GENERAL GUIDELINES FOR 765/ 400/ 220/ 132 KV SUB-STATION & SWITCH-YARD OF THERMAL/ HYDRO POWER PROJECTS

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FOREWORD

There has been a demand from the players in the power sector that CEA as an apex body in the sector, should finalize Standard Specification/ Design criteria/ Guidelines for power plant equipments to attract wider participation by equipment suppliers and encourage competition on one hand and reducing the time for pre-award activities, design & engineering and manufacturing on the other hand. With this objective in mind, CEA issued the 'Standard Technical Specification for Main Plant Package' in September 2008 and subsequently 'Standard Design Criteria/ Guidelines for Balance of Plant' in September 2010 for thermal power projects of 2x500MW or above. To continue the standardization of equipments/ systems in power sector, the standardization of various electrical equipments in the sub-stations/ switchyard was also taken up.

Switchyard/ Sub-station upto 400kV have generally been installed in the country. For higher unit sizes of 660/ 800MW, 765kV level switchyards/ sub-stations are also expected to be installed. Further, GIS and hybrid GIS are likely to be installed in near future. Accordingly, the document entitled "General Guidelines for 765/ 400/ 220/ 132kV Sub-stations and Switchyard for Thermal/ Hydro Power Stations" covering design criteria, parameters, other factors considered for selection/ design of various associated equipments/ systems and their constructional features is an attempt in this regard.

Views of major players in the field of power have also been considered to reflect wider consensus in this area.

I do hope that the utilities would find the document quite useful for effective planning and implementation and saving considerable time in project execution in the country.

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CONTENTS

GENERAL GUIDELINES FOR 765/ 400/ 220/ 132kV SUB-STATIONS AND SWITCHYARD OF THERMAL/ HYDRO POWER PROJECTS

1.0 INTRODUCTION

i) This document is an effort to consolidate maximum possible technical information/ data pertaining to switchyard for thermal/ hydro power projects and also sub-stations as per general prevailing practices for the use/ guidance. However, the site specific requirements need to be looked into by the owner/ developer of the systems.

ii) The sub-stations/ switchyards constitute of transmission system, which interconnects power transmission circuits and transformation between networks of different voltages. It is required to pay careful attention in planning, designing and constructing the sub-stations/ switchyards, since its reliability directly affects the power supply availability. Sub-stations generally comprise of switchgear, power transformer, control, protection, monitoring and automation equipment. The highest transmission system voltage in operation in the country is 800kV. Further, 1200kV level is also under consideration in near future.

iii) The sub-stations are of three types based on its use, viz Substations attached to thermal/ hydro power stations (which is generally called as Switchyard), interconnecting sub-stations, step-down (EHV/HV, EHV/MV, HV/MV) substation. However, the sub-stations shall be of Air insulated sub-station (AIS), Gas insulated sub-stations (GIS) or Hybrid sub-stations.

AIS is most commonly used so far; however, GIS/ hybrid substation may be adopted considering techno-economic viability. GIS is generally preferred, where availability of space and safety are major constraints, seismic prone areas, coastal areas and very heavily polluted areas etc.

Hybrid sub-station (combination of AIS and GIS) are available upto 220kV level which requires comparatively less space than AIS. For renovation/ augmentation of existing AIS, hybrid option may be adopted considering space constraints and techno-economic viability.

iv) This document describes salient parameters and technical features of equipment required for sub-stations and switchyard associated with thermal/ hydro generating stations. Specific details in respect of GIS and hybrid sub-station have been covered in Annexure-A and B.

2.0 SYSTEM PARAMETERS

The system parameters for 765kV, 400kV, 220kV, 132kV and 33kV are given in Schedule - 1

3.0 SWITCHING SCHEMES

The selection of switching schemes depends on operational flexibility, system safety, reliability & availability, ability to facilitate the system control and cost. However, other types of switching schemes can be considered, if system demands.

Following switching schemes shall generally be adopted at various voltage levels of switchyards/ sub-stations. The various types of switching schemes are shown in the Annexure -C."

Voltage level (kV)	**Switching schemes**		
	Air insulated sub-station/ Switchyard	**Gas insulated sub-station/ Switchyard**	**Hybrid sub-station/ Switchyard**
765	Breaker and a half scheme	Breaker and a half scheme or Double bus scheme	---
400	Breaker and a half scheme or Double main & transfer bus scheme	Breaker and a half scheme or Double bus scheme	---
220	Double main & transfer bus scheme or Double bus scheme	Double bus scheme	Double bus scheme
132	Main and transfer bus scheme or Double bus scheme	Double bus scheme or Single bus scheme with sectionalizer	Double bus scheme or Single bus scheme with sectionalizer

Notes :
(1) In case of Breaker and a half scheme, the layout shall be either standard D or I type.

(2) In case of GIS/ hybrid sub-station, the double bus bar scheme is most preferred economic solution with high reliability.

4.0 LAYOUT

The actual layout shall depend upon the type of sub-station/ switchyard (viz Air insulated sub-station (AIS), Gas insulated sub-station (GIS) or Hybrid sub-station). The area required would depend on voltage level, switching schemes, number of feeders of different voltage levels, no. of transformers, compensating equipments and possibility of future expansion.

In case of thermal power stations, the location of the switchyard shall be decided depending upon the wind profile to avoid additional pollution on account of water droplets from cooling towers.

4.1 Air insulated sub-station (AIS)

i) Safety clearances:

Safety clearances for different voltage levels and different configurations are given in Schedule - 2

ii) Bay width and depth :

For estimation purpose, approximate width and depth (excluding peripheral road and fencing) of bays for various switching schemes at different voltage level are given below:

Voltage level and switching scheme	Dimension	
	Width (m)	Depth (m)
1) 765kV system :		
Breaker & half scheme (I-type)[1]	52[2]	320
2) 400kV system :		
i) Breaker and a half scheme		
- I-type	27	170
- D-type	27+21+27	120[3]
	27+21+27	170[4]
ii) Double main & transfer bus scheme	28	120
3) 220kV system :		
i) Double main & transfer bus scheme	18	75
4) 132kV system :		
i) Double bus scheme	12	73.4 ≈ 75
ii) Main and Transfer	12	75

[1] In case of 765kV, only I-type is adopted, [2] Considering 765kV 1-phase transformer/ fire wall, 54M may be considered. Further economization can be done based on feeders/ transformers & reactor requirements during detailed engineering, [3] D on one side of bus only, [4] D on both side of bus

iii) Provision of space for suitable number of spare bays shall be provided in the switchyard/ sub-station for future expansion.

iv) The bays shall be arranged suitably such that skew/ deviation of outgoing and incoming connections shall not exceed 30^0. The safety clearances shall be reviewed critically in case skew/ deviation angle exceeds 15^0.

v) Fencing shall be provided around the switchyard/ sub-station area to restrict unauthorized entry.

vi) Roads including drainage system shall be provided in the switchyard/ sub-station for maintenance of equipment and vehicular movement within the yard.

vii) Equipments shall be suitable for hotline washing wherever specified.

viii) *Layout aspects :*

a) AIS for thermal power plants

In case of thermal power plants, switchyard will be located in a fenced area separate from the TG building. The transmission line take-off gantry designed with suitable deviations shall be placed at the opposite end to the generator transformer and the station transformer end of the bus bars.

The necessary equipments such as IEDs, transducers etc. shall be housed either in switchyard control room or outdoor air conditioned kiosks (air conditioned bay control rooms) for control and protection purpose. All switchyard equipments shall be controlled either from switchyard control room or outdoor air conditioned kiosks; moreover, equipment of generator shall be controlled from main control room of the unit(s).

The control room shall preferably be located to oversee the entire switchyard from the control room. However, video cameras may also be installed suitably for viewing the switchyard. Switchyard control room building shall be air-conditioned and properly ventilated, single/ double storied, located generally inside the switchyard premises between transformer yard and switchyard. Layout shall take into account the fire protection requirements and oil soaking/ collection pit in case of oil filled reactors/ auto-transformers located in switchyard.

b) AIS for hydro power plants

The hydro power plants are generally located in the hilly terrain. The switchyard/ pothead yard is made in two or three steps depending on land availability near power plant since complete leveled land in one stretch is generally not available. The switchyard shall be well protected from the falling stones on the equipments from adjoining hills.

The switchyard equipment control shall be provided locally from outdoor air conditioned kiosks (air conditioned bay control rooms) or from power house control room. The synchronization of the line feeder shall be possible from both.

The control room shall preferably be located to oversee the entire switchyard from the control room. However, video cameras may also be installed suitably for viewing the switchyard.

c) AIS for sub-stations

The layout of the AIS shall depend on area available for the sub-station, the number of line bays of different voltage levels, the number of main transformers, busbar/ switching schemes, protection against direct lightning and the possibility of future extension. Sufficient area shall also be taken into consideration for future expansion.

The outgoing line corridors shall be considered with minimum number of crossings between different circuits. The location of dead-end tower for incoming/ outgoing line bays (at different voltage levels) shall be considered for planning the layout and orientation of sub-station. The sequence of different bays (line bays, transformer bays, bus coupler, bus transfer bay etc.) shall also be considered.

The control room building shall be suitably located to have an entire view of sub-station. However, video cameras may also be installed suitably for viewing the sub-station. The dimension of the building depends on the control, protection, monitoring and automation system proposed to be provided for the sub-station.

4.2 Gas insulated sub-station

Gas insulated sub-station (GIS) shall be either outdoor or indoor type. Minimum maintenance space shall also be considered while designing the layout. In case of hydro power stations, wherever GIS is located inside the power house building, the necessary equipments for interconnection with the grid may be located on the surface of the pothead yard.

4.3 Hybrid sub-station :

Hybrid sub-station shall be outdoor type. The bus-bar arrangement shall be air insulated and the clearances shall be as given for AIS. All other switching equipments viz. circuit breaker, disconnector, earth switch shall be enclosed in a gas compartment as mentioned in GIS. The exact dimensions shall be as per the voltage level of the switchgear and manufacturer practice.

5.0 SUB-STATION/ SWITCHYARD EQUIPMENT

The sub-station/ switchyard shall generally comprise of the following equipments :

i) Bus bars
ii) Switchyard hardware (clamps, connectors, insulator strings etc.)
iii) Circuit breakers
iv) Disconnectorss and earth switches
v) Current transformers
vi) Voltage transformers
vii) Surge arrestors
viii) Power transformer (ICT and Reactors)
ix) Wave trap
x) Diesel generator

Features of the equipment at i), ii) and vii) above, pertain to AIS and hybrid sub-stations whereas description for equipment at iii) to vi) pertains to AIS only. Features of the equipment at viii) to x) are applicable for all types of sub-station/ switchyard.

Specific details of equipment applicable for GIS and Hybrid type sub-station/ switchyard are covered in enclosed Annexure-A and B respectively.

5.1 Bus bars (applicable for AIS & hybrid sub-station)

i) The outdoor bus bars shall be of strain/ flexible and/ or rigid type. The overhead conductors shall be strain/ flexible type, which are strung between supporting structures and strain/ tension type insulators. The bundle conductor bus bars may be considered for 220kV and above system to optimize the steel structures. In the rigid type, pipes are used for bus-bars and also for making connections to various equipments, wherever required. The bus bar and the connections are supported on the pedestal mounted post insulators.

ii) The bus bar material for rigid type shall generally be of aluminium pipes of grade 63401WP conforming to IS:5082. For strain/ flexible type bus-bar, Aluminium Conductor Steel Reinforced (ACSR)/ All Aluminiun Conductor (AAC) shall generally be used.

iii) All steel structures shall be galvanized (Galvanization thickness shall be higher, in case of polluted and coastal areas). For long spans, in case of rigid conductors expansion joints shall be provided to avoid strain on the supporting insulators due to thermal expansion or connection of pipes.

iv) All galvanized steel structures shall be designed for the worst combination of dead and live loads. Wind loads, short circuit forces, seismic forces, conductor/ earth wires stringing tensions, secondary effects such as shrinkage rise or fall in

temperature, etc. shall also be considered. However, seismic and wind load are not considered simultaneously.

5.2 Switchyard hardware (applicable for AIS & hybrid sub-station)

5.2.1 Clamps and connectors

i) Clamps and connectors (for connecting to equipment terminals and conductors) shall be of aluminium alloy casting type A6 as per IS 617 or equivalent. In case of copper terminals, the clamps and connectors shall be of 2mm thick bi-metallic liner/ strip. Clamps and connectors for connecting to shield wires shall be of galvanised mild steel.

ii) Clamps and connectors shall be of same current rating as that of the connected equipment with temperature rise limited to 35^0C over ambient temperature of 50^0C. All current carrying parts shall be at least 10mm thick.

iii) Flexible connectors, braids or laminated strips shall be of copper/ aluminium.

iv) Bolts, nuts and plain washers shall be hot dip galvanized mild steel for sizes M12 and above. For sizes below M12, these shall be electro-galvanized mild steel. A4/A2 grade SS bolts can also be used in case of heavily polluted and coastal areas. The spring washers shall be electro-galvanized mild steel.

v) Rigid bus connections between the equipments shall be of flexible type at one end and fixed type at the other end. Generally, connector shall be of fixed type for disconnectors and flexible type for circuit breakers, CTs and power transformers.

5.2.2 Insulator string and hardware

i) Disc/ long rod type porcelain or composite type insulators shall be provided for tension and suspension string assembly for overhead bus conductor. It shall be wet process porcelain or composite Ball and Socket type.

ii) Salient parameters for insulator string

The salient parameters for 765kV, 400kV, 220kV, 132kV and 33kV system insulator string are given in Schedule - 3

iii) Hollow bushing type porcelain or composite insulator shall be used for housing various equipments, e.g. CB, CT, VT, surge arrestor etc. Porcelain or composite insulator shall be used for Bus Post Insulator (BPI) e.g. support of bus conductor (ACSR and IPS Tube), WT etc. For heavily polluted area, composite insulators shall be preferred.

iv) Salient features of bus post insulators

The salient features for 765kV, 400kV, 220kV, 132kV and 33kV system bus post insulators are given in Schedule - 4

v) Spacers shall be of non-magnetic material. Its nuts and bolts shall be of hot dip galvanized mild steel. It shall also meet the requirement of clamps and connectors.

5.3 Circuit breaker (applicable for AIS)

i) Circuit breaker (CB) shall be of SF_6, outdoor type, C2-M2 class as per IEC 62271-1 and 100. However for reactor switching, circuit breaker shall be M2 class.

ii) Circuit breaker shall be of live tank or dead tank type. In case of dead tank type CB, conventional outdoor CTs as described elsewhere shall not be required; however, bushing type CTs shall be provided on either side of CB. The dead tank CB shall have following features :

- The enclosure shall be made of either Al/Al Alloy or mild steel (suitably hot dip galvanised). The maximum temperature of enclosure with CB carrying full load current shall not exceed the ambient temperature by more than 20^0C.

- The enclosure shall be designed for the mechanical and thermal loads. The enclosure shall be manufactured and tested according to the pressure vessel codes (ASME code for pressure vessel, Section VIII of BS:5179, IS:4379, IS-7311). It shall also be as per Indian Boiler Regulations.

- It shall be routine tested at 1.5 times the design pressure for one minute. It shall also be type tested at the bursting pressure of 5 times the design pressure.

iii) Circuit breaker shall be provided with three identical single phase units with single and three phase auto re-closing features (as applicable). In case of 132kV system, circuit breaker may be of three pole type, if single phase auto-reclosing feature is not required. For 33kV system, circuit breaker shall be of three pole type.

iv) Circuit breaker shall be provided with anti-pumping and trip free features and shall be remote controlled from control room with provision for local and manual control feature.

v) Circuit breaker shall be provided with 2 trip coils and 1 close coil per operating mechanism for 132kV and above. It shall be possible to trip the circuit breaker even in the event of failure of auxiliary power supply to the mechanism.

vi) The gap between the open contacts shall withstand at least rated phase to ground voltage for 8 hours at zero gauge pressure of SF_6 gas due to leakage.

The breaker shall also withstand all dielectric stress in open condition at lock out pressure continuously (i.e. 2 pu across the breaker continuously and power frequency withstand test conducted for at least 15 minutes is acceptable for its validation).

vii) Circuit breaker shall be capable of clearing short line fault (kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current.

viii) Circuit breaker shall be capable of switching on/ off shunt reactor without exceeding over voltage limits mentioned elsewhere.

ix) Circuit breakers used for reactor switching duties shall be tested for inductive load switching as per IEC 62271-110.

x) Circuit breaker shall be capable of interrupting the steady state and transient magnetising current corresponding of power transformers.

xi) SF_6 gas shall be as per IEC-60376, 60376A and B. SF_6 circuit breaker shall be supplied with gas for first filling and minimum 20% extra gas in non-returnable sealed containers. SF_6 gas filling, evacuating, purification and drying plant, portable type, shall be provided as an optional feature along with all necessary equipment such as gas cylinder etc.

xii) SF_6 gas density monitor with temperature compensation shall be provided with respective pressure switches/ gauges. It shall be possible to dismantle the monitor without draining SF_6 gas. The contacts of density monitor and pressure switches shall be provided for permissive in closing and tripping operation.

xiii) The 765/ 400kV circuit breakers shall be provided with pre-insertion resistors (wherever applicable for line feeders) or controlled switching device (wherever applicable viz Reactor and Transformer Switching Breakers) to limit the switching surge over voltage.

a) Pre Insertion Resister (PIR)

765/ 400kV circuit breaker shall be provided with single step PIR of class C2-M2 class as per IEC 62271-1. The maximum rating/ pre-insertion time shall be 450Ω/ 9ms and 400Ω/ 8ms for 765 and 400kV CBs respectively to limit switching surges to a value as specified elsewhere. PIR contacts shall open immediately after closing of main circuits or atleast 5ms prior to opening of main contacts at rated air/ gas pressure, where the PIR contacts remain closed.

The resistor shall have thermal rating for the following duties:

- Terminal fault: Close – 1 minute – Open – Close Open 2minute – Close –1 minute – Open Close Open.

- Re-closing against trapped charges: Duty shall be same as above. The 1st,3rd and 4th closures shall be on de-energized line while 2nd closing shall be made with lines against trapped charge of 1.2 pu of opposite polarity.

- Out of phase closing : One closing operation under phase opposition that is with twice the voltage across the terminals.

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

b) Controlled switching device

The control relay shall have facility to record and monitor the switching operations. It shall be possible to make adjustments to the switching instants to optimize the switching behavior as necessary. It shall be provided with self diagnostic facilities, alarms and downloading and display facility for the settings and measured values. The controller shall be PC compatible.

The controller shall meet the requirements of IEC 60255-4 Appendix 'E' class III regarding HF disturbance test; Fast transient test as per IEC 61000-4 level III and Insulation test as per IEC 60255-5.

In case of breaker to be operated manually, controller shall also get manual command from remote. The controller shall be able to analyze the current and voltage waves available through the signals from secondaries of CTs and CVTs for the purpose of calculation of optimum moment of the switching the circuit breaker and issue command to circuit breaker to operate.

The controller shall also have an adaptive control feature to consider the next operating time of the breaker in calculation of optimum time of issuing the switching command. The accuracy of the operating time estimation by the controller shall be better than (+) 0.5ms. The controller shall have time setting resolution of 0.1ms or better.

xiv) Circuit Breaker along with its operating mechanism shall be subjected to type, routine and acceptance tests as per IEC:62271-100. In case type tests are not to be performed and type test reports are to be submitted, the manufacturer shall furnish certificate of conformity to relevant standards form the test laboratory. In addition, the following tests shall also be performed :

- Speed curves for each breaker shall be obtained by a suitable operation analyzer/ travel recorder to ascertain breaker contact movement during opening, closing, auto-reclosing and trip free operation under normal and limiting operating conditions (control voltage, pneumatic/ hydraulic pressure etc.). The tests shall show the speed of contacts directly at various stages of operation, travel of contacts, opening time, closing time, shortest time between

separation and meeting of contacts at break make operation etc. This test shall also be performed at site.

- Measurement of dynamic contact resistance measurement for arcing and main contacts shall be performed. Signature of dynamic contact resistance measurements shall be taken as reference for comparing the same during operation and maintenance in order to ascertain the healthiness of contact.

- Controlled switching equipment validation tests (type test)

- Seismic withstand test in un-pressurized condition (type test)

xv) Salient features of circuit breaker

The salient features for 765kV, 400kV, 220kV, 132kV and 33kV system circuit breakers are given in Schedule - 5

5.4 Disconnectors (Isolators) and earth switches (applicable for AIS)

i) Disconnectors shall be of outdoor horizontal centre break/ double break/ pantograph type/ vertical break/ knee-type with/ without earth switch as per IEC 62271-102. It shall be possible to interchange position of earth switch on either side. Type of disconnector shall be as per layout requirent.

ii) 765/ 400/ 220/ 132kV system disconnectors and earth switches shall be motor operated and 33 kV system disconnectors shall be manual operated type.

iii) 765/ 400kV system disconnectors and earth switches shall be individual pole operated and 220/132/33kV system shall be gang operated type. However, 220kV tandem disconnectors shall be individual-pole operated type.

iv) Disconnectors/ earth switches shall be provided with pad-locking arrangement to prevent operation in case of emergency.

v) 765/ 400/220/132/33kV disconnectors shall be of mechanical endurance class-M2 type as per IEC 62271-102.

vi) The earthing switches shall be capable of discharging trapped charges of the associated lines. 765/ 400/ 220/ 132kV earth switches shall also comply with the requirements of IEC 62271-102, in respect of induced current switching duty as defined for Class-B and short circuit making capability Class E-0 for earthing switches.

vii) Earthing switches shall be locally operated.

viii) Mechanical and electrical safety interlocking shall be provided to prevent closing of disconnector when main earth switch is closed and vice-versa.

ix) Disconnector and earthing switches along with its operating mechanism shall be subjected to type, routine and acceptance tests as per IEC: 62271-102. In case type tests are not to be performed and type test reports are to be submitted, the manufacturer shall furnish certificate of conformity to relevant standards from the independent and approved test laboratory. In addition, the seismic withstand type test on disconnector mounted on support structure shall also be carried out.

x) Salient features of disconnector and earthing switches

The salient features for 765kV, 400kV, 220kV, 132kV and 33kV system disconnector and earthing switches are given in Schedule - 6

5.5 Current transformer (applicable for AIS)

i) Current transformer (CT) shall be single phase, oil immersed (with Class A insulation)/ SF_6 gas filled and self-cooled as per IEC 60044-1. It shall be either dead tank or live tank type. The secondary terminals shall be brought out at the bottom to a weather-proof (IP55) terminal box. All ratios shall be provided at the secondary taps.

ii) CT shall be of single primary of ring/ hair pin type. Power frequency (PF) terminals to measure tan delta and capacitance shall also be provided. These secondary terminals shall be terminated to stud type non-disconnecting terminal blocks.

iii) For bar-primary inverted type CT, the following shall also be provided:

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

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

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

iv) For 765 kV system CT, the rated extended primary current shall be 200% of rated primary on all taps except 3000/1A tap. At 3000/1A tap the rated extended primary current shall be 120%. At 3000/1A tap, the CT shall be thermally rated for 200% for 15 minutes and 120% continuous. The secondary winding shall be rated for 2A continuously.

For 400 kV system CT, the rated extended primary current of the CT shall be 200% of rated primary on all except 2000/1A tap. At 2000/1A tap the rated extended primary current shall be 120%. At 2000/1A ratio, the CT shall be thermally rated for 200% for 15minutes and 120% continuous.

For 400 kV CT rated for 3000A, the rated extended primary current shall be 120% for 3000/1A tap and 180% for 2000/1A tap and 200% for lower tap ratios. The secondary windings shall be rated for 2A continuously. Further, the intermediate tapping at 3000-2000A and 2000-500A shall be suitable for using as 1000/1A and 1500/1A ratios.

For 220/ 132kV system CT, the rated extended primary current shall be 120% or 150% (as per requirement) on all cores of the CT.

v) Protection class CT shall maintain the required accuracy for burdens ranging from 25% to 100% of rated burden and up to the accuracy limit factor/ knee point voltage in case of relaying CT.

Metering CT shall maintain the required accuracy for current ranging from 5% to 120% of rated current or specified rated extended current whichever is higher.

For 0.2S and 0.5S class CT, accuracy shall be maintained between 1% to 120% of rated current.

vi) For 765kV CT, the instrument security factor (ISF) at lowest tap shall be less than ten (10) for metering core.

For 400/ 220/ 132/ 33kV CT, the ISF at all taps shall be less than five (5) for metering core. If any auxiliary CT/ reactor are used in the CTs then all parameters specified shall have to be met treating auxiliary CT as an integral part of the CT. The auxiliary CT/ reactor shall preferably be inbuilt construction of the CT.

vii) 765/ 400/ 220/ 132kV CT shall be suitable for high speed auto re-closing (wherever required).

viii) CT shall be suitable for horizontal transportation. CT shall withstand all the stresses during transportation.

ix) CT shall be subjected to type, routine and acceptance tests as per IEC 60044-1. In case type tests are not to be performed and type test reports are to be submitted, the manufacturer shall furnish certificate of conformity to relevant standards from independent and approved test laboratory. The following additional type tests (for 765/ 400/ 220/ 132kV system CT) shall also be carried out :

- Radio interference test.

- Seismic withstand test

- Thermal stability test applicable at rated voltage and rated extended thermal current simultaneously by synthetic test circuit. (not applicable for SF_6 filled CT)

- Thermal co-efficient test i.e. measurement of tan-delta as a function of temperature (at ambient and between 80^0C & 90^0C) and voltage (at 0.3, 0.7, 1.0 and 1.1 Um/$\sqrt{3}$) (not applicable for SF_6 filled CT)

- Multiple chopped impulse test as per IEC 60044-1.

- CT shall be subjected to Fast transient test (multiple chopped impulse test) to assess the CT performance for withstanding high frequency over-voltage due to closing and opening operation of disconnectors during its service.

x) CT burden shall not be less than 5VA to achieve required 0.2S accuracy class.

xi) Salient features of current transformer

The salient features for 765kV, 400kV, 220kV, 132kV and 33kV system current transformers are given in Schedule - 7

5.6 Voltage transformer (applicable for AIS)

i) Voltage transformer (VT) shall be capacitor voltage divider type (CVT)/ electromagnetic type (E_mVT). VT shall be single phase, oil immersed (with Class A insulation)/ SF_6 gas filled and self-cooled. VTs of 33 kV class shall be of electromagnetic type.

ii) CVT on lines shall be suitable for Carrier Coupling.

iii) E_mVT / CVT shall be provided with three secondary windings; two windings for protections and one winding for metering.

iv) CVT shall be suitable for high frequency (HF) coupling required for power line carrier communication (PLCC). Carrier signal shall be prevented from flowing to electro-magnetic unit (EMU) circuit of VT with radio frequency (RF) choke/ reactor over entire carrier frequency range (40 to 500kHz). HF terminals shall be brought out through a suitable bushing.

v) EMU comprising compensating reactor, intermediate transformer and protective & damping devices shall be provided with separate terminal box with all secondary terminals brought out.

vi) The damping device permanently connected to one of the secondary windings shall suppress ferro-resonance oscillations also.

vii) Miniature circuit breakers (MCB)/ HRC fuse shall be provided on the secondary winding of the VT. The auxiliary contacts shall be provided in the MCB for interlocking and alarm purpose.

viii) E_mVT/ CVT shall be subjected to type, routine and acceptance tests as per IEC 60044-1/ IEC 60044-5. In case type tests are not to be performed and type test reports are to be submitted, the manufacturer shall furnish certificate of conformity to relevant standards from the independent and approved test laboratory. The following additional type tests (for 765/ 400/ 220/ 132kV system) shall also be carried out :

- High frequency capacitance and equivalent series resistance measurement (as per IEC-60358).

- Seismic withstand test

- Stray capacitance and stray conductance measurement of the low voltage terminal (as per IEC 60358).

- Determination of temperature coefficient test (as per IEC 60358).

- Radio interference test as per IEC 60044-5

ix) VT burden for metering class winding shall not be less than 50VA to achieve 0.2 accuracy class.

x) Salient features of voltage transformer

The salient features for 765kV, 400kV, 220kV, 132kV and 33kV system voltage transformers are given in Schedule - 8

5.7 Surge arrestors (applicable for AIS & hybrid sub-station)

i) Surge arrester (SA), conforming to IEC 60099-4 in general, shall be of heavy duty, station class, and metal oxide gapless type without any series or shunt gaps. SA shall be single pole, hermetically sealed with non-linear blocks of metal oxide material.

ii) The rated voltage of SA and other characteristics shall be as per system requirements. SA shall preferably be provided near line entrances, transformers to achieve proper insulation coordination.

The parameters given here are indicative only. Detailed study regarding insulation co-ordination and selection of SA shall be carried out to finalize actual parameters, nos., locations, energy capability etc. to provide adequate protective margin between the peak impulse voltages with other inter-connected sub-stations.

iii) SA shall also discharge over-voltages due to switching of un-loaded transformers, reactors and lines.

iv) 765kV system SA shall discharge severe re-energisation switching surges on line with surge impedance of 270 Ω and capacitance of 13nF/km.

400kV system SA shall discharge severe re-energisation switching surges on a 450km long line with surge impedance of 300Ω and capacitance of 11.986nF/km and over voltage factor of 2.3 pu.

v) 765kV SA shall discharge energy equivalent to Class 5 of IEC on two successive operation followed immediately by 50Hz energisation with a sequential voltage profile as per system studies. However, typical values are 1000kVp for 3 peaks and 910, 885, 866kVp for 0.1, 1.0, 10sec. respectively.

400kV SA shall discharge energy equivalent to Class 4 of IEC on two successive operation followed immediately by 50Hz energisation with a sequential voltage profile as per system studies. However, typical values are 650kVp for 3 peaks and 575, 550, 475kVp for 0.1, 1.0, 10sec. respectively.

220/132kV SA shall discharge energy equivalent to Class 3 of IEC on two successive operations.

vi) SA shall be of CB duty cycle (i.e. O-0.3 sec-CO-3 min-CO).

vii) SA shall be fitted with pressure relief devices (PRV) and diverting ports for preventing shattering of insulator housing in the event of arrester failure.

viii) The sealing arrangement of SA stacks shall be of grooved flanges with the O-rings/elliptical cross-section gaskets of Neoprene or Butyl rubber.

ix) Self-contained discharge counters without any auxiliary supply, suitably enclosed for outdoor application shall be provided for each single pole unit alongwith necessary connections.

Leakage current meter (mA) shall be provided within the same enclosure. In case of remote monitoring the same may be kept separately.

x) The above surge monitor with discharge counters and leakage current meter shall be mounted on a support structure and shall be tested for IP-66 degree of protection.

The arrangement for surge monitor enclosure fixing to the structure shall be at its rear/ bottom. Connection between the SA base and surge monitor shall be through a 2m (minimum) long insulated copper rod/ strip of minimum cross sectional area of 75mm^2. It shall be terminated at rear/ bottom side of the surge monitor.

xi) SA shall be subjected to type, routine and acceptance tests as per IEC60099-4. In case type tests are not to be performed and type test reports are to be submitted, the manufacturer shall furnish certificate of conformity to relevant standards from independent and approved test laboratory.

SA monitors shall also be connected in series with the test specimens during residual voltage and current impulse withstand tests to establish its performance. Additional routine/ functional tests with one 100A and 10kA current impulse (8/20μ-sec.) shall also be performed on the surge monitor. Surge monitors shall be routinely tested for water dip test at 1.5m for 30minutes. No water vapors shall be visible on the monitor glass.

xii) Salient features of surge arrestor

The salient features for 765kV, 400kV, 220kV, 132kV and 33kV system surge arrestors are given in Schedule - 9

5.8 Power transformer :

5.8.1 Inter-connecting auto transformer :

i) 765/400/33kV or 765/220/33kV or 400/220/33kV or 400/132/33kV auto-transformers (ICT) with on-load tap changer (OLTC) conforming to IEC 60076/ IS 2026 shall be provided for inter connection between 132kV or 220kV and/or 400kV and 765kV switchyard buses.

All the auto-transformers shall be running in parallel and their tap changers shall be controlled by keeping any of them as master and others as followers. The 33kV tertiary winding shall be un-loaded or loaded with shunt reactor/ capacitor as per system requirement/ application.

ii) 765kV ICT shall be of single phase type and 400kV ICT shall be of three phase/ single phase type as per rating and transportation limitations and shall be used for bi-directional flow of power.

iii) ICT shall be of ONAN/ ONAF/ (OFAF/ ODAF) cooled type or ONAN/ ONAF1/ ONAF2 cooled type.

It shall be provided with minimum 5x25% unit coolers. Each unit cooler shall be provided with its own cooling fans, oil pumps etc.

iv) It shall be capable of operating at full load for at least ten (10) minutes during total failure of auxiliary power supply to cooling fans and pumps without exceeding winding hot spot temperature exceeding 140^0C.

It shall also be capable of operating for 20 minutes in the event of failure of oil circulating pumps or blowers associated with all unit coolers except one unit cooler without exceeding winding hot spot temperature exceeding 140^0C.

v) The maximum flux density in any part of the core and yoke at rated MVA, voltage and frequency shall not exceed 1.9 tesla at the lowest tap position under 10% continuous over voltage condition.

vi) 765kV ICT shall have constant impedance between High Voltage (HV) and Intermediate Voltage (IV)/ Low Voltage (LV) (tertiary). 400kV ICT shall have constant ohmic impedance between HV and IV/LV (tertiary).

vii) The air core reactance of HV winding of transformer shall not be less than 20%. The knee point voltage shall not be less than 1.1 pu.

viii) External or Internal reactors shall not be used to achieve the HV/LV (tertiary) and IV/ LV (tertiary) impedance specified.

ix) The temperature of any part of the core or its support structure in contact with oil shall not exceed 120^0C under normal operating condition and 130^0C under most extreme operating condition.

x) The insulation of core to bolts and core to clamp plates shall withstand a voltage of 2 kV(rms) for 1minute.

xi) The insulating oil shall be virgin high grade inhibited, conforming to IEC 60296

xii) It shall withstand and give desired performance, without injurious heating for combined voltage and frequency fluctuations. It shall withstand over fluxing conditions of 110, 125 and 140% for continuous, 1 minute and 5 seconds respectively.

xiii) It shall be capable of being loaded upto 150% of rated load as per IS 6600/ IEC 60076-7. There shall be no limitation for overloading imposed by bushing, tap changer etc or any other associated equipment.

xiv) In case of sub-station, if spare ICT is envisaged, the same shall be properly erected on foundation, oil filled and commissioned for long term storage.

xv) It shall be subjected to type, routine and acceptance tests as per IEC 62271-102.

xvi) Salient features of Inter-connecting auto transformer

a) 500MVA, 765/√3/400/√3/33kV, single-phase ICT

The salient features for 500MVA, 765/√3/400/√3/33kV, single-phase Inter-connecting auto transformer are given in Schedule – 10(A)

b) 500 or 315MVA (whichever is applicable), 400/220/33kV ICT (constant ohmic impedance type)

The salient features for 500 or 315MVA, 400/220/33kV Inter-connecting auto transformer (constant ohmic impedance type) are given in Schedule – 10(B)

5.8.2 Shunt and neutral reactors

i) Reactor shall conform to IEC 60076/ IS 2026. 765kV reactor shall be of single phase type and 400kV reactor shall be of three/ single phase type as per rating and transportation limitations.

ii) Reactor shall be of oil immersed with natural cooling (ONAN). The insulating oil shall be virgin high grade inhibited, conforming to IEC-60296.

iii) Shunt reactor shall be gapped core or magnetically shielded air core type (shell type) of construction. In case of coreless construction, a magnetic shield shall be provided around the coreless coils and non-magnetic material sheet shall form the central core to minimize the vibrations.

iv) Reactor impedance ratio (X_0/X_1) as mentioned elsewhere shall be achieved either by adopting single phase construction in separate tanks or by adopting 5 limb core construction.

v) Shunt reactors will be connected to the 765/ 400kV transmission lines for reactive load compensation and controlling the dynamic over voltage in the system due to load rejection.

vi) Shunt Reactors shall be capable of operating continuously at a voltage 5% higher than rated voltage. The thermal and cooling system shall be designed accordingly.

vii) Neutral grounding reactor shall be provided for grounding of the neutral point of shunt reactors to limit the secondary arc current and the recovery voltage to a minimum value. The NGR of switchable reactor may be by-passed during switching in/ out of the reactor.

viii) 765kV reactor shall be subjected to switching surge over voltage of 1.9 pu and temporary over voltage of the order of 1.4 pu for about 10 cycles followed by power frequency over voltage upto 830kVrms for about five minutes. The reactor shall withstand the stress due to above transient dynamic conditions which may cause additional current flow as a result of changed saturation characteristics/ slope beyond 1.25 pu voltage.

400kV reactor shall be subjected to switching surge over voltage of 2.5 pu and temporary over voltage of the order of 2.3 pu for few cycles followed by power frequency over voltage upto 1.5 pu. The reactor shall withstand stress due to above transient dynamic conditions which may cause additional current

flow as a result of changed saturation characteristics/ slope beyond 1.5 pu voltage.

ix) 765kV reactor shall withstand the following over voltages of 1.10, 1.25 and 1.50 of U_m for continuous, 1 minute and 5 seconds respectively repeatedly without risk of failure, where Maximum continuous operating voltage (U_m) and Nominal voltage (U_n) are $800/\sqrt{3}$kV and $765/\sqrt{3}$kV respectively.

x) The crest value of the third harmonic component in phase current shall not exceed 3% of the crest value of fundamental when reactor is energized at rated voltage with sinusoidal wave form.

xi) The maximum temperature on any metal part shall not exceed 130^0C.

xii) The insulation of core to bolts and core to clamp plates shall withstand a voltage of 2kV (rms) for 1 minute.

xiii) The maximum allowable hot spot temperatures and surface temperatures in the magnetic circuit shall be 125^0C and 20^0C respectively.

xiv) The temperature of any part of the core or its support structure in contact with oil shall not exceed 120^0C under normal operation and 130^0C under the most extreme operating circumstances.

xv) In case of sub-station, if spare reactor is envisaged, the same shall be properly erected on foundation, oil filled and commissioned for long term storage.

xvi) Vibration and stress level of $765/\sqrt{3}$ kV reactor shall not to exceed 200microns peak to peak at rated voltage and frequency. Average vibrations shall not exceed 60 microns peak to peak. Tank stresses shall not exceed 2.0kg/mm^2 at any point on the tank. The measurements are to be made at U_m.

xvii) Salient features for $765/\sqrt{3}$ kV (1 phase) shunt reactor and neutral reactor :

a) Shunt reactor (1 phase) ($765/\sqrt{3}$) kV

The salient features for $765/\sqrt{3}$ kV (1 phase) shunt reactor are given in Schedule – 11 (A)

b) Neutral reactor (765kV)

The salient features for 765kV neutral reactor are given in Schedule – 11(B)

xviii) Salient features of 400/√3) kV (1 phase) shunt reactor and neutral reactor

a) Shunt reactor (1 phase) (400/√3) kV

The salient features for 400/√3 kV (1 phase) shunt reactor are given in Schedule – 12 (A)

b) Neutral reactor (400kV)

The salient features for 400kV neutral reactor are given in Schedule – 12(B)

5.8.3 Monitoring systems and special equipments for ICT and reactor (optional) :

ICT or reactors of 400kV and above system shall additionally be provided (if required) :

i) On-line insulating oil drying system

Each transformer or reactor shall be provided with an on line insulating oil drying system of adequate rating in addition to provision of air cell in conservators for sealing of the oil system against the atmosphere. The system shall be designed for very slow removal of moisture that may enter the oil system or generated during cellulose decomposition.

ii) On line dissolved hydrogen and moisture monitoring system

Microprocessor based on line dissolved hydrogen and moisture monitoring system shall be provided to detect and measure dissolved hydrogen and water content continuously even at very low concentrations in transformer oil. The monitor shall be suitable to detect and measure dissolved hydrogen in ppm, without significant interference from other fault and atmospheric gases. The monitor shall provide water content measured in ppm or percentage relative saturation (RS).

iii) Flow sensitive conservator isolation valve

In order to restrict the supply of oil in case of a fire in transformer, flow sensitive conservator isolation valve shall be provided to isolate the conservator oil from the main tank.

In case of flow of oil from conservator to main tank is more than the normal operating conditions, the valve shall shut off by itself with provision of manual reset. The valve shall be located in the piping between the conservator and the buchholz relay and shall not affect the flow of oil from and to the conservator in normal conditions. It shall be provided with valve open/close position indicator along with alarm indication in control room during closing operation of valve. This valve shall be provided with locking arrangement for normal position and oil filling/ filtration position.

iv) Optical sensors (for 500MVA, 765/ 400kV ICT; 765kV reactors)

Adequate number of optical temperature sensors (at least 8 numbers) shall be fitted with each transformer/ reactor unit. This optical sensor measuring system shall be of direct measurement non-calibrating type. All the sensors shall be brought out to individual cooler control cabinet to facilitate measurement of temperature. The measuring unit shall retain temperature data for at least 30 days and shall have facility to download.

v) Oil storage tank

The oil storage tank (minimum capacity of $20m^3$ with 2m diameter) along with complete accessories including a self mounted centrifugal oil pump for transformers/ reactors shall be provided conforming to Indian Standards for storage at a temperature of 100^0C. The oil storage tanks shall be towable on pneumatic tyres and rested on manual screw jacks of adequate quantity and size. The tank shall be cylindrical in shape and mounted horizontally and made of mild steel plate of adequate thickness.

The tank (fitted with manhole, outside and inside access ladder, silica gel breather assembly, inlet and outlet valve, oil sampling valve with suitable adopter, oil drainage valve, air vent, pulling hook on both ends of the tank etc.) shall have adequate number of jacking pad so that it can be kept on jack while completely filled with oil. The tank shall be provided with suitable saddles so that tank can be rested on ground after removing the pneumatic tyres.

The accessories shall include suitable rubber hoses (four numbers of 50NB and two numbers of 100NB) with couplers and unions each not less than 10m long and one number of digital vacuum gauge with sensor.

vi) Oil sample bottle

Oil sampling bottles (capacity of one litre) shall be provided to collect oil samples from transformers and reactors for dissolved gas analysis. The design of stainless steel oil sampling bottles shall be such that loss of hydrogen shall not exceed 5% per week. An impermeable oil-proof, transparent plastic or rubber tube of about 5mm diameter and of sufficient length shall also be provided with each bottle along with suitable connectors, heat resistant borosilicate glass syringe and three way stop cock valve.

5.8.4 Design review of power transformer and reactor

i) Design reviews shall be conducted by Owner at different stages of the procurement process for transformer and reactor of 765kV. The design review shall be conducted generally following the "Guidelines for conducting design reviews for transformers 100MVA and 123kV and above" prepared by CIGRE

SC 12 Working Group 12.22. However the entire responsibility of design shall be with the manufacturer.

ii) The design review shall at least include the following :

- Core and magnetic design
- Winding and tapping design
- Short-circuit withstand capability
- Thermal design (including review of localised potentially hot area)
- Cooling design
- Overload capability
- Eddy current losses
- Seismic design (as applicable)
- Insulation co-ordination
- Tank and accessories
- Bushings and barrier design
- Tap changers
- Protective devices
- Fans, pumps and radiators
- Sensors protective devices-its location, fitment, and level of redundancy
- Oil and oil preservation system
- Corrosion protection
- Electrical and physical interfaces with sub-station
- Earthing
- Processing and assembly
- Testing capabilities
- Inspection and test plan
- Transport and storage
- Sensitivity of design to specified parameters
- Acoustic noise
- Spares, inter-changeability and standardization
- Maintainability

5.9 Wave trap

i) Wave trap (WT) shall be outdoor type suitable for mounting on post insulators/ CVT/ suspension type. WT shall be equipped with suitable bird barriers and shall be provided with suitable corona rings to meet corona and radio interference performance.

ii) The wave trap shall be broadband type tuned for its entire carrier frequency range. The resistive component of impedance of the line trap within its bandwidth shall not be less than 450Ω for 765/ 400kV system and 570Ω for 220/ 132kV system.

iii) The coil of wave trap shall tolerate short circuit current of transmission line and shall withstand the mechanical stress resulting from it. HF tuning elements shall be placed in a separate sealed unit.

iv) The wave trap shall have a protective device, such that temperature rise of the magnetic field of the main coil at continuous rated current or rated short time current shall not result significant alteration in its protective function and/ or physical damage. The protective device shall neither enter into operation nor remain in operation following transient actuation by the power frequency voltage developed across the wave trap by the rated short time current.

v) The protective device in the form of surge arrester shall be gapless or gapped type. For proper co-ordination with the surge arresters installed in the switchyard, its rated discharge current shall be 10kA.

5.10 Diesel generator

i) In case of thermal/ hydro power project, no separate DG set shall be envisaged; however, emergency AC supply shall be fed from main plant diesel generator (DG).

In case of sub-station one number of 100kVA and 250kVA DG set complete with Automatic Mains Failure (AMF) panel and other accessories shall be provided for 132kV and 220/ 400kV sub-station respectively. For 765kV substation alongwith 400/ 220/ 132kV sub-station, DG set of 500 kVA rating shall be provided. It shall be possible to start/ stop DG set from remote and local.

ii) Diesel engine, Alternator, AMF panel, batteries and chargers shall be installed outdoor in a suitable weather-proof enclosure, which shall be provided for protection from rain, sun, dust etc.

iii) The net output rating of DG shall be 100/ 250 or 500kVA, 1500RPM, 0.8Pf, 415V, 3 phase, 50Hz considering de-ration for engine and alternator separately due to temperature rise inside the enclosure and on account of power reduction due to auxiliaries.

iv) DG set shall also be rated for 110% of full load for 1 hour in every twelve hrs of continuous running.

6.0 SUB-STATION/ SWITCHYARD CONTROL AND MONITORING SYSTEM:

The following equipment shall be provided for switchyard/ sub-station control and monitoring system which are applicable for all types of sub-stations/ switchyards (AIS/ GIS/ Hybrid).

6.1 Sub-station automation system

i) Sub-station automation system (SAS) workstations, equipment/ panels/ marshalling cabinets etc. for 765/400/220/132kV switchyard (whichever is applicable) shall be located in a control room. Alternatively, only work stations can be located in the control room and remaining equipment may be

located in air-conditioned kiosks (AC kiosks) provided bay-wise in the switchyard/ sub-station.

ii) SAS shall be an integrated system to carry out control, monitoring, protection, metering and communication functions of all 765/400/220/132kV feeders. SAS shall have extensive range of system control and data acquisition (SCADA) function. SAS shall be based on IEC 61850 and IEC 60870-5-104 protocol. All devices shall be compatible to the above protocols. SAS shall have the capability to link with local dispatch centre (LDC) for availability based tariff (ABT) and energy management.

iii) The equipment, in general, not limited to the following shall be provided for SAS:

- 2 no. Human Machine Interfaces (HMI's) with 21 inch TFT monitors as Operator Working Stations (OWS); in sub-station/ switchyard control room. (in case of thermal/ hydro stations, one HMI shall also be provided in Main Control Room of units)

- 1 no. HMI with 21 inch TFT monitor as Operator-cum-Engineering-Work Station (OES)

- SAS panels comprising of control, interlock and protection for each feeder, bus-bar protection, tariff metering panels, Global Positioning System (GPS) for time synchronization

- Marshalling cabinets
- Communication links and Ethernet, Printers, Scanners etc.

- Un-interrupted Power Supply (UPS)

iv) The entire sub-station/ switchyard shall be controlled and supervised from HMI. The priority shall always be on the lowest enabled control level. Clear control priorities shall be provided to prevent simultaneous operation of any equipment at the same time from more than one control levels (AC kiosks, sub-station/ switchyard control room, main control room).

v) SCADA shall be adaptable to any system changes viz. actual sub-station/ switchyard configuration, voltage levels etc.

6.1.1 Control, interlock, protection panels

i) Wherever more than one voltage levels (e.g. 765kV and 400kV or 400 kV and 220/132kV) are envisaged, separate panels shall be provided for different voltage levels.

ii) The panels shall be of simplex type and integral part of SAS to provide control, supervision, protection and interlocking for line, bus-coupler, by-pass,

station transformers, generator transformer and ICT feeders including bus-bar (BB) and local breaker back-up (LBB) protections of the switchyard at each voltage level.

iii) The panels shall include necessary control switches, bay control units (BCU), indicating lamps/ LED's, indicating meters, instruments, mimic diagram/ module, annunciation equipment etc. for the various feeders.

6.1.2. Air conditioned kiosk

i) In case AC kiosks are envisaged, the same shall also be provided for control, protection purpose described above. The kiosk shall be provided with fire alarm system with minimum two detectors and it shall be monitored by SAS. The air conditioner for the kiosk shall be controlled and monitored by SAS also. In case, space is not available in the existing kiosk, one additional kiosk for bus bar protection and also the PLCC system shall be located at suitable location in switchyard.

ii) Kiosk shall be made of "sandwich insulated panels" 80mm thick with poly-urethane foam (PUF) as filler material between polyester pre-coated cold rolled steel.

iii) The insulation characteristics of PUF material shall conform to following minimum requirement:

S.N.	Details	Unit	Parameters
1)	Thickness	mm	78.6
2)	Density	kg/ m^3	40
3)	Compressive strength	kg/ cm^3	1.2
4)	Tensile strength	kg/ m^2	3.6
5)	Bending strength	kg/ m^2	4.0
6)	Adhesion strength	kg/ m^2	2.9
7)	Dimension stability		
	- at -25^0C	%	0.1
	- at 38^0C	%	0.4
8)	Temperature range	^{0}C	-15 to 95
9)	Thermal conductivity	kcal/hr/m/^{0}C	0.02

10)	Fire resistance: Horizontal burn (BS 4735)	mm	<125
11)	Water absorption (@100%RH)	%	0.2
12)	Vapour permeability	$g/hr/m^2$	0.08/ 0.12
13)	Self extinguishing		Yes

iv) The thickness of the inner and outer steel sheet except floor panel sheet shall be minimum 0.8mm and 0.6mm respectively. The outer bottom sheet shall be hot dip galvanised steel sheets of minimum 1.0mm thickness to avoid rusting at bottom. The sandwich panels shall be manufactured by high pressure injection techniques. Each kiosk shall be installed with environment control system comprising of two units of air conditioners working in conjunction through a micro processor based controller for desired operation.

v) The system shall be designed for 24 hours, 365 days of the year to maintain inside kiosk temperature for proper operation of critical equipment. One of the air-conditioner shall be running at a time and on failure of the same, the other unit shall start automatically. To ensure longer life of the system, the redundant units shall also be running in cyclic operation through the controller. However, during running of one air-conditioner unit, if inside temperature of the shelter reaches to a predefined (i.e. 35^0C), the other unit shall start running to maintain the temperature to specified value (i.e. $23+2^0$C) and gives alarm. After achieving this temperature, the other unit shall again shut off.

vi) The air conditioning unit shall be completely self-contained. All components of the units shall be enclosed in a powder coated cabinet. The unit shall be assembled, wired, piped, charged with refrigerant and fully factory tested. Suitable isolation or other by-passing arrangement shall be provided such that any unit/ component could be maintained/ repaired without affecting the running standby unit. The maintenance of unit shall be possible from outside the kiosk.

vii) The compressor shall be hermitically sealed scroll type. Compressor shall be mounted on vibration isolated mountings. Valve shall be provided for charging/ topping up of refrigerant.

viii) The kiosk shall be erected minimum 300mm above the finished ground level on pedestal to avoid any water ingress.

ix) The kiosk shall be provided with dust and rain protection and air tightness.

6.1.3 Metering

i) kV, kA, MW, MVAR, pf, Hz, measurements (in general) of the feeders shall be provided in the SAS panels/ AC kiosks.

ii) The energy meters for tariff metering shall be provided as per "Central Electricity Authority (Installation and Operation of Meters) Regulation, 2006" as amended till date. The accuracy class shall be 0.2S or better as stipulated in the above regulation and its amendments.

iii) The location of the energy meters as per the above regulation shall be as follows:

- Main and Check meters on all line feeders
- Standby meter on HV side of all generator transformer feeders
- Standby meter on HV side of all station transformer feeders
- Main and Standby meters of all ICT feeders

6.1.4 Protections:

i) The Intelligence Electronic Devices (IED's) shall provide numerical electrical protections of all the feeders. However, part of the protections for generator transformer bay in a generating station may be implemented in main control room of the unit. All the protections shall be provided on all three phases unless stated otherwise.

ii) The numerical protection shall be provided with continuous self-monitoring and cyclic test facilities. The internal clock of the system shall be synchronized using synchronizing pulse from Time Synchronizing System.

iii) All numerical protections shall be provided with setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity.

iv) Each numerical protection scheme shall have a serial interface on the front for local communication through PC and printer. At least one more RS485 serial ports, working on an open protocol like MODBUS or IEC:60870-5-103, shall be provided for remote communication, data transfer etc.

v) Facilities shall be provided to access each discrete protection function through OWS and OES. A print out of all settings, scheme logic, event records etc. shall be accessible. Display of various measured parameters during normal as well as fault condition on segregated phase basis shall be provided. In addition to the above, LEDs and back lit LCD screen shall be provided for visual indication and display of messages related to major trips/ alarms. Necessary multilevel password protection shall be provided.

vi) The sampling rate of analog inputs, the processing speed and processing cycle of digital values shall be selected so as to achieve the operating times of various protection functions. In case all the necessary protections are not a part of the standard numerical protection scheme, separate discreet numerical protection shall be provided for the same.

vii) The protection system shall be arranged to provide two independent, high performance and reliable systems with separate, monitored DC supplies, separate CT, VT cores, separate cables and trip relays to obtain 100% redundancy.

viii) Necessary auxiliary relays, timers, trip relays, etc. required for interlocking, alarm, logging, etc. and completeness of the scheme shall be provided.

ix) Relays shall be provided with self-reset contacts except for the trip lockout relays and interlocking (contact multiplication) relays, which shall have hand-reset contacts. However, for remote operation, electrical reset type relays may be adopted.

x) Suitable measures shall be provided to ensure that transients present in CT and VT connections due to extraneous sources in high voltage system shall not damage to the numerical and other relays. CT saturation shall not cause any mal-operation of numerical protection.

xi) Only DC/DC converters shall be provided in the numerical protections, wherever necessary to provide a stable auxiliary supply. If SMPS systems are provided, the noise-generated by it shall not affect the function of the protection. DC batteries shall not be acceptable.

6.1.4.1 Lines feeder protections :

i) The line feeders shall be provided with numerical distance protection alongwith other necessary protections viz. over-current, over-voltage etc. The distance protections shall have but not limited to the following features:

- Stepped time-distance characteristics and four or five independent zones
- Mho or quadrilateral or other suitably shaped characteristics
- Adjustable characteristics angle setting
- Independent continuously variable time setting range for each zone
- Variable residual compensation
- Switch-onto-fault (SOF) with memory circuits and defined characteristics in all 3-ph and to operate instantaneously on closing of circuit breaker to zero-volt 3-ph fault
- Weak end in-feed feature
- Suitable for 1-ph and 3-ph tripping
- Suitable for use in permissive under-reach/ over-reach/ blocking communication mode
- Power swing blocking feature
- Auto re-closeing
- Check synchronisation
- Dead line charging features
- Over Voltage protection
- 'On-line' type Distance to fault locator

ii) The line feeders shall be provided with following minimum protection functions :

a) For 765/ 400/ 220kV line feeder:

- Main-I non-switched distance protection (with carrier aided scheme)
- Main-II non-switched distance protection (with carrier aided scheme)
- Directional phase over current and earth fault protection (2 sets for 765kV and 1 set for 400/ 220/ 132kV)
- Over voltage (two stages) protection (2 sets) (Protection applicable for 765/ 400kV only)
- Local breaker back-up protection
- Under voltage protection (for isolator interlocking purpose)

b) For 132kV line feeder:

- Distance protection (suitable for carrier aided protection scheme)
- Directional phase over current and earth fault protections.
- Local breaker back-up protection
- Under voltage protection (for isolator interlocking purpose)

6.1.4.2 Bus shunt reactor, Line with neutral reactor (765/ 400kV) protections :

Following minimum protection functions for shunt reactor:

- Differential protection – Main-I
- Differential protection – Main-II
- Back-up impedance (Mho characteristics) protection
- Restricted earth fault protection

6.1.4.3 Bus-coupler feeder protections :

Following minimum protection functions shall be provided for bus coupler feeder:

- Instantaneous over current protection: The instantaneous over current protection units (high set) on two phases (R, B) for phase to phase and three phase faults and one instantaneous over current protection unit (high set) for zero sequence current to cover all phase to ground faults shall be provided. Links shall be provided in the trip circuits to disconnect these protections.

- Instantaneous over current protection: The instantaneous over current protection units (low set) on two phases (R, B) for phase to phase and three phase faults and one instantaneous over current protection unit (low set) for zero sequence current to cover all phase to ground faults shall be provided. Links shall be provided in the trip circuits to disconnect these protections.

- Local breaker back-up protection

6.1.4.4 Station transformer feeder protections for 400/ 220/ 132kV system (applicable for thermal plants) :

Following minimum protection functions for station transformer feeder:

- Differential protection (2 nos. for 400kV system only)
- Over-fluxing protection
- Restricted earth fault protection
- Back-up directional over current protection
- Over load protection
- Local breaker back-up protection

6.1.4.5 Inter-connecting auto-transformer (ICT) feeder protections:

Following minimum protection functions shall be provided for ICT:

a) 765/ 400kV side:

- Line differential protection (wherever required)
- ICT differential protection
- Directional over current and earth fault protection
- Over load protection
- Restricted earth fault protection
- Over-fluxing protection
- Local breaker back-up protection

b) 220 or 132kV side:

- ICT differential protection (refer 'a' above)
- Directional over current protection and earth fault protection
- Restricted earth fault protection (refer 'a' above)
- Local breaker back-up protection

c) 33kV side:

In case 33kV winding of ICT's is loaded with 3-ph reactors, the same shall be connected through circuit breaker. The following minimum protections shall be provided on the 33kV side of ICT and 33kV reactor:

- ICT differential protection (refer 'a' above)
- Reactor differential protection
- Reactor over current and earth fault protection
- Restricted earth fault protection (refer 'a' above)
- Neutral displacement protection to be connected to open delta winding of 110V of voltage transformer.

6.1.4.6 Local breaker back-up (LBB) protection:

LBB protection as mentioned above shall be provided for 765/400/220/132kV circuit breaker. This will isolate the respective bus-bar through its bus-bar protection trip relays and equipment, whenever its associated protection has acted but the breaker failed to open due to any reason. The protection will also cover faults between post mounted CT's and associated breakers.

6.1.4.7 Bus-bar protection:

i) Each bus-bar shall be provided with a high-speed bus-zone differential protection. The protection shall have high through fault stability and adequate sensitivity for internal faults. The scheme shall also include a check feature/ redundant busbar protection.

ii) The output-tripping relays for the bus-bar protection shall be hand reset type and one no. relay shall be provided for each feeder and two (2) numbers for bus-coupler feeder for tripping the breaker.

iii) Necessary relays for monitoring the continuity of the CT secondary shall also be provided.

6.1.5 Phase Monitoring Unit (PMU) :

6.1.5.1 Supervisory Control and Data Acquisition System (SCADA)/ Energy Management System (EMS) technology presently available is capable of providing only steady state view of the power system. The 'Wide Area Measurement System' (WAMS) facilitating dynamic real time measurement and visualization of power system are being implemented to control, monitor and tackle emergency situations of the grid to enhance availability and reliability. Synchrophasor measurements using Phasor Monitoring Units (PMUs) alongwith Fibre Optic connectivity and communication equipments shall be provided on sub-stations at 400kV and above levels and switchyard of generating stations at 220kV and above levels as per the report of PGCIL on 'Unified Real Time Dynamic State Measurement' (URTDSM) system, implementation of which is in progress in the country.

The dispersely located PMUs shall communicate with Phasor Data Concentrators (PDCs) installed at certain strategic location at State, Regional and National levels. Various analytical tools, visualization software package available at PDC levels shall be used for monitoring the entire inter-connected grid on real time basis, which are useful in monitoring safety and security of the grid as well enable in taking control/ corrective action in the new regime of grid management.

6.1.5.2 Salient features of PMUs :

The PMUs alongwith necessary testing and configuration shall be supplied and preferably be located near the control and relay panels. The CT/ CVT connections shall be extended from the control and relay panels. The PMUs shall conform to IEEE C37.118 and meet the following requirements :

i) The PMU will be standalone in the sub-station/ switchyard control rooms/ relay panel room.

ii) The PMU shall measure the electrical parameters in the power system frequency band of 45 – 55Hz.

iii) The auxiliary power to PMUs shall be from sub-station/ switchyard DC supply.

iv) The PMUs shall be provided with minimum configuration of 9 analog input channels (1 set of 3-phase voltages, 2 set of 3-phase currents) and 8 digital inputs.

v) The PMUs shall measure the following:

- 3-phase positive sequence voltages as magnitude and angle (Polar form) quantities

- 3-phase positive sequence currents magnitude and angle (Polar form) quantities

vi) Integration of PMU to PDC shall conform to IEEE C37.118, for communication

vi) The PMUs shall be suitable for configuring the data sampling rate of 10, 25, 50 samples per second. Actual rate shall be user selectable.

vii) The PMUs shall have continuous self monitoring, diagnostic feature and capable to identify and communicate problems and shall generate alarm in case of any abnormality which shall be displayed locally and shall be transferred to the PDC also.

viii) There shall be provision for HMI (Human Machine Interface) in PMU to perform setting changes. Alternatively, portable configuration device for PMUs may be provided.

ix) Remote configuration facility shall be provided in PMU.

x) The PMUs shall communicate with PDC on Ethernet interface.

xi) GPS based time facility shall be provided to synchronize PMU clock with time accuracy of atleast 1 microsecond.

xii) For multiple PMUs at a sub-station/ switchyard, the router with firewall shall be provided.

6.1.6 Uninterrupted Power Supply :

i) Uninterrupted power supply (UPS) at 220/ 110V AC single phase of solid-state SCR/ Power Transistor type, continuous duty having overload capacity of 120% of rated capacity at 0.8 pf for 2 minutes and with battery back up of 30 minutes for the SAS system shall be provided.

ii) The battery shall be stationary, high discharge pocket plate Ni-Cd type. The rated ampere-hour capacity of cell/ battery shall be at reference temperature of 27^0C, constant current discharge at 5 hour rate (C_5) and end cell voltage of 1 V/cell.

iii) 100% float-cum-boost charger, solid state type with full wave fully controlled 3 phase bridge configurations shall be provided. The charger shall be provided with automatic voltage regulation, current limiting, smoothing filter circuit and soft start feature. The output voltage of the charger shall be regulated within ±1% of the set value for any load variation from 0 to 100% for specified AC input voltage and frequency variations. The ripple content in charger DC output shall be limited to ±1%.

6.2 Power Line Carrier Communication (PLCC)

6.2.1 Power Line Carrier Communication (PLCC) for 400/ 220/ 132kV system

a) PLCC shall be used for communication link between 400/ 220/ 132kV switchyard of thermal/ hydro power plant and interconnecting sub-stations through 400/ 220/ 132kV transmission lines. PLCC panels shall be located in the control room or in AC kiosks

PLCC equipment comprising of not limited to the following shall be provided:

- Coupling devices (Line matching unit and protective devices).
- Coupling filters
- High frequency cable
- Power line carrier terminals
- Private Automatic Exchange
- 48V DC power supply equipment
- Wave Trap for the above transmission lines

b) PLCC link shall be provided with carrier protection of the transmission lines with tele-metering and speech communication in dialing mode.

Wave trap shall be inserted into the transmission lines to prevent undue loss of carrier signal for all power system conditions.

c) PLCC equipment requirements

i) Coupling device (Line matching unit and protective devices) shall be interposed between the CVT and the connection line (co-axial cable) to the PLCC terminals to ensure:

- The efficient transmission of signals from the connection line to the high voltage line and vice versa.

- The safety of personnel and protection of low voltage parts of the installation against the effects of power frequency voltage and over voltages. Phase-to-phase coupling is to be adopted.

ii) Coupling filters in conjunction with the capacitor of CVT shall constitute a broadband pass filter. The characteristic impedance of the associated transmission line shall match with the impedance of the connection line for PLCC transmitter/ receiver.

iii) The primary of the coupling unit shall have low impedance at the operating frequency of the transmission line (50Hz), so that the capacitor charging current (drainage of charging current) of the CVT is grounded.

iv) The matching transformer of the coupling device shall be provided with galvanic isolation between input and output circuits and shall withstand a test voltage of atleast $3kV_{rms}$ for 1 minute.

v) The coupling device shall be provided with a protective device to protect the carrier equipment against excess voltage on defective CVT.

vi) A surge arrestor (SA) shall be connected directly between the primary and earth terminals to protect the coupling device and the carrier frequency connection. The surge arrestor shall have power frequency spark over voltage co-ordinated with the equipment ahead of it.

vii) The coupling device shall conform to the following carrier frequency operating characteristics between phase to earth coupling units :

1)	Nominal impedance (equipment side)	Ω	150 (for balanced secondary circuit) 75 (for unbalanced secondary circuit)
2)	Maximum composite loss	dB	2
3)	Transmission band	kHz	40 to 500

viii) The composite loss is the power loss in the carrier signal after passing through the coupling devices alongwith CVT's. Coupling unit shall be loaded with its primary and secondary impedance while capacitor is assumed to have no loss.

ix) The capacitance of the CVTs with which the coupling unit is to be used for the above transmission band shall be provided by the manufacturer.

x) Two no. phase to earth coupling units shall be capable of inter-phase or inter-line coupling. In case any separate matching transformer or matching unit is required, the same shall be acceptable.

xi) Suitable earthing switches for grounding the low voltage terminals of CVT for carrying out maintenance or any other works on coupling unit shall be provided.

xii) The coupling device shall be suitable for outdoor mounting and shall be fitted on the steel structure. Temperature of metallic equipment mounted outdoor is expected to rise upto 65^0C with ambient temperature of 50^0C.

xiii) The connection between coupling device and CVT shall be with $6mm^2$ copper wire tapped with 11kV insulation tapes.

xiv) *Ratings and requirements of PLCC terminals*

The rating and requirements of PLCC terminals are given in Schedule - 13

xv) High frequency cable shall be provided to connect coupling unit installed in the switchyard to the PLCC terminals installed indoors.

The cable shall be lead sheathed and round steel wire armoured. The cable shall be insulated to withstand a test voltage of 4kV rms for one minute between conductor and outer sheath. The high frequency co-axial cable with 75Ω impedance (unbalanced) shall also be acceptable.

The values of attenuation per km of the cable at various values of carrier frequencies in the range of 40 KHz to 500 kHz shall be provided by the manufacture.

The maximum attenuation at various frequencies shall be as follows:

Frequency (kHz)	**Attenuation (dB/km)**
10	0.8
60	1.4
300	3.3
500	4.7

The cable shall be supplied on drum lengths of 500 or 1000 meters.

xvi) PLCC terminals : Single side band PLCC terminals of latest version equipped for fixed frequency duplex system working shall be provided for superimposed channels (multipurpose) for speech and protection purpose. The

PLCC terminals shall be provided with HF hybrid filters and shall have necessary frequency stability so that adjacent channel working is possible.

xvii) The PLCC terminals shall be provided with emergency call facilities from the carrier sets for point to point carrier communication with telephone set suitable for hanging inside the cabinet.

6.2.2 Power Line Carrier Communication (PLCC) for 765kV system

i) Digital power line carrier communication (DPLC) conforming to latest IEC or equivalent standard shall be provided for 765kV system. DPLC shall be suitable for use with the outdoor equipment viz. line traps, CVT, coupling device, HF cable as described in analogue PLCC described above.

ii) DPLC will primarily be provided for speech and data services. PLC terminals shall be fully co-coordinated to match with the specific requirement for transmission/ reception.

iii) General Technical Data

a) Carrier frequency section of DPLC terminal

The PLCC equipment shall support DPLC mode of operation which shall be software programmable via PC/ Notebook.

Modulation and coding shall be implemented as software functions in digital signal processing (DSP) technology. Transmission mode shall be of duplex working type.

The nominal carrier frequency shall be programmable from 40 to 500kHz minimum.

The carrier frequency stability shall be equal or better than ±1ppm over the operating temperature range.

The nominal bandwidth for transmitting or receiving shall be programmable from 4 to 8kHz in steps of 4kHz. DPLC terminal at bandwidth of 4kHz shall be suitable for following configuration:

- Speech + 4x 200 Baud Data (minimum)
- The modems for the above requirement shall be supplied with DPLC and shall be an integral part of the equipment.
- Transmit (Tx) and receive (Rx) bands shall be configurable for adjacent or non-adjacent operation.

- Transmit output power shall be user programmable for 10, 20 or 40W PEP (Peak Envelope Power). However, minimum 80W PEP transmit power shall be supplied for achieving desired SNR in 765kV long transmission lines (more than 300km) to overcome the noise.

- The nominal output impedance shall be programmable as 75 or 125Ω unbalanced, or 150 Ω balanced as an option.

- The return loss in the transmitter band shall be >10dB

- The tapping loss shall be <1.5dB (as per IEC:60495).

- The AGC range of the receiver shall be 40dB (minimum)

b) System operation

The PLCC equipment shall be programmable via Laptop PC/ Note book/ Human Machine Interface (HMI)/ Graphical User Interface (GUI) based on MS Windows OS.

The PLCC system shall facilitate the programming and monitoring of the DPLC terminals in the standard GUI/ HMI (Human Machine Interface).

Programming software shall be incorporated in the HMI for monitoring and programming of the PLCC terminals. One number Laptop PC with above programming software shall be provided.

Potential free contact shall be made available for monitoring critical alarm/ link failure of the DPLC. The potential free contact shall be suitable for rated voltage of 0.1A, 220V DC.

c) Speech (voice signal) transmission

In digital telephony the data rate of compressed telephony shall be field programmable using PC/ Notebook for each telephony channel

Speech interfaces shall be configurable as 4-wire E&M, 2-wire FXO or 2-wire FXS.

Inter-channel crosstalk shall be compliant with IEC60495.

A compander according to ITU-T G.162 shall be configurable via HMI for each speech channel. The digital PLCC shall be suitable for connection to PABX for speech requirement.

A service phone shall be provided with each PLC terminal, multiplex with the main speech channel.

d) Broadband Data Transmission

The PLCC terminal shall be provided with an integrated modems for broadband/ high speed data transmission. Transmission speed and spectral bandwidth shall be programmable via PC/ Notebook.

The gross speed and transmission bandwidth shall be programmable for up to 28.800kbit/s in 4kHz spectral bandwidth, up to 72kbit/s in 8kHz bandwidth.

The data rates shall be selectable in steps, compliant with commonly used standardized data rates such as 1200, 2400, 4800 and 9600Bauds.

The system shall support automatic transmission speed adaptation (DSA-dynamic speed adaptation) in at least 2 user-defined steps, self-adapting to the prevailing line condition (noise and interference). In case of decrease of SNR, priority shall be given to data over voice. However uninterrupted flow of data shall be ensured even at a level of SNR =25dB.

The broadband modem shall provide a facility for automatic detection and suppression of narrowband interferers.

e) Data multiplexing

The PLCC terminal shall be provided with an internal multiplexer for the time division multiplexing of up to 8 serial data channels which can be allocated individually to the internal modems.

Data ports shall be compliant with V.24/V.28, RS232 and/ or V.11/ X.21/ X.24 s per functional requirement.

All data ports shall be electrically isolated from ground and against each other. An ethernet port shall be provided for equipment configuration via LAN, or for general IP forwarding. It shall have facility to operate @ 9600bits/s at good SNR of 35dB and above within the nominal Band width of 4kHz. The above functionality shall be possible for SNR of 25dB for Band with of 8kHz.

f) General requirement for digital type terminals

i) Supply voltage 48V DC +15%, –10%. (positive pole earthed)

ii) In the input circuit of the PLCC terminal protective devices shall be provided in the form of zener diodes or surge suppressers in order to eliminate any surge transfer through the coupling device or the surge induced in the connecting path of HF cable.

iii) Compressors and expanders shall be provided to improve voice transmission characteristics for the system. The companders shall have at least 2:1 compression ratio with a corresponding expansion ratio of 1:2.

The operating range of compander shall be compatible with the audio power levels specified for 4 wire operation. The improvement gained by companders shall not be considered for power allocation and shall be in-hand reserve.

iv) Speech+Data channels shall independently fulfill the SNR requirements out of the power allocated to its channel from the total power of the PLCC terminals.

v) Fail safe devices shall be provided to avoid a malfunction in one unit or damage of any sub-assembly. All plug-in equipment shall be fitted with features to avoid improper insertion. The electrical cables shall not be routed across sharp edges or near sources of high temperature. The adjustments, which are susceptible to maladjustment from accidental contact/ vibration shall be equipped with suitable locking devices.

vi) The PLCC set shall be designed to give guaranteed performance from 0 to 50^0C. The thermal capability of the equipment shall be so designed to be operational upto 55^0C.

vii) The carrier set shall be provided with suitable supervision and alarm facilities. Individual parts of the carrier set should be accessible from front making it possible to place the carrier cabinets side-by-side. All components and parts of the carrier set shall be suitably tropicalised.

6.2.3 The type of PLCC and number of channels per line and number of codes per channel shall be decided during detailed engineering as per the requirement and practice of the utility/ project

6.3 Auxiliary power supply for sub-station/ switchyard

6.3.1 415V AC system

The 415V AC system shall provide power supply to 415V switchgears, DC system, circuit breakers, disconnectors, lighting panels etc. of the entire switchyard system. Indicative details/ parameters are mentioned below.

6.3.1.1 LT transformers

i) The 11/0.433kV or 3.3/ 0.433kV (whichever is applicable) LT transformers shall be provided with delta-connected primary and a star–connected secondary with the star point brought out solidly earthed for 415V system.

ii) Salient features of LT transformers :

The salient features of LT transformer are given in Schedule - 14

6.3.1.2 415V switchgears:

i) The switchgears shall be indoor, metal clad having following features:

1) Circuit breakers	Air break, three pole, spring charged, horizontal drawout type, suitable for electrical operation
2) Switchgear	Fully drawout type, single front
3) MCC	Fully drawout type, single front
4) ACDB	Fixed type, single front

ii) The system parameters for 415V system shall be as follows:

1) Nominal system voltage	V	415
2) Highest system voltage	V	433
3) Voltage variation	%	±10%
4) Rated frequency	Hz	50
5) Frequency variation	%	+3 to -5
6) System earthing		solidly grounded
7) Maximum system fault level	kA	50 (for 3s)

iii) All 415V switchgears, AC and DC distribution boards (DBs), etc shall have following features:

- Shall be of single front, fully draw-out, metal enclosed, indoor, floor mounted and free standing type.

- All frames and load bearing members shall be fabricated using mild steel structural sections or pressed and shaped cold rolled sheet steel of thickness not less than 2mm.

- Frame shall be enclosed in cold rolled sheet steel of thickness not less than 2mm (CR). Doors and covers shall also be of cold rolled sheet steel of thickness not less than 1.6mm. Stiffeners shall be provided wherever necessary. Removable gland plates of thickness 3mm (hot/ cold rolled sheet steel) or 4mm (non-magnetic material) shall be provided for all panels.

6.3.2 DC system

The DC system comprising of adequate capacity of 220V DC battery and its chargers shall be provided for protection and monitoring system of the various

panels, circuit breakers, isolators, lighting etc. of the entire switchyard system. However, 110V DC system may also be adopted for sub-stations.

6.3.2.1 DC battery

i) The system parameters of 220/ 110V DC system shall be as follows:

1) Nominal system voltage	V	220	110
2) Highest system voltage	V	242	121
3) Voltage variation	V	187-242	99-121
4) Ambient temperature	^{0}C	50	50
5) System earthing		Unearthed	Unearthed
6) Maximum system fault level	kA	25 (for1s)	25 (for 1s)

ii) The DC system shall be ungrounded and comprise of 2x100% sets of 220V of either Lead–Acid Plante or Nickel-Cadmium Battery banks each provided with trickle and boost chargers and 2 no. DC distribution boards (DCDB) for switchyard loads.
For sub-station application, Valve Regulated Lead Acid (VRLA) type battery may also be acceptable.

iii) The ampere-hour capacity of DC storage battery shall be based on three (3) hour supply. Minimum emergency lighting system with reduced illumination during failure of main power supply shall be provided.

iv) Battery duty cycle:

Load	Duration	Type of Loads
1) Continuous load	3 hours	Relays/ IEDs, HMIs, CB spring charging, isolator interlocking load, miscellaneous permanently connected loads etc.
2) Emergency load	1 hour	Emergency lighting loads
3) Momentary load	1 minute	CB closing, tripping loads (considering simultaneous occurrence as per system)

v) Salient features of battery :

a) Lead Acid Plante type battery:		
1) Battery Voltage	V	220/ 110

2) Battery type		Stationary Lead Acid Plante high discharge type
3) Capacity for ten(10) hour rate to 1.85V/ cell at 27^{0}C any time during the entire duty cycle		As required
4) Nominal discharge voltage/ cell	V	2.0
5) Float voltage per cell	V	2.2
b) Ni-Cd Type Battery		
1) Battery Voltage (V)	V	220/ 110
2) Battery type		Stationary Ni-Cadmium Pocket Plate High discharge type (KPH)
3) Capacity for five(5) hour rate to 1.14 V/Cell at 27^{0}C any time during the entire duty cycle		As per system requirement
4) Nominal discharge voltage/cell	V	1.2
5) Float voltage per cell	V	1.42

6.3.2.2 Battery charger

Battery charger for Lead-Acid Plante type battery: The batteries shall be trickle charged at 2.15–2.25V per cell. All chargers shall also be capable of boost charging the associated DC battery at 2.0–2.7V per cell at the desired rate.

Battery charger for Nickel-Cadmium type battery: The batteries shall be trickle charged at 1.4–1.42V per cell. All chargers shall be capable of boost charging the associated DC battery at 1.53–1.7V per cell at the desired rate.

6.3.2.3 DC distribution board (DCDB)

The DCDB shall be fixed type, single/ double front type

Each battery bank associated with trickle charger and boost charger shall be connected to respective distribution board. At least 20% spare feeders with minimum 1 no. of each type and rating shall be provided in the DCDB. The essential load/ system shall be provided with duplicate supply from separate sections of DCDB.

Each DCDB shall be provided with (a) Earth fault detection relays (to give alarm on earth fault in positive or negative of the system) (b) Under/ over voltage relays for 'DC voltage low/ high' annunciation (c) Voltmeter with selector switch for positive to earth, negative to earth and between positive and negative voltages measurement/ indication.

7.0 POWER AND CONTROL CABLES, LAYING & TERMINATION

i) 415V power cables shall be 1.1kV grade, heavy duty, stranded aluminium conductor, PVC type-A insulated galvanized steel wire/ strip armoured, flame retardant low smoke (FRLS) extruded PVC type ST1 outer sheathed.

The sizing of all power cables shall be based on current rating; however, de-rating factors corresponding to temperature and grouping of cables shall also be considered.

ii) Control cables shall be 1.1kV grade, heavy duty, stranded copper conductor, PVC type A insulated, galvanized steel wire/ strip armoured, flame retardent low smoke (FRLS) extruded PVC of Type-ST1 outer sheathed.

iii) Cables shall run in GI cable trays/ rigid GI conduits to the extent possible. Cable trays shall be ladder/ perforated type. Cable tray support system shall be pre-fabricated. Modular type trays may be considered wherever, feasible.

iv) Cable trays shall have standard width of 150mm, 300mm and 600mm and standard lengths of 2.5metre. Minimum thickness of mild steel sheets used for fabrication of cable trays and fittings shall be 2mm. The thickness of side coupler plates shall be minimum 3mm.

v) Suitably routed cable trenches shall be provided to accommodate power and control cables from marshalling box in the yard to the respective panels in the control room building or outdoor air conditioned kiosks (air conditioned bay control rooms). The cables entering the control room building will be laid in pipes with suitable sealing at wall openings to prevent entry of water and rodents into the building through the cable trench opening.

8.0 LIGHTING

i) Illumination shall be provided in the switchyard area and switchyard control room building. The illumination level shall be 30–50Lux (average) for outdoor switchyard and 300Lux (average) for switchyard control room.

ii) For outdoor illumination, HPSV floodlights will be installed on street lighting poles/ Lighting cum Lightning Masts (LCLM)/ Lighting Tower at suitable locations to provide requisite level of illumination. For approach/ work roads, pole mounted high pressure sodium vapour lamp fixtures shall be used.

iii) In outdoor area and control room, 20% of the lighting shall be on AC emergency. DC emergency lighting shall also be provided in critical operating areas in the control room. Incandescent lamp/ LED/ CFL fixtures shall be used for emergency lighting.

iv) Supply to the illumination system shall be from 415V AC distribution board through 3-ph 415/ 415V dry type isolation transformer provided in incomer of Main Lighting Distribution Board (MLDB). MLDB shall consist of 2x100% incomers and bus-coupler.

Outgoing feeders shall be provided with triple pole Miniature circuit breaker (MCB) with neutral links to feed the Lighting Panels (LP). In LP's, single phase outgoing feeders shall be provided to feed the lighting circuits.

v) 240V AC, 6/16A, 3 pole socket outlets with switch shall be provided in office rooms. 240V, AC, 20A, 3 pole socket outlet with switch shall also be provided in the office room. 63A welding power sockets shall be provided at alternate bay marshalling kiosks in the switchyard.

vi) In case of sub-stations, high beam flood light fixtures shall be provided in strategic locations near equipment in addition to the normal lighting provided in the yard; however, these shall be normally switched OFF and switched ON during maintenance.

9.0 GROUNDING

i) The grounding grid shall be designed as per IS 3043/ IEEE 80. It shall be ensured that the grid resistance shall be such that the touch and step potentials are within the safe limit. All equipments, structures etc. shall be connected to grounding mat as per IE rules, code of practice for earthing and IEEE 80 at two separate and distinct locations.

ii) A grounding mat shall be provided at a minimum depth of 600mm in the sub-station/ switchyard to provide low impedance discharge path for lightning surges/ system fault current to earth.

iii) The earthing conductor size shall be designed for a life expectancy of minimum forty (40) years and for maximum system fault current of time duration 1.0sec. whichever is higher. The minimum rate of corrosion of steel used for earthing conductor shall be considered as 0.12mm per year for designing its size.

iv) MS rods/ Pipes of 40mm diameter, 3000mm long shall be used as main ground electrode to be connected to grid conductor. These electrodes shall be located at suitable locations.

The risers from MS rod/ flat shall be provided upto a height of 300mm from the ground level at different locations for equipment connection by GS flat of adequate size.

v) The auxiliary earth mat of 1500mmx1500mm size comprising of closely spaced conductor at 300mmx300mm shall be provided below the operating handle of the disconnector at a depth of 300 mm from ground level. The operating handle shall be directly connected to the earthing mat.

vi) The sub-station/ switchyard ground grid shall be connected to the main plant grid with two connections through test links and earth pits.

vii) The entire area of the sub-station/ switchyard shall be filled with 150/100mm thick gravels to restrict the growth of grass in outdoor sub-station/ switchyard. The gravels shall consist of 75/50mm thick of 40mm stone size on the top and 75/50mm thick of 20mm stone size below.

The resistivity of gravel shall be 3000Ω-mtr.

viii) Separate earth electrodes shall be provided for lighting mast, surge arrestors and transformer neutrals, VT.

ix) Metal pipes and conduits shall be effectively earthed at two points.

Metallic sheaths/ screens and armour of multi-core cables shall be earthed at both ends. Metallic sheaths and armour of single core cables shall be earthed at switchgear end only.

x) The alternate post of the sub-station/ switchyard fence shall be connected to earthing grid by one GS flat. The gates shall be connected to the earthed post by flexible lead.

xi) Railway tracks within the plant area shall be bonded across fish plates and connected to earthing grid at several locations.

xii) Cable tray shall be earthed at minimum two points by GS flats to earthing grid. The distance between earthing points shall not exceed 30m.

xiii) The minimum size of earthing conductor for various equipments is given below :

SN	Item	Size & Material
a.	Main earthing conductor to be buried in ground	40mm dia MS rod
b.	Conductor above ground and earthing leads (for equipment)	75x12mm GS flat

c.	Conductor above ground and earthing leads (for coloumns and aux. structures)	75x12mm GS flat
d.	Earthing of indoor LT panels, control panels and outdoor marshalling boxes, JBs and Lighting panels etc.	50x6mm GS flat
e.	Rod earth electrode	40mm dia, 3000mm long MS rod
f.	Pipe earth electrode (in treated earth pit) as per IS	40mm dia, 3000mm long GS pipe
g.	Earthing of motors	25x3mm GS flat
h.	Earthing conductor along outdoor cable trenches	50x6mm GS flat
i.	Earthing of lighting poles	20mm dia, 3000mm long MS rod

10.0 SHIELDING

i) The sub-station/ switchyard shall be protected from direct lightning strokes by either GI shield wires (7/3.66mm) strung to the peak of gantry towers or suitably located lightning masts or both in addition to surge arresters.

ii) GI flats/ shield wires shall be used as down conductors for connecting the shield wires/ lightning masts to the grounding grid. The zone of protection shall depend upon structure height, overall shape and physical location of the structures in the sub-station/ switchyard & equipment to be protected.

iii) GS shield wires shall be strung between gantry supports and wall of main power house over the phase conductors for the generator transformers and station transformers.

iv) The complete shielding network shall be connected to the main ground mat of the sub-station/ switchyard.

11.0 FIRE DETECTION, ALARM AND PROTECTION SYSTEM

i) Sub-station/ switchyard control room shall be provided with automatic inert gas system and analogue addressable microprocessor based fire detection, alarm and protection system. Fire detectors (heat detectors and smoke detectors) shall be located at strategic locations in rooms of sub-station/ switchyard building.

ii) Adequate no. of portable CO_2 and dry chemical powder types fire extinguishers shall be provided in suitable locations in the sub-station/ switchyard building.

iii) Fire alarm panel(s) shall be provided with independent sealed type batteries with boost cum float charging facilities.

iv) Fire protection system for outdoor sub-station/ switchyard is not envisaged; however, it shall be provided with adequate fire hydrant points connected to fire protection system of main plant.

12.0 STRUCTURAL AND CIVIL WORKS

12.1 Structures

i) The following galvanized steel structures for sub-station/ switchyard shall be provided:

- Gantry towers and Girders
- Lightning cum lighting towers
- Lighting towers
- Circuit breakers, disconnectors and
- Current transformer and Voltage transformer
- Lightning arrestors, wave traps
- Bus post insulator (BPI)
- Cable support, etc.

ii) All structural steel members in sub-station/ switchyard shall be hot dip galvanized as per IS 4759 or equivalent. The fasteners shall also be galvanized per IS 1367 (Part-13). Bolts and nuts shall be as per IS 802. The spring washers shall be electro-galvanised as per IS 1573. The materials, structural loads and stresses of towers and equipment supporting structures shall be per IS 802.

iii) Lighting masts shall be provided with minimum two number platforms with one no. at the top level. An internal ladder shall be provided to climb upto top level platform. The top of platform shall be provided with grating, GI pipe hand railing and toe guard plates.

iv) The following shall be considered for designing sub-station/ switchyard structures:

a) Gantry towers and girders

Sub-station/ switchyard structures shall be designed for combination of following loads :

- dead load
- live loads
- wind load
- seismic load
- loads for deviation of conductor
- loads for unbalanced tension in conductor
- torsional load for unbalanced vertical and horizontal forces
- erection loads
- short circuit forces including snap in case of bundled conductors etc.

The material for gantry towers and girders shall be per IS 2062. Dead Load and live load shall be as per IS 875. The permissible stress in steel structures shall be more than that mentioned in IS 802/ IS 800.

The factor of safety for the design of members shall be considered as 2.0 for normal condition & broken wire condition and 1.5 for combined short circuit, broken wire condition.

b) Equipment structures

Supporting structures for equipment shall comprise of galvanized pipe supports (ERW pipe of grade YST 21 or higher)/ lattice structural steel supports. The pipe supports shall be designed as per IS 806 and IS 1161. The lattice steel supports shall be designed as per IS 802.

The fabrication and erection of the Sub-station/ switchyard structures shall be generally as per IS 802 and IS 800. All materials shall be shop fabricated and galvanized.

Diagonal wind condition shall be considered for the design of lightning mast.

c) Switchyard control room

The Sub-station/ switchyard control room shall be single/ two storied RC framed building with brick or hollow concrete block masonry cladding. The grade of concrete shall be M25.

d) Cable trenches

All cable trenches shall be of RCC with RCC pre-cast cover. Adequate steel inserts shall be provided, wherever required for support of cables.

e) Loads

- Wind load: The mean wind speed shall be as per IS 875 (Part-3). The terrain category shall be as per IS 875 (Part-3).

- Seismic load: Seismic load shall be considered as per IS 1893.

- Temperature load: System and system component design criteria, which require ambient temperature extremes shall use the range from (-)3.9^{0}C to 48.3^{0}C for dry bulb temperatures.

12.2 Civil works

i) Basis of all civil design for foundations of all structures shall be geo-technical investigation report. The report shall constitute the main soil data viz recommended type of foundation, safe bearing capacity for various types of foundations and other investigation data soil resistivity, water table etc.

The civil specification for Main Plant shall be followed as a guideline for Sub-station/ switchyard equipment foundations, control room building.

ii) The switchyard area shall be filled with 150/100mm thick gravels to restrict the growth of grass in outdoor sub-station/ switchyard. The gravels shall consist of 75/50mm thick of 40mm stone size on the top and 75/50mm thick of 20mm stone size below.

Each layer shall be compacted by using ½ ton roller with 4-5 passes and suitable water sprinkling. Before laying the gravel fill, the top layer of the soil shall be treated for anti-weed considering the types of weeds found in the vicinity.

12.3 Fencing

The fence around sub-station/ switchyard area shall comprise of PVC coated GI chain link fencing of minimum 8G (including PVC coating) of 75mm mesh size and of height 2.4m above the toe wall with a 600mm high concertina at the top, such that total fence height of 3m above the toe wall is achieved. The diameter of the steel wire for chain link fence (excluding PVC coating) shall not be less than 12G.

13.0 INTERNATIONAL/ INDIAN STANDARDS

The list of major International/ Indian Standards is given in Schedule - 15

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Annexure - A

GAS INSULATED SUBSTATION (GIS)

1.0 GENERAL

i) Gas insulated sub-station comprising of operating devices, accessories and auxiliary equipment shall be metal-enclosed SF_6 gas type as per IEC 62271-203. GIS shall be indoor/ outdoor type. However, indoor type shall be preferred considering its long life with respect to easy maintenance. The ladders and walkways shall be provided wherever necessary for access to the equipment.

ii) 765/ 400kV system GIS shall be single phase type. 220/ 132kV system GIS shall be three phase or single phase or a mixture of both. 33kV GIS shall be three phase type.

iii) The arrangement of gas sections/ compartments shall be such as to facilitate future extension of any make on either end without drilling, cutting or welding on the existing GIS. It shall not be necessary to move or dislocate the existing sub-station bays for adding the equipment.

GIS shall be totally safe against inadvertent touch of any of its live parts. It shall be protected against all types of voltage surges.

iv) GIS shall include but not be limited to the following:

- Circuit breakers
- Disconnecting switches (isolators)
- Maintenance earthing switches
- Fast acting earthing switches
- Current transformers
- Voltage transformers
- Bus and elbow sections
- Cable end enclosures
- SF_6 to air bushings
- GIS to transformer direct-connections
- Surge arresters
- Density switches, secondary cable etc.
- Support structures for the GIS
- Insulating SF_6 gas
- Local control cubi<
- Monitoring system

2.0 SYSTEM PARAMETERS

The system parameters for 765kV, 400kV, 220kV, 132kV and 33kV are given in Schedule - 1

3.0 CONSTRUCTIONAL REQUIREMENTS

i) GIS shall be of the free standing, self-supporting with easy accessibility to all the parts during installation and maintenance with all high-voltage equipment installed inside gas insulated metallic and earthed enclosures, suitably sub-divided into individual arc and gas proof compartments preferably for:
- bus bar disconnectors
- intermediate compartment
- circuit breakers
- line disconnectors
- current transformers
- voltage transformers
- gas insulated bus duct section between GIS and XLPE cable
- gas insulated bus section between GIS and transformer/ reactor (if applicable)

ii) GIS assembly shall consist of separate modular compartments e.g circuit breaker compartment, bus bar compartment filled with SF_6 gas and separated by gas tight partitions. The maintenance on one feeder shall be possible without de-energising the adjacent feeders. Accessories viz. particle trap, pressure relief devices, desiccants etc. shall be provided for each compartment.

iii) The material and thickness of the enclosures shall withstand the internal flash over without burn through at rated fault current for a period as per IEC 62271-203.

iv) Each pressure filled enclosure shall be designed and fabricated to comply with the requirements of the applicable pressure vessel codes and based on the design temperature and pressures as per relevant IEC. The maximum gas leakage for GIS shall not be more than 0.5% per year.

v) The fabricated metal enclosures shall be of non-magnetic material with high resistance to corrosion, low electrical losses and negligible magnetic losses.

vi) The disconnecting switches and earth switches shall preferably be provided with windows to inspect switch contact positions directly.

vii) Enclosures shall be single phase/ three phase (as applicable) encapsulation for busbars and feeder section bays. The sub-station shall be modular in design with provisions of future extensions.

The conductors and live parts shall be mounted on high graded epoxy resin insulators. These insulators shall be designed for high structural strength and electrical dielectric properties. It shall be properly shaped to provide uniform field distribution and to minimize the effects of particle deposition either from migration of foreign particles within the enclosure or from the by-products of SF_6 breakdown under arcing conditions.

viii) Shipping sections tested in the factory shall be assembled by bolted and sealed flange connections only. Field welding of enclosures shall not be done. The size of the pre-assembled shipping sections shall be big enough for easy transportation. The assembly tested in the factory shall not be dis-assembled for shipment.

ix) The flanged connections shall be provided with gas seals between the flange surfaces. Suitable means shall be used to protect the gas seal from the external environment for outdoor application. Connections including bolts and nuts shall be protected from corrosion. Support insulators shall be the section barriers.

x) Support insulators shall be provided to maintain the conductors and enclosures in proper relation.

xi) The switchgear shall be sectionalized with gas tight barriers between sections or compartments. Static filters, density switches, filling & evacuation valve and safety diaphragm/ pressure relief device etc. shall be provided in each compartment. The filters shall be capable of absorbing water vapour which may penetrate into the enclosures and by-products of SF_6 during interruption.

xii) Continuous bus lengths without gas segregation shall not be provided.

xiii) Each section shall be provided with necessary valves for evacuation and refill of gas without evacuation of any other section.

xiv) Each gas compartment shall be provided with temperature compensated gas density switch for gas monitoring and maintenance.

xv) Pressure relief devices shall be provided in the gas sections to protect the main gas enclosures from damage or distortion during the occurrence of abnormal pressure increase or shock waves generated by internal electrical fault arcs.

Rupture diaphragms with suitable deflectors shall be provided to prevent uncontrolled bursting pressures developing within the enclosures under worst operating conditions.

xvi) The enclosure shall be sized for carrying induced current equal to the rated current of the bus. The conductor and the enclosure shall form the concentric pair with effective shielding of the field internal to the enclosure.

xvii) The enclosure shall be designed to eliminate the external electromagnetic field to reduce electro dynamic stresses under short circuit conditions. The average intensity of electromagnetic field shall not be more than 50 μ-tesla.

xviii) The temperature rise of accessible enclosure shall not exceed 20^0C above the ambient temperature. In the enclosures which are not be touched during

normal operation, the temperature rise limit may be permitted upto 30^0C above the ambient temperature.

xix) The fabricated metal enclosure shall be of aluminum alloy having high resistance to corrosion, low electrical losses and no magnetic losses.

4.0 CIRCUIT BREAKER

i) Circuit breaker (CB) shall be of SF_6 gas insulated single phase/ three phase (as applicable) type. It shall be self-blast/ puffer type and consist of one interrupting chamber upto 245kV and maximum two interrupting arcing chambers upto 765kV.

ii) The arrangement shall be horizontal/ vertical as per manufacturer preferred layout considering space limitation and taking into account the worst service conditions/ forces imposed by earth quake. The breaker enclosure shall have provision for easy withdrawal of the interrupter assemblies. The removed interrupter assembly must be easily and safely accessible for inspection and possible repairs.

iii) Circuit breaker shall be M2 class as per IEC 62271-100 and shall be capable of :

- Interrupting the steady and transient magnetizing current

- Interrupting line/ cable charging current as per IEC without re-strikes and without use of opening resistors.

- Clearing short line fault (kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current

- Breaking 25% of rated fault current at twice rated voltage under phase opposition condition.

- Withstanding minimum 20no. of interruptions at rated short circuit current with associated rate of rise of recovery voltage without requiring change of any parts.

- Interrupting symmetrical short circuit current under out-of-phase switching conditions.

iv) Circuit breaker shall be provided with suitable operating mechanism for opening and closing. It shall permit checking adjustments and opening characteristics. Each mechanism shall be provided with two trip coils. The breakers shall be re-strike-free.

v) All making and breaking contacts shall be sealed and free from atmospheric effects. The gap between the open contacts shall withstand minimum rated

phase to ground voltage for eight hours at zero pressure above atmospheric level of SF_6 gas due to its leakage. In the interrupter assembly there shall be an adsorbing product box to minimize the effect of SF_6 decomposition products and moisture.

vi) The facility to attach operational analyzer to record travel, speed and closing time measurement etc. after installation shall be provided.

vii) Circuit breaker shall be capable of high speed single and three phase re-closing.

viii) The closing coils and other auxiliary devices shall operate satisfactorily at all voltages between 85-110% of the rated control voltage and trip coils between 70-110% of rated control voltage.

ix) Salient features of circuit breakers

The salient features for 765kV, 400kV, 220kV, 132kV and 33kV system circuit breakers are given in Schedule - 5

5.0 DISCONNECTORS (ISOLATORS) & EARTH SWITCHES

a. Disconnectors :

i) Disconnectors shall be single pole, group operated with motor operated mechanism as per IEC 62271-102. The provision of emergency manual operation shall also be included. Safety interlocks shall be provided to prevent closing of disconnectors when main earth switch is closed and vice versa.

ii) All main contacts shall be silver plated or with silver inserts. Once initiated, the motor mechanism shall complete an open or close operation without requiring the initiating contact to be held closed. The contact shielding shall prevent restrikes and high local stresses due to transient recovery voltages.

iii) Disconnector shall be provided with minimum 8 NO and 8 NC contacts make and break auxiliary contacts. The make-before-break contacts shall be provided for CT switching scheme.

b. Earth switch

i) Earth switch shall be provided with manual operating mechanism as per IEC-62271-102. If electrical operating mechanism is envisaged, motor operated mechanism shall be provided with electrical control from local position. Safety interlocks shall be provided for closing of earth switch when disconnector is closed and vice versa.

ii) The padlocking arrangement of earth switches shall be provided in open/ close position.

iii) The earth switch and its operating mechanism shall be provided with flexible copper conductors of minimum size of $50mm^2$ to earth with the ground. The earth switch connection to ground shall be rated for fault current and provided with a silver plated terminal connector suitable for steel strap of adequate rating for connection to the grounding grid.

iv) Earth switch shall be provided with at least 6 NO and 6 NC auxiliary contacts.

c. *Fast acting earthing switch*

i) Fast acting earthing switches as per IEC 62271-102, located on the line side of feeder bay module shall be of three-pole, group operated, high speed, make-proof type to discharge the charging currents in addition to their safety grounding function. It shall interrupt inductive currents and withstand transient recovery voltage (TRV) also.

ii) The rating of short circuit making current of earth switch shall be at least equal to its peak withstand current rating. The switches shall have electrostatic and electromagnetic induced current switching capability also.

iii) Earthing switch shall be provided with clearly identifiable local positive driven mechanical indicator and position indicator on the bay module control cabinet and provision for remote signalling.

iv) Earthing switch operation shall be possible local bay module control cabinet or remote control room in addition to opening of the associated disconnector.

v) Earthing switch shall be electrically interlocked with circuit breaker and disconnector to prevent closing of earth switch if the circuit breaker and disconnector are closed and vice-versa.

vi) The earth switch and its operating mechanism shall be provided with flexible copper conductors of minimum size of $50mm^2$ to earth with the ground. The earth switch connection to ground shall be rated for fault current and provided with a silver plated terminal connector suitable for steel strap of adequate rating for connection to the grounding grid.

vii) Earthing switch shall be provided with atleast 4NO and 4NC auxiliary contacts.

d. *Salient features for disconnector and earth switch*

The salient features for 765kV, 400kV, 220kV, 132kV and 33kV system disconnector and earthing switches are given in Schedule - 6

6.0 CURRENT TRANSFORMERS

i) Current transformer (CT) and its accessories for protection and metering as per IEC 60044-1 shall be incorporated into the GIS. It shall be of metal enclosed type.

The secondary windings shall be air-insulated and mounted inside metal enclosure. CT shall be provided with effective electromagnetic shields to protect against high frequency transients typically 1-30MHz. CT shall be suitable for high speed auto-reclosing. CT shall be provided with marshalling box for secondary terminals.

ii) For 765 kV system CT, the rated extended primary current shall be 200% of rated primary on all taps except 3000/1A tap. At 3000/1A tap the rated extended primary current shall be 120%. At 3000/1A tap, the CT shall be thermally rated for 200% for 15 minutes and 120% continuous. The secondary winding shall be rated for 2A continuously.

For 400 kV system CT, the rated extended primary current of the CT shall be 200% of rated primary on all except 2000/1A tap. At 2000/1A tap the rated extended primary current shall be 120%. At 2000/1A ratio, the CT shall be thermally rated for 200% for 15minutes and 120% continuous.

For 400 kV CT rated for 3000A, the rated extended primary current shall be 120% for 3000/1A tap and 180% for 2000/1A tap and 200% for lower tap ratios. The secondary windings shall be rated for 2A continuously. Further, the intermediate tapping at 3000-2000A and 2000-500A shall be suitable for using as 1000/1A and 1500/1A ratios.

For 220/ 132kV system CT, the rated extended primary current shall be 120% or 150% (as per requirement) on all cores of the CT.

iii) Protection class CT shall maintain the required accuracy for burdens ranging from 25% to 100% of rated burden and up to the accuracy limit factor/ knee point voltage in case of relaying CT.

Metering CT shall maintain the required accuracy for current ranging from 5% to 120% of rated current or specified rated extended current whichever is higher.

For 0.2S and 0.5S class CT, accuracy shall be maintained between 1% to 120% of rated current.

iv) CT burden shall not be less than 5VA to achieve required 0.2S accuracy class.

v) Salient features of current transformer

The salient features for 765kV, 400kV, 220kV, 132kV and 33kV system current transformers are given in Schedule - 7

7.0 VOLTAGE TRANSFORMERS

i) Voltage transformers (VT) shall be of the electromagnetic type with SF_6 gas insulation as per IEC 60044-2. VT shall be located in a separate module and will be connected phase to ground. In case of line feeder, wherever PLCC is required, outdoor capacitive voltage transformer (CVT) shall also be provided.

ii) VT shall be effectively shielded against high frequency electromagnetic transients. VT shall have three secondary windings. VT secondaries shall be provided with MCBs.

iii) VT burden for metering class winding shall not be less than 50VA to achieve 0.2 accuracy class.

iv) Salient features of Voltage transformer

The salient features for 765kV, 400kV, 220kV, 132kV and 33kV system voltage transformers are given in Schedule - 8

8.0 OUTDOOR BUSHINGS

Porcelain bushings shall be as per IEC 60137. SF_6 to air bushing shall be of ceramic insulator and pressurized with SF_6 gas. The conductor shall be supported by the insulator cone at the switchgear end and the high-voltage electrode at the air end. The shed form and creepage path length shall be as per requirements and service conditions

9.0 SURGE ARRESTORS

i) Surge arrestors (SA) shall be outdoor air insulated/ SF_6 gas insulated metal oxide and gapless type as per IEC 60099-4. The metal housing of SF_6 gas insulated SA shall be connected to the metal enclosure of the GIS with a flanged, bolted and gasketed joint so that the arrester housing is grounded through the GIS enclosure. The ground connection shall be sized for GIS fault level.

ii) The detailed system studies and calculations including insulation co-ordination shall be carried out prior to evolve the required parameters, locations, energy capabilities etc. of SA.

iii) Salient features of surge arrestors

The salient features for 765kV, 400kV, 220kV, 132kV and 33kV system surge arrestors are given in Schedule - 9

10.0 GAS INSULATED BUS DUCT

The components of GIS shall be connected by SF_6 bus consisting of an inner conductor and outer enclosure. The enclosure shall be connected with bolted and gasketed joints. The bus conductor shall be connected with plug-in contacts with silver plated contact surface. The bus system shall withstand the mechanical and thermal stresses due to rated fault currents, thermal expansion and contraction created by temperature cycling.

11.0 HV POWER CABLE CONNECTION (if applicable)

The cable end box shall be as per relevant IEC. The final connection of the high voltage cable circuits in GIS shall be with single-phase cables. All cable end modules shall be suitable for connecting single core, XLPE solid dielectric cable or low pressure oil filled cable type of maximum continuous voltage.

The design of link and connections shall ensure that when removed the resulting gap can withstand impulse and power frequency test voltages applicable to switchgear and cable high voltage DC test voltage.

12.0 HV POWER TRANSFORMER CONNECTION (if applicable)

Transformers shall be connected to GIS outgoing bus duct using complete enclosed adapters. The transformer bushing housing shall be as per IEC 61639. The adapter shall have a removable bus link to allow electrically disconnecting the transformer from the bus, testing of the bus/ transformer separately and removal of the transformer if required.

The bus enclosure shall be insulated from the transformer tank to minimize circulating currents through the transformer tank. The adapter unit shall also contain a bellow assembly and flexible conductor connections to minimize vibration transfer from the transformer.

13.0 GAS SYSTEM

i) GIS shall be provided with adequate sulfur hexa-fluoride (SF_6) gas to pressurize the complete system. One zone/ compartment shall be pressurized to the rated nominal density at a time. Additional 20% (minimum) of SF_6 gas shall also be provided.

ii) The gas leakage from each compartment of GIS shall not be more than 0.5% per year. During transportation, SF_6 compartments shall be filled with N_2 and refilled with SF_6 at site.

iii) The rated pressure of SF_6 gas in GIS equipment shall be as low as possible, while still meeting the requirements for electrical insulation and space limitations to reduce the effects of leaks and to ensure that there is no chance of the gas liquefying at the lowest ambient temperature. The initial gas pressure or density at the time of charging the equipment shall provide a 10% margin above the minimum allowable operating pressure.

iv) SF_6 gas shall be as per IEC 60376. Certificate of poison inspection shall be provided with supplied gas.

v) Temperature-compensated gas density monitoring devices shall be provided for gas compartment. Any pipe-work connection between the various gas compartments and a centralized measuring device shall not be provided.

vi) Self sealing vacuum couplings shall be provided on all gas compartments to facilitate filling and recharging.

vii) Gas filling and evacuating plant shall be provided necessary for filling-in/ evacuating SF_6 gas from GIS. This shall include all the necessary gas cylinders for temporarily storing the evacuated SF_6 gas. The capacity of temporary storage facilities shall be sufficient for storing the maximum quantity of gas that may be evacuated during maintenance/ repair work of at least one complete bay of GIS.

14.0 LOCAL CONTROL CUBICLES

Local control cubicles shall be provided for control & interlocking, local operation of various equipments, and indicating & measuring equipment for each bay/ module.

15.0 GIS EARTHING

i) GIS shall be provided with facility to connect with ground mat risers. This provision shall consist of grounding pads to be connected to the ground mat riser near the equipment.

ii) The earthing system shall be based on multi-point design ensuring the protection in case of indirect contact (touch or step voltages, in case of fault) and transient phenomena in case of lightning or switching operations.

iii) The three enclosures of single phase GIS shall be bonded at the ends of GIS to neutralize the flow of circulating currents. All wirings to GIS shall be shielded and grounded.

iv) The enclosure of GIS shall be adequately grounded to limit the potential difference between individual sections within allowable limit of 65-130V during faults.

v) Earthing conductors shall withstand rated short circuit current. Conductors with copper bars shall be preferred over copper wires. Separate ground strips to short circuit flanges and earthing switches shall not be provided.

16.0 GIS FOUNDATION GROUNDING

In GIS sub-stations, concrete foundations may cause irregularities in current discharge path. Therefore, a simple monolithic concrete steel reinforced slab is advantageous, both as auxiliary grounding device and for seismic reasons.

17.0 MONITORING SYSTEM

a) Dew point meter

Dew point meter for measuring the dew point of SF_6 gas of CB/GIS shall be portable and adequately protected for outdoor use. The meter shall be provided with dew point hygrometer with digital indication to display the dew point temperature in ^0C, ^0F or PPM. It shall be capable of measuring the corresponding pressure at which dew point is being measured.

b) Partial discharge monitoring system

The equipment shall be used for detecting different type of defects in GIS viz particles, loose shields and partial discharges. The instrument shall also be able to detect partial discharges in cable joints, terminations, CT and PT etc.

18.0 GIS BUILDING (if applicable)

GIS and other associated equipments of different voltage class may be accommodated in one building in same/ different floors or in different building depending on site requirement.

19.0 INTERNATIONAL/ INDIAN STANDARDS

The list of major International/ Indian Standards is given in Schedule - 15

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Annexure - B

HYBRID GAS INSULATED SUB-STATION

1.0 GENERAL

i) The hybrid sub-station may also be adopted upto 220kV level depending upon site conditions and requirements. Hybrid sub-station shall be outdoor type.

ii) The bus bars of hybrid sub-station shall be air-insulated type; however, its main functional units viz. circuit breaker, dis-connectors & earth switches are enclosed in SF_6 gas insulated housing. Current transformers shall be an integral part of gas compartment module. Integration of SF_6 voltage transformer and cable sealing ends should also be possible (as per requirement).

iii) The hybrid sub-station shall be outdoor type as per IEC 62271-203. The hybrid sub-station shall be isolated phase type with non-magnetic enclosure.

iv) Shipping sections tested in the factory shall be assembled by bolted and sealed flange connections only. Field welding of enclosures shall not be done. The size of the pre-assembled shipping sections shall be big enough for easy transportation. The assembly tested in the factory shall not be dis-assembled for shipment.

2.0 SYSTEM PARAMETERS

The system parameters for 220kV, 132kV and 33kV are given in Schedule - 1

3.0 CONSTRUCTIONAL REQUIREMENTS

i) The hybrid GIS module shall be suitable for outdoor application. The bus bar shall be conventional air insulated type. All the live-key functions viz CB, disconnectors, earthing switches etc. shall be SF_6 sealed type as in GIS. Connections with bus-bars shall be with silicon rubber type bushings.

ii) All hybrid GIS modules shall also be in line with the requirements as given in Annexure 'A' for GIS.

4.0 CIRCUIT BREAKER

i) The circuit breaker installed horizontally or vertically shall be of three phase/ single phase encapsulated type.

Single-pressure, single-break, self-compression auto puffer type SF_6 circuit-breakers with minimum maintenance contact system shall be provided.

ii) The breaker operating mechanism shall be of spring type. It shall be suitable for three pole auto reclosure.

iii) Salient parameters for circuit breaker

The salient features for 220kV, 132kV and 33kV system circuit breakers are given in Schedule - 5

5.0 DISCONNECTORS (ISOLATORS) & EARTH SWITCH

i) Disconnectors shall be SF_6, three or single phase encapsulated type. All switches shall be three phase linkage operated by a maintenance free self-contained electric motor.

ii) Disconnector and its earth switch shall be interlocked with electromechanically and electrically. Manual operation shall be possible in case of failure of auxiliary system.

iii) The apparatus shall be provided with portholes to allow visual inspection of the contacts of the dis-connector/ earthing switch.

iv) Earthing switches on the line side of overhead line feeders shall be provided with make-proof contacts and high speed operating mechanism so that they are suitable for switching capacitive and inductive currents as well as on closing on to a fault.

v) Salient parameters for disconnectors and earth switch :

The salient features for 220kV, 132kV and 33kV system disconnector and earthing switches are given in Schedule - 6

6.0 CURRENT TRANSFORMER

i) Toroidal current transformers of single or multi ratio type mounted outside/ inside the high voltage enclosure with grounded cores shall be preferred.

ii) Salient parameters for current transformer

The salient features for 220kV, 132kV and 33kV system current transformers are given in Schedule - 7

7.0 VOLTAGE TRANSFORMER

i) Voltage transformer (VT) shall be installed external to switchgear module. In case VT is an integral part of switchgear module, it shall be metal-enclosed, gas insulated inductive. It shall be mounted directly on the high voltage enclosure with plug-in contacts to allow easy removal.

ii) VT shall be effectively shielded against high frequency electromagnetic transients. VT shall have three secondary windings. VT secondaries shall be provided with MCBs.

iii) VT burden for metering class winding shall not be less than 50VA to achieve 0.2 accuracy class.

iv) Salient features of Voltage transformer

The salient features for 220kV, 132kV and 33kV system voltage transformers are given in Schedule - 8

8.0 OTHER EQUIPMENTS/ SYSTEMS

The requirements of equipments/ systems shall be as given in AIS/ GIS as applicable.

a. Bushing
b. Surge arrestors
c. Gas system
d. Local control cubicles

9.0 INTERNATIONAL/ INDIAN STANDARDS

The list of major International/ Indian Standards is given in Schedule - 15

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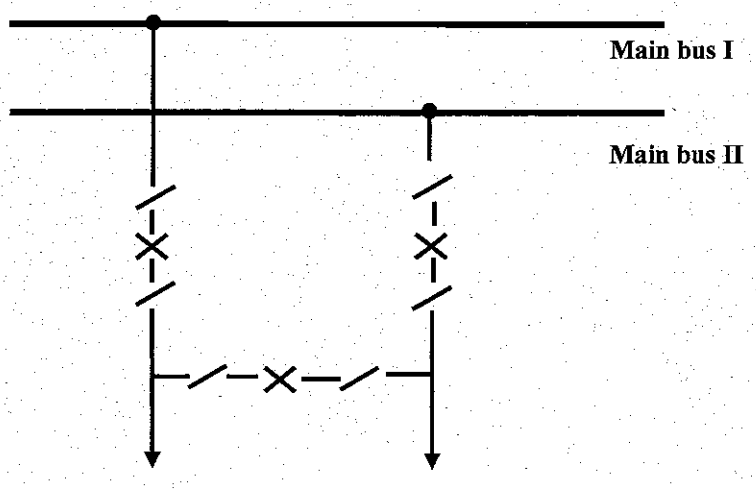
Annexure - C

BUS BAR ARRANGEMENT

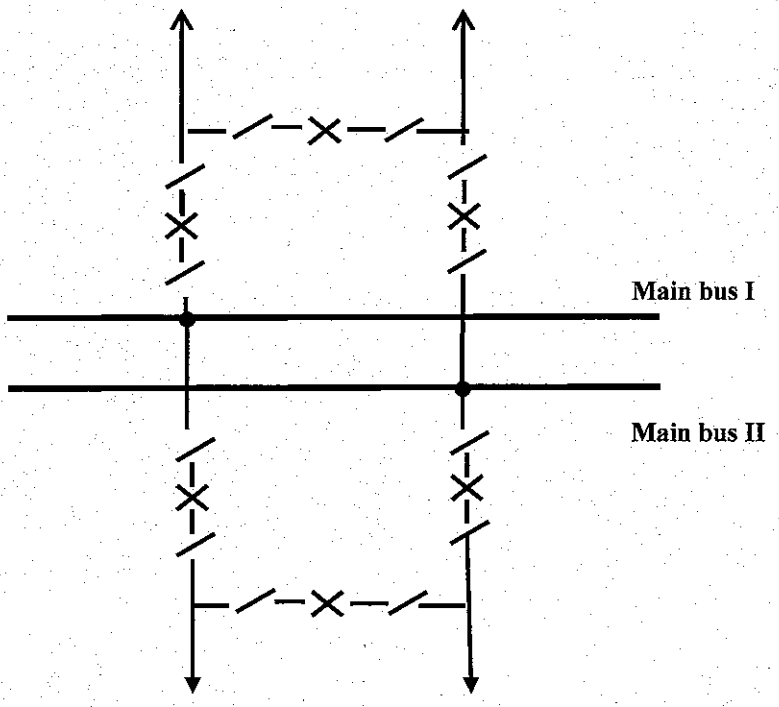
1) Sketch-A:

Breaker and a half scheme - (D type) (2 bays on one side)



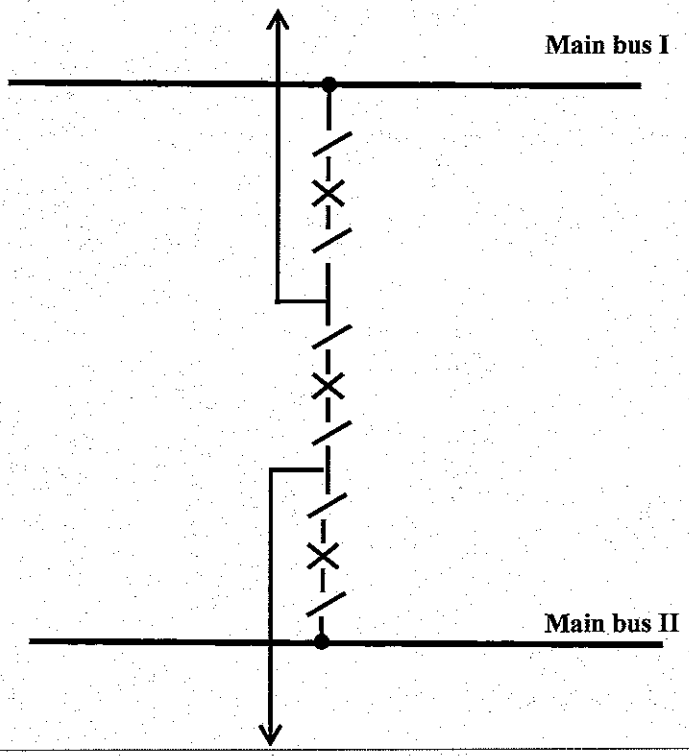
2) Sketch-B:

Breaker and a half scheme - (D-type) (2 bays on both side)



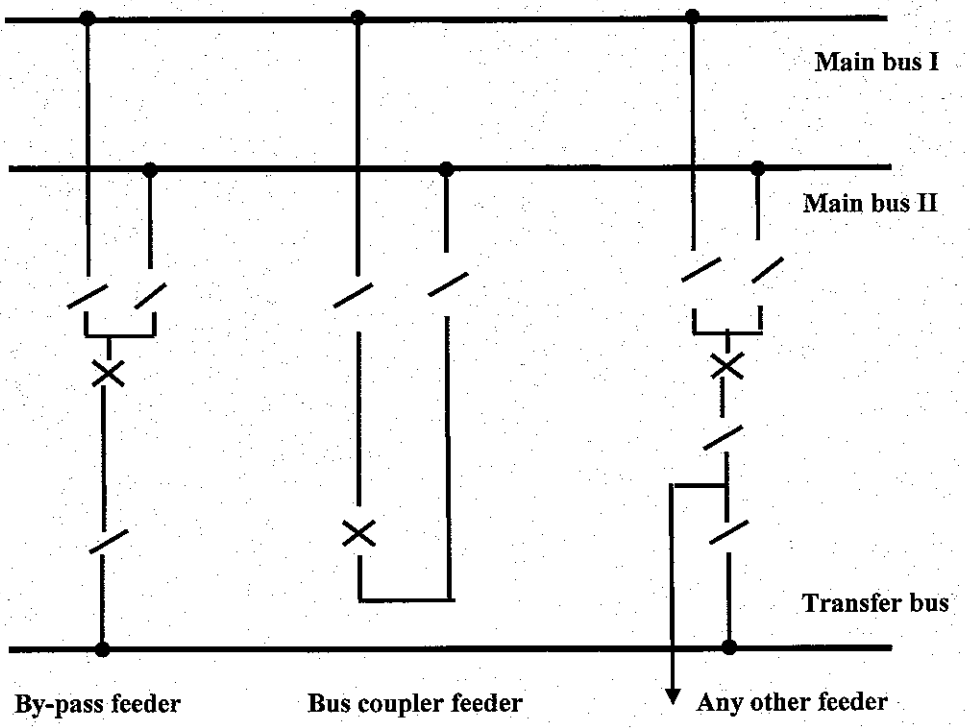
3) Sketch-C:

Breaker and a half scheme (I-type) (2 bays)



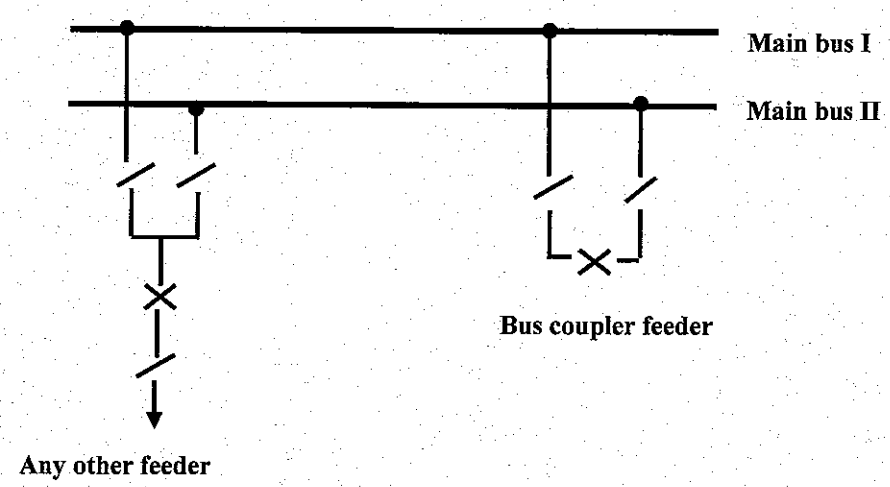
4) Sketch-D:

Double main & transfer bus scheme (one feeder bay+1 bus coupler bay +1 by-pass bay)



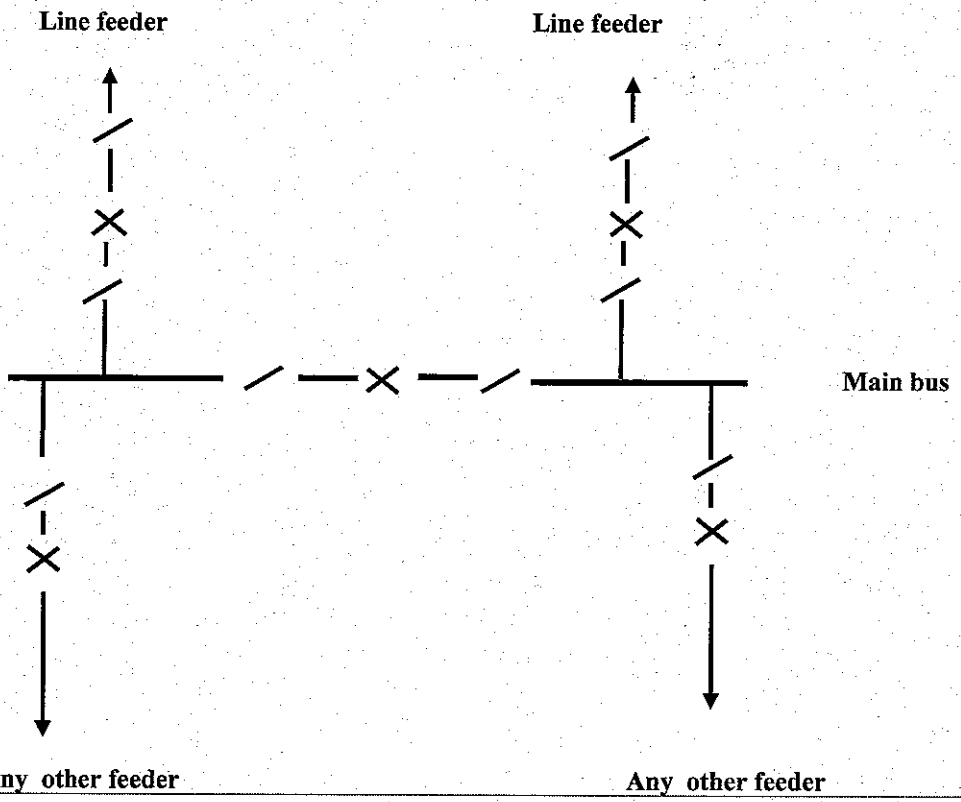
5) Sketch-E:

Double bus scheme (one feeder bay + 1 bus coupler bay)



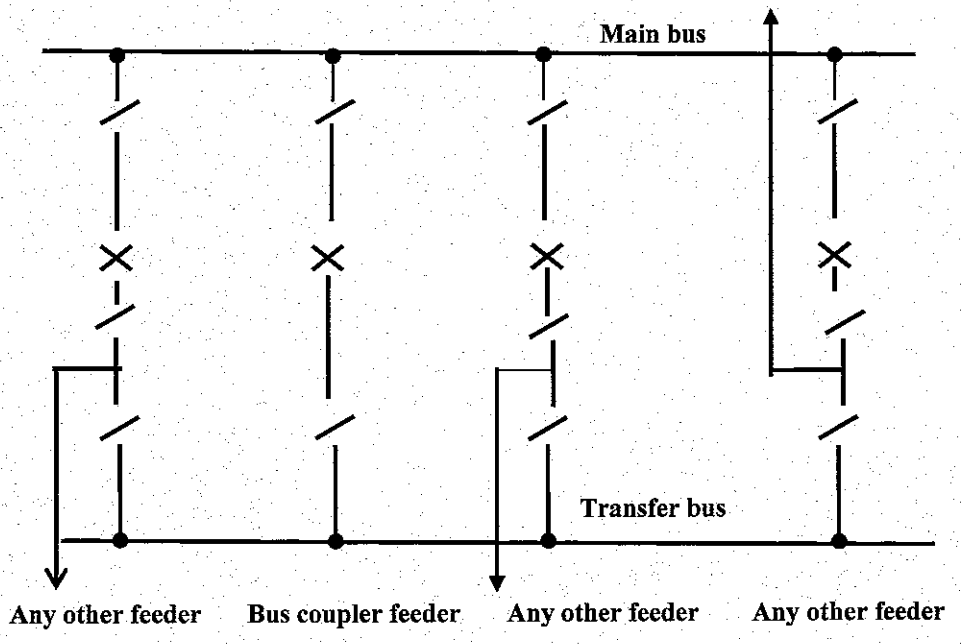
6) Sketch-F:

Single bus scheme with sectionalizer



7) Sketch-G:

Main & transfer bus scheme



8) Legends

Circuit breaker

Isolator

Note: Other items e.g. CT, CVT, SA, earth switches are not shown in sketch

SCHEDULE -1
[See clause nos. 2.0, Annexure A (clause 2.0, Annexure B (clause 2.0)]

SYSTEM PARAMETERS

SN	Details	Unit	765kV system	400kV system	220kV system	132kV system	33kV system
1)	Nominal/ Rated voltage	kVrms	765	400	220	132	33
2)	Highest system voltage	kVrms	800	420	245	145	36
3)	Phase	nos.	3	3	3	3	3
4)	Rated frequency	Hz	50	50	50	50	50
5)	Ambient temperature	^{0}C	50	50	50	50	50
6)	Specific creepage distance (1) (2) (3) Light Medium Heavy Very Heavy	mm/ kV	 16 20 25 31	 16 20 25 31	 16 20 25 31	 16 20 25 31	 16 20 25 31
7)	Rated fault current and its duration	kA	40/ 50 1 sec.	40/ 50/ 63 1 sec.	40/50 1 sec.	31.5 1 sec.	25 3 sec.
8)	Minimum corona extinction voltage	kVrms	508	320	156	105	NA
9)	Maximum radio interference voltage (RIV) for frequency between 0.5&2.0 MHz	µ-volt	2500 (at 508 kVrms)	1000 (at 320 kVrms)	1000 (at 156 kVrms)	500 (at 92 kVrms)	NA
10)	Seismic acceleration	g	0.3	0.3	0.3	0.3	0.3
11)	System neutral earthing		Effectively earthed	Effectively earthed	Effectively earthed	Effectively earthed	Effectively earthed
12)	Auxiliary AC supply (3Ph, 4wire, 50 Hz)	V	415±10%	415±10%	415±10%	415±10%	415±10%
13)	Auxiliary DC supply (2 wire ungrounded)	V	220±10%	220±10%	220±10%	220±10%	220±10%

(1) For a thermal power plant, very heavy pollution conditions shall be considered.
(2) Increase in pollution level in future shall be considered for selecting the specific creepage distance
(3) Polymeric insulators may preferably be considered for heavy polluted and also coastal areas.

SCHEDULE -2
[See clause nos. 4.1 (i)]

SAFETY CLEARANCES

	Minimum Clearances	Unit	765kV system	400kV system	220kV system	132kV system	33kV system
1)	Phase to phase	mm	7600[1] 9400[2]	4000[1] 4200[3]	2100	1300	320
2)	Phase to earth	mm	4900[4] 6400[2]	3500	2100	1300	320
3)	Safety working clearance (Sectional clearance)	mm	10300	6500	5000	3800	3000
4)	Ground Clearance[5]	mm	14000	8000	5500	4800	3700
5)	Height of insulator's bottom from ground[6]	mm	2440	2440	2440	2440	2440

[1] for conductor-conductor configuration [2] for rod-structure configuration

[3] for rod-conductor configuration [4] for conductor-structure configuration

[5] It is the elevation of live conductor above plinth level.

[6] It is the height of lowest portion of insulators supporting live conductor, equipment parts etc. where it meets the earthed metal from the ground

Notes:

(a) The above values are valid for altitude not exceeding 1000mtrs. A correction factor of 1.25% per 100mtrs. is to be applied for increasing the air clearance for altitudes more than 1000mtrs. and up to 3000mtrs.

(b) The above safety working clearances are based on an insulation height of 2.44m, which is the height of lowest point on the insulator (where it meets the earthed metal) from the ground.

(c) "Safety Working Clearance" is the minimum clearance to be maintained in air between the live part of the equipment on one hand and earth or another piece of equipment or conductor on which it is necessary to carry out the work.

(d) The minimum clearance values at sl. no. 1), 2) & 3) as given in the table are mandatory.

The clearances at sl. no. 4) & 5) of the table are typical values. The electrical field studies should be carried out to ensure that electrostatic field at 1.8M above ground below the outer most phase is less than 10kV/m. However, where the field exceeds this value suitable protection like grounded shielding wire/grid may be provided."

SCHEDULE -3
[See clause nos. 5.2.2 (iii)]

SALIENT PARAMETERS FOR INSULATOR STRING[1]

SN	Details	Unit	765kV system[2]	400kV system	220kV system	132kV system	33kV system
1)	Nominal/ Rated voltage	kVrms	765	400	220	132	33
2)	Highest system voltage	kVrms	800	420	245	145	36
3)	Minimum total specific creepage distance of the insulator string	mm	20,000	10,500	6125	3625	900
4)	Total no. of discs per strings (porcelain type)	Nos.	47	25	15	10	4
5)	Lightning (Full wave) impulse withstand voltage (1.2/50 µs)	kVp	2100	1425	1050	650	170
6)	Switching impulse withstand voltage (250/2500µs) – dry & wet	kVp	1550	1050	NA	NA	NA
7)	One minute power frequency withstand voltage of complete string with corona control rings : - dry - wet	kVrms	 830 870	 630 680	 --- 460	 --- 275	 --- 70
8)	Minimum corona extinction voltage level of string with corona control rings - dry	kVrms	508	320	156	105	NA
9)	Maximum radio interference voltage (RIV) of string with corona control rings across 300 Ω resistor at 1 MHz)	µ-volt	2500 (at 508 kVrms)	1000 (at 320 kVrms)	1000 (at 156 kVrms)	500 (at 92 kVrms)	NA
10)	Minimum electro mechanical strength	kN	210	120	120	120	120
11)	Type of insulator (porcelain type)		Antifog	Antifog	Antifog	Antifog	Antifog
12)	Minimum creepage distance	mm	430	430	430	430	430

	of individual insulator units (porcelain type)						

(1) Parameters given here are for installations at altitudes not exceeding 1000m above mean sea level (MSL). For higher altitudes, required correction factor shall be considered as per relevant standards

(2) The 765 kV equipments are imported, the parameters mentioned herein are in line with IEC practices.

SCHEDULE -4
[See clause nos. 5.2.2 (iv)]

SALIENT FEATURES OF BUS POST INSULATORS[1]

	Details	Unit	765kV system	400kV system	220kV system	132kV system	33kV system
1)	Nominal/ Rated voltage	kVrms	765	400	220	132	33
2)	Highest system voltage	kVrms	800	420	245	145	36
3)	Minimum total creepage distance	mm	20,000	10,500	6125	3625	900
4)	Lightning (Full wave) impulse withstand voltage (1.2/50 µs)	kVp	2100	1425	1050	650	170
5)	Switching impulse withstand voltage (250/2500µs) – wet	kVp	1550	1050	NA	NA	NA
6)	One minute power frequency withstand voltage- dry and wet	kVrms	830	680	460	275	70
7)	Minimum corona extinction voltage	kVrms	508	320	156	105	NA
8)	Maximum radio interference voltage between phase and ground	µ-volt	2500 (at 508 kVrms)	500 (at 305 kVrms)	500 (at 156 kVrms)	500 (at 92 kVrms)	NA
9)	Type		Solid core	Solid core	Solid core	Solid core	Solid core
10)	Total minimum cantilever strength	kg	800[2]	800	800	800	800
11)	Minimum torsional moment		As per IEC-273	As per IEC-273	As per IEC-273	As per IEC-273	As per IEC-273

[1] Parameters given here are for installations at altitudes not exceeding 1000m above mean sea level (MSL). For higher altitudes, necessary correction factor shall be considered as per relevant standards

[2] Value indicated for 765 kV is minimum, however same is to be increased as per layout requirement.

SCHEDULE -5

[See clause nos. 5.3 (xv), Annexure A (clause 4.0 (ix), Annexure B (clause 4.0 (iii)]

SALIENT FEATURES OF CIRCUIT BREAKER[1]

SN	Details	Unit	765kV system	400kV system	220kV system	132kV system	33kV system
1)	Rated current [2]	A	3150	2000/ 3150	1600/ 2500	1250	as required
2)	Operating mechanism		Spring/ hydraulic or its combination	Pneumatic/ Spring/ hydraulic or its combination	Pneumatic/ Spring/ hydraulic or its combination	Pneumatic / Spring/ hydraulic or its combination	Spring
3)	Rated fault current & its duration [3] [4]	kA	40/ 50 (1 sec.)	40/ 50/ 63 (1 sec.)	40/ 50 (1 sec.)	31.5 (1 sec.)	25 (3 sec.)
4)	Rated short circuit making current	kA_p	100/ 125	100/ 125/ 157.5	100/ 125	78.5	62.5
5)	Rated operating duty cycle :						
5a)	for auto-reclosing type		O-0.3sec-CO - 3min-CO	O-0.3sec-CO -3min-CO	O-0.3sec-CO -3min-CO	O-0.3sec-CO - 3min-CO	------
5b)	for non-auto reclosing type		------	------	------	------	CO-15sec-CO
5c)	for non-auto reclosing type (Generator Transformer CB of hydro projects)		O-3min-CO - 3min-CO	O-3min-CO -3min-CO	O-3min-CO -3min-CO	O-3min-CO - 3min-CO	O-3min-CO - 3min-CO
6)	Lightning (Full wave) impulse withstand voltage (1.2/50 µs)						
6a)	between line terminals and ground	kV_p	2100	1425	1050	650	170
6b)	between terminals with circuit breaker contacts open :	kVp			1050	650	170
	- Lightning impulse voltage applied to one terminal	kVp	2100	1425	---	---	---
	- Power frequency voltage applied to opposite terminal	kVp	455	240	---	---	---

7)	Switching impulse withstand voltage (250/2500μs) dry & wet						
7a)	between line terminals and ground	kV_p	1550	1050	----	----	----
7b)	between terminals with circuit breaker contacts open :				----	----	----
	- Switching impulse voltage applied to one terminal	kVp	1175	900			
	- Power frequency voltage applied to opposite terminal	kVp	650	345			
8)	One minute power frequency withstand voltage:						
8a)	between line terminals and ground	kV_{rms}	830	520	460	275	70
8b)	between terminals with circuit breaker contacts open	kV_{rms}	1150	610	460	275	70
9)	Minimum corona extinction voltage in open and close position	kVrms	508	320	156	105	----
10)	Maximum radio interference voltage for frequency between 0.5 to 2 MHz in open and close position	micro-volt	2500 (at 508 kVrms)	1000 (at 320 kVrms)	1000 (at 156 kVrms)	500 (at 92 kVrms)	----
11)	First pole to clear factor		1.3	1.3	1.3	1.3	------
12)	Maximum line charging current (rms)[5]	A	900	600	125	50	10
13)	Rated cable charging breaking current capacity(rms)	A	---	400	250	160	50
14)	Break time : - Total break time upto rated breaking current - Rated break time	ms	 45 40	 45 40	 65 60	 65 60	 105 100
15)	Making time (closing time)	ms	< 150	< 150	< 200	< 200	< 200

16)	Difference in instants of closing/ opening of contacts[6]						
	- within a pole	ms	2.5	2.5	2.5	---	----
	- Between poles (for opening)	ms	3.3	3.3	3.3	---	---
	- Between poles (for closing)	ms	5	5	5	---	---
17)	Maximum noise level[7]	dB	140	140	140	140	140
18)	Maximum over- voltage on switching of transformer on no-load	p.u.	< 1.9	< 2.3	---	---	---
19)	Closing time	ms	100	100	100	100	100
20)	DC control voltage	V	220	220	220	220	220
21)	Auxiliary contacts continuous current rating	A	10	10	10	10	10
22)	Auxiliary contacts breaking capacity (for circuit time constant ≥ 20 ms)	A	2	2	2	2	2

[1] Parameters given here are for installations at altitudes not exceeding 1000m above mean sea level (MSL). For higher altitudes, necessary correction factor shall be considered as per relevant standards.

[2] In case of hydro power stations, lower values of rated current may be used as per requirement.

[3] The percentage DC component corresponding to minimum opening time under required operating condition. shall be as per IEC -62271-100

[4] 765/400/220/132kV Circuit breaker shall be capable of breaking 25% of the rated fault current at twice the rated voltage under phase opposition condition.

[5] The values indicated here are applicable for sub-stations. The breaker shall interrupt the rated line charging current with test voltage immediately before opening, equal to the product of $U/\sqrt{3}$ & 1.4 as per IEC: 62271-100.

[6] The above shall be at rated control voltage and the rated operating and quenching media pressures

[7] The noise level at base and upto 50 m distance from the base of the CB

SCHEDULE -6
[See clause nos. 5.4.(x), Annexure A (clause 5.0 (d), Annexure B (clause 5.0 (v)]

SALIENT FEATURES OF DISCONNECTOR AND EARTHING SWITCHES(1)

SN	Details	Unit	765kV system	400kV system	220kV system	132kV system	33kV system
1)	Nominal/ Rated voltage	kV	765	400	220	132	33
2)	Highest system voltage	kV	800	420	245	145	36
3)	Rated current	A	3150	2000/ 3150	1600/2500	1250	as required
4)	Rated fault current and its duration	kA	40/50 (1 sec)	40/50/63 (1 sec)	40/50 (1 sec)	31.5 (1 sec)	25 (3 sec)
5)	Rated dynamic short circuit current	kAp	100/125	100/125/157.5	100/125	78.75	62.5
6)	Operating mechanism		AC motor operated & manual	AC motor operated & manual	AC motor operated & manual	AC motor operated & manual	Manual
7)	Lightning (Full wave) impulse withstand voltage (1.2/50 µs)						
7a)	between line terminals and ground	kV_p	2100	1425	1050	650	170
7b)	between terminals with disconnector contacts open :	kVp			1200	750	195
	- Lightning impulse voltage applied to one terminal	kVp	2100	1425	---	---	---
	- Power frequency voltage of opposite polarity applied to other terminal	kVp	455	240	---	---	---
8)	Switching impulse withstand voltage (250/2500µs) dry & wet						
8a)	between line terminals and ground	kV_p	1550	1050	----	----	----
8b)	between terminals with circuit breaker contacts open :				----	----	----
	- Switching impulse voltage applied to one terminal	kVp	1175	900			
	- Power frequency voltage of opposite polarity applied to other terminal	kVp	650	345			

9)	One minute power frequency withstand voltage:						
9a)	between line terminals and ground	kV_{rms}	830	520	460	275	70
9b)	between terminals with disconnector contacts open	kV_{rms}	1150	610	530	315	80
10)	Operating time	Sec.	≤ 20	≤ 12	≤ 12	≤ 12	≤ 12
11)	Minimum corona extinction voltage in open and close position	kVrms	508	320	156	105	----
12)	Maximum radio interference voltage for frequency between 0.5 to 2 MHz in open and close position	µ-volt	2500 (at 508 kVrms)	1000 (at 320 kVrms)	1000 (at 156 kVrms)	500 (at 92 kVrms)	----
13)	Total operating time	sec	≤20	≤12	≤12	≤12	≤12
14)	Phase to phase spacing	mm	15000	7000 / 6000	4500 / 4000	3000	1500
15)	DC control voltage	V	220	220	220	220	220
16)	Auxiliary contacts continuous current rating	A	10	10	10	10	10
17)	Auxiliary contacts breaking capacity (for circuit time constant ≥20ms	A	2	2	2	2	2

(1) Parameters given here are for installations at altitudes not exceeding 1000m above mean sea level (MSL). For higher altitudes, necessary correction factor shall be considered as per relevant standards.

SCHEDULE -7
[See clause nos. 5.5 (xi), Annexure A (clause 6.0 (v), Annexure B (clause 6.0 (ii)]

SALIENT FEATURES OF CURRENT TRANFORMER

SN	Details	Unit	765kV system	400kV system	220kV system	132kV system	33kV system
1)	Nominal/ Rated system voltage	kV	765	400	220	132	33
2)	Highest system voltage	kV	800	420	245	145	36
3)	No. of cores[1]	Nos.	6/ 5	5	5	5	3
4)	Rated primary current	A	3000	2000/ 3000	1600	1200	as required
5)	Rated transfor-mation ratio						
5a)	Protection [1] [2] :						
	- Bus differential	A	3000-2000-500/1	2000-1000/ 3000-2000-500/ 1	1600 - 800/ 1	1200 - 600/ 1	----
	- Other	A	3000-2000-500/ 1	2000-1000-500/ 3000-2000-500/1	as required/ 1	as required/ 1	as required/ 1
5b)	Metering[3]	A	3000-2000-500/ 1	2000-1000-500/ 3000-2000-500/ 1	as required / 1	as required/ 1	as required/ 1
6)	Rated fault current and duration	kA	40/ 50 (1 sec)	40/ 50/ 63 (1 sec)	40/ 50 (1 sec)	31.5 (1 sec)	25 (3 sec)
7)	Rated dynamic short circuit current	kA_p	100/ 125	100/125/157.5	100/125	78.75	62.5
8)	Lightning (Full wave) impulse withstand voltage (1.2/50µs) - between line terminals and ground	kVp	2100	1425	1050	650	170
9)	Switching impulse withstand voltage (250/2500µs) - between line	kVp	1550	1050	----	----	----

	terminals and ground (dry & wet)						
10)	One minute power frequency withstand voltage - between line terminals and ground	kVrms	975 (dry only)	630 (dry only)	460	275	75
11)	One minute power frequency withstand voltage of secondary winding	kV	5	5	5	5	5
12)	Minimum corona extinction voltage	kV_{rms}	508	320	156	105	----
13)	Maximum radio interference voltage for frequency between 0.5 to 2 MHz	µ-volt	2500 (at 508 kVrms)	1000 (at 320 kVrms)	1000 (at 156 kVrms)	500 (at 92 kVrms)	----
14)	Maximum partial discharge level	pC	As per IEC	10	10	10	10
15)	Cantilever strength[4]	kg.	500	500	350	350	350

(1) For hydro power stations, No. of CT cores and ratios may be as per actual requirement.
(2) Accuracy class: PS for differential protection and 5P20 for other protection
(3) The accuracy class for tariff metering core shall be equal to 0.2S or better as per the 'Central Electricity Authority (Installation and operation of Meters) Regulations, 2006'.
(4) The cantilever strength shall be 150kg for polymer housing

SCHEDULE -8

[See clause nos. 5.6 (x), Annexure A (clause 7.0 (iv), Annexure B (clause 7.0 (iv)]

SALIENT FEATURES OF VOLTAGE TRANSFORMER

SN	Details	Unit	765kV system	400kV system	220kV system	132kV system	33kV system
1)	Nominal/ Rated voltage	kV	765	400	220	132	33
2)	Highest system voltage	kV	800	420	245	145	36
3)	Fault current and duration	kA	40/50 (1 sec)	40/50/63 (1 sec)	40/50 (1 sec)	31.5 (1 sec)	25 (3 sec)
4)	Rated primary voltage	kV	800/√3	420/√3	245/√3	145/√3	36/√3
5)	Rated secondary voltage[1]	V	110/√3	110/√3	110/√3	110/√3	110/√3
6)	Accuracy class						
	- protection		3P	3P	3P	6P	6P
	- metering[2]		0.2	0.2	0.2	0.2	0.2
7)	Lightning (Full wave) impulse withstand voltage (1.2/50 µs) - between line terminals and ground	kVp	2100	1425	1050	650	170
8)	Switching impulse withstand voltage (250/2500µs) - between line terminals and ground (dry & wet)	kVp	1550	1050	----	----	----
9)	One minute power frequency withstand voltage - between line terminals and ground	kVrms	975 (dry only)	630 (dry only)	460	275	75
10)	Minimum corona extinction voltage	kVrms	508	320	156	105	----
11)	Maximum Radio interference voltage for frequency between 0.5 to 2 MHz	micro-volt	2500 (at 508 kVrms)	1000 (at 320 kVrms)	1000 (at 156 kVrms)	500 (at 92 kVrms)	----
12)	Standard reference range of frequencies for which the accuracies are valid						
	- protection	%	96 to 102	96 to 102	96 to 102	96 to 102	NA

	- measurement	%	99 to 101	99 to 101	99 to 101	99 to 101	NA
13)	High frequency capacitance for entire carrier frequency range	%	80 to 150% of rated capacitance	80 to 150% of rated capacitance	80 to 150% of rated capacitance	80 to 150% of rated capacitance	NA
14)	Equivalent resistance over entire carrier frequency range	Ω	< 40	< 40	< 40	< 40	---
15)	Stray capacitance and stray conductance of LV terminal over entire carrier frequency range		As per IEC 60358	As per IEC 60358	As per IEC 60358	As per IEC 60358	---
16)	One minute power frequency withstand voltage (LV side):						
16a)	between LV (HF) terminal and earth						
	- for exposed terminals	kV_{rms}	10	10	10	10	10
	- for terminals enclosed in weather proof enclosure	kV_{rms}	4	4	4	4	4
16b)	for secondary winding	kV_{rms}	3	3	3	3	3
17)	Rated voltage factor						
	- continuous		1.2	1.2	1.2	1.2	1.2
	- for 30 seconds		1.5	1.5	1.5	1.5	1.5
18)	Maximum partial discharge level	pC	As per IEC	10	10	10	10
19)	Rated capacitance[3]	pF	4400 (+10, -5%)	4400 (+10, -5%)	4400 (+10, -5%)	4400 (+10, -5%)	---
20)	Cantilever strength[4]	kg	500	500	350	350	350

[1] The minimum burden for metering VT shall be 50VA to ensure 0.2 M accuracy class.

[2] The accuracy class for tariff metering core shall be equal to 0.2 or better as per the 'Central Electricity Authority (Installation and operation of Meters) Regulations, 2006'.

[3] For PLCC, capacitance values shall be as follows :
- for 765kV system : 4400/ 8800 picco-farad
- for 400 & 220kV system : 4400/ 5575/ 6600/ 8800 picco-farad
- for 132kV system : 4400/ 5575/ 6600 picco-farad

[4] Cantilever strength shall be 150kg for polymer housing.

SCHEDULE -9
[See clause nos. 5.7 (xii), Annexure A (clause 9.0 (iii)]

SALIENT FEATURES OF SURGE ARRESTOR

SN	Details	Unit	765kV system	400kV system	220kV system	132kV system	33kV system
1)	Rated system voltage	kV	765	400	220	132	33
2)	Highest system voltage	kV	800	420	245	145	36
3)	Rated arrester voltage	kV	624	336	216	120	30
4)	Continuous operating voltage (COV) at 50^0C	kV_{rms}	490	267	168	102	25
5)	Discharge current (8/20µs wave):						
5a)	Nominal discharge current	kAp	20	20	10	10	10
5b)	Discharge current at which insulation co- ordination will be done	kAp	20	20	10	10	10
6)	Minimum discharge capability(1)	kJ/kV	13	12	5	5	5
7)	Maximum residual voltage for :						
7a)	Lightning impulse current						
	- 20kA	kV_p	1480	850	----	----	----
	- 10kA	kV_p	----	800	600	330	90
	- 5kA	kV_p	----	----	560	310	85
7b)	Switching impulse current						
	- at 2kA	kV_p	1220	670	----	----	NA
	- at 1kA	kV_p	1180		500	280	NA
	- at 500A		----	650	----	----	NA
7c)	Steep current impulse at nominal discharge current		1480	925	650	380	110
8)	Long duration discharge class (as per IEC)		Class 5	Class 4	Class 3	Class 3	Class 3
9)	Prospective symmetrical	kA(rms)	40/ 50	40/ 50/63	40/50	31.5	25

	fault current for pressure relief test (for 0.2 Sec.)						
10)	Low current long duration test value		As per IEC (2000μs)	As per IEC (2400μs)	As per IEC (2400 μs)	As per IEC (2400 μs)	As per IEC (2400 μs)
11)	High current impulse test value (4/10 micro sec.)	kAp	100	100	100	100	100
12)	Minimum corona extinction voltage	kVrms	508	320	156	105	NA
13)	Maximum radio interference voltage for frequency between 0.5 to 2 MHz	micro-volt	2500 (at 508 kVrms)	500 (at 320 kVrms)	500 (at 156 kVrms)	500 (at 92 kVrms)	---
14)	Full wave impulse withstand voltage (1.2/50μs) –between line terminals and ground	kV_p	As per IEC 60099-4	1425	1050	650	170
15)	Switching impulse withstand voltage (250/2500μs) - between line terminals and ground (Dry & Wet)	kV_p	As per IEC 60099-4	1050	NA	NA	NA
16)	One minute power frequency withstand voltage between line terminals and ground (dry & wet)	$kV_{(rms)}$	As per IEC 60099-4	630	460	275	70
17)	Maximum Partial Discharge for arrester at (1.05 x COV)	pC	10	50	50	50	50
18)	Cantilever strength[2]	Kg	500	500	350	350	350

[1] with respect to rated voltage of arrester

[2] The cantilever strength shall be 150kg for polymer housing.

SCHEDULE -10 (A)
[See clause nos. 5.8.1 (xvii) (a)]

SALIENT FEATURES OF INTER-CONNECTING AUTO TRANSFORMER

500MVA, 765/√3/ 400/√3/ 33kV, single-phase ICT

1)	Rating (HV/IV/LV):	MVA	500/ 500/ 167[1]
2a)	Cooling		ONAN/ ONAF/ (OFAF or ODAF) or ONAN/ ONAF1/ ONAF2
2b)	Rating at different cooling	%	60/ 80/ 100
3)	Voltage ratio	kV	765/√3 / 400√3/ 33
4)	Vector Group:		YNaOd11
5)	Percentage impedance [2]		
	- HV and IV	%	14 (with IEC tolerance)
	- HV and LV	%	195
	- IV and LV	%	180
6)	Air core reactance of HV	%	20 (minimum)
7)	Service		Outdoor
8)	Duty		Continuous
9)	Over load capacity		As per IEC – 60076-7
10)	Ambient temperature	^{0}C	50
11)	Temperature rise		
	- top oil	^{0}C	40 (thermometer method)
	- winding	^{0}C	45 (resistance method)
12)	Cooling medium		Mineral oil
13)	Lightning (Full wave) impulse withstand voltage (1.2/50 micro sec)		
	- HV	kVp	1950
	- IV	kVp	1300
	- LV	kVp	250
14)	Switching impulse withstand voltage (250/2500 micro sec)		
	- HV	kVp	1550
	- IV	kVp	1050
	- LV		---

15)	One minute power frequency with stand voltage		
	- HV	kVrms	---
	- IV	kVrms	---
	- LV	kVrms	95
16)	Winding connection		
	- HV		Star auto
	- IV		Star auto
	- LV		Delta
17)	Neutral connection		
	- HV		Solidly grounded
	- IV		Solidly grounded
	- LV		Ungrounded
18)	Insulation		
	- HV		Graded
	- IV		Graded
	- LV		Uniform
19)	Tan delta of windings		< 0.005 (at 20^0C)
20)	Tap ranger variation	%	(±) 5.5 in 22 steps (on HV winding)
21)	Partial discharge level at 1.5 pu	pC	100 (maximum)
22)	Noise level (principal tap)	dB	< 75 (for ONAN) and < 80 (at full load)
23)	Transformer bushing [3]		
23a)	Type		
	- HV		Oil filled condenser/ resin impregnated paper
	- IV		Oil filled condenser/ resin impregnated paper
	- Neutral		Solid porcelain/ oil communicating
	- LV		Oil filled condenser/ resin impregnated paper
23b)	Rated voltage		
	- HV	kV	800
	- IV	kV	420
	- Neutral	kV	36
	- LV	kV	52

23c)	Rated current		
	- HV	A	As per transformer rating and IEC 60076-7, IEC 60076, IEC 60137
	- IV	A	As per transformer rating and IEC 60076-7, IEC 60076, IEC 60137
	- LV	A	Based on 5MVA rating
23d)	Lightning (Full wave) impulse withstand voltage (1.2/50 micro-sec)		
	- HV	kVp	2100
	- IV	kVp	1425
	- Neutral	kVp	170
	- LV	kVp	250
23e)	Switching impulse withstand voltage (250/2500 micro second)		
	- HV	kVp	1550
	- IV	kVp	1050
	- Neutral	kVp	---
	- LV	kVp	---
23f)	One minute power frequency with stand voltage		
	- HV	kVrms	970
	- IV	kVrms	630
	- Neutral	kVrms	70
	- LV	kVrms	95
23g)	Corona extinction voltage		
	- HV	kVrms	508
	- IV	kVrms	320
	- Neutral	kVrms	---
	- LV	kVrms	---
23h)	Tan delta		< 0.004 (at 20^0C)
23i)	Bushing CT:		
	- 500 MVA (single phase)		
	Core 1	A	3000/ 1, PS (HV/IV/ Neutral
	Core 2	A	1500/ 1, 0.2, 30VA (HV) 3000/ 1, 0.2, 30VA (IV)
	- 333.3 MVA (single phase)		
	Core 1	A	3000/ 1, PS (HV/IV/ Neutral
	Core 2	A	1500/ 1, 0.2, 30VA (HV) 3000/ 1, 0.2, 30VA (IV)

24)	Neutral CT[4]	A	400/ 1, PS

[1] Continuous thermal rating of LV (tertiary) winding shall be capable of 5MVA (minimum) active loading.
[2] On principal tap at rated MVA of HV and IV winding at 75^0C
[3] Without arcing horns
[4] To be located in the neutral conductor connecting common neutral point with earth for earth fault protection.

SCHEDULE -10(B)
[See clause nos. 5.8.1 (xvii) (b)]

SALIENT FEATURES OF INTER-CONNECTING AUTO TRANSFORMER (CONSTANT OHMIC IMPEDANCE TYPE)

500 or 315MVA (whichever is applicable), 400/ 220/ 33kV ICT (constant ohmic impedance type)

1)	Rating (HV/IV/LV):	MVA	500/ 500/ 167[1] (3 phase) or 167/ 167/ 56[2] (1 phase) or 315/ 315/ 105[3] (3 phase) or 105/ 105/ 35[4] (1 phase)
2a)	Cooling		i) ONAN/ONAF/(OFAF or ODAF) or ii) ONAN/ONAF1/ONAF2 or iii) OFAF unit cooler (for GIS sub-station application only)
2b)	Rating at different cooling	%	60/ 80/ 100 for cooling mentioned in i) & ii) above and 100% for cooling mentioned in iii) above
3)	Voltage ratio	kV	400/220/ 33 (3 phase bank) 400/√3 / 220√3/ 33 (1 phase)
4)	Vector Group:		YNaOd11
5)	Percentage impedance [5]		
	- HV and IV	%	12.5 at Principal tap (with IEC tolerance)
	- HV and LV	%	60 (minimum indicative value)
	- IV and LV	%	45 (minimum indicative value)
6)	Air core reactance of HV	%	20 (minimum)
7)	Service		Outdoor
8)	Duty		Continuous
9)	Over load capacity		As per IEC – 60076-7
10)	Ambient temperature	^{0}C	50

11)	Temperature rise		
	- top oil	^{0}C	40 (thermometer method)
	- winding	^{0}C	45 (resistance method)
12)	Cooling medium		Mineral oil
13)	Full wave impulse withstand voltage (1.2/50 micro sec)		
	- HV	kVp	1300
	- IV	kVp	950
	- LV	kVp	250
14)	Switching impulse withstand voltage (250/2500 micro sec)		
	- HV	kVp	1050
	- IV		---
	- LV		---
15)	One minute power frequency with stand voltage		
	- HV	kVrms	570
	- IV	kVrms	395
	- LV	kVrms	95
16)	Winding connection		
	- HV		Star auto
	- IV		Star auto
	- LV		Delta
17)	Neutral connection		
	- HV		Solidly grounded
	- IV		Solidly grounded
	- LV		Ungrounded

18)	Insulation		
	- HV		Graded
	- IV		Graded
	- LV		Uniform
19)	Tan delta of windings		< 0.005 (at 20^{0}C)
20)	Tap ranger variation	%	(±) 10 in steps of 1.25% (on HV winding)

21)	Partial discharge level at 1.5 pu	pC	100 (maximum)
22)	Noise level (principal tap)	dB	< 75 (for ONAN) and < 80 (at full load)

23)	Transformer bushing [6]		
23a)	Type		
	- HV		Oil filled condenser/resin impregnated paper
	- IV		Oil filled condenser/resin impregnated paper
	- Neutral		Solid porcelain/oil communicating
	- LV		Oil filled condenser/resin impregnated paper
23b)	Rated voltage		
	- HV	kV	420
	- IV	kV	245
	- Neutral	kV	36
	- LV	kV	52
23c)	Rated current		
	- HV	A	1250
	- IV	A	2000 (for 500MVA) 1250 (for 315MVA)
	- Neutral		2000 (for 500MVA) 800 (for 315MVA)
	- LV		3150
23d)	Full wave impulse withstand voltage (1.2/50 μ-sec)		
	- HV	kVp	1425
	- IV	kVp	1050
	- Neutral	kVp	170
	- LV	kVp	250

23e)	Switching impulse withstand voltage (250/2500 micro second)		
	- HV	kVp	1050
	- IV	kVp	---
	- Neutral	kVp	---
	- LV	kVp	---
23f)	One minute power frequency		

	with stand voltage		
	- HV	kVrms	630
	- IV	kVrms	460
	- Neutral	kVrms	75
	- LV	kVrms	95
23g)	Corona extinction voltage		
	- HV	kVrms	508
	- IV	kVrms	320
	- Neutral	kVrms	---
	- LV	kVrms	---
23h)	Tan delta		< 0.004 (at 20^0C)
23i)	Bushing CT:		
	- 500 MVA (single phase)		
	- core 1		1600/ 1, PS (HV/IV/Neutral)
	- core 2		600/ 1, 0.2 (HV) 1000/1, 0.2 (IV)
	- 315 MVA (single phase)		
	- core 1		1000/ 1, PS (HV/IV/Neutral)
	- core 2		1000/ 1, 0.2 (HV) 600/1, 0.2 (IV)
24)	Neutral CT(7)		400/ 1, PS

(1) Continuous thermal rating of LV (tertiary) winding shall be capable of 167MVA (minimum) reactive and 5MVA (minimum)active loading

(2) Continuous thermal rating of LV (tertiary) winding shall be capable of 56MVA (minimum) reactive and 2MVA (minimum)active loading

(3) Continuous thermal rating of LV (tertiary) winding shall be capable of 105MVA (minimum) reactive and 5MVA (minimum)active loading

(4) Continuous thermal rating of LV (tertiary) winding shall be capable of 35MVA (minimum) reactive and 2MVA (minimum)active loading

(5) On principal tap at rated MVA of HV and IV winding at 75^0C

(6) Without arcing horns

(7) To be located in the neutral conductor connecting common neutral point with earth for earth fault protection

SCHEDULE -11(A)
[See clause nos. 5.8.2 (xvii) (a)]

SALIENT FEATURES FOR 765/√3 KV (1 PHASE) SHUNT REACTOR

1)	Rating	MVAR	80/110 (1 phase for 3 phase bank)
2)	Nominal/ Rated voltage		765 /√ 3 kV
3)	Maximum operating voltage		800 /√ 3 kV
4)	Winding connection (3 phase)		Star with neutral brought out
5)	Neutral earthing		Earthed through neutral reactor
6)	X_0 / X_1 ratio		0.9 to 1.0
7)	Magnetizing characteristics		Linear upto 1.5 pu(1)
8)	Tolerance on current	---	0 to +5% for a 1 phase unit and ±1 among different phases of 3 phase bank
9)	Permissible unbalance current	%	±1 (among different phases)
10)	Ambient temperature	^{0}C	50
11)	Temperature rise		
	- top oil	^{0}C	40 (thermometer method)
	- winding	^{0}C	45 (resistance method)
12)	Service		Outdoor
13)	Cooling medium		Mineral oil
14)	Lightning (Full wave) impulse withstand voltage (1.2/50 μ-sec)		
	- winding	kVp	1950
	- neutral of reactor(2)	kVp	550
15)	Switching impulse withstand voltage (250/2500 μ-sec)		
	- winding	kVp	1550
	- neutral of reactor		---

16)	One minute power frequency with stand voltage		
	- winding		---
	- neutral of reactor	kVrms	230
17)	Tan delta of windings		< 0.005 (at 20^0C)
18)	Partial discharge level (1.5pu)	pC	100 (maximum)
19)	Noise level	dB	< 80 at 800/ √3 kV and rated frequency
20)	Reactor bushing (3)		
20a)	Type		
	- HV		Oil filled condenser bushing with test tap/ resin impregnated paper
	- Neutral		Oil filled condenser bushing with test tap/ resin impregnated paper
20b)	Rated voltage		
	- HV	kV	800
	- Neutral	kV	145
20c)	Rated current		
	- HV	A	As per rating of transformer bushing and IEC
	- Neutral	A	As per rating of transformer bushing and IEC
20d)	Lightning (Full wave) impulse withstand voltage (1.2/50 µsec)		
	- HV	kVp	2100
	- Neutral	kVp	650
20e)	Switching impulse withstand voltage (250/2500 µsec)		
	- HV	kVp	1550
	- Neutral	kVp	---
20f)	One minute power frequency with stand voltage		
	- HV	kVrms	970
	- Neutral	kVrms	275

20g)	Corona extinction voltage		
	- HV	kVrms	508
	- Neutral	kVrms	
20h)	Tan delta (at 20^0 C)		< 0.004
20i)	Bushing CT:		
	- core 1		i) 300/1, PS (Line side) ii) as per WTI requirement (Neutral side)
	- core 2		i) 300/1, PS (Line side) ii) 3000-2000-500/1, PS (Neutral side)
	- core 3		i) 300/1, PS (Line side) ii) 3000-2000-500/1, PS (Neutral side)
	- core 4		i) 300/1, 1M (Line side) ii) 300/1, PS (Neutral side)

(1) The saturation characteristics shall required to be furnished by the manufacturer
(2) Neutral is to be brought out through 145kV class bushing.
(3) Without arcing horns

SCHEDULE -11(B)
[See clause nos. 5.8.2 (xvii) (b)]

SALIENT FEATURES FOR 765KV NEUTRAL REACTOR

1)	Rating	MVAR	As per project system studies
2)	Rated voltage	kV	145 (as per insulation strength)
3)	Type		Dry type air core
4)	Insulation		Graded or Uniform
5)	Maximum continuous current	A_{rms}	20
6)	Rated short time current	A_{rms}	240[1] (for 1 minute)
7)	Rated impedance at rated short time and continuous current	Ω	As per project system studies
8)	Connection		Between neutral of shunt reactor and ground
9)	Service		Outdoor
10)	Lightning (Full wave) impulse withstand voltage (1.2/50 μ-sec)		
	- line side	kV_p	550
	- ground side	kV_p	95
11)	One minute power frequency with stand voltage		
	- line side	kV_{rms}	230
	- ground side	kV_{rms}	38
12)	Grounding		Solidly grounded
13)	Mounting[2] :		
	i) Pedestal insulator		
	- Type		Porcelain/ Silicon rubber

			(Polymer)
	- Creepage distance	mm	438 (minimum)
	- Full wave impulse withstand voltage (1.2/50 μ-sec)	kV_p	125
	- One minute power frequency with stand voltage	kV_{rms}	38
	ii) Mounting structure type		Non magnetic
14)	Neutral CT (common):		300/1, PS

(1) However, the reactor shall be of $600A_{rms}$ to ensure mechanical robustness
(2) The reactor shall be mounted high above ground level for free and safe access of personnel.

SCHEDULE -12(A)
[See clause nos. 5.8.2 (xviii) (a)]

SALIENT FEATURES FOR 400/√3 KV (1 PHASE) SHUNT REACTOR

1) Rating	MVAR	50/63/80/125 (1 phase for 3 phase bank)
2) Nominal/ Rated voltage		400 /√ 3 kV
3) Maximum operating voltage		420 /√ 3 kV
4) Winding connection (3 phase)		Star with neutral brought out
5) Neutral earthing		Earthed through neutral reactor
6) X_0 / X_1 ratio		0.9 to 1.0
7) Magnetizing characteristics		Linear upto 1.5pu(1)
8) Tolerance on current	%	0 to +5 for a 1 phase unit and ±1 among different phases of 3 phase bank
9) Permissible unbalance current	%	±1 (among different phases)
10) Ambient temperature	^{0}C	50
11) Temperature rise		
- top oil	^{0}C	40 (thermometer method)
- winding	^{0}C	45 (resistance method)
12) Service		Outdoor
13) Cooling medium		Mineral oil
14) Lightning (Full wave) impulse withstand voltage (1.2/50 µ-sec)		
- winding	kVp	1300
- neutral of reactor(2)	kVp	550
15) Switching impulse withstand voltage (250/2500 micro sec)		
- winding	kVp	1050
- neutral of reactor		---

16) One minute power frequency with stand voltage		
- winding		---
- neutral of reactor	kVrms	230
17) Tan delta of windings		< 0.005 (at 20^0C)
18) Partial discharge level (1.5pu)	pC	100 (maximum)
19) Noise level	dB	< 80 at 400/ √3 kV and rated frequency
20) Reactor bushing [3]		
20a) Type		
- HV		Oil filled condenser bushing with test tap/ resin impregnated paper
- Neutral		Oil filled condenser bushing with test tap/ resin impregnated paper
20b) Nominal/ Rated voltage		
- HV	kV	420
- Neutral	kV	145
20c) Rated current		
- HV	A	800
- Neutral	A	800
20d) Lightning (Full wave) impulse withstand voltage (1.2/50 μ-sec)		
- HV	kVp	1425
- Neutral	kVp	650
20e) Switching impulse withstand voltage (250/2500 μ-sec)		
- HV	kVp	1050
- Neutral	kVp	---
20f) One minute power frequency with stand voltage		
- HV	kVrms	630
- Neutral	kVrms	270
20g) Corona extinction voltage		
- HV	kVrms	320
- Neutral	kVrms	

20h) Tan delta		< 0.004 (at 20^0C)
20i) Bushing CT:		
- core 1		i) 300/1, PS (Line side) ii) as per WTI requirement (Neutral side)
- core 2		i) 300/1, PS (Line side) ii) 3000-2000-500/1 or 2000-1000-500/1, PS (Neutral side)
- core 3		i) 300/1, PS (Line side) ii) 3000-2000-500/1 or 2000-1000-500/1, PS (Neutral side)
- core 4		i) 300/1, 1M (Line side) ii) 300/1, PS (Neutral side)

(1) The saturation characteristics upto 2.5 pu shall also be furnished by manufacturer

(2) Neutral is to be brought out through 145kV class bushing.

(3) without arcing horns

SCHEDULE -12(B)
[See clause nos. 5.8.2 (xviii) (b)]

SALIENT FEATURES FOR 400KV NEUTRAL REACTOR

1)	Rating	MVAR	As per project system studies
2)	Nominal/ Rated voltage	kV	145 (as per insulation strength)
3)	Type		Natural oil cooled
4)	Insulation		Graded or Uniform
5)	Maximum continuous current	A_{rms}	10
6)	Rated short time current	A_{rms}	60 (for 10 sec)
7)	Rated impedance at rated short time and continuous current	Ω	600 to 2500 (As per project system studies)
8)	Connection		Between neutral of shunt reactor and ground
9)	Service		Outdoor
10)	Cooling medium		Mineral oil
11)	Ambient temperature	^0C	50
12)	Temperature rise		
	- top oil	^0C	45 (thermometer method)
	- winding	^0C	50 (resistance method)
13)	Lightning (Full wave) impulse withstand voltage (1.2/50 μ-sec)		
	- line side	kVp	550
	- ground side	kVp	95
14)	One minute power frequency with stand		

	voltage		
	- line side	kVrms	230
	- ground side	kVrms	38
15)	Tan delta of winding (at 20^0C)		< 0.005
16)	Reactor bushing (1)(2)(3)		
16a)	Type		
	- HV		Oil filled condenser bushing with test tap/ resin impregnated paper
	- Neutral		Solid porcelain or Oil communicating
16b)	Rated voltage		
	- HV	kV	145
	- Neutral	kV	24
16c)	Rated current		
	- HV	A	800
	- Neutral	A	
16d)	Lightning (Full wave) impulse withstand voltage (1.2/50 µsec)		
	- HV	kVp	650
	- Neutral	kVp	125
16e)	One minute power frequency with stand voltage		
	- HV	kVrms	275
	- Neutral	kVrms	50
16f)	Tan delta		< 0.004 (at 20^0C)
17)	Grounding		Solidly grounded
18)	Mounting :		
	- HV		Tank cover
	- Neutral		Tank cover
19)	Neutral CT (common):		300/1, PS

(1) The reactor shall be mounted high above ground level for free and safe access of personnel.

(2) Neutral to be brought out through 24kV class bushing

(3) without arcing horns

SCHEDULE -13
[See clause nos. 6.2.1 (c) (xiv)]

RATINGS & REQUIREMENTS OF PLCC TERMINALS

1)	Mode of transmission		Single side band amplitude modulation
2)	HF range	kHz	40 to 500
3)	Nominal carrier frequency band	kHz	1no..x4 (for single channel sets) 2nos..x4(for twin channel sets)
4)	- Effectively transmitted speech freq. band or signal freq. band when only speech or signal is transmitted	Hz	300 to 3400or more
5)	Effectively transmitted, speech plus signal freq band in case of multi-purpose air conditioned kiosks use	Hz	Speech: 300 to 2000 Signal: 2160 to 3400 or more
6)	Nominal Impedance: Carrier freq side: VF side:	 Ω Ω	 150 balanced or 75 unbalanced 600
7)	Nominal carrier freq power		Adequate to maintain prescribed S/N ratio under adverse conditions
8)	Supply voltage (DC)	V	48 (-10 to +15%)
9)	Freq difference between voice freq band transmitter and receiver in a pair of PLC terminals		As per relevant IEC/ IS
10)	Stability of carrier freq. from its nominal value	Hz	± 10
11)	Effectively transmitted speech and data signal freq. band	kHz	Within 0.3 to 3.7
12)	Relative level across 600Ω		

	(VF side) - 4 wire transmit - 4 wire receive - 2 wire transmit - 2 wire receive	dB dB dB dB	0 to - 17 (-)3.5 to (+)8 0 (-)7
13)	Level regulations control (Automatic Gain Control)		In case of a 30dB change in the carrier frequency signal level within the regulation range, the change in voice frequency receiver levels of both speech & signals shall be less than 1dB
14)	Telephone signaling channel		Frequency shift keying (pulse distortions) of the tele-phonic signaling channel at signaling speed of 10 pulse per second shall be less than 5ms for one pair of terminals. The signaling channel shall be operated by a potential free open or closed contact at the transmit side and provide a potential free change over contact at the receiver side. All relays to be provided in the speech circuits shall be hermetically sealed.
15)	300 - 400Hz : -0.9 to +3.0dB 400 - 600 Hz :- 0.9 to +1.8 dB 600 - 1600 Hz. :- 0.9 to +0.9 dB 1600-2000 Hz. :- 0.9 to +1.8 dB	or	+1.5dB for the complete band of 300 to 2000Hz (without com-pander).
16)	- Permissible limits for variation of overall loss (attenuation) of the speech channel relative to 800Hz for back to back operation of one pair of terminals without com-pander		

SCHEDULE -14
[See clause nos. 6.3.1.1 (ii)]

SALIENT FEATURES OF LT TRANSFORMERS

SN	Details	Unit	Parameters		
			For 11kV system	**For 3.3kV system**	**For 415V system**
1)	Type		2 winding	2 winding	2 winding
2)	Service		Indoor [1]/ Outdoor	Indoor [1]/ Outdoor	Indoor [1]/ Outdoor
3)	Phases	Nos.	3	3	3
4)	Ratings		As required	As required	As required
5)	Duty		Continuous	Continuous	Continuous
6)	Windings :				
6a)	Insulation		Uniform	Uniform	Uniform
	- Power frequency withstand voltage	kV rms	28	10	3
	- Basic impulse withstand voltage	kVp	75	40	----
	- Highest voltage for each winding	kV	12	3.6	0.433
6b)	Ambient temperature	^{0}C	50	50	50
6c)	Temperature rise				
	Outdoor:				
	- top oil (by thermometer)	^{0}C	50	50	50
	- winding (by resistance)	^{0}C	55	55	55
	Indoor:				
	- winding (by resistance)	^{0}C	90[3]	90[3]	90[3]
7)	Earthing		solidly grounded	solidly grounded	solidly grounded
8)	Tap changer (off	%	±5 (2.5%	±5 (2.5%	±5 (2.5%

	circuit) - on HV side		steps)	steps)	steps)
9)	Bushing:				
	- Rated voltage	kV	12	3.6	1.1
	- Basic Impulse level	kVp	75	40	----
	-Wet, dry power withstand voltage	kV	28	10	3
	- Minimum creepage distance	mm	300	90	25
	- Mounting	mm	Transformer body	Transformer body	Transformer body
10)	Terminal details:				
	-High Voltage		Bus-duct	Bus-duct	Bus-duct/ Cable box (2)

(1) Dry type: epoxy cast resin/ resin encapsulated air cooled type
(2) Non-segregated bus-duct for transformers rated 1000kVA and above shall be provided
(3) it may be lower as per class of insulation.

Notes:
1) The class of insulation of the dry type transformer shall be Class F or better.
2) The noise level at rated voltage and freq. shall be as per NEMA Pub TR.

SCHEDULE -15 [See clause nos. 13.0, Annexure A (clause 19.0 , Annexure B (clause 9.0)]	
INTERNATIONAL/ INDIAN STANDARDS	
IEC 60044-1	Instrument Transformers - Current transformers
IEC 60044-2	Instrument Transformers - Inductive voltage transformers
IEC 60044-4	Instrument Transformers - Measurement of partial discharges
IEC 60044-5	Instrument Transformers – Capacitive voltage transformers
IEC 60050 Ch. 421	International Electro-technical vocabulary- Power transformers and reactors
IEC 60060	High voltage test techniques
IEC 60071	Insulation co-ordination – Application guide
IEC 60076	Power transformers
IEC 60076 - 7	Power transformers - Loading guide for oil-immersed power transformers
IEC 60076 - 11	Power transformers – dry type transformers
IEC 60099-4	Surge arrestors - Metal oxide surge arrestors without gaps for AC systems
IEC 60099-5	Surge arrestors - Selection and application recommendation
IEC 60129	Specification for alternating current disconnectors and earthing switches
IEC 60137	Insulated bushings for alternating voltage above 1000V
IEC 60185	Current transformer
IEC 60214 Part 1,2	Tap changers

IEC-60255 (1 - 23)	Electrical relays
IEC 60267	Guide to testing of circuit breakers with respect to out-of-phase switching
IEC 60270	High voltage test techniques - Partial discharge measurements
IEC 60273	Characteristic of indoor and outdoor post insulators for systems with nominal voltages greater than 1000 V
IEC 60296	Mineral insulating oil for transformers and switchgear
IEC 60353	Line traps for AC power systems
IEC 60358	Coupling capacitors and capacitor dividers
IEC 60364	Electrical installations for buildings
IEC 60376	Specification of technical grade sulfur hexafluoride (SF_6) for use in electrical equipment
IEC 60422	Mineral insulating oils in electrical equipment - Supervision and maintenance guidance
IEC 60427	Synthetic testing of high voltage alternating current circuit breakers
IEC 60439	Low-voltage switchgear and control-gear assemblies
IEC 60479	Effects of current on human beings and livestock
IEC 60480	Guidelines for the checking and treatment of sulfur hexafluoride (SF_6) taken from electrical equipment and specification for its re-use
IEC 60481	Coupling devices for power line carrier systems
IEC 60495	Single sideband power-line carrier terminals
IEC 60529	Degrees of protection provided by enclosures (IP code)
IEC 60542	Application guide for on-load tap-changers
IEC 60567	Oil filled electrical equipment – sampling of gases and of oil for analysis of free and dissolved gases - guidance

IEC-60599	Mineral oil-impregnated electrical equipment in service - Guide to the interpretation of dissolved and free gases analysis
IEC 60621	Electrical installations for outdoor sites under heavy conditions (including open-cast mines and quarries)
IEC 60694	Common specifications for high-voltage switchgear and control gear standards
IEC 60815	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions
IEC 60870-5-103	Transmission Protocols, Companion standard for the informative interface of protection equipment
IEC 60870-5-101	Transmission Protocols, companion standards especially for basic telecontrol tasks
IEC 60870-5-104	Transmission Protocols, Network access for IEC 60870-5-101 using standard transport profiles
IEC 61000	Electromagnetical compatibility (EMC)
IEC 61128	Alternating current disconnector - Bus transfer current switching with disconnector
IEC 61129	Alternating current earthing switches induced current switching
IEC/TS 61639	Direct connection between power transformers and gas-insulated metal-enclosed switchgear for rated voltages of 72.5 kV and above
IEC 61850 (1-10)	Electrical substation automation
IEC 62056	Electricity metering – Data exchange for meter reading, tariff and load control
IEC 62155	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V
IEC 62271-1	High-voltage Switchgear and Control gear – common specifications
IEC 62271-100	High-voltage switchgear and controlgear - alternating

	current circuit breakers
IEC 62271-110	High-voltage switchgear and controlgear - High-voltage switchgear and controlgear - Inductive load switching
IEC 62271-102	High-voltage switchgear and controlgear – alternating current disconnectors and earthing switches
IEC 62271-203	High-voltage switchgear and controlgear - Gas Insulated metal enclosed switchgear for rated voltage above 52kV
IEC 62271-209	High-voltage switchgear and controlgear - Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV - Fluid-filled and extruded insulation cables - Fluid-filled and dry-type cable-terminations
IEC 62271 - 303	High-voltage Switchgear and Control gear - Use and handling of SF_6
IS 2026 Part 1 - 5	Power transformers
IS 2099	Bushings for alternating voltages above 1000 volts
IS 6600	Guide for loading of oil immersed transformers
IEEE standard 80	Guide for safety in AC substation grounding
IS 2705	Code of practice for current transformers
IS 3156	Voltage transformers
IS 3347 Part 1-8	Dimensions for porcelain transformer bushings for use in lightly polluted atmospheres
IS 9792 Part 1	Guide for testing, calibration and maintenance of AC electricity meters : Part 1 Single phase whole current watthour meters, Class 2.0
IS 11426 Part 1	Alternating current precision electricity meters for testing purposes : Part 1 Requirement for electro-mechanical meters
IS 11448	Application Guide for AC Electricity Meters
IS 13779	AC Static Watthour meters, Class 1 & 2 – Specification

IS 14697	AC Static transformer operated Watthour and VAR-hour meters, Class 0.2S, 0.5S and 1.0S - Specification
IS 15707	Testing, evaluation, installation and maintenance of AC electricity meters – Code of Practice
IS-15959:2011	Data Exchange for Electricity Meter Reading Tariff & Load Control – Companion Specification
CIGRE Publication 202	Guidelines for conducting design reviews for transformers 100 MVA and 123 kV and above
WG 1219	Short circuit performance of transformers
CENELEC/ SVDB	Pressure vessel codes

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APPENDICES

भारत सरकार
केन्द्रीय विद्युत प्राधिकरण
सचिव का कार्यालय
सेवा भवन, आर0 के0 पुरम्,
नई दिल्ली - 110 066
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No. CEA/5-41(08)/Secy/2009/ 148 Dated: 11.01.2010

Office Order

Sub: Constitution of a Committee of Experts for the preparation of a document entitled "Standard Design Criteria / Guidelines-765/400/220kV Switchyard for Thermal Power Stations (2x 500 MW or above)"-Reg.

In order to standardize the major parameters and set guidelines for Switchyards and associated equipment upto 765 kV and to bring out a document entitled "Standard Design Criteria / Guidelines-765/400/220kV Switchyard for Thermal Power Stations (2x 500 MW or above)", it has been decided to constitute a Committee comprising experts in the field of design, operation and maintenance of EHV Switchyards from CEA, utilities, manufacturers and consultants.

2. The Committee shall consist of the following members:-

(i)	Member (Power System), CEA	- Chairman
(ii)	Chief Engineer (SE&TD), CEA	- Member
(iii)	Representative from NTPC	- Member
(iv)	Representative from PGCIL	- Member
(v)	Representative from BHEL	- Member
(vi)	Representative from UPRVUNL	- Member
(vii)	Representative from M/s TCE	- Member
(viii)	Representative from M/s Lanco Infra	- Member
(ix)	Representative from M/s ABB	- Member
(x)	Representative from M/s Areva	- Member
(xi)	Representative from M/s Siemens	- Member
(xii)	Representative from M/s Reliance Infra	- Member
(xiii)	Chief Engineer (TE&TD), CEA	- Member Secretary

The Committee may co-opt any other member as it may deem necessary.

The Committee shall submit its report within 3(Three) months from the date of issue of this Order.

The TA/DA and other expenses shall be borne by the respective organizations of the members of the Committee.

All the Organizations / Power Utilities are requested to nominate their representative as member of the Committee along with an alternate member and intimate

to Chief Engineer (TE&TD), CEA, the Member Secretary of the Committee, Sewa Bhawan, R.K Puram, New Delhi – 110 066 (Tel. No. 011-26103488, E-mail – schander1950@yahoo.co.in.).

11.1.2010

(K.P.Singh)
Secretary, CEA
Tel. No: 011-26108476

1. Member (Power System), CEA
2. Chief Engineer (SE&TD), CEA
3. Chief Engineer (TE&TD), CEA along with Hard copy of chairman's approval & vetting file
4. CMD, M/s NTPC Limited, NTPC Bhawan, Scope Complex, Institutional Area, Lodi Road, New Delhi- 110003. Fax No. : 24363050
5. CMD, M/s Power Grid Corporation of India Ltd, SAUDAMINI, Plot No. 2, Sector 29, Gurgaon – 122001, Haryana. Fax No.: 0124- 2571760, 2571761
6. CMD, M/s BHEL, BHEL House, Siri Fort, New Delhi – 110 049. Fax No. 011-26493659
7. Managing Director, M/s UPRVUN Ltd., Shakti Bhawan, 14, Ashok Marg, Lucknow–226001 (U.P.). Fax No. : 0522-2287861
8. Managing Director, M/s TCE, Sheriff Centre, 73/1, St. Marks Road, Bangalore-560001. Fax No. 080-22274873
9. Managing Director, M/s Lanco Infratech Ltd., Plot No. 397, Phase-III, Udyog Vihar, Gurgaon – 122016. Fax No.: 0124- 4741400
10. Managing Director, M/s ABB Ltd., Corporate Office, 49, Race Course Road, Bangalore (Karnatka)Fax No. 91-80-22949148
11. Managing Director, M/s Areva T&D India, A-7, Sector – 65, NOIDA, Gautam Budh Nagar, (U.P.). Fax No. 0120-4790285
12. Managing Director, M/s Siemens Ltd., PTD-H1 (FACTS & HVDC), 6-A, Sector – 18, Maruti Industrial Area, Gurgaon – 122015. Fax No. 91-124-2846061
13. Director (Operation), M/s Reliance Infrastructure Ltd, Reliance Energy Division, 6th Floor, Santa Cruiz East, Mumbai – 400055.Fax No.: 022- 30371789

Copy for kind information to :

1. Member (Th), CEA
2. SA to Chairperson,CEA

List of Nominated Members from Various Organisations :

1.	PGCIL	:	Sh. M.C.Bhatnagar, GM (R&D), PGCIL Sh. R.K.Sarkar, AGM (Engg-S/S) Alternate Member : Sh. K.Rathore, DGM (Engg-S/S)
2.	NTPC	:	Sh. A.K.Gupta, GM (Elect. & C&I).
3.	BHEL	:	Sh. S.Nayar Alternate Member : Sh. V.K.Chauhan
4.	UPRVUN .	:	Sh. R.K.Katiyar, S.E.
5.	NHPC	:	Sh. Ratish Kumar, General Manager (DEM)
6.	TCE	:	Sh. M.S.Venkatesh Murthy, DGM (Elect.) Alternate Member : Sh. S.S.Satish, Senior Manager (Elect.)
7.	LANCO	:	Sh. Manoj Pant, GM (Elect.) Alternate Member : Sh. Sudhir Pathak, DGM (Elect.)
8.	ABB	:	Sh. N.Venu, Sr. Vice President
9.	SIEMENS	:	Sh. Jose Joseph, V.P. (High Voltage Substation) Alternate member : Sh. Satyendra Sharma, Chief Manager, Projects
10.	AREVA	:	Sh. Alok Gupta, GM, System-R5, PLSCI
11.	RInfra	:	Sh. Deepak Saxena, Asstt. VP.(Switchyard & Transmission) Alternate Member Sh. Rabindran Singh, Asstt. V.P. (Core Elect.)

List of Participants in the Meeting held on 9.4.2010 :

CEA :

1. Sh. S.M.Dhiman, Member (GO&D)
2. Sh. Suresh Chander, CE (TETD)
3. Sh. S.K.Thakral, CE (SETD)
4. Sh. R.K.Rastogi, CE(HETD)
5. Sh. Prabhat Mohan, Director, (SETD)
6. Sh. T.K.Saha, Director (Elect.) (TETD)
7. Sh. S.K.Ray Mohapatra, Director (SETD)
8. Sh. Sanjay Srivastva, Director (HETD)
9. Sh. Y.K.Swarnkar, Dy.Director, (SETD)
10. Sh. H.R.Arora, Dy. Director, TETD
11. Sh. B.R.Alwani, Asstt.Director-I, TETD

Committee Members :

1. Sh. M.C.Bhatnagar, GM, PGCIL
2. Sh. R.K.Sarkar, AGM, PGCIL
3. Sh. S.P.Hambarde, DGM, NTPC
4. Sh. Devendra Singh, BHEL
5. Sh. R.K.Katiyar, S.E., UPRVUN
6. Sh. Manoj Pant, Lanco
7. Sh. Satyendra Sharma, Siemens
8. Sh. Deepak Saxena, Asstt. V.P, RInfra
9. Sh. Purushottam Kalki, Areva
10. Sh. Jayant Amresh, Areva
11. Sh. Nagendra, Areva
12. Sh. Suranjan Pal, ABB
13. Sh. Vineet Sikka, ABB
14. Sh. Yogesh shendre, ABB
15. Sh. Rupinder Singh, ABB
16. Sh. Supushpa Kaushal, ABB