2t ON/I2t OFF options shall be available for short-circuit & earth fault protections to enhance discrimination with downstream devices.

The trip unit shall have integral test facility to verify the healthiness and to avoid

external calibration.

The protection release provided shall be microprocessor based. The protection release shall have LSIG protection as standard.

Protection Release shall have rating plug whereby over load setting range can be adopted based on load conditions without modifying any internal components of the Circuit breakers.

1-) Adjustable overload current settings from40% to100%ofratingofACB (In). With Overload time setting.

2-) Shortcircuitsettingfrom1 to10 times of Insetting

Short circuit timedelayadjustablefrom0.5 to0.8 sec.

3-) In stantaneous protection with an adjustable pick-up and an OFF position.

4-) Earth fault setting adjustable with time delay settings.

ACB release shall be able to continuously sense following elements for healthiness if any failure it should be indicated by LED /LCD Display.

The selective short circuit protection shall have setting possibility of either trip time independent of current or with constant specific let through energy. They selection of devices in upstream and downstream shall be such that complete discrimination is achieved.

The protection release shall be suitable to achieve both current and Time discrimination with downstream protection devices. Protection release considered shall have an option to achieve Zone selectivity with which downstream equipment’s and cables are protected against fault current in shortest possible time as per requirement in BOQ.

The protection releases of Air circuit breakers shall have built in data log function.

The communication protocol shall be modbus/any open protocol to interface with upstream BMS/SCADA systems.

All incomer Circuit Breakers shall have following additional features and measurement functions as standard:-

Protections:-

1.LSIG Protection

Measurements:-

1-)Voltage

2-)Power

3-)Power Factor.

4-)Frequency

5-)Energy

All outgoing ACB shall have additional features as below :-

1-)All outgoing ACB shall have LSIG protection and current metering.

2-)Chronological event storage.

# POWER FACTOR IMPROVEMENT

**POWER FACTOR CORRECTION EQUIPMENT THYRISTOR BASED**

* The Contractor shall ensure that the power factor correction equipment shall not cause harmonic resonance in the LV electrical network
* Each three phase capacitor unit shall be MPP self healing type with total losses not greater than 0.5 W/kvar..
* The capacitor unit shall be usable for indoor application with permissible overloads as below:
* Voltage overloads shall be 10% for continuous operation and 15% for 30 minutes in a 24 hours cycle
* Current overloads shall be 15 % for continuous operations and 50% for six hours in a 24 hours cycle.
* Over load of 35% continuously and 45%for six hours in a 24 hours cycle.
* All capacitors involved shall be disconnected instantaneously, and reconnected step by step at intervals after the supply is restored.
* APFC relays shall provide all necessary function of relay, controls, protection, announciation and condition monitoring. A no-volt and single phasing protection shall be provided.
* Local/off/auto selector switch and visual indication of energized capacitor with red lamps, etc shall be provided.
* Type tests for the equipment shall include 1.4 x operating voltage, temperature cycling and repeated switching.
* Overcurrent shall be 1.8 x In.
* Peak inrush current withstand capacity shall be 250 x In
* DETUNED FILTER
* Detuned harmonic filter reactors shall be used along with power capacitors to mitigate harmonics amplification and to avoid electrical resonance in LV electrical networks.
* The reactors hall be made of high grade copper windings upto 15 KVAr and of Aluminium design till 100 KVAr, having a three phase, iron core construction suitable for indoor use. The reactor are air cooled and the layout shall be in accordance with IEC 60289
* The permitted tolerance of inductance is ± 3% of rated inductance value.
* Reactor tuning factor shall be 7 % (189 Hz) and the current rating of the reactor shall include the effects of harmonics and other possible over-currents
* The limit of linearity of inductance of the filter reactor is: 1.8\*In with L=0.95\*LN.
* All reactors shall be fitted with a temperature sensitive micro-switch in the centre coil (normally open) for connection to trip circuits in case of high operating temperatures.

# MV Cable

**1. STANDARDS AND CODES**

All equipments, components, materials and entire work shall be carried out in conformity with applicable and relevant Bureau of Indian Standards and Codes of Practice, as amended upto date and as below. In addition, relevant clauses of the Indian Electricity Act 1910 and Indian Electricity Rules 1956 as amended upto date shall also apply. Wherever appropriate Indian Standards are not available, relevant British and /or IEC Standards shall be applicable.

Equipments certified by Bureau of Indian Standards shall be used in this contract in line with government regulations. Test certificates in support of this certification shall be submitted, as required.

It is to be noted that updated and current standards shall be applicable irrespective of dates mentioned along with ISS's in the tender documents.

PVC insulated heavy duty cables IS 1554 - 1988

Cross link polyethylene insulated PVC(sheathed XLPE cables) IS 7098 – 1985

Code of practice for installation and maintenance of power cables IS 1255 – 1983

Conductors for insulated electrical cables IS 8130 - 1984

Drums for electrical cable IS 10418 - 1982

Methods of test for cables IS 10810 - 1988

Recommended current rating IS 3961 - 1987

Recommended short circuit rating of high voltage PVC cables IS 5891 - 1970

**2. CABLES**

**2.2. Medium Voltage Cables**

Medium voltage cables shall be aluminium conductor XLPE insulated, PVC sheathed armoured conforming to IS 7098. Cables shall be rated for a 1100 Volts. The conductor of cables from 16 Sq. mm. to 50 Sq. mm. shall be stranded. Sector shaped stranded conductors shall be used for cables of 50 sq. mm and above. Conductors shall be made of electrical purity aluminium 3/4 H or H temper. Conductors shall be insulated with high quality XLPE base compound. A common covering (bedding) shall be applied over the laid up cores by extruded sheath of unvulcanised compound. Armouring shall be applied over outer sheath of PVC sheathing. The outer sheath shall bear the manufacturer's name and trade mark at every meter length. Cores shall be provided with following colour scheme of XLPE insulation.

1 Core : Red/Black/Yellow/Blue

2 Core : Red and Black

3 Core : Red, Yellow and Blue

3 1/2 /4 Core : Red, Yellow, Blue and Black

Current ratings shall be based on the following conditions.

a) Maximum conductor temperature 900 C

b) Ambient air temperature 450 C

c) Ground temperature 300 C

d) Depth of laying 750 mm

Short circuit rating of cables shall be as specified in IS 7098 Part-I.

Cables have been selected considering conditions of maximum connected loads, ambient temperature, grouping of cables and allowable voltage drop. However, the contractor shall recheck the sizes before cables are fixed and connected to service.

**3. DELIVERY, STORAGE AND HANDLING**

Cable drum shall be stored on a well-drained, hard surface, preferably of concrete, so that the drums do not sink in ground causing rot and damage to the cable drum. The cable drum shall conform to IS 10418. During storage, periodical rolling of drums, in the direction of arrow marked on the drum, shall be done once in 3 months through 900 C both ends of cables shall be properly sealed to prevent moisture ingress Drums shall be stored in well ventilated area protected from sun and rain. Drums shall always be rested on the flanges and not on flat sides. Damaged battens of drums etc. shall be replaced. Movement of drums shall always be in direction of the arrow marked on the drum. For transportation over long distance, the drums shall either be mounted on drum wheels and pulled by ropes or they shall be mounted on trailers etc. drums shall be unloaded preferably by crane otherwise they shall be rolled down carefully on suitable ramps. While transferring cable form 1 drum to another, the barrel of the new drum shall have diameter not less than the original drum. Cables with kinks or similar visible defects like defective armouring etc shall be rejected. Cables shall be supplied at site in cut pieces as per actual requirements.

**4. LAYING OF CABLES**

Cables shall be so laid that the maximum bending radius is 12 times the overall diameter of the cable for medium voltage cables and 20 times the overall diameter for 33 kV cables. Cables shall be laid in masonry trenches, directly on walls/cable trays, directly buried in ground or in pipes/ducts as elaborated below. Cables of different voltages and also power and control cables shall be laid in different trenches with adequate separation. Wherever available space is restricted such that this requirement cannot be met, medium voltage cables shall be laid above HT cables.

**4.1 In Masonry Trenches**

Wherever so specified, cables shall be laid in indoor/outdoor masonry/RCC trenches to be approved from Owner/PMC. Cables shall be laid on MS supports fabricated from minimum 38mm x 38mm x 6mm painted / galvanized angle iron supports grouted in trench walls at intervals not exceeding 600 mm. If required, cables shall be arranged in tier formation inside the trench. Suitable clamps, hooks and saddles shall be used for securing the cables in position and dressing properly so that the clear spacing between the cables shall not be less then the diameter of the cable. Trenches shall be provided with chaquered plate/RCC covers. Wherever so specified, trenches shall be filled with fine sand.

**5.2 On Trays/Walls**

Wherever so specified, cables shall be laid along walls/ceiling or on cable trays. Cable shall be secured in position and dressed properly by means of suitable clamps, hooks, saddles etc. such that the minimum clear spacing between cables is diameter of the cable. Clamping of cables shall be at minimum intervals as below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Type of cables** | **Size** | **Clamping by** | **Fixing intervals** |
| MV | Upto and including 25 sq mm | Saddles 1 mm thick | 45 cm |

**Note:** The fixing intervals specified apply to straight runs. In the case of bends, additional clamping shall be provided at 30 cm from the center of the bend on both sides.

Cable trays, of sizes as per schedule of quantities and drawings shall be of perforated doubled bend channel/ladder design unless otherwise stated. Cable trays shall be fabricated from minimum 2 mm thick sheet steel and shall be complete with tees, elbows, risers, and all necessary hardware. Cable trays shall comply with the following:

Trays shall have suitable strength and rigidity to provide proper support for all contained cables. Trays shall not have sharp edges, burrs or projections injurious to cable insulation. Trays shall include fittings for changes in direction and elevation. Cable trays and accessories shall be painted with one shop coated of red oxide zinc chromate primer and two side coats of aluminium alkyd paint or approved equivalent. Cable trays shall not have sharp edges, burrs or projection that may damage the insulation jackets of the wiring. Cable trays shall have side rails or equivalent structural members.

Unless otherwise specifically noted on the relevant layout drawing, all cable tray mounting works to be carried out ensuring the following:

Cable tray mounting arrangement type to be as marked on layout drawing. Assembly of tray mounting structure shall be supplied fabricated, erected & painted by the electrical contractor. Tray mounting structures shall be welded to plate inserts or to structural beams as approved by the Owner/PMC. Wherever embedded plates & structural beams are not available for welding the tray mounting structure electrical contractor to supply the MS plates & fix them to floor slab by four anchor fasteners of minimum 16 mm dia having minimum holding power of 5000 Kg at no extra cost. Maximum loading on a horizontal support arm to be 120 Kg. meter of cable run. Width of the horizontal arms of the tray supporting structures to be same as the tray widths specified in tray layout drawings, plus length required, for welding to the vertical supports. The length of vertical supporting members for horizontal tray runs shall be to suit the number of tray tiers shown in tray layout drawings. Spacing between horizontal supports arms of vertical tray runs to be 300 mm. Cable trays will be welded to their mounting supports. Minimum clearance between the top most tray tier and structural member to be 300 mm. Cables in vertical race ways to be clamped by saddle type clamps to the horizontal slotted angels. Clamps to be fabricated from 3 mm thick aluminium strip at site by the electrical contractor to suit cable groups. The structural steel (standard quality) shall be according to latest revision of IS: 226 & 808. Welding shall be as per latest revisions of IS: 816. All structural steel to be painted with one shop coat of red oxide and oil primer followed by a finishing coat of aluminium alkyd paint where any cuts or holes are made on finished steel work these shall be sealed against oxidation by red oxide followed by the same finishing paint. Steel sheet covers wherever indicated to be similarly painted. Trays shall be erected properly to present a neat and clean appearance. Trays shall be installed as a complete system. Trays shall be supported adequately by means of painted MS structural members secured to the structure by dash fasteners or by grouting. The entire cable tray system shall be rigid. Each run of cable tray shall be completed before laying of cables. Cable trays shall be erected so as to be exposed and accessible.

**4.3 Buried Directly in Ground**

**4.3.1 General**

Cables shall be so laid that they will not interfere with under ground structures. All water pipes, sewage lines or other structures which become exposed by excavation shall be properly supported and protected from injury until the filling has been rammed solidly in places under and around them. Any telephone or other cables coming in the way are to be properly shielded as directed by Engineer in charge. Surface of the ground shall be made good so as to conform in all respects to the surrounding ground to the satisfaction of Engineer in charge.

**4.3.2 Routing of cables**

Before cable laying work is undertaken, the route of the cables shall be decided with the Engineer in charge. While shortest practicable route shall be preferred, cable runs shall follow fixed development such as roads, footpaths etc with proper off-sets so that future maintenance and identification are rendered easy. Whenever cables are laid along well demarcated or established roads, the LV/MV cables shall be laid further from the kerb line than HV cables. Cables of different voltages and also power and control cables shall be kept in different trenches with adequate separation. Where available space is restricted, LV/MV cables shall be laid above HV cables. Where cables cross one another, the cables of higher voltage shall be laid at a lower level than the cables of lower voltage. Power and communication cables shall as far as possible cross at right angles. Where power cables are laid in proximity to communications cables the horizontal and vertical clearances shall not normally be less than 60 cm.

**4.3.3 Width of Trench**

The width of trench shall be determined on the following basis. The minimum width of trench for laying single cables shall be 350 mm. Where more than one cable is to be laid in the same trench in horizontal formation, the width of trench shall be increased such that the inter-axial spacing between the cables except where otherwise specified shall be at least 200 mm. There shall be a clearance of at least 150 mm between axis of the end cables and the sides of the trench.

**5.3.4 Depth of Trench**

The depth of trench shall be determined on the following basis:

• Where cables are laid in single tier formation, the total depth of the trench shall not be less than 750 mm for cables upto 1.1 kV and 1000 mm for cables above 1.1 kV.

• When more than one tier of cables is unavoidable and vertical formation of laying is adopted, the depth of trench shall be increased by 300 mm for each additional tier to be formed.

**4.3.5 Excavation of Trenches**

The trenches shall be excavated in reasonably straight lines. Wherever there is a change in direction, suitable curvature of 12 times the overall diameter of the largest cable shall be provided. Where gradients and changes in depths are unavoidable these shall be gradual. Excavation should be done by any suitable manual or mechanical means. Excavated soil shall be stacked firmly by the side of the trench such that it may not fall back into the trench. Adequate precautions shall be taken not to damage any existing cables, pipes or other such installations during excavation. Wherever bricks, tiles or protected covers or bare cables are encountered, further excavation shall not be carried out without the approval of the Owner/PMC. Existing property exposed during trenching shall be temporarily supported or propped adequately as directed by the Engineer in charge. The trenching in such cases shall be done in short lengths, necessary pipes laid for passing cables therein and the trench refilled as required. If there is any danger of a trench collapsing or endangering adjacent structures the sides shall be well shored up with timbering and/or sheathing as the excavation proceeds. Where necessary these may even be left in place when back filling the trench. Excavation through lawns shall be done in consultation with the Engineer in charge. Bottom of the trench shall be level and free from stone, brick, etc. The trench shall then be provided with a layer of clean dry sand cushion of not less than 170 mm.

**4.3.6 Laying of Cable in Trench**

The cable drum shall be properly mounted on jacks or on a cable wheel at a suitable location. It should be ensured that the spindle, jack etc are strong enough to carry the weight of the drum without failure and that the spindle is horizontal in the bearings so as to prevent the drum creeping to one side while rotating. The cable shall be pulled over rollers in the trench steadily and uniformly without jerks or strains. The entire cable length shall, as far as possible, be laid in one stretch. However when this is not possible the remainder of the cable shall be removed by flaking i.e. making one long loop in the reverse direction.

After the cable is uncoiled and laid over the rollers, the cable shall be lifted slightly over the rollers beginning from one end by helpers standing about 10 meters apart and drawn straight. The cable should then be taken off the rollers by additional helpers lifting the cables and then laid in the trench in a reasonably straight line. For short runs and cable sizes upto 50 sq mm 1.1 kV grade the alternative method of direct handling can be adopted with the prior approval of the Owner/PMC. If two or more cables are laid in the same trench care should be taken to preserve relative position. All the cables following the same routes shall be laid in the same trench. Cables shall not cross each other as far as possible. When the cable has been properly straightened the cores shall be tested for continuity and insulation resistance. The cable shall be measured thereafter.

Suitable moisture sealing compound/tape shall be used for sealing of the ends. Cable laid in trenches in a single tier formation shall have a covering of clean dry sand of not less than 170 mm above the base cushion of sand before the protective cover is laid. In the case of vertical multi-tier formation after the first cable has been laid a sand cushion of 300 mm shall be provided over the initial bed before the second tier is laid. If additional tiers are formed each of the subsequent tiers also shall have a sand cushion of 300 mm. The top most cable shall have final sand covering not less than 170 mm before the protective cover is laid. A final protection to cables shall be laid to provide warning to future excavators of the presence of the cable and also to protect the cables against accidental mechanical damage. Such protection shall be with second class bricks of not less than 200 mm x 100 mm x 100 mm (normal size) laid breadth wise for the full length of the cable to the satisfaction of the Engineer in charge. Where more than one cable is to be laid in the same trench this protective covering shall cover all the cables and project at least 50 mm over the sides of the end cables. In addition bricks on edge shall be placed along the entire run on either side of the cable run. The trenches shall then be back filled with excavated earth free from stones or other sharp edged debris and shall be rammed and watered in successive layers not exceeding 300 mm. Unless otherwise specified a crown of earth not less than 50 mm in the centre and tapering towards the side of the trench shall be left to allow for subsidence. The crown of earth should however not exceed to 100 mm so as not to be a hazard to vehicular traffic. Where road berms or lawns have been cut or kerb stones displaced the same shall be repaired and made good to the satisfaction of the Owner/PMC and all surplus earth and rocks removed to places as specified.

Sand filling to be done on both sides 150mm and below and upto 170 height and then brick protection and back filling after that. Check.

All glands should be double compression

**4.3.7 Laying In Pipes/Closed Ducts**

In locations such as road crossings, entry to buildings/poles in paved areas etc., cables shall be laid in pipes or closed ducts. Spun reinforced concrete pipes shall be used for such purposes and the pipe shall not be less than 100 mm in diameter for a single cable and not less than 150 mm for more than one cable. These pipes shall be laid directly in ground without any special bed. Sand cushioning and/or brick tiles need not be used in such installations. Unless otherwise specified the top surface of pipes shall be at a minimum depth of 1000 mm from the ground level when laid under roads, pavements etc.

The pipes for road crossings shall preferably be on the skew to reduce the angle of bend as the cable enters and leaves the crossing. Pipes shall be continuous and clear of debris or concrete before cable is drawn. Sharp edges at ends shall be smoothened to prevent injury to cable insulation or sheathing. No deduction shall be made for sand and bricks not used for cables passing through RCC Hume pipes or for parts of vertical cables at the lighting poles. Wherever so required, cables shall be laid at the bed of the lake through existing PVC pipe as itemized in bill of quantities.

**4.3.8 Laying Of Cables in Floors**

Laying of cables directly in floors shall be avoided and GI pipes of adequate size shall be used wherever necessary. However if the cables have to be laid direct in the floor specific written approval of Owner/PMC shall be obtained and the Contractor shall cut chases, lay the cables and make good the chases to original finish.

**4.3.9 Cable Entry into Buildings**

Cable entry into buildings shall be made through RCC pipes recessed in the floor. RCC Hume pipes shall be provided well in advance for service cable entries. The pipe shall be filled with sand and sealed at both ends with bitumen mastic to avoid entry of water. Suitable size manholes shall be provided wherever required to facilitate drawing of cables as per requirements.

**5 TERMINATION/JOINTING OF CABLES**

Soldered jointing/termination shall be totally avoided. Solder less terminations by using Dowel crimping tools and suitable legs shall be adopted for all cable terminations. Any terminations without use of proper crimping tool shall be liable to be rejected. In the case of aluminium conductors, it is to be ensured that the conductor oxidation is cleaned by means of emery paper and then a thin coat of tin is applied before pinching into any equipment. Heat shrinkable Raychem type or approved equivalent terminations shall be provided for High Voltage cables and Siemens make or approved equivalent make brass double compression glands shall be provided for Medium Voltage cable terminations. Straight through jointing of Medium Voltage or High Voltage cable shall normally be totally avoided. If absolutely unavoidable, such jointing shall be carried out as per procedure to be got specifically approved from Engineer in charge.

**7. CABLE LOOPS**

At the time of the installation approximately 3 meters of surplus cable shall be left

- at each end of the cable.

- on each side of underground straight through/tee/termination joints.

- at entries to buildings.

- and such other places as may be decided by the Engineer in charge.

This cable shall be left in the form of a loop.

Wherever long runs of cable length are installed cable loops shall be left at suitable intervals as specified by the Engineer in charge.

**8. BONDING OF CABLES.**

Where a cable enters any piece of apparatus it shall be connected to the casting by means of an approved type of armoured clamp or gland. The clamps must grip the armouring firmly to the gland or casting, so that in the event of ground movement no undue stress is placed on to the cable conductors.

**9. TESTING**

**9.1 Tests at Manufacturer's Work**

The cables shall be subjected to shop test in accordance with relevant standards to prove the design and general qualities to the cables as below (as per IS 10810) and as per approved GTP:

• Routine test on each drum of cables.

• Acceptance tests on drums chosen at random for acceptance of the lot.

• Type test on each type of cables, inclusive of measurement of armour DC resistance of power cables.

**9.2 Site Testing**

• All cables before laying shall be tested with a 500 V megger for 1.1 KV grade or with a 2,500/5,000 V megger for cables of higher voltages. The cables cores shall be tested for continuity, absence of cross phasing, insulation resistance to earth/sheath/armour and insulation resistance between conductors.

• All cables shall be subject to above mentioned test during laying, before covering the cables by protective covers and back filling and also before the jointing operations.

• After laying and jointing, the cable shall be subjected to a 1.5 minutes AC/DC pressure test.

• In the absence of facilities for pressure testing in accordance with clause above it is sufficient to test for one minute with 1000 V megger for cables of 1.1 kV grade and with 2,500/5,00 V megger for cables of higher voltages.

**9.3 Test Witness**

Tests shall be performed in presence of representative of Engineer in charge. The Contractor shall give at least fifteen (15) days advance notice of the date when the tests are to be carried out.

# EARTHING SYSTEM AND GROUND FAULT PROTECTION

**1. GENERAL**

All the non-current carrying metal parts of electrical installation shall be earthed properly. All metal conduits, trunking, cable sheaths, switchgear, distribution fuse boards, light fittings and all other parts made of metal shall be bonded together and connected by means of specified earthing conductors to an efficient earthing system. All earthing shall be in conformity with Indian Electricity Rules.

The Earthing System shall in totally comprise the following: -

a) Earth Electrodes

b) Earthing Leads

c) Earth Conductors

All three phase equipment shall have two separate and distinct body earths and single phase equipment shall have a single body earth.

**2. STANDARDS**

All equipments, components, materials and entire work shall be carried out in conformity with applicable and relevant Bureau of Indian Standards and Codes of Practice, as amended upto date and as below. In addition, relevant clauses of the Indian Electricity Act 1910 and Indian Electricity Rules 1956 as amended upto date shall also apply. Wherever appropriate Indian Standards are not available, relevant British and /or IEC Standards shall be applicable.

Equipments certified by Bureau of Indian Standards shall be used in this contract in line with government regulations. Test certificates in support of this certification shall be submitted, as required.

It is to be noted that updated and current standards shall be applicable irrespective of dates mentioned along with ISS's in the tender documents.

**3. EARTHING MATERIAL**

Materials of which the protective system is composed shall be resistant to corrosion or be adequately protected against corrosion. The material shall be as specified in the schedule of quantities and shall comply with the following requirements:

• Copper - When solid or stranded copper wire is used it shall be of the grade ordinarily required for commercial electrical work generally designated as being of 98% conductivity when annealed, conforming to Indian standard specifications.

• Galvanised Steel - Galvanised steel used shall be thoroughly protected against corrosion by hot dipped Zinc coating. The material coating shall withstand the test specified in IS 2309:1969.

• The strips to be used shall be in maximum lengths available as manufactured normally avoiding unnecessary joints.

**4 EARTH ELECTRODES**

• **Plate Earth Electrode**

The plate electrodes shall be of copper/ GI as called for in the schedule of quantities. The minimum dimensions of the electrodes shall be 600 mm x 600 mm. Thickness of copper electrodes shall not be less than 3 mm and of GI electrodes not less than 6 mm.The electrode shall be buried in ground with its face vertical and top not less than as mentioned in BOQ below ground level.

• Earth Electrode Pit Method of Installing Watering Arrangement

In the case of plate earth electrode, a watering pipe of 20 mm dia of medium class G.I. Pipe shall be provided and attached to the electrode. A funnel with mesh shall be provided at the top of this pipe for watering the earth. The watering funnel attachment shall be housed in masonry enclosure of not less than 300 x 300 x 300 mm. A RCC frame with cover having locking arrangement shall be suitably embedded in the masonry enclosure.

**4.1 Location of Earth Electrode**

The following guidelines shall be followed for locating the earth electrodes

* An earth electrode shall not be situated less than 3 meters from any building.
* The excavations for electrode shall not affect the column footings or foundations of the buildings. In such cases electrode may be further away from the building.
* The location of the earth electrode shall be such where the soil has reasonable chance of remaining moist, as far as possible.
* Entrances, pavements and road ways shall not be used for locating the earth electrode.

**4.2 Number of Earth Electrodes**

In all cases the relevant provision of rule 33, 61 & 67 of the Indian Electricity Rules 1956 as amended shall be complied with.

Metallic covers or supports of all medium or H.T. apparatus or conductors shall, in all cases be connected to not less than two separate and distinct earth electrodes.

**5. EARTHING LEADS**

The strip earthing leads shall be connected to the Earth Electrode at one end and to the metallic body of the main equipment at the other end. The earthing lead shall connect to the earthing network in the installation.

• **Earthing Lead Sizes**

Strip earthing leads shall be of copper/GI and as per specifications.

• **Earthing Lead Installation**

The length of buried strip earthing lead shall be not less than 15 meters and shall be buried in trench not less than 0.5 m deep.

If conditions necessitates use of more than one earthing lead they shall be laid as widely distributed as possible preferably in a single straight trench or in a number of trenches radiating from one point.

• **Method Of Connecting Earthing Lead To Earth Electrode**

In the case of plate earth electrode the earthing lead shall be securely bolted to the plate with two bolts, nuts, check nuts and washers as required by IS 3043 : 1987.

All materials used for connecting the earth lead with electrode shall be GI in case of GI Pipe and GI plate earth electrodes or tinned brass in case of Copper plate electrode.

• **Protection OfEarthing Lead**

The earthing lead from electrode onwards shall be suitably protected from mechanical injury and corrosion by a 15 mm dia GI pipe in case of wire and 100/40 mm dia medium class GI Pipe

The portion of the G.I. pipe within ground shall be buried at least 30 cm deep (to be increased to 60 cm in case of road crossing or pavements). The portion within the building shall be recessed in walls and floors to adequate depth.

**6. EARTHING CONDUCTORS**

Earthing conductors shall form the earthing network throughout the installation for earthing of all non- carrying metal parts.

**• Connection of Earthing Conductors**

• Main earthing conductors shall be taken from the earth connections at the main switch boards to all other switchboards in the network.

• Sub-mains earthing conductors shall run from the main switch board to the sub distribution boards and to the final distribution boards.

• Loop earthing conductors shall run from the distribution boards and shall be connected to any point on the main/sub-main earthing conductor, or its distribution board or to an earth leakage circuit breaker.

• Metal conduits, cable sheathing and armouring shall be earthed at the ends adjacent to switch boards at which they originate, or otherwise at the commencement of the run by an earthing conductor in effective electrical contact with cable sheathing, Switches, accessories, lighting fitting etc shall be effectively connected to the Loop Earthing Conductors. These though rigidly secured in effective electrical contact with a run of metallic conduit shall not be considered earthed, even though the run of metallic conduit is earthed.

**• Earthing Conductor Installation**

The earthing conductors inside the building wherever exposed shall be properly protected from mechanical injury by running the same in GI pipe of adequate size.

Joints shall be riveted and brazed in approved manner.

Sweated lugs of adequate capacity and size shall be used for termination. Lugs shall be bolted to the equipment body to be earthed after the metal body is cleaned of paint and other oily substances and properly tinned.

**• Sizing of Earthing Conductors**

All fixtures, outlet boxes and junction boxes shall be earthed with Bare copper wires as specified.

* All 3 phase switches and distribution boards upto 60 amps rating shall be earthed with 2 Nos. distinct and independent 4 mm dia copper/6 mm dia GI wires. All 3 phase switches and distribution boards upto 100 amps rating shall be earthed with 2 Nos. distinct and independent 6 mm dia copper/8 mm dia GI wires. All switches, bus bar, ducts and distribution boards of rating 200 amps and above shall be earthed with a minimum of 2 Nos. separate and independent 25 mm x 3 mm copper/25mm x 6 mm GI tape.

**7. PROHIBITED CONNECTIONS**

Neutral conductor, sprinkler pipes, or pipes conveying gas, water, or inflammable liquid, structural steel work, metallic enclosures, metallic conduits and lighting protection system conductors shall not be used as a means of earthing an installation or even as a link in an earthing system.

**8. RESISTANCE TO EARTH**

No earth electrode shall have a greater ohmic resistance than 1 ohms as measured by an approved earth testing apparatus. In rocky soil the resistance may be upto 1 ohms. The electrical resistance measured between earth connection at the main switchboard and any other point on the completed installation shall be low enough to permit the passage of current necessary to operate fuses or circuit breakers, and shall not exceed 1 ohm.

**9. ROUTINE AND COMPLETION TESTS**

**1. INSTALLATION COMPLETION TESTS**

At the completion of the work, the entire installation shall be subject to the following tests:

1. Wiring continuity test

2. Insulation resistance test

3. Earth continuity test

4. Earth resistivity test

Besides the above, any other test specified by the local authority shall also be carried out. All tested and calibrated instruments for testing, labour, materials and incidentals necessary to conduct the above tests shall be provided by the contractor at his own cost.

**2. WIRING CONTINUITY TEST**

All wiring systems shall be tested for continuity of circuits, short circuits, and earthing after wiring is completed and before installation is energized.

**3. INSULATION RESISTANCE TEST**

The insulation resistance shall be measured between earth and the whole system conductors, or any section thereof with all fuses in place and all switches closed and except in concentric wiring all lamps in position of both poles of the installation otherwise electrically connected together, a direct current pressure of not less than twice the working pressure provided that it does not exceed 1100 volts for medium voltage circuits. Where the supply is derived from AC three phase systems, the neutral pole of which is connected to earth, either direct or through added resistance, pressure shall be deemed to be that which is maintained between the phase conductor and the neutral. The insulation resistance measured as above shall not be less than 50 meg.ohms divided by the number of points provided on the circuit the whole installation shall not have an insulation resistance lower than one meg.ohms.

The insulation resistance shall also be measured between all conductors connected to one phase conductor of the supply and shall be carried out after emoving all metallic connections between he two poles of the installation and in those circumstances the insulation shall not be less than that specified above.

The insulation resistance between the frame work of housing of power appliances and all live parts of each appliance shall not be less than that specified in the relevant Standard specification or where there is no such specification, shall not be less than half a meg.ohms or when PVC insulated cables are used for wiring 11.5 meg.ohms divided by the number of outlets. Where a whole installation is being tested a lower value than that given by the above formula subject to a minimum of 1 Meg.ohms is acceptable.

**4. TESTING OF EARTH CONTINUITY PATH**

The earth continuity conductor including metal conduits and metallic envelopes of cable in all cases shall be tested for electric continuity and the electrical resistance of the same along with the earthing lead but excluding any added resistance of earth leakage circuit breaker measured from the connection with the earth electrode to any point in the earth continuity conductor in the completed installation shall not exceed one ohm.

**5. TESTING OF POLARITY OF NON-LINKED SINGLE POLE SWITCHES**

In a two wire installation a test shall be made to verify that all non-linked single pole switches have been connected to the same conductor throughout, and such conductor shall be labeled or marked for connection to an outer or phase conductor or to the non-earthed conductor of the supply. In the three of four wire installation, a test shall be made to verify that every non-linked single pole switch is fitted to one of the outer or phase conductor of the supply. The entire electrical installation shall be subject to the final acceptance of the Architect as well as the local authorities.

**6. EARTH RESISTIVITY TEST**

Earth resistivity test shall be carried out in accordance with IS Code of Practice for earthing IS 3043.

**7. PERFORMANCE**

Should the above tests not comply with the limits and requirements as above the contractor shall rectify the faults until the required results are obtained. The contractor shall be responsible for providing the necessary instruments and subsidiary earths for carrying out the tests. The above tests are to be carried out by the contractor without any extra charge.

**8. TESTS AND TEST REPORTS**

The Contractor shall furnish test reports and preliminary drawings for the equipment to the Owner/PMC for approval before commencing supply of the equipment. The Contractor should intimate with the tender the equipment intended to be supplied with its technical particulars. Any test certificates etc., required by the local Inspectors or any other Authorities would be supplied by the Contractor without any extra charge.

**Earthing (Chemical )**

(i) Maintenance free chemical Earthing as per IS 3043:1987.

(ii) The Earth Electrode shall be made of high tensile low carbon steel circular rod, molecularly bonded with copper on outer surface.

(iii) The Earth Electrode shall be minimum 17 mm. diameter and 3 meters long.

(iv) The minimum copper bonding thickness shall be of 250 microns.

(v) The Earth Enhancement material is a superior conductive material that improves earthing effectiveness. It improves conductivity of the earth electrode and ground contact area. It shall have following characteristics-

a. Earth enhancement material must be eco-friendly and tested from NABL authorized test lab.

b. Earth enhancement material must be tested for resistive value <0.3 ohm-meter from NABL authorized test lab.

c. It should not contain salt.

(vi) Per electrode earth enhancement material should be minimum 50 Kg.

(vii) All joints and connection at earth electrode should have exothermic weld.

(viii) In case of server and suffocated equipment use ring earthing of 2/3 electrode.

(ix) All earth pits should be covered with whether proof FRP pit cover.

(x) All installation/connection work should be as per supplier.

# LIGHTNING PROTECTION SYSTEM AND SPDs

The comprehensive Lightning protection plan - consist both External Lightning Protection and Internal surge protection as per the guideline of IS/IEC 62305 standard and NBC 2016

**1.0 Scope:**

New standard IS/IEC 62305 supersedes old IS 2309:1989 standard for lightning protection This Section covers necessary requirement of protection of structure from external lightning using new Indian standard IS / IEC 62305, following the various methods and internal lightning protection using surge protection, as defined in the said standard. Please refer IS/IEC 62305 for detail.

**2.0 Standard - Brief:**

A. New standard define & mentions the requirement for Lightning protection via its four chapters i.e.

• IS/IEC 62305-1:2010, Protection against lightning – Part 1: General Principles

• IS/IEC 62305-2:2010, Protection against lightning – Part 2: Risk management

• IS/IEC 62305-3:2010, Protection against lightning – Part 3: Physical damage to structures and life hazard

• IS/IEC 62305-4:2010, Protection against lightning – Part 4: Electrical and electronic systems in structures.

B. Before designing, it is essential to determine the risk involved as per IS/IEC 62305-2, in the structure and depending on the risk involved, level of protection is determined which is basis of designing as per IS/IEC 62305-3.

C. The design shall be made according to IS/IEC 62305-3 using any or combination of three methods, as per defined lightning protection level: -

⇒ Rolling sphere method

⇒ Mesh method

⇒ Protective angle method

The designing is based on level of protection of individual building / structure determined by Risk assessment. It differentiates between four classes of lightning protection system. A Class I lightning protection system provides the maximum protection and a Class IV, by comparison, the least.

D. Separation distance shall be considered while designing the ELP as per IEC 62305-3 which is essential to avoid creepage flashover. It can be achieved either by maintaining physical separation distance or by use of special cable - High voltage insulated (HVI) cable, as a down conductor to compensate the need of the separation distance, as per IS/IEC 62305 & NBC 2016.

E. Generally, in new construction buildings, it is recommended to use reinforced down conductor and earthing. As per clause E.4.3.1 of IS/IEC 62305-3:2010, It is to be ensured for continuity and maximum overall resistance of 0,2 ohm shall be achieved and can be checked by measuring the resistance between the air-termination system and a ground plate (grounding bus-bar / grounding termination) at ground level.

F. Lightning Protection components shall be tested for natural weathering and exposure to corrosion in i.e Salt Mist Treatment test according to EN 60068-2-52 and Humid Sulphurous atmosphere treatment test according to BS EN ISO 6988.

G. Special measure has to be taken for building above 60m, while designing Lightning protection, to protect the building above against side flashes.

Metal compatibility shall be ensured to avoid corrosion and contact resistance at connection point.

External Lightning Protection (ELP):

The design shall be made according to IS/IEC 62305-3 using any or combination of three method - Rolling sphere, Angle of protection and Mesh method as per defined lightning protection level and same shall be approved by Owner/PMC for zone of protection.

**3.0** Lightning Protection components shall be tested for natural weathering and exposure to corrosion in i.e. Salt Mist Treatment test according to EN 60068-2-52 and Humid Sulphurous atmosphere treatment test according to BS EN ISO 6988. Metal compatibility shall be ensured to avoid corrosion and contact resistance at connection point.

Risk Analysis: The design shall be accompanied with proper Risk Analysis as per IS/IEC 62305-2 to determine level of protection required for particular structure which will be basis of design.

External Lightning Protection comprises of below listed items: All components shall meet the requirement of IEC 62305 standard.

1. Air terminal: It shall be made of Aluminum or it's alloy, complying to EN 62561-2. It shall be mounted in such a way that as far as possible drilling shall be avoided on roof top. The terminal shall withstand wind velocity of 145KM/hour. The length of the Air-terminal rod varies from 1mtr to 4mtr or even higher on special occasion, depending on design to finalize Bill of Material.

Fixing Accessories- suitable fixing accessories used with Air-terminal to withstand Lightning current and suitable clamp complying to EN 62561-1 for connecting Air terminal with roof conductor.

1. Down conductor: Preferably round conductor (long length, minimum joints) shall be made of Aluminum or it's alloy or GI or Copper or Stainless Steel, min dia 8 mm, complying to complying to EN 62561-2. Wherever, it is not possible to maintain the separation distance, special islaoted cable (like HVI) can be used to avoid separation distance.

Separation distance:

It is necessary to maintain separation distance of down conductors as per IS/IEC 62305-3, to prevent dangerous flashover between the parts of the external lightning protection system and conductive parts inside the structure (electrical / electronic equipment, pipes, ventilation ducts, etc.) resulting from a direct lightning strike. In case separation is not possible, Special conductors / cable (HVI Cable), according to EN 62305-3 & NBC 2016, may be used for discharging the lightning current to earth while maintaining a sufficient separation distance. High-voltage-resistant insulated down conductor for keeping the separation distance from conductive parts Natural components made of conductive materials, which will always remain in/on the structure and will not be modified (e.g. interconnected steel-reinforcement, metal framework of the structure, etc.) may be used as parts of an LPS. The reinforcing rods of walls or concrete columns and steel structural frames may be used as natural down-conductors.

As per clause E.4.3.1 of IS/IEC 62305-3:2010, It is to be ensured for continuity and maximum overall resistance of 0,2 ohm shall be achieved and can be checked by measuring the resistance between the air-termination system and a ground plate (grounding bus-bar / grounding termination) at ground level.

1. Roof Conductor: Preferably round conductor (long length, minimum joints) shall be made of Aluminum or it's alloy or GI or Copper or Stainless Steel, min dia 8 mm, complying to EN 62561-2

Fixing Accessories- suitable fixing accessories to be considered to support Roof conductor @ 1 meter as per IS/IEC 62305-3.

1. Clamp for support to conductor: The conductor shall be made of Stainless Steel/GI and shall be supported with the structure at every 1 mtr, as far as drilling shall be avoided on roof top. The clamps shall be tested for natural weathering and exposure to corrosion in i.e. Salt Mist Treatment test according to EN 60068-2-52 and Humid Sulphurous Atmosphere treatment test according to BS EN ISO 6988. In special application, if drilling is not possible, special adhesive clamp is recommended to hold roof conductor on roof / shed.
2. Test clamps: It shall be made of Stainless Steel/GI and shall be used for every down conductor at 1meter (approx) above to ground level (connection / disconnection purpose).
3. Earthing system: Each down conductor shall be terminated to either earth electrode or ring earth, Earth electrode shall be 3/4" dia, 10 feet long, UL listed, min 254-micron copper coating over mild steel, -Each earth electrode shall be supported with RoHS certified, low resistivity (≤0.2ohm mtr) Ground Enhancement Material (min22.6Kg), performs in all soil condition, increases the contact area with earth electrode. The final resistance using one rod or ring, shall be ≤ 10 Ω.
4. GI Strip for Earthing : The strip used for connecting down conductor from test link to earth Electrode. Metal: Galvanized Iron, Size: 25X6, Coating of Galvanization: Min 86 micron.
5. Equi-potential bond: All metal (natural conductor) components shall be bonded together with roof/down conductor for equi-potential bonding.
6. Quantity: to be determined for each and individual building / structure as per IS/IEC 62305-2 & 3.
7. Lightning Flash Recorder:The Lightning system shall be installed complete with the Lightning flash recorder/counter with digital recording.

The Lightning flash recorder, complying to EN 62561-6, shall consist of a mechanical 3 digit display which will register all Lightning discharges with a sensitivity of up to 100KA 10/350 µs Lightning impulse current.

The Lightning flash recorder shall be housed in IP 65 rated enclosure and will operate without reliance on batteries or an external power source.

It shall be installed on the most direct down conductor, at height of about 2 meter above ground level or as per user guideline.

**4.0** Internal Lightning Protection

The Internal Surge Protection Device shall be selected as per zone of protection described in IEC 62305, 61643-11/12/21, 60364-4/5. Depending on Zone concept of provided in IEC 62305 – 1 & 4.

LPZ -OB & LPZ 1: At Mains entry point (Main LT Panel): Type 1 + 2, i.e.

SPD Combined Arrester with Integrated Backup Fuse.

LPZ1 & LPZ 2: Sub distribution panel at each floor will be used with Type 2 SPD i.e

SPD with integrated fuse - for each Sub Distribution Panel

CCTV control room Panel + Server room Panel + IT building panel will be used with Type 2 SPD i.e Type 2 SPD guard for each Panel

All data network will be protected using suitable Surge Protection Device.

**4.1 Power Line Protection**

Main Distribution Board shall have Type 1 SPD to discharge Lightning current surges for 415 V AC, 3 phase 4 wire (TT) configuration. UPS / Sub Distribution Board shall have Type 2 SPD to discharge switching surges for 415 V AC, 3 phase 4 wire (TT) configuration. Server and sensitive equipments shall have Type 3 SPD at their power input to discharge switching surges.

Type 1, Type 2 and Type 3 devices shall be from same manufacturer to achieve the co-ordination

Type 1 SPD (with inbuild Fuse) - at Main LT Panel

a) The device shall be non-exhausting metal encapsulated, spark gap based technology.

b) The device shall be tested as per latest and valid IEC 61643-11:2011 or EN 61643-11:2012 standards.

c) The device shall be rated for 255 V (Uc) between L-N and N-E.

d) The SPD should be tested for Temporary overvoltage and it shall with stand 440 V / 120 minutes.

e) The device shall be capable to discharge Lightning current (10/350µs) of 25kA (L-N) and 100kA(N-E).

f) The device shall have voltage protection level of device shall be ≤ 1.5 KV including inbuilt fuse for L-N.

g) The device shall have Follow current extinguishing capability [L-N]/[N-PE] : 100 kArms / 100 Arms

h) The device shall have follow current limitation/Selectivity resulting in no tripping of a 20 A gL/gG fuse up to 50 kArms between L-N.

i) The device shall have built in fuse and operation of SPD shall be independent of Line current for L-N SPD. The short circuit with stand capability of the device shall be 100 KArms for L-N SPD.

j) The device shall have mechanical indication for both the states (green for ‘healthy’ and red for failure) on L-N and N-PE connected SPD.

k) The device shall be certified by KEMA or VDE as per IEC 61643-11:2011 or or EN 61643-11:2012.

Type 2 SPD (with in-built Fuse) - at Each Sub Distribution Panel – for Load current more than 125A:

a) The device shall be single shield high duty discharge capacity Zinc Oxide Varistor between L-N and single shield high discharge capacity spark gap between N-Earth.

b) he device shall be suitable for 3 phase 4 wire (TT) OR 1 Phase 2 wire system with nominal voltage parameters of 230 Vac ±10% between L-N and 415 Vac ±10% between L-L

c) The device shall be capable to discharge 12 KA (10/350 µs, lightning current) between N-PE and 40 KA (8/20 µs switching surges)

d) Voltage Protection level of device shall be ≤ 1.5 KV including built in fuse (for L-N SPD).

e) The device shall have built in fuse and operation of SPD shall be independent of Line current for L-N SPD.

f) The device shall have mechanical indication for both the states (green for ‘ok’ and red for failure) on all modules (L-N and N-PE)

g) The device shall have pluggable option to change cartridge without disconnection.

h) The device shall be tested for Vibration and Shock as per EN 60068-2

i) The device shall be certified by KEMA as per IEC 61643-11:2011 or EN 61643-11:2012.

Note: it is important select proper Type 1 and Type 2 SPDs to ensure achieve co-ordination.

Type 2 SPD: For CCTV Control Room Panel, Server room panel & IT room panel (for load current less than 125A)

a) The device shall be single shield high duty discharge capacity Zinc Oxide Varistor between L-N and single shield high discharge capacity spark gap between N-E.

1. The device shall be suitable for 3 phase 4 wire (TT) OR 1 Phase 2 wire system with nominal voltage parameters of 230 Vac ± 10% between L-N and 415 Vac ±10% between L-L
2. The device shall be capable to discharge 12 KA (10/350 µs, lightning current) between N-PE and 40 KA (8/20 µs switching surges)
3. Voltage Protection level of device shall be ≤ 1.5 KV
4. The device shall have mechanical indication for both the states (green for ‘s’ and red for failure) on all modules (L-N and N-PE)
5. The device shall have pluggable option to change cartridge without disconnection.

g) The device shall be tested for Vibration and Shock as per EN 60068-2.

h) The device shall be certified by KEMA as per IEC 61643-11:2011 or EN 61643-11:2012.

**4.2** Data Line Protection:

Telephone line at MDF Shall consist of Lightning current protector directly coordinated with fine suppressor Lightning current arrestor shall be expandable to a combined lightning current and surge arrester by means of coarse and fine suppressor protective plug.

The integrated disconnection block contacts allow for testing, measuring and patching with plugged-in protection. The three-pole gas discharge tubes have a fail-safe function with visual fault indication.

Fault indication: Visual color change

Nominal voltage: 180 V DC

Max Continuous Operating Voltage: 180 V DC

Max Continuous Operating Voltage: 127 V AC

D1 total 10/350 µs (Iimp) 5KA

D1 per line 10/350 µs (Iimp) 2.5 KA

C2 total Nominal Discharge (In) (8/20 µs) 10 KA

Voltage protection level: ≤500 V

Shall comply IEC 61643-21 and approved by third party like EACRF Protection:

Protection for UHF/VHF co-axial cable with “N” termination:

Lightning current arrester: SPD class TYPE 1, for coaxial 50 Ohm antenna systems, shall be tested acc. to EN 61643-21, suitable for remote supply, exchangeable gas discharge tube.

Max. continuous operating voltage (d.c.): 180 V

D1 Lightning impulse current (10/350 µs): 5 kA

C2 Nominal discharge current (8/20 µs): 20 kA

Frequency range: 0-2.5 GHz

**4.3 Protection for CCTV System**

The IP based camera shall be installed with suitable surge protection device for communication interface over POE at both the ends.

General Specification of SPD:

a) The device shall be capable to discharge lightning impulse current (at 10/350µs) of 0.5KA & 10 KA total nominal discharge current (at 8/20µs).

b) The device shall be suitable for maximum continuous DC voltage of 48V.

c) Voltage Protection level (line to line / line to ground) of device shall be ≤ 700V.

d) The device shall be enclosed within Zinc die cast material.

e) The device shall be DIN rail mounted adopter type with sockets.

f) The device shall comply to IEC 61643-21/ EN 61643-21 and shall be UL approved.

g) Cut-off frequency shall be minimum 100 MHz.

**4.4** Earthing system:

In general, a low earthing resistance is recommended. The recommended value of the overall earth resistance of 1 Ω is fairly conservative in the case of structures in which direct equi-potential bonding is applied. The resistance value shall be as low as possible in every case but especially in the case of structures endangered by explosive material. (Refer to IS/IEC 62305-3 Clause E.5.4.1).

Above ground metal piping in the process/valve area (subject to non Cathodically protected) shall be earthed (Refer IEC 62305-3, Annex ‘D’ Para D.5)

From the viewpoint of lightning protection, a single integrated structure earth-termination system is preferable and is suitable for all purposes (i.e. lightning protection, power systems and telecommunication systems). By interconnecting the earthing system of a number of structures, a meshed earthing system is obtained. This will give low impedance between buildings and has significant LEMP protection advantages.

Thus, different earthing systems like lightning protection earthing, electrical earthing, safety earthing, electronics earthing etc. shall be interconnected. And places where direct interconnection is non-permissible then use of isolating spark gaps (ISG) is recommended to create equi-potential bonding throughout the earthing system at the event of lightning.

ISG shall be complying to IEC 62561-3, used at the places where direct interconnection is non-permissible to create equi-potential bonding throughout the earthing system at the event of lightning with lightning impulse current (10/350 µsec / Iimp) up to 100 KA and rated impulse sparkover voltage of ≤1.25 KV with IP 67 degree of protection.

# Street Lighting

* + - 1. **Octagonal Poles**

**Detail specifications of Galvanized Octagonal poles.**

**Design** The Octagonal Poles shall be designed to withstand the maximum wind speed as per IS 875. The top loading i.e. area and the weight of fixtures are to be considered to calculate maximum deflection of the pole and the same shall meet the requirement of BS: 5649 Part VI 1982.

* + - 1. **Pole Shaft**

The pole shaft shall have **octagonal** cross section and shall be continuously tapered with **single longitudinal welding**. There shall not be any circumferential welding. The welding of pole shaft shall be done by Submerged Arc Welding (SAW) process.

All **octagonal** pole shafts shall be provided with the rigid flange plate of suitable thickness with provision for fixing 4 foundation bolts. This base plate shall be fillet welded to the pole shaft at two locations i.e. from inside and outside. The welding shall be done as per qualified MMAW process approved by Third Party Inspection agency.

* + - 1. **Door opening**

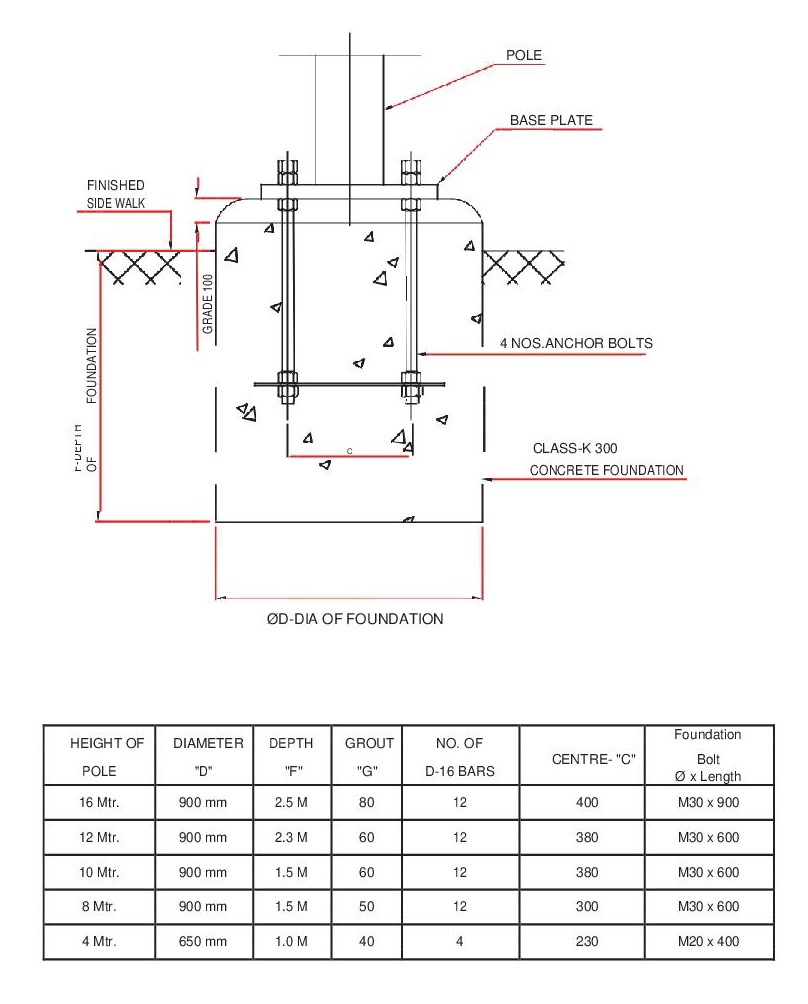
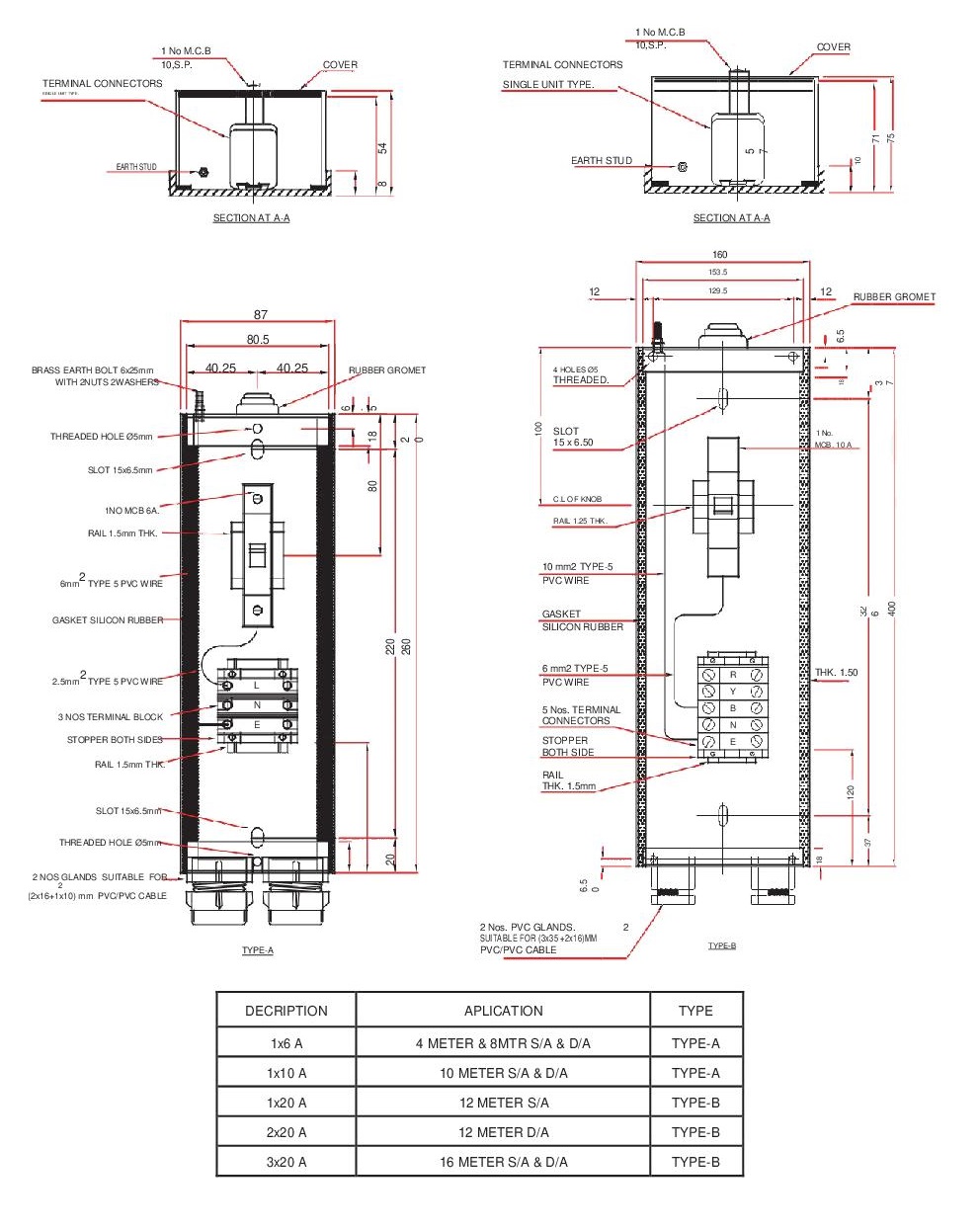
The octagonal Poles shall have door of approximate 500 mm length at the elevation of 500 mm from the Base plate. The door shall be vandal resistance and shall be weather proof to ensure safety of inside connections. The door shall be flush with the exterior surface and shall have suitable locking arrangement. There shall also be suitable arrangement for the purpose of earthing. The pole shall be adequately strengthened at the location of the door to compensate for the loss in section.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Material** | Octagonal Poles | HT Steel Conforming to grade S355JO. | | |
|  | Base Plate | Fe 410 conforming to IS 226 / IS 2062 | | |
| **Welding** | Foundation Bolts | EN.8 grade | |  |
|  | The welding shall be carried out confirming to approved procedures duly | | | |
|  | qualified by third party inspection agency. The welders shall also be | | | |
|  | qualified for welding the octagonal shafts. | | |  |
| **Pole sections** | The Octagonal Poles shall be in single section (upto 11 Mtr). There shall not | | | |
|  | be any circumferential weld joint. | | |  |
| **Galvanization** |  |  |  | **The galvanizing** |
|  | The poles shall be hot dip galvanized as per IS 2629 / IS 2633 / IS 4759 | | | |
|  | shall be done in single dipping standards with average coating thickness of 85-100 micron | |  |  |
|  | standards with average coating thickness of 70 micron | | |  |
|  |  |  | . |  |
| **Fixing Type** | The Octagonal Poles shall be bolted on a foundation with a set of four | | | |
|  | foundation bolts for greater rigidity. | | |  |

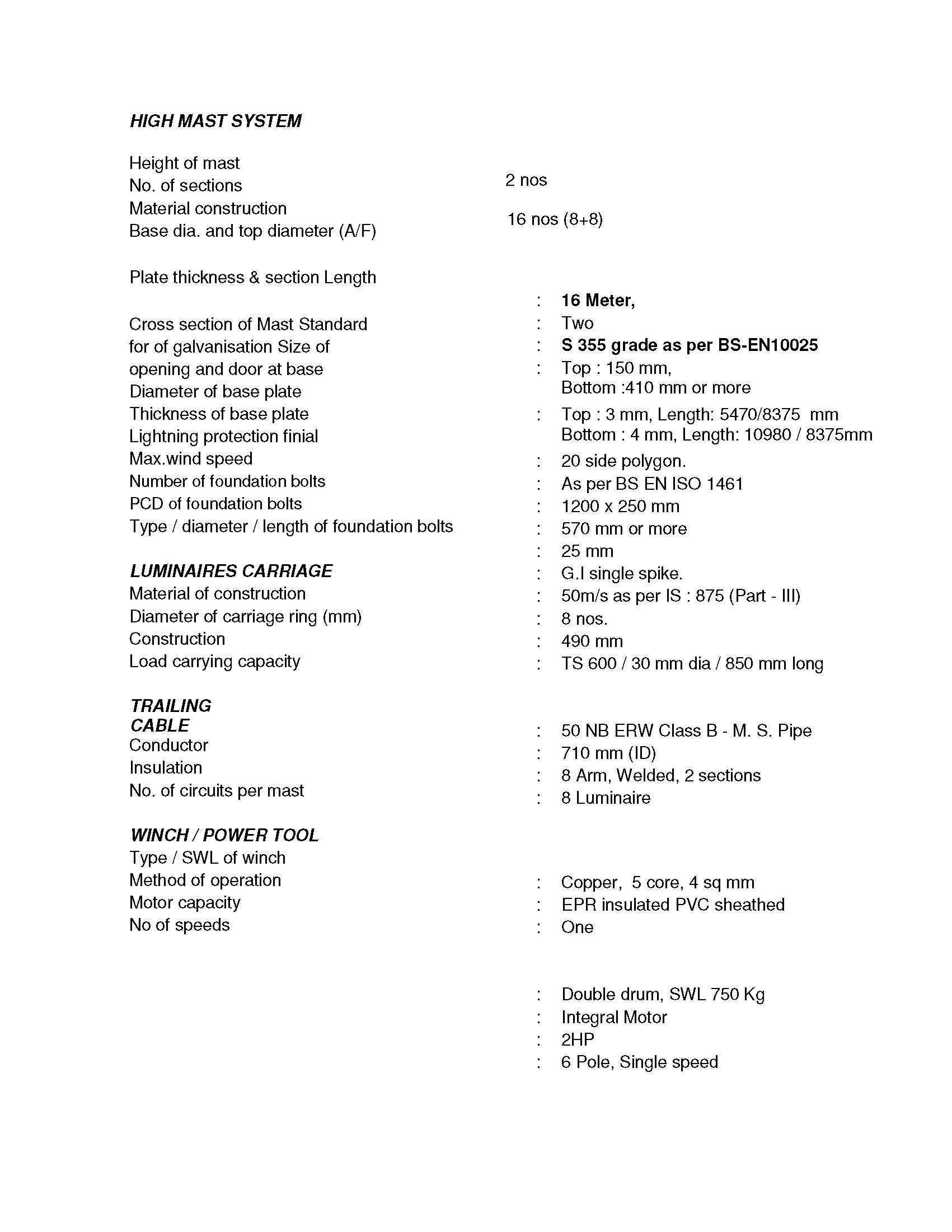
**Top Mountings** The galvanized mounting bracket shall be supplied along with the Octagonal Poles for installation of the luminaries.

* + - 1. **BRACKET FOR STREET LIGHT FITTINGS AND FOUNDATION DETAILS**

The brackets shall be made of specified size NB G.I heavy duty pipe approx. 1.4 M long, bent at the center at an angle of 120 degree, with necessary holding brackets, hold fasts etc. with special reducer at end to accommodate type of street light fitting to be fixed. The bracket shall have one coat of anti -corrosion paint before dispatch to site and two coats of approved make and shade of enamel paint. See schematic attached drawing of street light poles. Shop drawing shall be submitted by the contractor for approval and execution.



***REQUIREMENT***



|  |  |  |
| --- | --- | --- |
| ***STAINLESS STEEL WIRE ROPE*** |  |  |
| Grade / construction | : | AISI 316, 7/19 construction |
| Number of ropes | : | Two continuous |
| Diameter (mm) | : | 6 mm |
| Braking load capacity | : | 2350 kg x 2 |

# Solar external lighting -

|  |
| --- |
|  |
| Al. Pressure Diecast |
| UV stabilized Polycarbonate |
| Horizontal and vertical Pole mounting |
| 2000lm |
| 11 w |
| 175 |
| IP65 |
| 1 |
| N.A |
| >70 |
| 5700 |
| 12V DC |
| Integrated MPPT charger with Driver(DIM) |
| Both >90% |
| In- built PIR sensor |

**Specifications:-**

|  |  |  |
| --- | --- | --- |
| Product Catgeory | solar street lighting and renewable energy street lighting | |
| Specification Title | Specification Value | |
| Confirm to specification | As per MNRE specification for Solar Photovoltaic Lighting Systems & Power Packs - White LED &#x28;W-LED&#x29; Based Solar Street Lighting Systems | |
| Model as per MNRE Specification | Model: IV | |
| Battery | Model IV : With Lithium Ferro phosphate battery. Operates from dusk to dawn &#x28; first four hours at full brightness & rest of the time at lower level, with motion sensor&#x29; | |
| Battery Type, make &amp; model | 11.1 volt-20ah,li-ion | |
| Autonomy | For Model I: 3 days or minimum 42operating hours per permissible discharge | |
| Type of Light source | White light emitting diode &#x28;W-LED&#x29; | |
| Colour temperature of White - LED | 5700 | |
| Light output | 2000 | |
| Duty cycle | Dusk to dawn as per MNRE | |
| PV module (Wp) under STC | Model I: 40 | |
| PV module chemistry | Crystalline silicon solar cells | |
| PV module efficiency | 18 | |
| PV module certification | For humidity, freeze and damp heat tests certificate conforming to IEC 61215 Edition II / BIS 14286 from an NABL or IECQ accredited laboratory | |
| Battery capacity ( 12V-AH @ C/10) | 20 AH | |
| No load current consumption | 20 | |
| Warranty for street lighting system including battery | 5 | |
| Warranty for Pv module | 25 | |
| Necessary cables and connectors as part of supply of lighting system | Yes | |
| Scope of supply | without errection and commissioning | |
| Yes | |

**Earthing For External lighting poles:-**

**2.1 Brief Scope**

a) The brief scope of work shall be carrying out necessary excavation, providing and fixing of earth electrode with GI pipe and funnel, providing and filling of soil enhancement material, construction of earth pit chambers, Providing earth pit cover, painting of earth pit covers, measurement of earth pit resistance and connecting the earth pit to earth grid/equipments conforming to IS- 3043.

1. The necessary tools and tackles, material and labour required for all the works mentioned hereunder to complete the works upto the satisfaction of Project Manager, is in the scope of the contractor. No additional payment will be made for the same.

**2.2 EXCAVATION OF EARTH PITS:**

Excavation shall be carried out by means of manual digging the soil where ever is practicable or by means of auguring the soil. After excavation broken lumps and stones, if any, are to be removed from the earth pit.

**2.3 PROVIDING AND FIXING OF EARTH ELECTRODE**:

a) The job includes providing of 50 mm diameter NB class B, GI pipe of 3 meters length. Bottom portion of the GI earth electrode is to be made sharp for easy penetration into the soil.

b) GI Earthing strip of 300 mm (Length) x 6 mm (Thickness) x50 mm (Width) bent to the shape of the pipe and welded at 75 mm from top portion of GI earth electrode. Tapped holes of 10 mm diameter shall be provided on the GI earthing strip for connecting earthing strips to the earth electrode.

c) Funnel with a mesh shall be provided on the top portion of the earth electrode for watering purpose.

d) GI earthing strip welded to the earth electrode at the top shall have hot dip galvanized coating of not less than 10 microns thickness.

**2.4 PROVIDING AND FILLING OF EARTH ENHANCEMENT MATERIAL:**

The job includes filling up of the earth pit with earth enhancement materials after placing the earth electrode in the excavated earth pit. Earth enhancement materials shall be watered and rammed as tight as possible for shall be carried out proper bonding of the electrode with the adjacent soil. Earth enhancement material shall be filled 300 mm in diameter, around electrode in place of soil, charcoal or coke dust.

**2.5 CONSTRUCTION OF EARTH PIT CHAMBER:**

The job includes providing earth pit chambers, Depth of the earth pit chamber should be 400 mm from the ground level. The earth pit chamber and cover should be at finished ground level.

**2.6 PROVIDING EARTH PIT COVERS:**

a) The job includes providing not less than 6 mm thick Mild steel chequered /cast iron plate on the top portion of the earth pit chamber with suitable handle for lifting arrangement. A base frame of suitable dimensions shall be fixed to the top portion of the earth pit chamber to accommodate earth pit cover.

b) The job includes painting of earth pit cover, wherever metallic earth pit covers are provided. The earth pit is to be provided with earth pit display board having identification number

c) Inside portion of the pit shall be cleaned properly.

**2.7 IDENTIFICATION OF EARTH PITS:**

a) Earth pit display boards on top of an iron rod duly painted / available wall with white letters with paint in black background, marked with of earth pit number, individual pit resistance, due date for measurement and name of location on the display board shall be provided by the contractor for each individual earth pit.

**2.8 MEASUREMENT OF EARTHPIT RESISTANCE:**

a) The job includes measurement of resistance of the earthpits when connected to grid as well as individually.

b) The values will be tabulated and submitted to Project Manager-in-charge.

c) If the individual earth pit resistance is not within the limits (01 ohms) then soil enhancement material shall be added or new earth pit shall be provided.

**2.9 SUPPLY & LAYING OF EARTH STRIP:**

a) Supply & Laying of 50x6 mm GI earth strip.

b) All hardware (nut, bolt & washer etc.), used for connection/joints except where welding is done, shall be made of stainless steel (SS).

c) Joints and tapings in the main earth loop shall be made in such a way that reliable and good electrical connections are permanently ensured. All welded joints shall be suitably protected by applying red oxide paint and bitumen.

d) The earth strip should be laid in at about depth of 150 mm from ground level and to be connected to equipments and earth grid at the installations. After laying of earth strip, concrete floor / brick floor/ soft soil shall be restored. At some locations (like-Wall and roof etc.) earth strip shall be fixed/clamped to the surface with the help of appropriate clamps.

**2.10 General:**

a) The quantity of earth strip to be laid at each location will be as per the direction of Project manager.

b) Welding should be free from defects; the joint is to be properly cleaned.

c) Bolting of earth strips to be done at end of connecting earth strip to earth pit and also at the other end where earth strips are connected to equipments/structures etc.

d) The necessary tools and tackles, material and labour required for connecting new earthpits to adjacent pits / main earth grid is in the scope of the contractor. No additional payment will be made for the same.

e) The contractor is responsible for any damage caused while carrying out earth pit jobs.

i. Drains, pipes, electrical cables, telephone cables, and similar services encountered in the course of the works shall be guarded from injury by the contractor at his own cost, so that they may continue in full and uninterrupted to the satisfaction of the Owner/PMC thereof.

ii. Should any damage be done by the contractor to any mains, pipes cables or lines (whether above or below ground etc.) whether or not shown on the drawings the contractor must make at his cost good the damage without delay to the satisfaction of the Owner/PMC

iii) Permissions - While doing the work, it is the responsibility of the contractor to take the all the necessary permissions/permits from the Employer/Engineer-in-charge of the site.

g) In some locations, the work may be carried out near Live High voltage bus bars/lines, contractor has to follow all safety rules & regulations etc. and guide his manpower for safe working.

# COMPACT SUB-STATION WITH DRY TYPE TRANSFORMER

**Detailed Specification: Table of Contents**

1. Applicable Codes & Standards

2. Applicable Service Conditions

3. General Design Criterion For Package Substations

4. Specific Requirement

5. Specifications For Enclosure Of Compact Type Package Sub-Station

6. Technical Specification Of 11kv SF6 Metal Enclosed, Indoor Ring Main Unit (RMU).

7. Dry Type Distribution Transformer

8. L.T. Panel

9. Type / Routine Test On Package Substation

1. **APPLICABLE CODES & STANDARDS**
   1. All equipment and material shall be designed manufactured and tested in accordance with the latest applicable IEC and equivalent IS standards.
   2. The Package Sub-station offered shall in general comply with the latest issues including amendments of the following standards.

|  |  |
| --- | --- |
| **Particulars** | **Standards** |
| High Voltage Low Voltage Pre-Fabricated Substation | IEC:61330/ 62271-202 |
| High Voltage Switches | IEC 60265 |
| Metal Enclosed High Voltage Switchgear | IEC 60298/ IEC62271-200 |
| High Voltage Switchgear | IEC 60694 |
| Low Voltage Switchgear and Control gear | IEC 60439 |
| Power Transformers | IEC 60076 |

1. **APPLICABLE SERVICE CONDITIONS**
   1. The Package substation shall be suitable for continuous operation under the basic service conditions indicated below

* Ambient Temperature: 50 Deg C
* Relative Humidity: up to 95%
* Altitude of Installation: up to 1000m
  1. The Enclosure of High Voltage switchgear-control gear, Low Voltage switchgear control gear & Transformer of the package substation shall be designed to be used under **normal outdoor service condition** as mentioned. The enclosure should take minimum space for the installation including the space required for approaching various doors & equipment inside.

1. **GENERAL DESIGN CRITERIA FOR PACKAGE SUB-STATION**
   1. The required Package Sub-station should consist 11KV Extensible SF6 Gas insulated Compact Switchgear with cable isolators and Vacuum Circuit Breaker as protection + Dry typeTransformer + Low Voltage Switchgear with all connection accessories, fitting & auxiliary equipment in an Enclosure to supply Low-voltage energy from high-voltage system as detailed in this specification.
   2. The complete unit shall be installed on a substation plinth (base) as Outdoor substation located at very congested places. The transformer Low Voltage side shall be connected to Low Voltage switchgear. The connection cables to consumer shall be taken out from the Low Voltage switchgear.
   3. The prefabricated-package substation shall be designed for:
      1. Compactness,
      2. Fast installation, (to be read in line with the project milestones)
      3. Maintenance free operation,
      4. Safety for worker/operator & public
   4. The Switchgear of Package Sub-station shall be capable of withstanding all type of Stresses whether mechanical or electrical or developed due to short circuits (listed in ratings and requirements clause) without any damage or deterioration of the materials.
   5. For continuous operation at specified ratings temperature rise of the various switchgear components shall be limited to permissible values stipulated in the relevant standard and / or this specification.
2. **SPECIFIC REQUIREMENT**
   1. The main components of a prefabricated- package substation are Transformer, High-voltage switchgear-control gear, Low-voltage switchgear-control gear and corresponding interconnections (cable, flexible , bus bars ) & auxiliary equipment. The components shall be enclosed, by a common enclosure. “Assembly of enclosures” shall not be permitted in order to ensure continuity of design and integrity of arc-proof enclosure.
   2. All the components shall comply with their relevant IEC and Indian standards.
   3. Ratings:

| **Description** | **Unit** | **Value** |
| --- | --- | --- |
| Rated Voltage / Operating  Voltage | kV rms | 11 |
| 1. Rated frequency & Number of phases | Hz & nos. | 50 & 3 |
| 1. Rated maximum power of substation | kVA | **1250 kVA** |
| 1. Rated Ingress protection class of Enclosure | IP: | IP-23 for Transformer Compartment and IP: 54 for LT & HT Switchgear Compartment. |
| 1. Rated temp Class of Transformer Compartment |  | K15 |
| 1. HV Insulation Level |  |  |
| 1. Rated withstand voltage at power frequency of 50 Hz | kV rms | 28 |
| 1. Rated Impulse withstand Voltage | kV peak | 75 |
| 1. HV Network & Bus bar |  |  |
| 1. Rated current | Amp | 630A |
| 1. Rated short time withstand current | kA rms / 3 sec | 20 |
| 1. Making capacity for switch-disconnector &earthing switches | kA peak | 50kA |
| 1. Breaking capacity of Isolators | Amp | 630A |
| 1. Rated and Breaking Capacity of Fixed-Type VCBs | Amp, kA | 630A, 20kA |
| 1. Operator Safety | Mandatory classification. Under IEC 62271-202 | Type Tested Design for maximum Internal Arc duration with RMU inside the enclosure, Operator and Pedestrian safety  Designation: IAC AB 20kA/01-second. |
| 1. **Metering & Indication Scheme** | Required | **HV Side** – Class 1.0 accuracy Bus-PT arrangement with Digital Voltmeter, suitable ratio MFM and ON/OFF/TRIP LED indications for Transformer Feeder VCB  **LV Side –** Class 1.0 accuracy MFM and ON/OFF/TRIP LED indications for Main ACB |
| 1. **LV Network** |  | 2000 amp. ACB |

1. **SPECIFICATIONS FOR ENCLOSURE OF COMPACT TYPE PACKAGE SUB-STATION** 
   1. The outdoor enclosure shall be made of galvanized Sheet Steel suitable for local weather conditions
   2. The enclosure shall be of partially modular design of GI sheets fastened by riveting.
   3. The thickness of enclosure shall be 1.5 mm for non load bearing members & 2mm for load bearing members.
   4. The enclosure shall be powder coated / Wet Polyurethane paint.
   5. The protection degree of the Enclosure shall be **IP54 for LT & HT switchgear compartment & IP23 for Transformer compartment.** Proper / adequate ventilation aperture shall be provided for natural ventilation by way of Louvers etc.
   6. Artificial or enforced measures to restrain temperature rise like cooling fans or corrugation of enclosure are not acceptable.
   7. The metal base shall ensure rigidity for easy transport & installation.
   8. Substation will be used in outdoor application hence to prevent enclosure from rusting/corrosion, welding should be avoided. Modern techniques such as riveting/clinching etc. are encouraged.
   9. Considering the outdoor application of the substation the doors shall be provided with proper interlocking arrangement for safety of operator and to avoid corrosion door should have stainless steel hinges. Door should be provided with stoppers.
   10. Interconnection between HT switchgear and transformer shall be using 1Cx3x185 sq.mm al. unarmored XLPE cable and between transformer and LT switchgear shall be using busbar.
   11. **Internal Fault**: Failure within the package substation due either to a defect, an exceptional service condition or mal-operation may initiate an internal arc. Such an event may lead to the risk of injury, if persons are present. It is desirable that the highest practicable degree of protection to persons shall be provided. The Design shall be tested as per IEC61330/62271-202.
   12. **Type test report of arcing due to internal fault should submitted with offer. The Package substation shall be tested for internal arc test –AB for 20KA for 1 sec (A operator , B-pedestrian)**
   13. Covers & doors are part of the enclosure. When they are closed, they shall provide the degree of protection specified for the enclosure. Ventilation openings shall be so arranged or shielded that same degree of protection as specified for enclosure is obtained. Additional wire mesh may be used with proper Danger board for safety of the operator. All covers, doors or roof shall be provided with locking facility or it shall not be possible to open or remove them before doors used for normal operation have been opened. The doors shall open outward at an angle of at least 900 & be equipped with a device able to maintain them in an open position. **The doors shall be lockable type with cylindrical shooting bolt and the locking arrangement shall be covered by magnetic flap. The roof of the transformer compartment shall be detachable type to access the transformer for maintenance purpose.**
   14. **Earthing** : All metallic components shall be earthed to a common earthing point. It shall be terminated by an adequate terminal intended for connection to the earth system of the installation, by way of flexible jumpers/strips & Lug arrangement. The continuity of the earth system shall be ensured taking into account the thermal & mechanical stresses caused by the current it may have to carry. The components to be connected to the earth system shall include :
       1. The enclosure of Compact Package substation,
       2. The enclosure of High voltage switchgear & control gear from the terminal provided for the purpose,
       3. The metal screen & the high voltage cable earth conductor,
       4. The transformer tank or metal frame of transformer,
       5. The frame &/or enclosure of low voltage switchgear,
   15. There shall be an arrangement for internal lighting activated by associated switch for HV, Transformer & LV compartments separately.
   16. **Labels**: Labels for warning, manufacturer’s operating instructions etc. shall be durable & clearly legible.
   17. **Cleaning & Painting:** The paints shall be carefully selected to withstand tropical heat and rain. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling. **The enclosure shall be painted with polyurethane paint/ Powder coated**
2. **TECHNICAL SPECIFICATION OF 11KV SF6 METAL ENCLOSED, INDOOR RING MAIN UNIT (RMU) / COMPACT SWITCHGEAR (CSG).** 
   1. This RMU/CSG should be complete with all components necessary for its effective and trouble free operation along with associated equipment etc. such components should be deemed to be within the scope of Contractor.
   2. **The RMU/CSG should be fixed type SF-6 insulated with Vacuum circuit breakers** with O/C & E/F relay for the protection of the transformer. It should be maintenance free equipment, having stainless steel robotically welded IP67 enclosure.
   3. **STANDARDS AND REFERENCE DOCUMENTS** 
      1. ***Codes and Standards:*** The **RING MAIN UNIT (RMU) / COMPACT SWITCHGEAR (CSG)** should be designed, manufactured and tested to the latest version of:

* IEC 60694 Common specifications for high-voltage switchgear and control gear standards.
* IEC 62271-200 : A.C metal-enclosed switchgear and control gear for rated voltages above 1KV and up to and including 72KV and the IEC Codes herein referred.
* IEC 60129/ IEC 62271-102: Alternating current disconnections (isolators) and earthing switches
* IEC 60529: Classification of degrees of protection provided by enclosures
* IEC 60265 High-voltage switches-Part 1: Switches for rated voltages above 1kV and less than 52 kV
* IEC 60056: Circuit breakers
* IEC 60420 High-voltage alternating current switch-fuse combinations
* IEC 60185 Current transformers
* IEC 60186 Voltage transformers IEC 60255 Electrical relays
* Any other codes recognized in the country of origin of equipment might be considered provided that they fully comply with **IEC & Indian standard**s.
  + 1. **The design of the switchgear should be based on safety to personnel and equipment during operation and maintenance, reliability of service, ease of maintenance, mechanical protection of equipment, interchangeability of equipment and ready addition of future loads.**
  1. RMU / CSG of the Package Sub-station should have following configuration:
     1. 11KV SF6 INDOOR Ring Main Unit (RMU) / COMPACT SWITCHGEAR (CSG), comprising of 630A Load break Switches, and Fixed-Type 630 A Vacuum Circuit Breakers with (3 O/C & 1E/F ) Relays, 1 No. metering module and Aux. Supply Unit with Battery backup
     2. The CSG shall be manual operated for LBS & VCB.
        1. **Load break switch (630A) with Manual operation - Load break switch should have the following**
* Manually operated 12 KV, 630A Load Break switch and Earthing Switch with making capacity
* “Live Cable” LED Indicators through Capacitor Voltage Dividers mounted on the bushings.
* Mechanical ON/OFF/EARTH Indication
* Anti-reflex operating handle
* Cable testing possible without disconnection of cables.
* Cable boxes suitable for 1 X 3C x 300 sq mm XLPE Cable with right angle Cable Terminal Protectors.
* Cable boxes should be Arc Proof and interlocked with respective Earthing Switches.
* For Safety of operator it should not be possible to open the cable box unless the earth Switch is ON.
* The ON-OFF operation of the load break switch shall be manually at local
  + - 1. **Circuit Breaker (630A) –with manual operation Circuit Breaker should have the followin**g:
* Manually operated 630 A fixed type Vacuum circuit breaker with series disconnector cum earthing switch with making capacity
* Mechanical tripped on fault indicator
* Auxiliary contacts 1NO and 1NC
* Anti-reflex operating handle
* “Live Cable” LED Indicators thru Capacitor Voltage Dividers mounted on the bushings.
* 3O/C + 1E/F self powered relay with Low and High set for Over current and Earth Fault. Relay should have facility to display the maximum loaded phase current also. Relay should have facility to trip the breaker from remote commands without shunt trip coil.
* Protection and Metering Class CTs of suitable ratio, 2.5VA burden, Class 10P10 for Protection and Class 1.0 for Metering
* Mechanical ON/OFF/EARTH Indication
* The ON-OFF operation of the VCB shall be manual/motorised at local & operated through SCADA from remote
* Breaker ON/OFF/TRIP LED Indications
  + - 1. **Metering Module - Metering Module should have the following**
* Air insulated metering module 11kV
* Potential Transformer with HT fuse on primary side and MCB on secondary side for protection.
* Primary voltage: 11000:V3 V, Secondary voltage: 110:V3 V.
* Burden winding 1: 25 VA, Class winding 1: 1.0.
* Digital Voltmeter (Acc.Cl.1.0), R-Y-B LED indications
* Digital MFM (Acc.Cl.1.0)
* Space heater with thermostat.
* All parameters should be available at control room through SCADA
  + - 1. **Common Items –**
* Gas Pressure Low Manometer
* Suitable isolation MCB, control and terminals etc.
  1. RMU/CSG of the Package Sub-station should have following features:
     1. Modular, metal enclosed design.
     2. RMU/CSG must be made of robotically welded Non Ferrite, Non magnetic stainless steel of grade 304 with thickness of minimum 2.5 mm with all live parts inside stainless steel tank
     3. The RMU/CSG should have provision of Gas refilling at site, in case there is some leakage of the gas.
     4. Cable covers must be interlocked with Earth switch to have complete safety of operating person. The cable bushings shall be bolted, site replaceable type design.
  2. DIELECTRIC MEDIUM
     1. **SF6 GAS shall be used for the dielectric medium**, **Arc quenching should take place in vacuum** for 11KV RMU’s/CSG’s in accordance with IEC376. It is preferable to fit an absorption material in the tank to absorb the moisture from the SF6 gas and to regenerate the SF6 gas following arc interruption. The SF6 insulating medium shall be constantly monitored via a temperature compensating gas pressure indicator offering a simple go, no-go indication.
  3. **DESIGN CRITERIA** 
     1. ***Service conditions***
        1. The offered switchgear and control gear should be suitable for continuous operation under the basic service conditions indicated below. Installation should be in normal indoor conditions in accordance with IEC 60694.
* Ambient temperature -1oC to +45oC
* Relative humidity up to 95%
* Altitude of installation up to 1000m, IEC 60120
  1. ***General structural and mechanical construction*** 
     1. The offered RMU/CSG should be of the fully arc proof metal enclosed, free standing, floor mounting, flush fronted type, consisting of modules assembled into one or more units. Each unit is made of a cubicle sealed-for life with SF6 and contains all high voltage components sealed off from the environment. The overall design of the switchgear should be such that front access only is required. It should be possible to erect the switchboard against a substation wall, with HV and LV cables being terminated and accessible from the front.
     2. **The units should be constructed from robotically welded NON Ferrite, Non Magnetic grade stainless steel of grade 304 of minimum 2.5mm thickness to ensure very high degree of precision in sealing of SF6 tank**. The design of the units should be such that no permanent or harmful distortion occurs either when being lifted by eyebolts or when moved into position by rollers.
     3. The cubicle should be have a pressure relief device. In the rare case of an internal arc, the high pressure caused by the arc will release it, and the hot gases is allowed to be exhausted out at the bottom of the cubicle. A controlled direction of flow of the hot gas should be achieved.
     4. The switchgear should have the minimum degree of protection (in accordance with IEC 60529)
* IP 67 for the tank with high voltage components
* IP 2X for the front covers of the mechanism
* IP 3X for the cable connection covers
  + 1. **The RMU/CSG shall be internally arc tested for 20kA for 1 sec for the gas tank & it should be internally arc tested for cable compartment with arc proof doors. Relevant type test reports should be submitted by the manufacturer.**
    2. **CIRCUIT BREAKERS** 
       1. Vacuum bottles should be use as interrupters of the currents. The circuit breaker main circuit should be connected in series with a three-position disconnector – earthing switch. The operation between circuit breaker and disconnector earthing must be interlocked.
       2. Vacuum circuit breaker must self tripping and have self powered relay
    3. **Bus bars** 
       1. Comprising the 3 single phases copper bus bars and the connections to the switch or circuit breaker. The bus bar should be integrated in the cubicle Bus bars should be rated to withstand all dynamic and thermal stresses for the full length of the switchgear.
    4. **Earthing Switch** 
       1. Earthing switches should be rated equal to the switchgear rating.
       2. Earthing switches should be quick make type capable of making Rated Fault Current. Ear thing switch should be operated from the front of the cubicle by means of a removable handle.
    5. **The mechanisms**
       1. All mechanisms should be situated in the mechanism compartment behind the front covers outside the SF6-tank. The mechanism for the switch and the earthing switch is operating both switches via one common shaft. The mechanism provide independent manual operation for closing and opening of the switch, independent closing of the earthing switch and dependent opening of the earthing switch.
       2. The mechanism for the T-off switch and earthing switch is operating both switches via one common shaft. The mechanism has stored spring energy and provide independent manual operation for closing and opening of the switch, independent closing of the ear thing switch and dependent opening of the ear thing switch. The mechanism for the vacuum circuit breaker (VCB) and disconnector- earthing switch is operating the VCB and the disconnector earthing switch via to separate shafts. The mechanism for the VCB has stored spring energy and provides independent manual operation for closing and opening of the VCB. The mechanism has a relay with related CT’s and/or remote tripping device. The mechanism for the disconnector earthing switch provide independent manual operation for closing and opening of the disconnector, independent closing of the earthing switch and dependent opening of the earthing switch.
    6. **Front covers**
       1. The front cover contains the mimic diagram of the main circuit with the position indicators for the switching devices. The voltage indicators are situated on the front panels. Access to the cable bushings is in the lower part of each module.
    7. **Position indicators** 
       1. The position indicators are visible through the front cover and are directly linked to the operating shaft of the switching devices.
    8. **Voltage indicator** 
       1. The voltage indicators are situated on the front cover, one for each module, and indicate the voltage condition of each incoming cable. Identification of the phases is achieved with labels L1, L2 and L3 on the front of the voltage indicators. The voltage indicator satisfies the requirements of IEC61243.
    9. **Cable compartment** 
       1. The Cables access in the RMU/CSG shall be from the front.
       2. **The cable bushings shall be bolted type and should be replaceable at site whenever required.**
    10. **Power connection.**
        1. The cables are installed in the dedicated compartment below the mimic front cover. At the bottom of the cable compartment, an earthing bar system made of copper/GI with a minimum cross section of 120 mm2 should be fitted. In each compartment the earthing bar should be fitted with 4 screws M10. The earthing system is connected to the tank by a copper/GI bar, which rises up to the connecting point of the tank behind the rear partition wall on the middle of the switchgear.
    11. ***INTERLOCKING.*** 
        1. The mechanism for the cable switch should be provide a built in interlocking system to prevent operation of the switch when the earthing switch is closed, and to prevent operation of the earthing switch when the switch is in the closed position.
        2. The mechanism for the T-off switch should be provide a built in interlocking system to prevent operation of the switch when the earthing switch is closed, and to prevent operation of the earthing switch when the switch is in the closed position. The mechanism for the VCB and the disconnector-earthing switch should be has a built in interlocking system to prevent operation of the disconnector earthing switch when the VCB is in the closed position.
        3. Further is should not be possible to Open the Cable doors unless the Earthing Switch is Turned ON. In case the Cable door is accidentally left open a positive interlock shall prevent operation of Load Break Switch and Isolators / Breaker from any operation.
    12. **Current Transformers** 
        1. All current transformers should be complying with IEC 60185.
        2. Current transformers should be of dry type, with ratings and ratios as required.
        3. Cable current transformers used in circuit breaker modules should be maximum 100mm wide. Current transformers used in metering cubicles should be having dimensions according to DIN 42600, Narrow type. Current transformer shall be placed in the cable covers so that it can be easily replaced at site without removing the bushings.
  1. **TECHNICAL DATA**

|  |  |  |
| --- | --- | --- |
| **S.No.** | **Particular** | **Description** |
| 1 | Standard to which Switchgear complies | IEC & IS |
| 2 | Type of Ring Main Unit / Compact Switchgear | Metal Enclosed, Panel type, Compact Module |
| 3 | Number of phases | 3 |
| 4 | Whether RMU is type tested | Yes |
| 5 | Whether facility is provided with pressure relief | Yes |
| 6 | Insulating gas | SF6 |
| 7 | Nominal operating gas pressure | 1.4 bar abs. 20° C |
| 8 | Gas leakage rate / annum % | 0.1% per annum |
| 9 | Expected operating lifetime | 30 years |
| 10 | Whether facilities provided for gas monitoring can be delivered | Yes, temperature compensated manometer |
| 11 | Material used in tank construction | Stainless steel sheet, grade AIS 304 / equiv. |
| 12 | Rated operating sequence of Circuit Breaker | O –3min-CO-3min-CO |
| 13 | Mechanical operations of switch | CO 1000 |
| 14 | Mechanical operations of circuit breaker | CO 3000 or higher |
| 15 | ***Degree of protection*** |  |
|  | High Voltage live parts | SF6 tank IP 67 |
|  | Front cover mechanism | IP 2X |
|  | Cable covers | IP 3X |

* 1. **TESTING AND CERTIFICATION.**
     1. **TYPE TESTS.** 
        1. Units should be type tested in accordance with IEC standards 60056, 60129, 60265, 60298,60420,60529 and 60694. The following type tests should perform on the HT Switchgear and report should submit with offer.

Short time and peak withstand current test

Temperature rise tests

Dielectric tests

Test of apparatus i.e. circuit breaker and earthing switch - Arc fault test

Measurement of resistance of main circuit.

Mechanical endurance test.

Duty cycle test.

Internal arc test for HT chamber.

Type test reports for above type shall be submitted with the offer.

* + 1. **ROUTINE TESTS.**
       1. Routine tests should be carried out in accordance with IEC 60298 & IS standards. These tests should be ensure the reliability of the unit.
       2. Below listed test should be performed as routine tests before the delivery of units;
       - Withstand voltage at power frequency
       - Measurement of the resistance of the main circuit
       - Withstand voltage on the auxiliary circuits
       - Operation of functional locks, interlocks, signalling devices and auxiliary devices - Suitability and correct operation of protections, control instruments and electrical connections of the circuit breaker operating mechanism - Verification of wiring
       - Visual inspection
       - Time travel characteristics measurement facility for Breaker should be available with the manufacturer to access the quality of RMU.

1. **CAST RESIN DRY TYPE TRANSFORMER**

The make of the dry type transformer shall be the same as the make of compact substation manufacturer. This specification covers the requirements of design, manufacture, testing and supply of cast resin dry type transformers complete with all the accessories and fittings for efficient and trouble-free operation.

* 1. **CODES & STANDARDS**
     1. The equipment covered by this specification shall, unless Other wise stated to be designed, constructed and tested in accordance with latest revisions of relevant Indian standards / IEC publications.

IS 1271 - Classification of Insulating Materials.

IS 2026 - Power transformers (part I - V)

IS 2099 - Bushing for alternating voltages above 1000 V

IS 2705 - Current transformers

IS 3202 - Code of practice for climate proofing

IS 3639 - Power transformer fittings and accessories

IS 4257 - Porcelain bushings for transformers

IS 11171 - Dry type Transformer

IS 8478 - Application guide for tap-changers

IS 10028 - Code of practice for selection, installation and maintenance of transformers.

* 1. **GENERAL DESIGN FEATURES**
     1. All transformers shall be of the latest design, dry type Cast Resin only.
     2. The type of cooling shall be Natural Air cooled (AN) and the corresponding ratings for each transformer shall be as indicated in the specific requirements.
     3. Each transformer shall be suitable for operation at full rated power on all tapings without exceeding the applicable temperature rise.
     4. It shall be possible to operate the transformer satisfactorily, with the loading guide specified in IS-6600. There shall be no limitations imposed by bushings, tap changers auxiliary equipment to meet this requirement.
     5. The transformers shall be designed to be capable of with-standing, without injury, the thermal and mechanical effects of short-circuits between phases or between phase and earth at the terminals of any winding with full voltage applied across the other winding for periods given in relevant standards. There shall be no limitations imposed by any part/component of the transformer/off load tap links to meet the short circuit level Specified.
     6. Each transformer shall be designed for minimum no-load and load losses within the economic limit and shall be able to have minimum loss at the rated load condition.
     7. All electrical connections and contacts shall be of ample cross sections for carrying the rated current without excessive heating.
     8. The transformer shall be capable of continuous operation at full load rating under the following conditions.
        1. Voltage variation = ± 10%
        2. Frequency variation = ± 5%
        3. Combined voltage and frequency variation (Absolute sum) = 10%
  2. **CONSTRUCTION**
     1. The transformer shall be dry type, AN cooled suitable for Compact substation application.
     2. The core-clamping frame shall be provided with lifting eyes having ample strength to lift the complete core and winding assembly.
     3. Off circuit tapings shall be provided on the HV windings. Tap changing is done by means of off-circuit links accessible through openings provided.
     4. The lifting lugs and rollers shall be provided. A winding temp. Scanner shall be provided and is actuated by means of resistance temperature detectors embedded in LV windings of all three phases. It should have alarm and trip contacts at a specified temperature.
     5. The transformer shall be of IP00 protection class and will be installed in the transformer compartment of compact substation having IP23 protection class.
  3. **WINDINGS**
     1. The winding insulation shall be of Class ‘H” and temperature rise limit to Class H. i.e. 115 deg. C
     2. Windings shall be of electrolytic copper or aluminum conductors of high conductivity purity.
     3. Windings shall be designed to withstand the specified thermal and dynamic short circuit stresses.
     4. The windings shall be duly sectionalised. Accessible joints brazed or welded and finished smooth shall connect similar sections. No corona discharge shall result on the winding upon testing the transformer for induced voltage test as specified in IS.
     5. The end turns of the high voltage windings shall have reinforced insulation to take care of the voltage surges likely to occur during switching or any other abnormal condition.
     6. The high voltage and low voltage winding are shall be made of copper Conductors. HV winding will be always be resin casted under vacuum while LV winding can either be casted or pre-impregnated with resin.
  4. **CORE** 
     1. The double wound Core shall be constructed from non-ageing cold rolled Grain oriented steel sheets. The built core shall be painted with high temperature resistant paint to prevent corrosion at the edges of core plates and to withstand high temperatures. By using different core material optimisation of core losses shall be achieved. The yokes shall be firmly clamped between yoke channels or plates. The top & bottom yoke frames shall be secured to each other by means of tie-rods, which help in securing the winding in place.
     2. The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and the production of flux component at right angles to the planes of laminations which may cause local heating.
  5. **OFF-CIRCUIT TAP CHANGING LINKS**
     1. Off circuit tapings are provided on HV windings. Tap changing is done by means off circuit links. Use of tap changing links eliminates any moving parts as against a manually operated tap changer.
  6. **Terminal Arrangement** 
     1. HV side and LV side of transformer will have the top busbar arrangement for connection of HT side by means of cable and LT side by means of busbar.
  7. **Technical particulars of dry type transformer**

| **SR. NO.** | **DESCRIPTION** | **PARTICULARS** | |
| --- | --- | --- | --- |
| 01 | Type | Three Phase, 50 Hz, Core type, two winding, Cast Resin Dry type Transformer | |
|  | Make of transformer | Same as the make of compact substation | |
| 02 | Rating ( KVA ) | 1250 | |
| 03 | Winding material | Copper | |
| 04 | No load voltage ratio | 11 / 0.433 | |
| 05 | Connection   1. HV 2. LV | Delta  Star with neutral | |
| 06 | Vector group | Dyn 11 | |
| 07 | Insulation level (KVp/ KVrms)  a) HV  b) LV | 75 / 28  -/ 03 | |
| 09 | Type of Tap Changer for giving voltage variation to HV | Off ckt tap links | |
| 10 | Tapping range | +5 % to –5 % in step of 2.5% | |
| 11 | Temperature rise winding  over ambient temperature | 115 °C | |
| 12 | Class of Insulation | Class ‘H’ | |
| 13 | Enclosure | IP 00 ( Without Enclosure ) | |
| 14 | Method of Cooling | AN (Air Natural) | |
| 15 | No load losses at rated voltage & frequency (IS Tol.) | As per ECBC (latest updated) | |
| 16 | Full load loss at principle tap at 75º C (IS Tol.) | As per ECBC (latest updated) | |
| 17 | Termination  HV  LV | Cable  Busbar/BusLink | |
| 18 | Fittings for Dry type | | 2 Numbers Earthing Terminals, Rating and Diagram Plate, Bi-Directional Rollers, Lifting Lugs, Winding Temp Scanner. |

* 1. **PAINTING**
     1. All steel surfaces shall be thoroughly cleaned by sand blasting or chemical agents as required to produce a smooth surface free of scale, grease and rust. The external surface, after cleaning, shall be given a high quality red oxide or yellow quoted primer, followed by filler coats.
  2. **Routine Test**
     1. All Routine Tests in accordance with IEC 60076 / IS 2026 shall be carried out on each transformer.

1. **L.T. PANEL** 
   1. **System**:-
      1. **Declared voltage** :– 3 Phase,400V (±6%) 50 Hz,
      2. **Neutral** :– Solidly earthed at substation.
      3. **Busbar**– Aluminum
   2. **General finish**:- Tropical, totally enclosed, metal-clad, weather-proof, vermin and dust proof.
   3. **Construction :**
      1. **Enclosure**:- Dead Front type of enclosure shall be able to provide the degree of Protection IP:4X.
   4. **Circuit Ways:** As per Schedule
   5. **FOR GENERAL CHARACTERISTICS OF ACB - LT Panel Specification shall be referred for the same.**
2. **TYPE / ROUTINE TEST ON PACKAGE SUBSTATION**
   1. **TYPE TESTS FOR THE PACKAGE SUBSTATION:** 
      1. The Package Substations offered must be type tested as per IEC 61330/62271-202. The copy of type test summary should be submitted along with the tender. CSS manufactured in JV consortium shall not be accepted.
   2. R**outine Tests**: The routine tests shall be made on each complete prefabricated substation.
      1. Voltage tests on auxiliary circuit.
      2. Functional test.
      3. Verification of complete wiring.
      4. **Test Witness:** Routine test shall be performed in presence of Owner/PMC if so desired by them. The Contractor shall give at least fifteen (15) days advance notice of the date when the tests are to be carried out.
      5. **Test Certificates:** Certified reports of all the tests carried out at the works shall be furnished in three (3) copies for approval of the Owner/PMC.
   3. **Type Test Reports for Packaged Substation Enclosure:**
      * + - Tests to verify the degree of protection.
          - Arcing due to internal fault on HV side with sustained arcing of atleast 01-second and 20kA
          - Test to prove enclosure class - Temperature rise of the transformer inside the enclosure.
          - Short circuit test to prove the capability of the earthing circuits to be subjected to the rated peak and the rated short time withstand currents.
          - Tests to verify the withstand of the enclosure of the prefabricated substation against mechanical stress.

# SOLAR POWER GENERATION SYSTEM

**SCOPE OF WORK**

The general character and the scope of work to be carried out under this contract is illustrated in Schedule of work & Specifications. The Contractor shall as a System Integrator for providing an end to end Solution for the same, including but not limited to design, supply, erect, testing, commissioning of the required Solar Photo Voltaic power plant with accessories and peripherals like Solar inverter, cables, Cable termination & connections sockets & other suitable accessories, earthing, L T panels, Metering, DC system & Bus etc. and installation, performance testing, commissioning, warranty, etc. The contractor have to ensure the planning and smooth execution of the project. The Contractor shall carry out and complete the said work under this contract in every respect in conformity with the contract documents and with the direction of and to the satisfaction of the Engineer in charge. The contractor shall furnish all labour, materials and equipment as listed and specified otherwise, transportation and incidental necessary for supply, installation, testing and commissioning of the complete system through as described in the Specifications.

The Scope of these specifications includes civil works connected with the module mounting structure and other facilities described in the scope of work under special condition of contract.

The work shall be limited to 3 Phase AC Output at the LT Panel / Out Door ACDB near Inverter. Excluding Cabling, termination and associated work from Out Door ACDB to Main LT Panel. Although interfacing and commissioning for proper working shall be included in the above scope of work.

**TECHNICAL SPECIFICATIONS**

1. **Solar Photo Voltaic Module**
2. The Solar PV module will be minimum 250Wp 20V nominal rating
3. Solar modules offered shall be certified as per IEC 61215-2005 and IEC 61730 -1, -2.
4. SPV module shall contain Poly crystalline high power silicon solar cells. The solar cell shall have surface anti-reflective coating to help to absorb more light in all weather conditions.
5. The module frame shall be made of aluminium or corrosion resistant material, which shall be electrolytically compatible with the structural material used for mounting the modules .
6. Photo electrical conversion efficiency of SPV module shall not be less than 14%.
7. Fill factor of the module shall not be less than 0.70
8. Each module shall have low iron tempered glass front for strength & superior light transmission. It shall also have tough multi-layered polymer back sheet for environmental protection against moisture & provide high voltage electrical insulation.
9. Solar PV module shall be highly reliable, light weight and shall have a service life of more than 25 years.
10. The rated output of any supplied module shall not vary by more than 3% from the average power rating of all ratings. Each module, therefore, has to be tested and rating displayed. 1.10
11. The module shall perform satisfactorily in relative humidity upto 95% and temperature between – 40°C and 85°C.
12. The solar modules should have suitable encapsulation & sealing arrangements to protect the silicon cells from the environment. The encapsulation arrangement shall ensure complete moisture proofing for the entire life of solar modules.
13. Contractor must consider Shading Losses as per the relevant Industry Standard & Practice while designing the proposed power plant.
14. Guarantee on power output of solar module will be as follows:-

|  |  |
| --- | --- |
| **End of Year** | **Guaranteed Output** |
| 1 | 98.5% |
| 10 | 90% |
| 25 | 80% |

1. Marking:Each module shall carry the following clear and indelible markings:-

* name, monogram or symbol of manufacturer;
* type or model number;
* serial number;
* RFID Tag
* polarity of terminals or leads (colour coding is permissible)
* maximum system voltage for which the module is suitable
* date & place of manufacture;

1. **Module Mounting Structure**

The Plant and equipment will be installed on the civil foundation/structures to be constructed by the Contractor. the contractor shall make arrangement for the foundation or anchor bolts or other embedment’s etc.

The array structure shall be so designed that it will occupy minimum space without scarifying the output from SPV panels.

1. Design drawings with material selected shall be submitted for prior approval of Owner/PMC
2. The structure shall be designed to allow easy replacement of any module & shall be in line with the site requirements.
3. The array structure shall be made of hot dipped galvanized MS angles of suitable size.
4. The support structure design & foundation shall be designed to withstand wind speed upto 150 kmph using relevant Indian wind load codes.
5. The module alignment & tilt angle shall be calculated to provide the maximum annual energy output. This shall be decided based on the location of array installation.
6. All fasteners shall be of stainless steel of grade SS 304.
7. The array structure shall be grounded properly using maintenance free earthing kit
8. Galvanized Steel Structural must be considered for all type of structural steel proposed for the power plant
9. The mounting of solar modules shall be done on rooftop and entire Fabrication of elevated structure and the structure atop sloping roofs shall be done by the Contractor.
10. **POWER CONDITIONING UNIT (STRING INVERTER)**

String Inverter shall supply the DC energy produced by array to DC bus for inverting to AC voltage using its MPPT (Maximum Power Point Control) control to extract maximum energy from solar array and produce 415V AC(±5%), 3 phase, 50 Hz to synchronize with the grid through LT panels.

1. MPPT controller, inverter and associated control and protection devices etc. all shall be integrated into String Inverter.
2. The rating of String Inverter shall be suitable to the capacity offered
3. String Inverter shall provide 3 phase, 4150+/-2% V, 50+/-0 0.5 Hz supply on AC side with THD<3%.
4. DC voltage ripple content shall not be more than 3%.
5. Efficiency of String Inverter shall not be less than 94%.
6. Degree of protection of String Inverter housing should not be less than IP-55
7. It shall have protection features such as over voltage, short circuit, over temperature etc.
8. The inverter shall be efficient based on MPPT with IGBT reliable power based design.
9. The system should be capable of providing all the data including that of meter and String Inverter to the central software. All the equipments /hardware /software for complying to the same shall be ensured by contractor. The STRING INVERTER shall be capable of complete automatic operation, including wake-up, synchronization & shut down.
10. String Inverter shall have facility to display basic parameters of the system.
11. String Inverter shall be capable to synchronize independently & automatically/to be phase locked with Power Supply Authority grid power line frequency to attain synchronization & export power generated by the solar panel to Power Supply Authority grid.
12. Inverter shall be tested for islanding protection performance.
13. Only isolated inverters shall be used.
14. **Indications** (through LEDs & LCD display)

* Inverter ON
* Grid ON
* Inverter under voltage/over voltage
* Inverter over load
* Inverter over temperature.

1. **Protections:**

* Over voltage both at input & output
* Over current both at input & output
* Over/under grid frequency
* Over temperature
* Short circuit
* Protection against lightening
* Surge voltage induced at output due to external source.

1. Provision shall be available in the String Inverter for remote monitoring of following parameters
   * + DC power input
     + DC input voltage
     + DC current
     + AC power output
     + AC voltage (all the 3 phases and line )
     + AC current ( all the 3 phases and line)
     + Power factor

In addition to the above, energy values to be displayed

* The number of String Inverter and System voltage is indicative only. The contractor shall design the system to extract maximum efficiency with inbuilt redundancy.

1. **AC Distribution:**

Panels/Boards shall be suitable for operation on three phase, 415 volts, 50 cycles, 2+E wire system. All Distribution panels shall be CPRI tested design and manufactured by an approved manufacturer. All panel boards shall be IP 55 or better.

Distribution panels shall comply with the latest Relevant Indian Standards and Electricity Rules and Regulations and shall be as per IS-13947-1993. Distribution panels shall be 2 mm thick sheet steel cabinet for outdoor installation, Double front, wall mounting type and shall be form 1b construction. The Distribution panels shall be totally enclosed, completely dust and vermin proof and shall be with hinged doors and folded covers, Neoprene gasket, padlocking arrangement and bolted back. All removable/ hinged doors and covers shall be grounded by flexible standard connectors. Distribution panel shall be suitable for the climatic conditions as specified in Special Conditions. Steel sheets used in the construction of Distribution panels shall be 2 mm thick and shall be folded and braced as necessary to provide a rigid support for all components. The general construction shall confirm to BIS-8623-1977 (Part-1) for factory built assembled switchgear & control gear for voltage upto and including 1100 V AC.

Bus bar and interconnections shall be of high conductivity electrolytic grade copper as complying with requirement of IS : 5082 – 1981 and of rectangular cross section suitable for carrying the rated full load current and short circuit current. Bus bars and interconnections shall be insulated with heat shrinkable sleeve of 1.1 KV grade. Bus bars shall be supported on glass fiber reinforced thermosetting plastic insulated supports at regular intervals to withstand the force arising from in case of short circuit in the system. Maximum current density for the busbars shall be 1.4 A/sq.mm for copper busbars.

1. **Surge protection system**

The DIN channel mountable pluggable surge protection shall be installed in a network configuration, consisting of a single block MOV (Metal Oxide Varistor) based surge arrester having nominal surge handling capacity of 15 KA 8/20 µs &  maximum surge handling capacity of 30 KA 8/20 µs to provide protection between (L+, L-, earth). All surge arresters in these network configurations shall be of same manufacturer.  The Protection unit shall be based on Single block High Capacity Metal Oxide Varistors (MOV), capable of handling 15 KA 8/20 μs surges and shall be able to give an indication in the event module failure and shall be pluggable to facilitate the onsite replacement without disturbing the lines. One extra set of replacement protective device shall be furnished to the job site. Protection shall be manufactured to withstand a maximum continuous operating voltage of not less than 115% of normal RMS system voltage

1. **Cables and Hardware**

Cables of appropriate size to be used in the system shall have the following characteristics:

* + - Will meet IS 694/1554 standards
    - Temp. Range –10ºC to +80ºC.
    - Voltage rating 660/1000V
    - excellent resistance to heat, cold, water, oil, abrasion, UV radiation
    - Flexible

Cabling on DC side of the system shall be as short as possible to minimize the voltage drop in the wiring. The construction of DC Cable shall be in a two layer construction with a low smoke halogen-free, flame retardant and sunlight resistant cross-linked compound outer layer and halogen-free thermoset polyolefin inner layer.

* + - Suitable for continuous operating temperature of 90°C wet or dry
    - Vertical Flame Performance: EN 60332-1
    - Excellent UV and Ozone resistant
    - Suitable for wet, damp and humid locations
    - Specially designed for excellent flexibility
    - Compatible with all major connectors
    - Cold bend and impact: -40°C

1. **ENERGY METER**
2. An Energy Meter shall be provided as approved by the Owner/PMC to measure the delivered quantum of energy to the Street Lighting load.
3. Meter must be provided with the RS485 port.
4. Energy Meter should be import/export type ABT compliant, 0.5 Class of accuracy and must be modbus compliant for further integration with Central Monitoring Systems.
5. **INSTALLATION & COMMISSIONING**
6. Detailed project execution programme shall be submitted by the contractor. He shall be responsible for arranging all the tools /tackles and manpower for installation and commissioning of the complete system.
7. The contractor shall provide all necessary hoists, ladders, scaffoldings, Transportation of labour and materials necessary for proper execution and completion of the work.
8. The contractor during the execution of work shall coordinate with other agencies/existing associated work with the project and shall work in harmony with them without causing any hindrance or obstruction to the work.
9. **CONCRETE WORK**
10. Plain Concrete work: Providing and laying of Plain cement concrete of M-20 Grade, PCC 1:2:4 (1 cement : 2.0 Coarse sand : 4 Graded Stone aggregate), in foundation for module mounting structure, including ramming, dewatering, shuttering, shoring, strutting, curing tec. Complete in all respect.

# ENERGY AND POWER MANAGEMENT SOFTWARE

**Software - General:**

1. Furnish a dedicated, edge control, software platform (The Software Platform) that is purpose-built to be the operational interface for an Energy and Power Management System (EPMS) whose primary purpose is to support the provision and management of safe, reliable and efficient power within buildings and facilities. The Software Platform shall have specialized data acquisition, visualization, analysis and reporting tools specifically designed for Power Management applications such as:
   1. Electrical Distribution System Monitoring and Alarming.
   2. Electrical System Capacity Management.
   3. Power Quality Monitoring and Compliance.
   4. Multi Source Management.
   5. Continuous Electrical Thermal Monitoring.
   6. Breaker Setting Monitoring.
   7. Backup Power Testing.
   8. Power Events Analysis.
   9. Energy Usage Analysis and Energy Benchmarking.
   10. Utility Bill Verification and Cost Allocation.
   11. Energy Performance Analysis and Verification.
2. The Software Platform shall natively support (no additional installation or configuration of the software required) at least 112 devices specifically designed for power distribution and power quality monitoring including: programmable power analyzers, power meters, branch and multi-circuit meters, smart panels with communicating circuit breakers, protection relays, uninterruptable power supplies, active harmonic filters, capacitor bank controllers, electrical distribution thermal sensors.
   1. All registers shall be pre-mapped to standard measurement names – no additional register mapping required.
   2. All native device types will come with a comprehensive set of a factory device graphical screens – no additional graphics creation or installation required.
   3. All native device types have been factory-tested and proven to perform.
3. The Software Platform’s web applications shall be simultaneously accessible from their unique web addresses so that they may be embedded in other web-based software environments.
4. The functionality of the Software Platform shall be extensible whereby additional capabilities may be added via software license activation codes without the need to install additional software modules or add-ons.
5. The Software Platform shall be certified for use as a part of an ISO50001/50002 program and verifiably support compliance. In addition, the functionality shall support ongoing ISO50001 programs per the following areas of Section 4 of the ISO standard:
   1. Energy review.
   2. Energy baseline.
   3. Energy performance indicators.
   4. Monitoring, measurement, and analysis.
   5. Input to management review.
6. The Software Platform shall be designed to comply with cybersecurity standard IEC62443 at the component level: IEC62443-4-1 and IEC62443-4-2 (SL1).
7. The Software Platform shall be designed to streamline the process of checking and maintaining EN50160 and IEEE 519 Power Quality compliance.
8. The Software Platform shall natively support the vendor's continuous electrical thermal monitoring system with the ability to detect abnormal bus bar or cable temperatures due to loose or faulty connections and to prevent equipment damage and fire.
9. The Software Platform shall be designed to integrate and embed within the vendor’s Building Management System (BMS) software platform to provide Energy and Power Management applications within the context of the BMS environment.

**Software - Real Time Monitoring:**

1. The Software Platform shall support Auto Network Diagram Creation whereby a comprehensive set of linked hierarchical graphical diagrams is automatically created for all directly connected devices in the power monitoring network.
2. The Software Platform shall support advanced power quality meters with onboard High Speed Power Analysis with Disturbance Direction Detection (DDD) capabilities and come equipped with a built-in set of real-time graphical indicators for use in electrical one-line diagrams that indicate:
   1. The type of Power Quality Disturbance (sag, swell, transient).
   2. The direction of Power Quality Disturbance relative to the compliant DDD device (upstream, downstream).
3. The Software Platform shall provide real-time indication of the aggregated demand being measured by one or more devices in a predefined zone. The application shall allow:
   1. The demand for the zone to be expressed using either Kilowatts or normalized Kilowatts/Area.
   2. Visual indication of how the present demand for a zone compares with four (4) configurable limits / targets using a color scale.
   3. Configurable limits shall be further configurable to allow for the use of different values during an On-Peak period compared to an Off-Peak period.
4. The Software Platform shall allow web client users to quickly and easily create interactive dashboard visualization of any real-time measurements that:
   1. Display tabular and trend line views to compare device readings from multiple devices in the power monitoring network including power meters, circuit breakers, protection relays, uninterruptable power supplies, automatic transfer switches and generators.
   2. Permit users to create, modify, view and share views directly from the web client browser without the need for a separate software application.
   3. Support both physical and virtual devices defined in the system.
   4. Support exporting real time data into Excel formats directly from the web client browser environment.

**Software – Alarm and Event Analysis and Notification:**

1. The Software Platform shall be able to acquire specialized, high speed power disturbance data directly from onboard advanced power quality meters for the purpose of Power Events Analysis, including:
   1. Timestamped Power Events with Disturbance Direction Detection (DDD).
   2. Timestamped high speed (1/2 cycle sample rate) pre/post event RMS data.
   3. Pre/post event waveform captures (Voltage and Current all phases).
2. The Software Platform shall provide a web based power events analysis application that includes but is not limited to the following features:
   1. Automatic, intelligent clustering of events into alarms and multiple alarms from multiple devices into “incidents” to simplify the analysis of multiple cascading events.
   2. Automatic categorization of alarms and incidents into predefined categories such as Power Quality, Power Availability, Diagnostics and Other.
   3. Predefined views for events, alarms and incidents with intuitive navigation and easy to use, configurable filters based on priority, status, source and categories.
   4. Ability to create private or shared event, alarm and incident views with custom filters.
   5. Popup window with detailed information about where, what and when an alarm or incident happened, plus other relevant information including Power Quality details and a thumbnail summary view of all waveforms associated with the alarm or incident.
   6. For Power Quality alarms or incidents captured by Disturbance Direction Detection (DDD) compliant devices there shall be clear graphical indication of the direction of the disturbance (upstream or downstream relative to the DDD compliant device).
3. The Software Platform shall provide a graphical timeline view of alarms and events that constitute an “incident” in the electrical distribution network. The timeline view shall:
   1. Display alarms/events stacked by order of time for sequence of events analysis.
   2. Display the start and end of alarms/events with color-coded dots.
   3. Indicate the direction of a Power Disturbance and if there are captured waveforms associated with the incident.
   4. Have a configurable analysis window with a color-coded time slider that uses color to indicate areas in the timeline where there are greater numbers of alarms.
   5. Be able to display pre- and post-event high speed RMS data coming from supported power quality meters.
4. The Software Platform shall include a web-based Smart Waveform Analyzer interface with the following capabilities:
   1. Toggle on/off Voltage/Current channels.
   2. RMS calculation, zoom, pan, export to CSV.
   3. Interactive phasor and harmonic (voltage and current) diagrams.
   4. Allow multiple waveforms to be compared to each other.
5. The Software Platform shall include an alarm annunciator to display the total number of unacknowledged alarms with a breakdown of how many are high, medium and low priority and shall allow easy navigation to the alarm viewer with a single click.
6. The Software Platform shall provide the ability to send email notifications based on recent changes to the system which will be used to formulate notification types including:
   1. Communication Loss Notification – sent when the Software Platform loses communication with selected devices.
   2. Alarm Summary Notification – sent regularly to indicate changes in the average amount of high, medium, and low priority alarms.
   3. Power Quality Event Notification – sent regularly to indicate changes in the average amount, duration, and magnitude of Sag, Swell and Transient power disturbances.
7. The Software Platform shall have a web-based Alarm Configuration interface to allow end users to create smart alarms with the following capabilities:
   1. Realtime Analog and Digital Setpoints with options for time delays and custom alarm labels.
   2. Smart Over/Under Setpoints designed specifically for energy (WAGES) and power alarms based on historical average, standard deviation or maximum with options for time ranges, aggregation periods, multipliers and ability to compare specific time periods (Same Hour of Day and/or Same Day of Week).
   3. Communication Loss alarms with options for sensitivity and custom alarm labels.
   4. Schedules interface for end users to configure when smart software alarms are active or not.

**Software – Data Analytics and Visualization:**

1. The Software Platform shall include an interactive, web-based Dashboard application that provides auto-updating dashboard views that may contain not only energy and power data but water, air, gas, electric, and steam (WAGES), historical data trends, power quality performance data, images, and content from any accessible URL address.
2. Users shall be able to create, modify, view, and share their dashboards (including graphics, labels, scaling, measurements, date ranges, etc.) using only a browser and without the need for a separate software application to design, create, modify or publish dashboards.
3. The Software Platform shall support kiosk slideshow displays by assigning individual dashboards to slideshows to run in unattended mode, scrolling through designated dashboards at a configurable time interval.
   1. Any number of kiosk slideshow displays may be created and configured to run independently on any computer using a browser.
4. The Dashboard application shall provide a library of standard graphical objects (gadgets) including Bar, Pie, Trend, Real Time and Web Portal.
5. The Dashboard application shall provide a library of specialized energy usage graphical objects (gadgets) including Period Over Period Comparison, Pareto Charts, Heat Map / Carpet Plot and Sankey Diagrams.
6. The Dashboard application shall provide a library of specialized Power Quality graphical objects (gadgets) including PQ Downtime Impact, PQ Rating, PQ Incident Breakdown and Location.
7. The Software Platform shall provide an interactive, web-enabled Reports application that allows users to generate, modify, save and manage reports based on pre-formatted report templates (up to 64 templates) that are designed to support the following:
   1. Energy Cost Allocation and Bill Verification.
   2. Energy Usage, Modeling and Performance Verification.
   3. Power Quality Performance and Compliance (EN50160 and IEEE 519).
   4. Electrical Equipment Operation and Performance (Breakers, UPSs, Generators).
8. The reporting tool shall support automatic distribution (via email or shared folder) on a schedule basis or based on event or manual export using the following output formats: .csv, .xlsx, .pdf, .tiff, .html, .xml.

**Software – Technical Infrastructure:**

1. The Software Platform shall be able to be installed on a physical computer or virtual machine and shall support a variety of Windows operating systems including Server and non-Server class Windows operating systems.
2. The Software Platform shall support a variety of SQL Server Editions including Enterprise, Standard and Express Editions.
3. The Software Platform shall only require SQL Server Database Engine Services and Basic Management Tools and not require the installation of any other additional SQL components such as Analysis Services or Reporting Services.
4. The Software Platform shall support the following cybersecurity features:
   1. Encrypt the transmission of data between the Software Platform Server and its Web Clients using Transport Layer Security (TLS) version 1.2.
   2. Establish secure authentication between the Software Platform Server and its Web Clients using Certification Authority (CA) certificates.
   3. Encryption and hashing of system credentials using AES256 and SHA-512 respectively.
   4. Capable of installing into a Federal Information Processing Standard (FIPS) compliant environment.
   5. Application Whitelisting.
5. The Software platform shall support the integration of Windows Active Directory for users and groups from across multiple domains to facilitate the following:
   1. Login to the Software Platform using Windows credentials.
   2. Enforce password policies via Windows (complexity and expiration).
   3. Role-Based Access Control (RBAC).
6. The Software Platform shall intelligently and automatically acquire data from devices, including onboard events, trends and waveforms from natively-supported device types:
   1. Without any need for software configuration or data upload scheduling.
   2. Onboard, high resolution timestamps (1ms) shall be retrieved without degradation or modification even for devices that support clock synchronization via GPS, IRIG-B, NTP or PTP (Precision Time Protocol).
7. The Software Platform shall support logical device definitions based on inputs/outputs or channels on devices that represent a downstream device with the following features:
   1. Software user interface for device and measurement mapping.
   2. Bulk-import capability to create large numbers of logical devices without manual single-device configuration.
8. The Software Platform shall support real-time and historical data aggregation within defined hierarchy views (e.g. Tenants/Racks/Circuits, PDUs/RPPs/Panels, Buildings/Floors/Rooms, or any user defined view) with the following capabilities:
   1. Web-based, end user interface.
   2. Automatic and intelligent data aggregation across all nodes in the hierarchy for data visualization in Dashboards, Trends and Reports.
   3. Creation of virtual devices to enable applications such as net metering, common area allocation and apportionment.
   4. Update node names and associated time ranges in the hierarchy to properly reflect and accurately report on facility changes (e.g. tenant move in – move out).
   5. Bulk-import capability to create and edit large hierarchies without manual per-device setup.
9. The Software Platform shall support OPC DA Server 2.01 with the following capabilities:
   1. Provide default OPC Server tag mappings for all natively supported device types without the need to select, configure, or program the mapping of device registers to OPC tags.
   2. Provide a flexible means to add or change OPC mappings and shall support the ability to add custom measurements.
10. The Software Platform shall support OPC DA Client 2.01 and come with a built in OPC Test Client.
11. The Software Platform shall support device-level Modbus integration with the following capabilities:
    1. Modbus master to read/write registers in Modbus devices for monitoring and control applications.
    2. Support for at least 70 Modbus data formats including 16bit Signed/Unsigned Integers (S16-21, S16-12, U16-21, U16-12, S16-1-15), 16bit Signed/Unsigned Array (U16-21-ARRAY U16-12-ARRAY), 32bit Signed/Unsigned Integers Big-Endian and Little-Endian (S32-4321, S32-1234, U32-4321, U32-1234), 64bit Signed/Unsigned Integers (S64-21-87, U64-21-87, S64-87-21, U64-87-21), Signed/Unsigned Modulo10000 (S32-M10k-4321, S32-M10k-1234, U32-M10k-4321, U32-M10k-1234, S64-M10k-21-87, U64-M10k-21-87, S48-M10k-21-65, U48-M10k-21-65, S48-M10k-65-21, U48-M10k-65-21), Signed/Unsigned Modulo1000 (S64-M1K-87-21 U64-M1K-87-21), IEEE Float/Swapped Float (F32-4321, F32-1234, F64-87-21, F64-12-78), ASCII/ASCII Reverse, Packed Boolean/ Masked Boolean, Inverted Masked Boolean, Binary Coded Decimal (BCD, Packed BCD), Formats for Power Factor (PF Nexus, PF32, PF\_ALT), Formats for Date-Time (DateTime4\_UTC, DateTime4\_LOCAL, DateTime4, DateTime3\_UTC, DateTime3\_LOCAL, DateTime3, DateTime\_YMDhms\_UTC, DateTime\_YMDhms\_LOCAL, DateTime\_YMDhms, DateTime\_IEC870\_UTC, DateTime\_IEC870\_LOCAL, DateTime\_IEC870, DateTime3\_IEC870\_UTC, DateTime3\_IEC870\_LOCAL, DateTime3\_IEC870, DateTime3\_MDYhms\_UTC, DateTime3\_MDYhms\_LOCAL, DateTime3\_MDYhms, DateTime4\_MDYhms\_UTC, DateTime4\_MDYhms\_LOCAL, DateTime4\_MDYhms, DateTime2\_s2000, DateTime3\_s2000, DateTime4\_shmMDY, DateTime6\_smhDMY, DateTime7\_YMDhms, DateTime8\_MDYdowhmsc, DateTime6\_MDYhmms, DateTime\_NSX2\_UTC, DateTime\_NSX2\_LOCAL, DateTime\_NSX3\_UTC, DateTime\_NSX3\_LOCAL).
12. The Software Platform shall have a single, end user software application specifically designed for integrating Modbus and OPC device types and shall have the following capabilities:
    1. Simple creation and management of Modbus and OPC device definitions (device drivers) and association of device graphic template screens.
    2. Pre-defined, default measurement system (Common Data Model) for consistent mapping of Modbus registers and OPC tags to standard measurements.
13. The Software Platform shall support Web Services interoperability with the following capabilities:
    1. Web Services Server for sharing real-time, historical (i.e. timestamped trend data), and alarm data (i.e. timestamped event strings) from the Software Platform to other Web Services Client applications.
    2. User interface for Web Services configuration and mapping.
    3. Provide the ability to acknowledge alarms by authenticated and authorized clients.
14. The Software Platform shall have an Extract, Transform, and Load (ETL) engine for exchanging data between files, databases and systems with the following capabilities:
    1. User Interface for specifying connection information, data formats, measurement mappings and schedules.
    2. Support for importing data from .csv and .xml data files, Wonderware Historian databases and other 3rd party databases via OleDB connections.
15. The Software Platform shall support system-wide programs using a graphical, object-oriented application engine capable of logic and arithmetic functions, database queries, XML data import, complex logic-based alarming and data logging, email and text notifications.
16. The Software Platform shall remain online (including communications, logging, and alarming) and not require an operator to take the system offline during all system administration functions such as adding, modifying, or removing devices in the system; creating, modifying, or removing graphical diagrams, dashboards, tables, and reports; creating, modifying, or removing application logic programs in the application logic engine.
17. The Software Platform shall support offline software configuration management for efficient system deployments and upgrades with a dedicated user interface for creating, copying and deploying software configuration projects.
18. The Software Platform shall support internationalization and regional settings.
19. The Software Platform shall provide factory support for the following languages: Chinese (Simplified), Chinese (Traditional), English, French, German, Italian, Russian, Spanish, Polish, Czech, and Swedish.
20. The Software Platform shall support the ability to change its default language at any time directly from the web client without the need for any additional installation or advanced software configuration.

# LOW VOLTAGE ACTIVE HARMONIC FILTERS (to 480 VAC)

Design, Manufacture, Testing, Supply, Installation, Erection and commissioning of 3ph, Active Harmonic filter to compensate harmonic generated by Non linear loads connected.

Supply of Cable, Lugs, Accessories for Cable laying etc.

Cable laying is under the scope of supplier.

Supply of CTs (where ever required) for sensing harmonic current accurately is under the scopeof supplier.

Providing suitable space for all installation of AHF system and associated equipment.

Providing Air Conditioning system for cooling of AHF in case ambient is above 40Deg.

Clearance from Electrical inspectorate / state government authorities and/or any other concerned department.

**Criteria:**

The AHF manufacturer should be OEM.

Should be engaged in Design, Manufacturing of AHF for minimum 15 years.

Turn over should be minimum 2Billioon INR.

Should have dedicated Service team to attend any complaint within 24 hours.

The AHF should be type tested in third party lab – type test certificate should be provided when ever requested.

**Minimum Technical feature of AHF:**

* The AHF should be designed to respond within 25micro Sec.
* IGBT Switching frequency should be 20kHz.
* The CT shall be provided either Load end or Source end, the AHF should be capable of working in either condition.
* The AHF should work irrespective of CT Secondary (either 1A or 5A)
* The AHF should have the below mandatory features:
* IGBT 3 layer topology.
* Modular construction (number of un equal rated AHF can be paralleled seamlessly).
* Target setting of THDI%.
* Target setting of THDV%.
* Losses <2%.
* Ambient working upto 40Deg C.
* AHF should have capabilities as below:
* Load balancing.
* PF correction.
* Sag/Swell/flicker detection and correction (Origin of Sag/Swell/flicker can be Load or Grid).
* Harmonic cancellation from 2nd to 51st harmonic.
* Selectable individually from 2nd to 51st seamlessly.
* AHF should have HMI – for configuration, display with in built 3 channel Oscilloscope that can display waveforms, Bar graphs, phase angle, PF, Internal health monitoring, Fault logs etc.

**AHF Rating:**

* 300A, 440V, 3ph, 50Hz, 3level IGBT converter technology.
* 300A should be one incomer MCCB of rating 630A.
* The enclosure should be of IP31.

**Specification of Active Harmonic filter**

**PART 1 ‑ GENERAL**

1. **RELATED DOCUMENTS**
   1. Drawings and general provisions of the Contract, including General Conditions, and other applicable specification sections in the Project Manual apply to the work specified in this Section.
2. **SUMMARY**
   1. **Scope:** Design, Engineering, Manufacture of Active Harmonic Filter for harmonic filtering, Load balancing and Power Factor correction purpose (all three or any one of them). The sizing to be done accordingly.
   2. **Section Includes:** The work specified in this Section includes, but shall not be limited to, active harmonic filter as specified herein and as indicated or scheduled on the Drawings.
3. **REFERENCES**
   1. **General:** The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.
   2. **American Bureau of Shipping (ABS):**
      1. ABS 0001, "Rules for Building and Classing Mobile Offshore Drilling Units (MODU)."
      2. ABS 0002, "Rules for Building and Classing Steel Vessels."
   3. **Institute of Electrical and Electronics Engineers, Inc. (IEEE):**
      1. ANSI/IEEE 519 - 2014, "Guide for Harmonic Control and Reactive Compensation of Static Power Converters."
   4. **American Society of Civil Engineers (ASCE):**
      1. ASCE 7, "Minimum Design Loads for Buildings and Other Structures."
   5. **ASTM (ASTM):**
      1. ASTM E 329, "Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction."
   6. **Canadian Standards Association (CSA):**
      1. CSA C.22.2 No. 14, “Industrial Control Equipment.”
      2. CSA C.22.2 No. 66, “Specialty Transformers, Industrial Products.”
   7. **Federal Communications Code**:
      1. Electromagnetic Standard FCC 15j, Class A
   8. **International Code Council (ICC):**
      1. ICC IBC, "International Building Code."
   9. **International Electrotechnical Commission (IEC):**
      1. IEC 60529, “Degrees of Protection Provided by Enclosures (IP Code).”
      2. CE EMC Certification IEC/EN 60439-1, EN 61000-6-4 Class A, EN 61000-6-2
   10. **National Electrical Manufacturers Association (NEMA):**
       1. NEMA 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)"
   11. **National Fire Protection Association (NFPA):**
       1. NFPA 70, "National Electrical Code" (copyrighted by NFPA, ANSI approved) ‑ hereinafter referred to as NEC.
       2. NFPA 70E, "Standard for Electrical Safety Requirements for Employee Workplaces" (copyrighted by NFPA, ANSI approved).
       3. NFPA 5000, “Building Construction and Safety Code.”
   12. **Underwriters Laboratories, Inc. (UL):**
       1. UL 508, "Standard for Industrial Control Equipment."
       2. UL 1449, "Standard for Transient Voltage Surge Suppressers."
4. **SYSTEM DESCRIPTION**
   1. **Performance Requirements:**
      1. **General:** Active harmonic filter (AHF) shall be defined as a power electronic device consisting of power semiconductors known as insulated gate bipolar transistors (IGBT) that switch into the AC lines to modulate its output to mitigate detrimental harmonic current; correct the displaced reactive current (leading or lagging); and balance the current (also known as negative sequence current) for the power source.
         1. Converter design shall be a three-level design to optimize performance and minimize heat losses.
      2. Performance as defined assumes a properly sized AHF and impedance installed on nonlinear loads. Impedance shall be 3% or larger on every nonlinear loads.
         1. THD(v) shall be limited to not more than 5 percent as contributed by the loads at the location of each AHF. A THD(v) set point may be set to optimize performance of the AHF and maintain less than THD(v) set point. [Note: AHF cannot remedy THD(v) that is caused by other electrical systems or devices that AHF is not connected to remedy.]
         2. \*THD(i) shall be limited to 3% or less as long as AHF is 50% or more loaded and all nonlinear loads have 3% or larger input impedance. A THD(i) set point may be set to optimize THD(i) performance.
         3. \*Displacement power factor (PF) shall be corrected to 0.95 or better at the location of each AHF.
            1. Displacement PF shall never go leading due to AHF performance or design.
         4. \*Source current imbalance shall not exceed 2% phase-to-phase after correction.

(\*Sizing should be done accordingly)

* 1. **Service Conditions:** Active harmonic filter shall be suitable for the following conditions:
     1. **Operating Ambient Temperature Range:** 32°F (0 °C) to 104 °F (40 °C) maximum for floor standing units.
        1. Wall mount units rated less than 300A shall have an operating temperature range of 32°F (0 °C) to 113 °F (45 °C). 300A units shall be rated for 32°F (0 °C) to 104 °F (40 °C) maximum.
        2. Temperature derating shall be 2% per °C to 50°C (134°F) maximum ambient temperature.
     2. **Maximum Altitude:** 3300 feet (1000 m) with derating at 1% per 100 meters
     3. **Humidity:** to 95 percent, non‑condensing.

1. **SUBMITTALS**
   1. **Product Data:** Submit product data showing material proposed. Submit sufficient information to determine compliance with the Drawings and Specifications.
   2. **Shop Drawings:** Submit shop drawings for each product and accessory required. Include information not fully detailed in manufacturer’s standard product data.
   3. **Wiring Diagrams:** Submit wiring diagrams detailing power, signal, and control systems, clearly differentiating between manufacturer‑installed wiring and field‑installed wiring, and between components provided by the manufacturer and those provided by others.
2. **QUALITY ASSURANCE**
   1. **Qualifications:**
      1. **Manufacturer Qualifications:** Manufacturer shall be a firm engaged in the manufacture of low voltage active harmonic filters of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of 15 years.
      2. **Installer Qualifications:** Installer shall be a firm that shall have a minimum of five years of successful installation experience with projects utilizing low voltage active harmonic filters similar in type and scope to that required for this Project.
      3. **Inspecting and Testing Agency Qualifications:** To qualify for acceptance, an independent inspecting and testing agency hired by the Contractor shall demonstrate to the Architect/Engineer’s satisfaction that they are qualified according to ASTM E 329 to conduct testing indicated.
   2. **Regulatory Requirements:** Comply with applicable requirements of the laws, codes, ordinances, and regulations of Federal, State, and local authorities having jurisdiction. Obtain necessary approvals from such authorities.
   3. **Electrical Components, Devices, and Accessories:** Electrical components, devices, and accessories shall be listed and labeled as defined in NEC, Article 100, by an inspecting and testing agency acceptable to authorities having jurisdiction and marked for intended use.
   4. **Pre‑Installation Conference:** Conduct pre‑installation conference in accordance with. Prior to commencing the installation, meet at the Project site to review the material selections, installation procedures, and coordination with other trades. Pre‑installation conference shall include, but shall not be limited to, the Contractor, the Installer, and any trade that requires coordination with the work. Date and time of the pre‑installation conference shall be acceptable to the Owner and the Architect/Engineer.
3. **DELIVERY, STORAGE, AND HANDLING**
   1. Deliver materials to the Project site in supplier’s or manufacturer’s original wrappings and containers, labeled with supplier’s or manufacturer’s name, material or product brand name, and lot number, if any.
   2. Store materials in their original, undamaged packages and containers, inside a well‑ventilated area protected from weather, moisture, soiling, extreme temperatures, and humidity.
4. **PROJECT CONDITIONS**
   1. **Environmental Requirements:** Do not install low voltage active harmonic filters until space is enclosed and weatherproof; wet work in space is completed and nominally dry; work above ceilings is complete; and ambient temperature and humidity conditions are and will be continuously maintained at values equal to final occupancy.
5. **WARRANTY**
   1. **General:** 12 months from the date of installation or 18 months from the date of delivery whichever is earlier.
   2. **Additional Owner Rights:** The warranty shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to and run concurrent with other warranties made by the Contractor under requirements of the Contract Documents.

**PART 2 ‑ PRODUCTS**

1. **MANUFACTURERS**
   1. **Basis of Design:** Products specified shall be manufactured by Schneider Electric. Items specified are to establish a standard of quality for design, function, materials, and appearance. Equivalent products by other manufacturers are acceptable. The Architect/Engineer will be the sole judge of the basis of what is equivalent.
2. **EQUIPMENT SIZE/RATINGS**
   1. Active harmonic filter (AHF) shall be designed to operate from an input voltage of 380 volts AC to 480 volts AC, plus 10 percent, minus 15 percent at each nominal voltage.
   2. AHF shall be designed to operate with an AC supply frequency of 50 Hz or 60 Hz, +/- 3 Hz.
   3. AHF heat losses shall not exceed more than 3 percent of the unit kVAR rating.
   4. AHF amperage output ratings shall be 60, 120, 200, and 300 amperes.
      1. Actual ratings required are detailed in the electrical one-line drawings in this document.
      2. Up to 10 units of any size combination shall be able to be paralleled to inject current according to the information received from one set of supply current transformers (CTs) located at the source of supply for loads and all active harmonic filter. This known as closed loop logic and CT location.
      3. When parallel units are employed if one or more units is off line, the remaining units shall adjust their total output to attempt to make up for the unit(s) off line.
      4. All units operating in parallel shall have a common digital series communications connection between all of them.
      5. Each unit that receives the primary CT is considered a master unit. If any master is off line, another master shall control the system.
      6. Units not receiving primary CT are considered slaves.
      7. AHF that turns off all units when one is taken offline in the parallel arrangement is not acceptable.
      8. AHF that shut off the nonlinear loads (i.e. VSD) when AHF faulted is not acceptable.
   5. All floor standing units shall provide incoming bus bar terminations for both top and bottom entry. At least two cables per phase may be landed.
   6. AHF floor standing units shall include a door-interlocked circuit breaker rated at 200,000 AIC (amperes of interrupt capacity) at rated voltage up to 480 VAC.
   7. An energy saving feature shall be provided to permit stopping AHF when load goes below a desired set point (10% factory setting) and turn on at some higher set point (15% factory setting)
   8. Safety features include a dead front design where upon opening the enclosure door on floor standing units. Extreme measures must be taken to bypass this safety dead front desing. To perform service the enclosure door should never be opened without locking out the upstream feeder breaker.
      1. Incoming power shall be connected to the input circuit breaker within a power cable entry plenum. Once cable installation is complete and plenum covers are re-installed there shall be no access to incoming cabling.
   9. A service port is provided in the front cover of each unit chassis (IP00) such that with power disconnected a USB connection from a laptop computer may examine past performance and review all parameter set points and the event log. This may be used for commissioning or service.
3. **ACTIVE HARMONIC FILTER UNIT**
   1. **Enclosure:** Provisions shall be made for locking disconnects in the off position. Provisions for additional padlocking shall be made by the Owner using an approved lockout/tag-out device.
      1. AHF shall be provided in IP31 enclosure with bottom cable entry.
      2. When noted in the electrical one-line drawings, the AHF shall be incorporated into MCC or switchboard assemblies. This applies to all ratings up to 300 amperes.
   2. **Function of AHF:**
      1. AHF shall monitor the total current of the loads under review utilizing two CT mounted on the supply AC lines for all three phase loads and all AHF. If phase‑to‑neutral loads are connected (four wire system), three CT shall be required.
         1. AHF shall analyze the content of the supply current for harmonics from the 2nd to the 51st harmonic and shall determine the reactive current content representing displacement power factor and supply current balancing.
            1. AHF shall inject cancellation for every harmonic order from 2nd to 51th order. AHF with designs to inject less than all harmonic orders are unacceptable.
            2. To insure optimum system performance, all nonlinear loads shall have input line reactors included that are rated 3 percent or higher impedance (inductance).
            3. AHF shall include an option to achieve optimized PF correction. Optimized PF correction is designed to prevent correction when the system PF is better (closer to unity) than the programmed PF setpoint. Any AHF that reduces the system PF to attain a reduced set point are unacceptable.
         2. AHF shall provide field selection as harmonic filter, reactive current correction, or supply current balancing or any combination of the three modes. All modes shall be required for this project.
      2. AHF shall provide for current balancing of AC supply for harmonic and reactive currents regardless of actual load distribution per phase.
      3. AHF shall have up to 30 seconds of logic ride‑through in the event of power loss.
      4. AHF shall be designed with a current limiting function to protect the IGBT.
         1. When the current limit level is attained on any harmonic order, a message shall be displayed indicating the output capacity is operating at maximum capacity.
         2. Operation shall continue indefinitely at this reduced level without trip or degradation of AHF.
      5. AHF shall have automatic restart capability upon power loss return and fault resets.
         1. Fault trip limit shall occur after five restarts within a 5 minute period and provide positive shut down and notice thereof.
      6. Upon occurrence of the fault trip limit, AHF shall stop output current production and lock out restart until the fault is manually cleared.
      7. AHF shall incorporate an over‑temperature output roll back that shall reduce the total output current to reduce power component heating in order to maintain maximum current correction at the elevated temperatures within the electrical system.
         1. AHF shall monitor the incoming air temperature and invoke a hard trip of the unit at 124°F (51°C).
      8. AHF shall be compatible with SPD, EMC filters, SCR (thyristor) snubber circuits, and switched mode power supplies (SMPS).
   3. **Operator Interface:**
      1. AHF shall have a door‑mounted human machine interface (HMI) with touch screen control rated NEMA 4‑12 (IP65), dust‑tight and liquid‑resistant.

*Note: HMI is not suitable for outdoor use.*

* + 1. HMI shall provide run/stop control from every screen.
    2. HMI shall provide an oscilloscope feature to display specific parameters.
       1. Three sets of data may be monitored at a time. Up to twenty predefined parameters can be chosen for each curve.
       2. Performance trend curves shall be displayed for load total RMS current, load RMA harmonic current per phase, AHF harmonic current output per phase, AC mains voltage per phase, THDi, TDD, load RMS reactive current, and AHF RMS reactive current output.
       3. Bar graphs shall be provided for display of the mains and load harmonic current amplitudes per harmonic order.
       4. Selected internal curves shall be provided for diagnostic and performance checks
    3. HMI shall display operating and setup parameters and event/fault messages in plain English, no cryptic codes or symbols are permitted on the display.
       1. HMI shall display the mains voltage and CT current.
       2. Parameter adjustment shall be made via HMI and shall be password protected.
       3. HMI shall record and display an event log with time and date stamp. Event log shall be cleared via the stop function or power-off. A minimum of 100 events shall be stored.
    4. HMI shall provide external communications via an RJ45 connectors.
       1. Modbus TCP/IP shall provide remote run/stop and display of operating parameters, set‑up parameters and diagnostic functions.
    5. HMI shall have a safety feature that shall lock out all other forms of control during service and commissioning.
       1. After 15 minutes of non‑use the lockout shall clear and control functions shall revert to full functionality and remote control capability.
    6. HMI shall display a flashing warning screen in the event of a fault.
    7. HMI shall download pertinent parameters to a USB memory device to permit remote diagnostic evaluations and to save unit set up parameters.
    8. HMI shall include, but shall not be limited to, an on‑board commissioning guide with automatic detection features.
       1. AHF shall automatically check for proper AC line phase rotation. No specific phase rotation is required.
       2. AHF shall automatically test for CT phase rotation and polarity. If installation is incorrect, AHF shall be able to rotate and reorient CT’s through its own logic calculation. If proper alignment cannot be achieved, a fault warning and lockout of operation shall occur.
       3. AHF shall automatically calibrate the CT for optimum harmonic cancellation performance.
       4. AHF shall perform at full capacity for a period of 15 minutes to validate components meet temperature performance requirements in the installed location.
       5. In the event any of the above cannot be reconciled, HMI shall lock out AHF function until commissioning agent corrects, verifies, and clears each test.

1. **EXTERNAL CURRENT TRANSFORMER**
   1. Split core type current transformers shall be installed as defined herein and as shown on the Electrical Drawings.
   2. Primary current ratings of the CT’ shall be according to full load current rating of the circuit on which installed.
   3. Current transformer ratio shall be as shown on the electrical on-line drawings. Secondary rating shall be 1 or 5 amperes.
   4. Current transformers rated for 50-60 hertz shall be used.
   5. Class 1 (or better) accuracy shall be provided.
2. **SOURCE QUALITY CONTROL**
   1. Prior to shipment, the manufacturer shall fully test the performance at full current and voltage while functioning as a harmonic correction device to assure compliance with equipment specifications defined herein.
      1. A certified test report shall be provided to the Owner.