CENTRAL ELECTRICITY AUTHORITY

Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2010, Dated: 20.08.2010 with amendment Dated: 06.04.2015

Sl. No.	Description	Summary
1.	**General Requirements**	The Owner shall implement information technology based system for effective project monitoring so as to facilitate timely execution of the projects of capacity equal to or higher than capacity indicated below: • Thermal generating station-250 MW; • Hydro generating station-100 MW; • Transmission lines and sub-stations-220 kV and above.
COMMON TO ALL TYPES OF THERMAL GENERATING STATIONS		
2.	**General Technical Requirements**	1. The coal or lignite based thermal generating stations shall be designed to give life of not less than twenty five (25) years. 2. Gas turbine based Stations and IC engine based Stations shall be designed for life not less than fifteen (15) years.
3.	**Noise Level**	1. Noise level for the continuously operating equipment shall not be more than 85 dBA at a distance of 1 metre and at a height of 1.5 metre from any equipment except in case of Turbine Generator and IC engine based generating sets. Noise level for Turbine-Generators shall not exceed 90 dBA. Noise level for IC engine based generating sets of capacity upto 1 MVA shall meet the stipulations of MOE&F. 2. All the equipment and surfaces (excluding coal or lignite mills, pulverized fuel pipes and electrical equipment) having skin temperature more than 60°C shall be provided with required insulation along with cladding.
4.	**Layout considerations**	1. Adequate space shall be provided for unloading and maintenance purposes in Turbine Generator (TG) area. Requisite lay down area shall be provided for each unit on TG floor and same shall be approachable with electric overhead travelling (EOT) crane. 2. Adequate fire escape staircases shall be provided in TG building with fire doors at each landing.
COAL OR LIGNITE BASED THERMAL GENERATING STATIONS		
5.	**Operating Capabilities of a Unit in the Station**	1. The unit shall give MCR output under the following conditions: (a) Maximum cooling water temperature at site; (b) Worst fuel quality stipulated for the unit; (c) Grid frequency variation of -5% to +3% (47.5 Hz to 51.5 Hz) 2. The steam turbine shall be designed for a minimum of 4000 hot starts, 1000 warm starts and 150 cold starts during its life. 3. The unit shall have minimum rate of loading or unloading of 3% per minute above the control load (i.e. 50%MCR).
6.	**Steam Generator (Boiler) and Auxiliaries**	Minimum steam generator efficiency (%) = $92.5 - \frac{[\ 50xA + 630(M+9xH)}{HHV}$ 1. Boiler maximum continuous rating (BMCR) shall correspond to at least 102% of the steam flow at turbine inlet under VWO (valves wide open) condition plus

<table>
<tr><td></td><td></td><td>continuous steam requirement for auxiliary systems of the unit (e.g. fuel oil heating, etc.) when unit is operating above control load.
2. Pressure withstand capability of the furnace shall correspond to minimum +/- 660 mmwc at 67% yield strength or maximum expected pressure/draft of fans, whichever is higher.
3. Maximum average gas velocity, when using indigenous coal, in any zone of furnace, superheater, reheater, economizer shall be 10 m/sec to prevent erosion of pressure parts. However, maximum local velocity can be upto 12 m/s.
4. Pulverized fuel combustion based steam generator shall not require oil support above 40% unit load. However, FBC based steam-generator shall be designed such that oil support is not needed beyond 25% load.
5. The coal fineness achieved from the pulverisers shall be at least 70% thru 200 mesh (75 microns) and 98% thru 50 mesh (300 microns) at rated capacity of the pulveriser, with an input coal size up to 50 mm.
6. Specific weight of ash may be considered not more than 650 kg/m^3 for determining hopper storage capacity and not less than 1350 kg/m^3 for ESP structural design.
7. Pressure withstand capability of the ESP casing shall correspond to minimum +/- 660 mmwc at 67% yield strength and flue gas temperature of 200°C.</td></tr>
<tr><td>7.</td><td>Steam Turbine and Auxiliaries</td><td>The gross turbine cycle heat rate as guaranteed by the equipment manufacturer shall not exceed the following values:
<table>
<tr><th>Unit rating (MW)</th><th>Heat rate* (kcal/ kWh) at 100% MCR with motor driven BFP</th><th>Heat rate* (kcal/ kWh) at 100% MCR with turbine driven BFP</th></tr>
<tr><td>50 MW to less than 100 MW**</td><td>2280</td><td>-</td></tr>
<tr><td>100 MW to less than 200 MW**</td><td>2000</td><td>-</td></tr>
<tr><td>200 MW to less than 250 MW**</td><td>1970</td><td>-</td></tr>
<tr><td>250 MW to less than 500 MW**</td><td>1955</td><td>-</td></tr>
<tr><td>500 MW and above**</td><td>1895</td><td>1935</td></tr>
<tr><td>Supercritical units</td><td>1810</td><td>1850</td></tr>
</table>
*corresponding to reference conditions of 33^0C cooling water temperature and 0% de-mineralised water make up.
**sub-critical units.
• The steam turbine shall be provided with electronically controlled electro-hydraulic governing system. However, the steam turbines of rating higher than 200 MW shall be provided with back up governing system of mechanical hydraulic or electro- hydraulic type.
• For steam turbines of rating higher than 100 MW, turbine by-pass system of capacity not less than 60% of BMCR steam flow shall be provided for fast hot & warm start ups of unit, dumping steam in condenser during sudden" turbine trip (without tripping the steam generator), unit house load operation etc.</td></tr>
</table>

		• Condensate polishing system shall be provided in the steam turbine cycle for the units with rated pressure of about 170 kg/cm^2 and above at turbine inlet. • 3x50% or 2x100% condensate extraction pumps shall be provided for each unit. The design shall meet the requirements of HIS or equivalent. • Pulverised Fuel Combustion Based Units-2x50% or 1x100% turbine driven BFP(s) plus one (1) number motor driven BFP of adequate capacity for start up of the unit or 2X50% motor driven BFPs. • Fluidised Bed Combustion Based Units 2x100% motor driven BFPs.
8.	**Electrical System**	For the purpose of design of electrical equipment and systems, an ambient temperature of 50°C and relative humidity of 95% shall be considered. However, for equipment installed in air conditioned areas, design ambient temperature shall be 35° C.
9.	**Generator**	1. The generator shall comply with relevant IS/ IEC standard. The efficiency of generator shall be more than 98% at rated load. 2. For hydrogen cooled generators, hydrogen gas system shall be provided with driers of 2x100% duty to maintain dryness of hydrogen inside the machine. 3. For water cooled stator winding, stator water cooling system shall be closed loop type with 2x100% AC motor driven circulating water pumps, 2x100% de-mineralised (DM) water heat exchangers, 2x100% filters, one mixed bed de-mineraliser and one alkalizer unit (as applicable).
10.	**Excitation System**	1. The rated current of the excitation system shall be at least 110% of the machine excitation current at the rated output of the machine. 2. Automatic voltage regulator shall have 2x100% auto channels and automatic changeover.
11.	**Instrument Transformers**	The type and accuracy of current transformers for protection purposes shall comply with relevant IS/ IEC Standards. Current/Voltage transformers for metering shall also comply with Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006.
12.	**Power transformers**	1. Total capacity of coolers for each transformer shall be minimum 120% of actual requirements. 2. Mobile centrifuging plant of adequate capacity shall be provided for purifying the transformer oil.
13.	**High tension (HT) Switchgear**	Sulphur hexa fluoride (SF_6) or vacuum type of circuit breakers shall be provided for HT switchgear (11/6.6/3.3 kV) which shall be of draw out type, re-strike free, trip free, stored energy operated and with electrical anti-pumping features.
14.	**Low tension (LT) switchgear**	Air break type of circuit breakers shall be provided for LT switchgear (415 V) which shall be of draw out type, trip free, stored energy operated and with electrical anti-pumping features.
15.	**Bus ducts**	1. The generator busducts shall be segregated or isolated phase type. The busduct rated more than 3150 Amp and upto 6000 Amp shall be isolated phase type. The busduct rated more than 6000 Amp shall be continuous isolated phase type. 2. The HT busduct (11/6.6/3.3 kV) shall be segregated phase type and LT busduct (415V) shall be non-segregated phase type.

16.	**Power Supply System**	In thermal power stations with unit sizes greater than 100 MW, automatic bus transfer system (consisting of fast, slow, etc. transfer in auto mode) shall be provided to minimise time for transfer from unit to station buses at 11/ 6.6 kV levels. The 11/6.6/3.3 kV switchgear buses for balance of plant facilities shall be provided with auto reserve closure (ARC) facility between main incomer and reserve breakers. Critical 415 V switchgear buses shall also have ARC feature.	
17.	**Neutral Earthing**	Generator star point	Through dry type distribution transformer with secondary loaded with a resistor.
		Generator transformer, Station transformer-high voltage (HV) winding star point	Solidly earthed
		11 kV, 6.6kV or 3.3 kV system	Through a resistance in case of star connected windings Or Through artificial transformer with its secondary loaded with resistor in case of delta connected windings
		415 V system	Solidly earthed
		DC system	Unearthed
18.	**Earthing system**	The earthing system shall be designed for a life expectancy of at least forty (40) years and for maximum system fault current or 40 kA for 1.0 sec, whichever is higher. The minimum rate of corrosion of steel used for earthing conductor shall be considered as 0.12 mm per year while determining the conductor size.	
19.	**Protection system**	Fully graded protection system with requisite speed, sensitivity and selectivity shall be provided for the entire station.	
20.	**Power and control cables, and cabling**	Power and control cables shall be flame retardant low smoke (FRLS) type. Cables to be directly buried shall be essentially armoured type.	
21.	**Diesel Generator set**	One DG set shall be provided for each unit of 200 MW and above. In addition, there shall be one common standby DG set of same rating to serve a block of two units. For unit sizes less than 200 MW, one DG set may be provided for every two units. However, a Station with a single unit of 200 MW or higher rating shall be provided with two DG sets.	
22.	**DC system**	voltage levels of the DC system shall be 220 volts, 48 volts and 24 volts for control and protection of various equipment. However, 110V DC may be provided for off-site areas only. Two sets of batteries, each catering to 100% load, shall be provided for each DC system. One float -cum- boost charger shall be provided for each battery.	
23.	**Control system for steam generator and turbine generator**	1. Control systems integral to steam generator and turbine-generator shall be implemented as part of DDCMIS. However, turbine protection system and electro- hydraulic governing system may be implemented as per standard practice of turbine manufacturer. 2. The control system shall include on-line self-surveillance, monitoring and diagnostic facility providing the details of each fault at the MMI system. 3. All coal or lignite fired units of size 250 MW and above shall be provided with on-line efficiency monitoring and optimization system to maximize the	

		operational efficiency.
23.	**Control system for balance of plant**	Programmable logic controller (PLC) based or DDCMIS based control system with independent MMI system shall be provided for all the balance of plant facilities like coal or lignite handling plant, ash handling plant, cooling water system, water treatment plant etc.
24.	**Power supply system**	Independent, redundant and reliable 230 V or 110 V AC through uninterrupted power supply system (UPS) and/or DC power supply at standard voltage levels (e.g. 220V/ 48V/ 24V) shall be used for control and instrumentation systems.
25.	**Control Valves**	The control valves and accessories shall be designed, constructed and tested as per IBR, ASME code for power cycle piping and ASME boiler & pressure vessel code or equivalent.
26.	**Coal or lignite handling system**	The coal or lignite handling plant capacity shall be such as to meet the day's fuel requirement by its operation in 14 hours. A day's fuel requirement shall be worked out at 100% BMCR using worst coal or lignite plus a margin of 10%.
27.	**Fuel oil system**	The capacity of fuel oil storage facilities shall be adequate for the requirement of fuel oil for at least 30 days' operation of the Station.
28.	**Ash handling system**	Ash management plan for utilization and disposal of fly ash as well as bottom ash shall be formulated in accordance with MOE&F's requirements and any other stipulation of the CPCB and SPCB in this regard.
29.	**Cooling Water System**	The Cooling tower shall be of mechanical induced draft type or natural draft type depending upon site specific techno-economics. The design wet bulb temperature of the cooling tower shall correspond to the ambient wet bulb temperature which is not exceeded for more than 5% of the time during four summer months in an average year.
30.	**De-mineralisation System**	The demineralized water shall be stored in minimum 2 nos. DM water storage tanks of total storage capacity equal to 24 hour Station requirement.
31.	**Fire detection, alarm and protection system**	1. Transformers of rating 10 MVA and above or oil filled transformers with oil capacity of more than 2000 litres. 2. Alternatively, these transformers may be provided with Nitrogen injection based fire protection system. The transformers of 220kV or higher voltage may preferably be provided with Nitrogen injection based fire protection system in addition to automatic high velocity water spray system.
32.	**Ventilation and air-conditioning system**	Air- conditioned areas shall be maintained at about 25°C and 50 % relative humidity for comfort conditions. Water chilling unit or condensing units shall have 2x100% capacity equipment. Package type air-conditioners shall have 2x100% capacity or 3x50% capacity equipment.
33.	**Chimney**	Chimney may be single flue unitized or multi-flue for two or more units.
GAS TURBINE BASED THERMAL GENERATING STATIONS		
34.	**Operating Capabilities**	1. The gas turbine, steam turbine and all rotating auxiliaries shall be suitable for continuous operation within the frequency range of 47.5 Hz to 51.5 Hz. 2. Gas turbine rating (ISO) upto 100 MW shall be provided with black start facility.
		The gross heat rate of CCGT module as guaranteed by the equipment manufacturer shall not exceed the following values:

<table>
<tr><td></td><td></td><td>Gas Turbine rating (ISO)</td><td>Gross Heat Rate of CCGT module (on HHV basis) in kcal/kWh at ISO conditions with natural gas as fuel at 100% load</td></tr>
<tr><td></td><td></td><td>20MW to 30MW</td><td>2250</td></tr>
<tr><td></td><td></td><td>>30MW to 200MW</td><td>1825</td></tr>
<tr><td></td><td></td><td>> 200 MW</td><td>1700</td></tr>
<tr><td>35.</td><td>Heat Recovery Steam Generator (HRSG) and Auxiliaries</td><td colspan="2">1. HRSG shall comply with IBR requirements.
2. The design of HRSG shall be based on finned tube heat transfer banks of superheaters, evaporators, economisers etc. The fin density shall not be higher than 200 fins/m.</td></tr>
<tr><td colspan="4">INTERNAL COMBUSTION (IC) ENGINE BASED THERMAL GENERATING STATIONS</td></tr>
<tr><td rowspan="13">36.</td><td rowspan="13">Operating Capabilities of IC Engine based Generating Sets (Gen-sets)</td><td colspan="2">Diesel engine based Gen- sets (four stroke)</td></tr>
<tr><td>Gen- Set Rating</td><td>Gross Heat Rate (on HHV basis) in kcal/ kWh at 100% load</td></tr>
<tr><td>100 kW to 1 MW</td><td>2350</td></tr>
<tr><td>>1MW to 3MW</td><td>2250</td></tr>
<tr><td>>3MW to 10MW</td><td>2200</td></tr>
<tr><td>>10MW</td><td>2150</td></tr>
<tr><td colspan="2">Diesel engine based Gen- sets (two stroke)</td></tr>
<tr><td>Gen- Set Rating</td><td>Gross Heat Rate (on HHV basis) in kcal/ kWh at 100% load</td></tr>
<tr><td>3MWto10MW</td><td>2000</td></tr>
<tr><td>> 10 MW</td><td>1950</td></tr>
<tr><td colspan="2">Gas engine based Gen- sets</td></tr>
<tr><td>Gen- Set Rating</td><td>Gross Heat Rate (on HHV basis) in kcal/ kWh at 100% load</td></tr>
<tr><td>>1 MW to 3 MW</td><td>2400</td></tr>
<tr><td>>3 MW to 5 MW</td><td>2300</td></tr>
<tr><td>>5 MW</td><td>2150</td></tr>
<tr><td>37.</td><td>IC Engine and Auxiliaries</td><td colspan="2">The IC engine and auxiliaries shall comply with latest versions of applicable IS/ ISO/BS (British Standard) or equivalent codes.</td></tr>
<tr><td colspan="4">TECHNICAL STANDARDS FOR CONSTRUCTION OF HYDRO-ELECTRIC GENERATING STATIONS</td></tr>
<tr><td>38.</td><td>General Requirements</td><td colspan="2">1. While designing hydro- electric projects, the life of the civil works shall not be less than one hundred (100) years, while that of main electro-mechanical generating equipment i.e. turbine, generator, transformers, auxiliaries, etc, installed shall not be less than thirty five (35) years.</td></tr>
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		2. The generating units of rated capacity 50 MW and higher shall be capable of operation in synchronous condenser mode, wherever feasible. 3. The noise level shall not be more than 90 dBA at a distance of 1 metre from any equipment.
39.	**Hydraulic Turbines and Auxiliaries**	1. The hydraulic turbine shall comply with latest versions of relevant IS/ IEC standards. 2. The weighted average efficiency obtainable shall not be less than 93% for Francis, 92% for Kaplan and Bulb turbines and 91 % for Pelton, Deriaz and Propeller turbines. The peak efficiency at rated conditions shall be as high as possible and shall be higher than 94%, 93% and 91.5% respectively for these turbines. 3. The turbine shall be designed to withstand runaway speed for 15 minutes without causing any residual detrimental affect on future operation of the machine. 4. The guide-vanes, runner, discharge ring and other hydraulic passages shall be designed for a life of 8000 hours against excessive pitting caused by cavitations.
40.	**Governing System**	1. The performance requirements of the governing system shall be governed by relevant IS / IEC standards. 2. Piston type accumulator with nitrogen bottles shall be used for pressures higher than 60 kg/cm^2.
41.	**Electric overhead travelling (EOT) cranes**	The hook capacity shall be taken as 10% more than the maximum weight to be lifted inclusive of the weight of the lifting beam. If the maximum weight to be lifted is more than 300 Tonnes, two cranes each of equal capacity shall be deployed to lift the heaviest package in tandem operation.
42.	**Cooling water system**	The penstock tapping shall not be considered in case of high head installations i.e. where the penstock pressure is more than 10 kg/cm^2. If the penstock tapping results in a pressure of upto 10 kg/cm^2, a suitable pressure reducer depending on the requirement of net cooling water pressure (usually 3 to 5 kg/cm^2) shall be provided.
43.	**Fire fighting system**	1. The transformers or reactors of 10 MVA and higher rating or oil filled transformers or reactors with oil capacity of more than 2000 litres shall be provided with automatic high velocity water spray system as per relevant IS or Nitrogen injection based fire protection system. The transformers or reactors of 220kV or higher voltage may be provided with Nitrogen injection based fire protection system in addition to automatic high velocity water spray system. 2. The capacity of overhead / pressurised water tank shall be adequate to meet the fire water requirement for one generator transformer for 40 minutes, plus operation of one hydrant for 60 minutes. Two nos. of fire pumps, each capable of pumping water to fill the overhead water tank in 6 hours time shall be provided.
44.	**Electrical System**	1. For the purpose of design of equipment or systems, an ambient temperature of 40°C or higher as applicable to Station site and relative humidity of 95% shall be considered. 2. The generator shall be capable of safely withstanding the maximum stresses during normal operation, run-away speed conditions, two phase and three phase short circuit conditions, single phase earth fault, 180 degree and 120 degree out of phase synchronization, magnetic unbalance with 50% of the poles short circuited within the speed range of 1.3 times the rated speed, brake

		application, etc. 3. The current flowing in stator slot shall be limited to 3000-6000 Amperes with current through individual coil being limited to approximately 3000 Amperes.	
45.	**Generator Busduct**	Busduct rated more than 3150 Amps, shall be isolated phase type. The isolated phase ducts shall be preferred over the segregated phase bus ducts. Generator Busduct rated more than 6000 A shall be continuous isolated phase type.	
46.	**Instrument Transformers**	1. The current transformers shall be window type fitted around the bus conductors for meeting the protection and measuring requirements. 2. The voltage transformers shall be located in separate cubicle for each of the three phases and mounted in withdrawable cabinets.	
47.	**Machine Condition Monitoring Systems**	The following monitoring equipments/ systems for prediction of abnormality and preventive action shall be provided for the generating units rated for 100 MW and above: • Air gap monitoring: tolerance of ±10% shall be maintained • Vibration monitoring	
48.	**Excitation system**	The excitation system while operating at its maximum output, terminal voltage, power factor and speed shall be capable of changing from rated field voltage to 90 percent of ceiling voltage within 25 milliseconds for a sustained drop in generator terminal voltage of 5 percent.	
49.	**DC supply system**	1. The standard voltage rating for the DC system shall be 24V/ 48V for computerized control system and 220V/110V for control and protection etc. 2. The battery shall have sufficient capacity to meet unit and station loads in addition to 3 hours of uninterrupted emergency illumination requirement.	
50.	**Neutral earthing**	Generator transformer, Station transformer - HV winding star point	Solidly earthed
		11 kV, 6.6kV or 3.3 kV system	Through a resistance in case of star connected windings or Through artificial transformer with its secondary loaded with resistor in case of delta connected windings
		415 V system	Solidly earthed
		DC System	Unearthed
51.	**Electrical protection system**	1. All relays used shall be suitable for operation with CTs secondary rated for 1 Amp or 5 Amps as per relevant IS/ IEC/ IEEE standards. 2. Relevant IS/ IEC/ IEEE standards shall be applied for protection of generators, transformers and motors.	
52.	**Instrumentation**	Microprocessor based vibration monitoring and analysis system shall be provided for critical rotating equipments.	
SUB STATIONS AND SWITCHYARDS (66KV AND ABOVE)			
53.	**General**	The rated breaking current capability of switchgear and breakers to be installed at different voltage levels, based on available capacities of the breakers, shall be considered as shown below:	

		66 kV	31.5Ka (for 1 sec.)
		110/132 kV	31.5 kA (for 1 sec.)
		220 kV	40 kA (for 1 sec.)
		400 kV	40 or 50 kA (for 1 sec.)
		765 kV	40 or 50 kA (for 1 sec.)
		The transformation capacity of any single sub- station for meeting loads at different voltage levels shall not normally exceed the values indicated below:	
		Table 7765 kV	4500 MVA
		400 kV	1500 MVA
		220 kV	500 MVA
		110/132 kV	150 MVA
		66 kV	75 MVA
		The sub-station or switchyard shall be designed and constructed to give a life of not less than 25 years.	
54.	**Gas insulated sub-stations**	GIS shall be isolated phase or three phase non-magnetic enclosure type for voltage less than 400kV. For 400kV and higher voltage levels, it shall be isolated phase enclosure type.	
55.	**Hybrid sub-station**	In a hybrid sub-station, the bus-bars shall be air insulated type. Switchgear for a hybrid sub-station shall have some or all functional units enclosed in SF_6 gas insulated housing.	
56.	**Power Transformers**	The transformers shall be of two winding type or auto-transformers. Transformer banks (formed out of single phase units) and 5 limbed 3 phase units shall be provided with tertiary windings of rating one third of HV rating. The transformer shall be provided with on load tap changer (OLTC) as per power system requirement.	
57.	**Reactive Compensation**	Shunt Reactors, Capacitors	
58.	**Circuit Breakers**	1. The interrupting medium of circuit breakers shall be SF_6. Circuit breakers of 220 kV and above voltage class shall be suitable for single phase and three phase auto- reclosing. 2. Circuit breakers of 132 kV and below voltage class shall be suitable for three-phase auto- reclosing. 3. Each circuit breaker of 132 kV and above rating shall be provided with 2 nos. of trip coils. Two sets of trip circuits shall be connected to separate fuse or miniature circuit breaker (MCB) controlled DC supplies for greater reliability.	
59.	**Current/Voltage Transformers**	The accuracy class for metering core shall be equal to or better than the accuracy class of the meter specified in the Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006.	
60.	**Insulators**	The minimum specific creepage distances, as per relevant standard, shall be as indicated below:	

		Pollution level	**Specific creepage distance** (mm/kV of line-to-line voltage)
		Light	16
		Medium	20
		Heavy	25
		Very heavy	31
61.	**Fire Detection, Alarm and Protection System for Sub-station and Switchyard**	The transformers or reactors of 10 MVA and higher rating or oil filled transformers or reactors with oil capacity of more than 2000 litres shall be provided with automatic high velocity water spray system as per relevant IS or Nitrogen injection based fire protection system. The transformers or reactors of 220 kV or higher voltage may preferably be provided with Nitrogen injection based fire protection system in addition to automatic high velocity water spray system.	
62.	**Protection and Control**	1. **Protective Relaying System** -All main protection relays shall be of numerical type and communication protocol shall be as per IEC-61850/ relevant IS. 2. **Disturbance Recorders, Event Loggers and Time Synchronisation Equipment -** Each 765 kV, 400 kV and 220 kV line shall be provided with facility for disturbance recording, distance to fault locator and time synchronising equipment (TSE). 3. **Power Line Carrier Communication (PLCC)** • Power line carrier communication (PLGC) equipment complete for speech transmission, line protection, and data channels shall be provided on each transmission line of voltage rating 132kV and higher. • Each 765 kV or 400 kV or 220 kV line shall be provided with two protection channels in addition to one speech plus data channel for each direction.	
SUB- STATIONS (33/11 kV, 33/22kV AND 22/11kV)			
63.	**System Parameters**	**Parameter**	**33 kV**	**22 kV**	**11kV**
		Nominal system voltage (kV)	33	22	11
		Highest system voltage (kV)	36	24	12
		System earthing	Solidly earthed system	Solidly earthed system	Solidly earthed system
		Frequency (Hz)	50	50	50
		Lightning impulse withstand voltage (kV_{peak})	170	125	75
		Power frequency withstand voltage (dry) (kV_{rms})	70	50	28
64.	**General Consideration for 33/11 kV, 33/22 kV and 22/11 kV Sub-stations and**	1. The sub-stations in urban areas shall be provided with supervisory control and data acquisition (SCADA) system for monitoring and control. 2. The 33/ 11 kV or 33/ 22 kV or 22/ 11 kV sub-stations shall, at least have adequate capacity to cater to load growth for five (5) years. Adequate land for possible future expansion shall be provided in each case.	

<table>
<tr><td></td><td>Switching Stations</td><td>3. The maximum capacity of 33/ 11 kV or 33/ 22 kV or 22/ 11 kV sub-station shall be 60 MVA, 40 MVA and 40 MVA respectively.
4. Each 33/ 11 kV or 33/ 22 kV or 22/ 11 kV sub-station shall normally have two or more transformers.
5. All sub-stations shall have independent circuit breaker control of 33 kV or 22 kV incoming feeders, transformers and 22 kV or 11 kV outgoing feeders.</td></tr>
<tr><td>65.</td><td>Power Transformers</td><td>1. The transformers and fittings and accessories shall comply with the relevant IS.
2. Transformers shall withstand, without injurious heating, combined voltage and frequency fluctuations which produce the over fluxing conditions as: 125% for 1 minute and 140% for 5 seconds.
3. A transformer with off-circuit tap changer shall have taps ranging from (+) 2.5% to (-) 10% in steps of 2.5% each on the higher voltage winding for variation in the voltage.
4. A transformer with on-load tap changer shall have taps ranging from (+) 5% to (-) 15% in steps of 2.5% each on 33 kV or 22 kV winding for voltage variation.</td></tr>
<tr><td>66.</td><td>Bus-bars</td><td>Bus-bars shall be of Rigid type or Strain type.</td></tr>
<tr><td>67.</td><td>Circuit Breakers</td><td>1. Circuit breakers (CBs) shall comply with the provisions of relevant IS.
2. Rated short time current rating of 33 kV CBs shall not be less than 25 kA for 1 second and for 22 kV or 11 kV CBs shall not be less than 16 kA for 1 second. In case of rural areas for 11 kV CBs, this shall not be less than 12.5 kA for 1 second.</td></tr>
<tr><td>68.</td><td>Isolators and Earthing Switches</td><td>The rated current shall be at least 630 A at 36 kV and 24 kV. For 11 kV system, isolating switches of 400 Amps at 12 kV shall be used. The isolators shall be gang operated type. Earthing switches shall be suitable for manual operation.</td></tr>
<tr><td>69.</td><td>Lightning Protection</td><td>1. The surge arrester (SA) which responds to over-voltages without any time delay shall be installed for protection of 33 kV, 22 kV and 11 kV switchgear, transformers, associated equipment and 33 kV, 22 kV and 11 kV lines.
2. The rated voltage of surge arresters shall be 30 kV for use on 33 kV systems and with nominal discharge current rating of 10 kA. For system voltage of 22 kV, the rated voltage shall be 20 kV with nominal discharge current rating of 7.5 kA.
3. The rated voltage of surge arresters shall be 9 kV (rms) for solidly earthed 11 kV system (co-efficient of earth not exceeding 80 per cent as per relevant IS) with all the transformer neutrals directly earthed. The nominal discharge current rating shall be 5 kA.</td></tr>
<tr><td>70.</td><td>Cables</td><td>Power cables shall be cross linked poly ethylene (XLPE) insulated, poly vinyl chloride (PVC) sheathed type conforming to relevant IS. Cables shall be flame retardant low smoke (FRLS) type.</td></tr>
<tr><td colspan="3">DISTRIBUTION SUB-STATIONS (DSS)</td></tr>
<tr><td>71.</td><td>General</td><td>The system shall conform to the design parameters indicated below:
<table>
<tr><th>Parameter</th><th>33 kV</th><th>22 kV</th><th>11kV</th><th>0.415 V</th></tr>
<tr><td>Nominal system voltage (kV)</td><td>33</td><td>22</td><td>11</td><td>0.415</td></tr>
<tr><td>Highest system voltage</td><td>36</td><td>24</td><td>12</td><td>0.450</td></tr>
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</td></tr>
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<table>
<tr><td></td><td></td><td>(KV)</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>System earthing</td><td>Solidly earthed system</td><td>Solidly earthed system</td><td>Solidly earthed system</td><td>Solidly earthed system</td></tr>
<tr><td></td><td></td><td>Frequency (Hz)</td><td>50</td><td>50</td><td>50</td><td>50</td></tr>
<tr><td></td><td></td><td>Lightning impulse withstand voltage (kV_{peak})</td><td>170</td><td>125</td><td>75</td><td></td></tr>
<tr><td></td><td></td><td>Power frequency withstand voltage (dry) (kV_{rms})</td><td>70</td><td>50</td><td>28</td><td>3</td></tr>
<tr><td></td><td></td><td colspan="5">• The DSS with dry type transformer can be used for rooftop installation provided that the building is suitable for bearing the load and adequate fencing or isolation arrangement is ensured.
• The capacity of DSS shall be as per the load requirement keeping in view the future load growth for 5 years.</td></tr>
<tr><td>72.</td><td>Distribution Transformers</td><td colspan="5">1. The transformer can be oil filled, or dry type depending on requirements and shall be as per the Central Electricity Authority (Measures relating to Safety and Electricity Supply) Regulations 2010.
2. The efficiency of the oil filled distribution transformers shall not be less than the figures given below:</td></tr>
<tr><td></td><td></td><td colspan="2"></td><td>At 50% loading</td><td colspan="2">At 100% loading</td></tr>
<tr><td></td><td></td><td colspan="2">Below 16 kVA</td><td>98.0%</td><td colspan="2">97.0%</td></tr>
<tr><td></td><td></td><td colspan="5">• The transformer may be single phase or three phase. The cooling shall be ONAN for oil filled transformers.</td></tr>
<tr><td>73.</td><td>Surge Arresters</td><td colspan="5">1. Surge arresters shall normally be installed on the high voltage side of the transformer connected to overhead lines.
2. Surge arresters of rating 9 kV on 11 kV, 20 kV on 22 kV and 30 kV on 33 kV outdoor type shall be used for diverting the lightning surges to earth.</td></tr>
<tr><td>74.</td><td>Protection Systems</td><td colspan="5">1. Suitable high rupturing capacity cartridge fuse or moulded case circuit breakers (MCCB) or miniature circuit breakers (MCB) or air circuit break switch (ACB) shall be provided on low voltage side.
2. 33/0.4 kV DSS and 22/ 0.4 kV DSS- The high voltage side of these transformers shall be protected by circuit breakers or drop out fuses.
3. 11/0.4 kV DSS- The high voltage side of these transformers shall be protected by drop out expulsion type fuses or circuit breakers.</td></tr>
<tr><td>75.</td><td>LT Cables</td><td colspan="5">The LT cables may be armoured or unarmoured for transformers rated less than 100 kVA and shall be armored for transformers of 100 kVA and higher ratings.</td></tr>
<tr><td>76.</td><td>Meters</td><td colspan="5">The installation of meters shall be in conformance to the Central Electricity Authority (Installation and Operated of Meters) Regulations, 2006.</td></tr>
<tr><td>77.</td><td>Reactive Compensation</td><td colspan="5">In cases where loads fluctuate very fast, a suitable dynamic compensation like static compensator (STATCOM)/ thyristor switched capacitors shall be considered.</td></tr>
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<table>
<tr><th colspan="9">ELECTRIC LINES (66 KV AND ABOVE)</th></tr>
<tr><td>78.</td><td>Transmission System</td><td colspan="7">1. The transmission system shall be planned in an integrated manner and optimized considering the total network under central transmission utility (OTU) and state transmission utility (STU).
2. The adequacy of the transmission system shall be tested for one or more load generation scenarios comprising of peak and off peak conditions in summer, winter and monsoon seasons.</td></tr>
<tr><td rowspan="10">79.</td><td rowspan="10">Design and Construction of Transmission Lines</td><td colspan="7">The electrical design parameters of the transmission lines for altitude upto 1000 m above mean sea level (MSL) shall be as indicated in Table 16 below:</td></tr>
<tr><td>Parameter</td><td>66 kV AC</td><td>132 kV AC</td><td>220 kV AC</td><td>400 kV AC</td><td>765 kV AC</td><td>500 kV DC</td></tr>
<tr><td>Nominal voltage (kV)</td><td>66</td><td>132</td><td>220</td><td>400</td><td>765</td><td>500</td></tr>
<tr><td>Highest system voltage (kV)</td><td>72.5</td><td>145</td><td>245</td><td>420</td><td>800</td><td>525</td></tr>
<tr><td>Full wave impulse withstand voltage (1.2/50 micro sec.) (kV_{Peak})</td><td>325</td><td>650</td><td>1050</td><td>1550</td><td>2400</td><td>1800</td></tr>
<tr><td>Power frequency withstand voltage under dry condition (kVr_{ms})</td><td>140</td><td>275</td><td>460</td><td>680</td><td>830</td><td>-</td></tr>
<tr><td>Switching surge withstand voltage under wet condition (kVr_{ms})</td><td>-</td><td>-</td><td>-</td><td>1050</td><td>1550</td><td>1000</td></tr>
<tr><td>Minimum corona extinction voltage under dry condition (kV_{rms} phase to earth)</td><td>-</td><td>-</td><td>156</td><td>320</td><td>510</td><td>550</td></tr>
<tr><td>Maximum radio interference voltage (micro volts) at 1 MHz for phase to earth voltage of kV under dry condition</td><td>-</td><td>-</td><td>1000 at 156kV</td><td>1000 at 267kV</td><td>1000 at 510kV</td><td>1000 22 kV/cm conductor surface gradient</td></tr>
<tr><td colspan="7">For the transmission lines at altitudes higher than 1000 m above MSL, basic insulation level, impulse & switching surge withstand voltage requirements shall be kept higher than those indicated value as above, as per relevant standards and practices</td></tr>
<tr><td>80.</td><td>Conductor</td><td colspan="7">1. For transmission lines of 400 kV or higher voltage class, bundle conductors (minimum two conductors per phase for 400 kV AC and four conductors per phase for 500 kV DC and 765 kV AC) shall be used for satisfactory performance of transmission lines from corona and interference aspects.
2. The conductors may be of type aluminium conductor steel reinforced (ACSR), all aluminium alloy conductor (AAAC) or other new technology conductors</td></tr>
</table>

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<tr><td></td><td></td><td>conforming to relevant IS or IEC or other international standards and specifications depending on system requirements.</td></tr>
<tr><td>81.</td><td>Earthwire</td><td>The earthwire shall be either of galvanized stranded steel (GSS) or alternatively ACSR or AACSR conductor type. Optical fibre ground wires may also be used as earthwire.</td></tr>
<tr><td>82.</td><td>Towers</td><td>1. General :
(a) The towers shall be self-supporting lattice steel type and shall be a fully galvanised structure. Alternatively, guyed or pole structure towers may also be used.
(b) Ground clearance shall be as per requirements of Central Electricity Authority (Measures relating to Safety and Electricity Supply) Regulations as and when these are notified by the Authority.
2. Design of towers:
Reliability level- 1 corresponding to 50 year return period design loads due to wind as per relevant IS shall be considered for design of towers for transmission lines upto 400 kV. For higher voltage level transmission lines, reliability level-2 corresponding to 150 year return period wind loads shall be considered.
3. Foundations:
Structural design of foundations shall be done by limit state method with minimum overload factor as 1.1. The minimum factor of safety for design of pile or well foundations shall be 2.5.
4. Insulators, Insulator Strings and Hardware Fittings:
(a) Requisite type of suspension and tension insulator strings with disc insulators or long rod insulators offering equivalent performance shall be used.
(b) For critical locations with high pollution level, anti fog type insulators or polymer insulators may be used for better performance.
(c) For 765kV, specific creepage distance shall be decided judiciously by the Owner.
(d) under ultimate design wind loading conditions, the load on insulator string shall not exceed 70 % of its selected rating.
(e) under everyday temperature and no wind conditions, the load on insulator string shall not exceed 25% of its selected rating.</td></tr>
<tr><td>83.</td><td>Cables</td><td>Wherever construction of an overhead transmission line is not possible due to space constraints or right- of- way problems etc., the Owner can use high voltage cables for transmission of power.</td></tr>
<tr><td colspan="3">ELECTRIC LINES (33 KV AND BELOW)</td></tr>
<tr><td>84.</td><td>Electrical Design Parameters of the Electric Lines</td><td>The electrical design parameters of the electric lines for altitude upto 1000 m above MSL shall be as indicated in Table 19 below:
<table>
<tr><th>Parameter</th><th>33 kV</th><th>22 kV</th><th>11 kV</th><th>0. 415 kV</th></tr>
<tr><td>Nominal system voltage (kV)</td><td>33</td><td>22</td><td>11</td><td>0.415</td></tr>
<tr><td>Highest system voltage (kV)</td><td>36</td><td>24</td><td>12</td><td>0.450</td></tr>
<tr><td>System earthing</td><td>Solidly earthed system</td><td>Solidly earthed system</td><td>Solidly earthed system</td><td>Solidly earthed system</td></tr>
</table></td></tr>
</table>

		Frequency (Hz)	50	50	50	50
		Lightning impulse withstand voltage (kV_{peak})	170	125	75	-
		Power frequency withstand voltage (kV_{rms}) in dry condition	75	50	28	3
85.	**Routing of Electric Lines**	1. The route of the electric line shall be as short as possible. 2. The 33 kV or 22 kV line route shall be such as to avoid large habitations, and densely populated areas. 3. The electric line shall be close to a road for approach during construction and ease of maintenance.				
86.	**Supports (Poles and Towers)**	1. Poles may be used for 33 kV, 22 kV, 11 kV and LT lines (lines below 500 V) as per requirement. The poles shall be pre-cast concrete (PCC) pole, pre-stressed cement concrete (PSCC) pole, rolled steel joist, rail pole or steel tubular pole as required, provided PCC and PSCC poles shall not be used at cut-points and as end poles. 2. Poles shall conform to relevant IS as the case may be. 3. For angles of deviation of more than 10 degree, double pole structure shall be used.				
87.	**Line Span**	The span shall be within the range specified by IS.				
88.	**Earthing of Poles**	1. All metallic supports shall be permanently and effectively earthed. 2. Metal cross arms and insulator pins for PCC and PSCC poles shall be bonded together and normally earthed at every pole for 33 kV or 22 kV or 11 kV lines and at every 5th pole for lines below 500 volts. 3. Normally coil earthing shall be provided except for locations involving railways, telegraph line, power line crossings and special structures where pipe/rod type earthing shall be provided. 4. All poles above 650 volts, irrespective of inhabited areas, shall be earthed. For poles below 650 V guarding with continuous earth-wire shall be provided invariably, connected to earth at three equidistant points in one km.				
89.	**Anti Climbing Devices**	For this purpose barbed wire conforming to relevant IS for a vertical distance of 30 to 40 cm. at a height of 3.5 to 4 meters from ground level or clamps with protruding spikes at a height of 3 to 4 meter shall be used.				
90.	**Insulators, Insulator Strings and Hardware Fittings**	1. Pin insulators shall generally be used on the straight stretch of a line. The pin insulators may be used on lines up to 33 kV voltage level. 2. Shackle insulators shall be used in lines below 500 volts and these shall conform to IS. 3. Requisite type of suspension and tension insulator strings with disc insulators or long rod insulators offering equivalent performance shall be used on 33 kV or 22 kV or 11 kV lines. 4. Under ultimate design wind / snow loading conditions, the load on insulator string shall not exceed 70% of its selected rating. 5. Under everyday temperature and no wind/ snow conditions, the load on the insulator string shall not exceed 25% of its selected rating.				
91.	**Cables**	Underground cables or aerial bunched cables (ABC) of adequate rating can also be used for supplying power.				