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**Technical code for the design of
220kV ~ 750kV substation**

220kV ~ 750kV 变电站设计技术规程

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Technical code for the design of 220kV ~ 750kV substation

1 General provisions

1.0.1 In order to meet the needs of national and industry standardization construction, reach a unified standard technical principle for design of substation, allow the design of substation to meet the relevant national policies, laws, regulations, reach the requirements of safety and reliability, advanced and applicability, energy saving and environmentally friendly, it hereby develops this standard.

1.0.2 This standard is applicable to the design of the newly built, reconstructed, extended work of substation (switchyard) which has an AC voltage of 220kV ~ 750kV.

1.0.3 Substation design shall be combined with engineering features, actively and deliberately adopt new technologies, new device, new materials, new processes with application conditions.

1.0.4 In addition to the implementation of this standard, the design of substation shall also comply with the relevant national standards.

2 Terms

2.0.1

Substation

Part of the power system, which is concentrated in a defined location, including terminals, switches and control device, buildings and transformers for power transmission or distribution. It usually includes the facilities (such as protective devices) required for the safety and control of power system.

2.0.2

Uninterruptible power supply

The power supply which consists of a battery pack, an inverter, other circuits, that provides AC power when the power grid is out of power.

2.0.3

Substation automation system

A computer application system that implements functions such as information collection, processing, monitoring, control, operation management of substation based on computer, network, communication technologies.

2.0.4

Unattended operation mode

An operation management mode, in which the operation monitoring of the substation and the main control operation are carried out by the remote control end, the device of the substation is regularly patrolled and maintained. There are no on-duty personnel in the substation for fixed operation and maintenance.

2.0.5

Relay room

A place where the relay protection, automatic devices, transmitters, energy accumulation and recording instruments, auxiliary relay screens, etc., are installed.

2.0.6

Time synchronization system

3 Selection of the substation location

3.0.1 The site selection of the substation shall be based on the network structure, load distribution, urban-rural planning, land acquisition & demolition and the following provisions of the power system planning and design. It shall use technical and economic comparison and economic benefit analysis to select the optimal solution of site location.

3.0.2 When selecting the substation's location, pay attention to saving land and using the land reasonably. Try to use wasteland and inferior land, do not occupy or occupy less cultivated land or land of high economic benefits, minimize the earthwork or stonework.

3.0.3 The selection of substation's location shall conform to the approved prospective development plan of the power system in the region, meet the requirements for cable laying, reserve the laying channel of overhead and cable lines, avoid or reduce the crossover of overhead lines. The location of the terminal tower of overhead line should be arranged uniformly when planning the substation's location.

3.0.4 The selection of substation's location shall be based on transportation conditions and substation's construction needs, facilitating the connection of incoming roads and large-piece transportation. It shall use the technical and economic comparison to implement the large-piece transportation plans.

3.0.5 The substation's location shall have suitable geological and topographical conditions. It shall avoid unfavorable geological structures such as landslides, debris flows, subsidence zones, earthquake-fracture zones. It should avoid submerged caves, goafs, exposed and concealed river ponds, shore scouring areas, areas prone to rolling stones, try to avoid or reduce damage to forests and natural landscapes.

3.0.6 The substation's location shall avoid the natural areas and cultural relics that are mainly protected, do not cover the mineral resources. Otherwise, it shall obtain the written consent of the relevant departments.

3.0.7 The selection of substation's location shall meet the requirements of flood control and prevention. Otherwise, it shall take flood control and prevention measures.

3.0.8 There shall be a reliable source of water for production and domestic use near the substation's location. When groundwater is used as a water source, it shall carry out hydrogeological surveys or explorations, submit report.

3.0.9 There shall be reliable power supply around the substation's location which meet the requirements of substation construction and external power

4 General plan & layout of the substation

4.1 Plan of the substation

4.1.1 The general plan of the substation shall be coordinated with the local urban planning or industrial zone planning. It should make full use of the nearby public facilities such as traffic, water supply and drainage, flood control.

4.1.2 The layout of substations shall, based on the needs of process technology, operation, construction and expansion, combined with the needs of life and the natural conditions of the site, be planned according to the final scale, combining short-term and long-term, focusing on short-term. It should requisite land in phases according to the building needs. Production areas, access roads, cable incoming & outgoing corridors, location of terminal towers, location of water sources, water supply and drainage facilities, flood discharge and flood control facilities shall be arranged in a unified and rational manner.

4.1.3 For the substation in flood control and seismic fortification areas, it shall, based on such factors as geology and topography, arrange the main production constructions (structures) in relatively favorable areas.

4.1.4 The positioning of substation's location shall rationally use geological and topographical conditions. For the high and steep slope, it shall analyze its stability and the impact on the building and structures, take safety measures to prevent human and animal from falling.

4.1.5 The site of substation should adopt a flat slope layout. When the terrain has a large height difference, it may use a step arrangement.

4.2 General layout

4.2.1 The combination of plane and space of substation buildings shall, according to the process requirements, make full use of natural terrain, to ensure that the layout is compact and reasonable and the expansion is convenient.

4.2.2 The layout of the supporting and auxiliary buildings of the substation shall be uniformly planned according to the process requirements and use functions. It should, combining with the engineering conditions, use the combined building and multi-floor building, to improve the efficiency of use of the site and save land.

4.2.3 The type selection of power distribution device shall be adapted to local conditions. When the technical and economic indicators are reasonable, it

2. If the adjacent exterior walls of the two buildings are non-combustible and have neither door & window openings, nor exposed inflammable eaves, the fire separation distance may be reduced by 25% according to this Table.
3. If two buildings are adjacent to each other and the higher exterior wall is a firewall, the fire separation distance is not restricted. But the clearance between the doors and windows of the two buildings shall not be less than 5m.
4. When installing electrical devices such as oil-immersed transformers and reactors, collective or combustible medium capacitors within 5m outside the wall of production building and structure, within the range of this wall below the horizontal line 3m above the total height of device as well as 3m at both sides of the device contour, there shall be no door, window, or opening. When the exterior wall of the building is 5m ~ 10m from the outer contour of the device, the exterior wall within the above range may be provided with grade-A fire doors. It may be provided with fireproof window above the height of device, the fire endurance limit shall be not less than 0.9h.
5. The distance between the outdoor power distribution device and other buildings and structures is, unless otherwise specified, calculated by the structure. When the relay room is arranged in the outdoor power distribution field, the spacing is determined by the process.
6. The distance between the outdoor power distribution device and the roadside should not be less than 1.5m, or not be less than 1m under difficult conditions.
7. Where there is no firewall between the outdoor oil-immersed transformer, oil-immersed reactor and collective capacitor, the net fire-proof distance shall not be less than the following values: 5m for 35kV; 6m for 66kV; 8m for 110kV; 10m for 220kV and above.
8. The minimum spacing as not specified in the Table is indicated by "-", which can be determined according to the needs of process layout. The distance between the fence and the production buildings of category C, D, E or the living buildings in the substation may be limited if it meets the requirements of fire protection.
9. For the oil-free device, it does not consider spacing.

4.3 Vertical arrangement

4.3.1 The vertical design of the substation shall be carried out simultaneously with the general layout, meanwhile shall be coordinated with the elevations of the existing and planned roads, drainage systems, surrounding sites outside the substation. It should use the flat-slope type or step type. The design elevation of the substation area shall be determined according to the voltage level of the substation.

4.3.7 The drainage of the site shall be reasonably selected based on the terrain of the substation area, the rainfall of the site, the nature of the site soil, the vertical arrangement and road layout of the substation area. It should use the natural ground slope for drainage and seepage, open ditch of rainwater, concealed ditch, concealed tube, or mixed drainage method.

4.3.8 The vertical arrangement of the expanded and reconstructed substation shall be coordinated with the vertical arrangement of the original substation area and make full use of the original drainage facilities.

4.4 Trench layout

4.4.1 The layout of pipes and trenches shall be planned together with the final scale of the substation. The pipes and trenches shall be coordinated with each other and with building and structures in the plane and vertical arrangement, the short-term shall be combined with the long-term. It shall be reasonably arranged to facilitate expansion.

4.4.2 The layout of pipe and trench shall meet the following requirements:

1. Meet the process requirements, the pipe and trench path are short, easy to construct and maintain.
2. Under the premise of meeting the requirements of process and use, it shall be buried as shallow as possible, try to be consistent with the sloping direction of vertical design of the substation area, to avoid reverse slope.
3. When the pipe or trench fails, it shall not endanger the safety of the building and structures and cause pollution of drinking water sources and the environment.
4. Pipe and trench design shall take measures against chemical corrosion and mechanical damage, as well as anti-freeze measures in cold and freezing districts.

4.4.3 It shall, based on the factors such as process requirements, geological conditions, pipe material characteristics, medium in the pipe, layout of buildings and structures within the site, to determine the laying method of pipeline: direct burial, trenching, overhead, etc.

4.4.4 Under the conditions of meeting the safe operation and facilitating maintenance, the pipelines of the same type or the pipelines of different uses but having no mutual impact may be laid in the same trench.

4.4.5 Underground pipelines shall not be arranged within the range of impact by the foundation pressure of the building or structure.

than 7.0m. For the road section for motor vehicles and flatbed vehicles, the turning radius shall be determined according to the technical performance of the motor vehicles and flatbed vehicles. The longitudinal slope of the road in the substation should not be greater than 6%. In case of stepped layout, it should be not more than 8%.

4.5.7 The pavement of road within the substation should be cement concrete pavement. Where it has construction conditions and maintenance conditions, it may also use asphalt concrete pavement.

4.5.8 The width of the road in the substation is determined according to the following principles:

1. Trunk road from substation's gate to main control communication building and main transformer:
 - 1) It may be widened to 4.5 m for the 220kV substation;
 - 2) It may be widened to 5.5 m for the 330kV and above substation.
2. The trunk loop road in the substation shall meet the fire protection requirements; the pavement width is generally 4m.
3. The width of the maintenance road within the outdoor power distribution device as well as the road between the 500kV and above substations should be 3.0m.
4. The width of the pavement of small patrol path in the substation should be 0.6m ~ 1.0m. The width of the pavement of sidewalk connecting to the building should be 1.5m ~ 2.0m.

4.6 Site treatment

4.6.1 In the outdoor power distribution device area, it should set the operation floor according to the process requirements.

4.6.2 The substation site may adopt such treatment measures as gravel, pebble pavement or lime soil closure, or it may be properly greened.

4.7 Fence and gate

4.7.1 The fence of the substation area should be a solid wall which has a height of 2.2m ~ 2.8m. Where there are noise control requirements, the height of fence of substation may be determined as needed.

4.7.2 The gate of the substation should use lightweight iron doors or electric

5 Primary electrical

5.1 Electrical circuit connection

5.1.1 The electrical circuit connection of the substation shall be determined according to the status of the substation in the power system, the planned capacity of the substation, the nature of the load, the total number of components as connected to the line and transformer, the characteristics of the device, etc. It shall meet the requirements of reliable power supply, flexible operation, convenient operation and maintenance, investment savings, ease of transition or expansion.

5.1.2 For the final wiring mode of 500kV and 750kV power distribution device, when the total number of connecting components of the circuit and transformer is 6 circuits and above, meanwhile the substation has an important position in the system, it should use one and a half circuit-breaker for wiring. When it requires fragmented operation due to system's power flow control or limiting short-circuit current, it may segment the busbar.

When using one and a half circuit-breakers for wiring, it should pair the power supply circuit with the load circuit into a string. The circuits of same name should not be configured in the same string, but they can be connected to the busbar at the same side. When there are more than two transformers, two of them are in connected in the string, whilst the other transformers may not be connected in the string but directly connected to the busbar through the circuit-breaker.

5.1.3 330kV power distribution device may be connected by the use of one and a half circuit-breaker or double busbars. When it requires fragmented operation due to system's power flow control or limiting short-circuit current, it may segment the busbar.

5.1.4 When the total number of final connecting components of 330kV ~ 750kV power distribution device is not more than 6, and the substation is a terminal substation, under the premise of meeting the operation requirements, it may use the wiring methods such as line transformer group, bridge type, single busbar or 2 circuit-breakers in the line, "transformer busbar group" where the transformer is directly connected to the busbar.

5.1.5 For the 220kV or 110kV power distribution device in 330kV ~ 750kV substation, it may use the double busbar wiring method. When the technology is economical and reasonable, it may also be connected by the use of one and a half circuit-breaker. When using the double busbar wiring and the total number of components such as transformer as connected to the outgoing line is 10 ~ 14 circuits, it may install the segmented circuit-breaker on the same busbar;

to the final wiring.

For the power distribution devices of all levels of voltages which use the gas-insulated metal-enclosed combination electric device, after economic and technical demonstrations, it may use the wiring type with a small number of circuit-breakers.

5.1.10 It should not install a circuit-breaker for the shunt reactor circuit of 330kV ~ 750kV line. It may be based on the operation mode of the shunt reactor as parallelly connected to the line to determine whether to install the isolation switch.

5.1.11 When the reactive power compensation device at the low-voltage side of the 330kV ~ 750kV substation is a shunt capacitor or reactor, it may use a single busbar. No connection is made between the busbars at the low-voltage side of each transformer.

5.1.12 The transformer in the conventional power distribution device which uses the connection method of one and a half circuit-breaker is set according to the following principles:

1. Under the conditions of meeting the relay protection and measurement requirements, each string should be equipped with 3 groups of current transformers.
2. On the three phases of each circuit of outgoing line, it shall be equipped with the voltage transformers. On the main transformer and each group of busbars, it shall, according to the requirements of the relay protection, metering, automatic device, install the voltage transformers on one or three phases.

5.2 Main transformer

5.2.1 The selection of the main transformer capacity and the number of sets (groups) shall be determined according to the approved power system planning and design. When any transformer in the same voltage network of the substation is in an accident, the other components shall not exceed the requirements for accident overload. For substations with 2 sets (groups) and above main transformers, after 1 set (group) stops operation due to accident, the capacity of the remaining main transformers shall be such that the substation is not overloaded when the full load is 70%. Meanwhile, within the allowable time after taking into account of the overload capacity, it shall ensure the primary and secondary loads of the user. If the substation has other power sources to ensure the user's primary load after the transformer is out of service, it may install one set (group) of main transformer.

5.3.2 The design of high-voltage power distribution device shall, based on the load nature, environmental conditions, operation-maintenance requirements of the substation, give priority to the equipment and layout plan which saves resources and land.

5.3.3 The design of high-voltage power distribution device shall, based on the characteristics, scale, development plan of the project, achieve the principle of combining long-term and short-term and focusing on short-term.

5.3.4 The selection principle of the power distribution device is as follows:

1. In the 220kV substation, the power distribution device of 35kV and below should be arranged indoor, the power distribution device of 66kV should adopt the outdoor open medium-sized layout.
2. The power distribution device of the voltage levels 110kV and 220kV should choose the outdoor open split-phase middle open-phase split phase medium-sized, ordinary medium-sized, half-height layout.
3. The power distribution device of the voltage levels 330kV ~ 750kV should use the outdoor open medium-sized layout.
4. For areas with seismic fortification intensity of 8 degrees and above, it should not use the open supporting hard busbar power distribution device.
5. For the power distribution device of the voltage levels 66kV ~ 750kV, in such conditions as serious air pollution, site restrictions, high seismic fortification intensity, high-altitude environment conditions, through technical and economic demonstration, it may use the gas-insulated metal-enclosed collective electrical device.
6. In areas with severe atmospheric pollution (such as coastal areas, industrial pollution areas, etc.), the power distribution device can be arranged indoors.
7. Substations in urban area should adopt gas-insulated metal-enclosed collective electrical device. According to planning and environmental requirements, it may use the outdoor, indoor, underground power distribution devices.

5.3.5 The conductor selection design in the power distribution device shall comply with the provisions of the power industry standard "Design technical regulations for selecting conductor and electrical equipment" DL/T 5222.

requirements of the current national standard "Code for design of low voltage electrical installations" GB 50054 and the power industry standard "Technical code for designing AC station service of 220kV ~ 500kV substation" DL/T 5155.

5.6.2 Switchgear and 220kV substations shall be equipped with two mutual standby working transformers for station service. The 330kV ~ 750kV substation shall be equipped with two working transformers and one standby transformer for station service. The standby transformer for station service is powered by external reliably power supply.

The capacity of each station service transformer is selected based on the load as calculated for total station.

When there is only one main transformer, in addition to the use of high-voltage power supply in the station, there shall also be an external reliable power supply.

5.7 Lighting

5.7.1 The design of substation's electrical lighting shall comply with the requirements of the current national standards "Standard for lighting design of buildings" GB 50034 and the power industry standard "Lighting technical code for designing fossil fuel power plants and substations" DL/T 5390 DL/T 5390.

5.7.2 The safety of lighting device shall comply with the requirements of the current national standard "National safety technical code for electric equipment" GB 19517. The safety distance between the luminaire and the high-voltage live component shall meet the requirements of the power industry standard "Code of safety operation in power engineering construction (Part of substation)" DL 5009.3.

5.7.3 For the lighting device as installed on a structure which has lightning rod or lightning protection line, the power line shall take measures to prevent lightning overvoltage conduction.

5.8 Selection & laying of the cable

5.8.1 The design of cable selection and laying of substation shall comply with the requirements of the current national standard "Code for design of cables of electric engineering" GB 50217. The design of cable's fire blocking shall also comply with the requirements of the current national standard "Code for design of fire protection for fossil fuel power plants and substations" GB 50229 and "Code of design on building fire protection and prevention" GB 50016. The fire blocking materials shall comply with the requirements of the current national standard "Firestop material" GB 23864.

6 System and secondary electrical

6.1 Relaying protection and automatic device

6.1.1 Substation shall, according to the safe operation needs of the power system, be equipped with the following protective device:

1. According to the voltage level, the line protection of outgoing configuration, auxiliary protection, fault recording device;
2. Configure the busbar protection according to the voltage level and busbar connection type;
3. Follow the requirements of the power industry standard "Guide on security and stability for power system" DL 755 to install the safety automatic control devices;
4. Main transformer protection;
5. Reactive device protection, protection of station service transformer.

6.1.2 The design of substation's relay protection and safety automatic devices shall comply with the requirements of current national standard "Technical code for relaying protection and security automatic equipment" GB 14285.

6.2 Dispatch automation

6.2.1 The substation shall, according to the safe operation and monitoring needs of the power system dispatch, be equipped with the following dispatch automation device:

1. Telecontrol communication device;
2. Electric energy metering device;
3. Synchronous phasor measurement device;
4. Dispatch data network access device;
5. Secondary system's safety protection device;
6. Power quality harmonic monitoring device.

6.2.2 The design of substation's dispatching automation shall comply with the provisions of the power industry standard "Specifications for the design of

6.4 Monitoring & control system and electrical secondary wiring

6.4.1 The 220kV ~ 750kV substation shall use computer monitoring.

6.4.2 The design of the substation's computer monitoring system shall meet the requirements of the power industry standard "Technical code for designing computerized monitoring and control system of 220 ~ 500kV substations" DL/T 5149.

The computer monitoring system shall be able to realize reliable, reasonable complete monitoring, measurement, control of the substation, have all the telecontrol functions such as telemetry, remote signaling, remote regulating, remote control, have the ability to exchange information with the dispatching communication center. The monitoring system should adopt an open hierarchical distributed structure, which consists of a station control level, a bay level, the network device.

6.4.3 The design of the substation's metering and measuring device shall comply with the requirements of the current national standard "Code for design of electrical measuring device of power system" GB 50063 and the power industry standard "Technical code for designing electrical measuring and energy metering device" DL/T 5137.

6.4.4 The substation's computer monitoring system should adopt the communication criteria as specified in the power industry standard "Substation communication network and system" DL/T 860.

6.4.5 The substation is configured with 1 set of common clock synchronization system; the clock source uses dual configuration. The timing range of the clock synchronization system includes: station control level equipment of monitoring system, protection and fault information management sub-station, protection device, measurement and control device, fault recording device, fault ranging, phasor measurement device, other intelligent devices in the station. Clock synchronization accuracy and punctuality accuracy meet the timing accuracy requirements of all device in the station.

6.4.6 The design of the secondary wiring of the substation shall comply with the provisions of the power industry standard "Technical code for designing of electrical secondary wiring in fossil fuel power plants and substations" DL/T 5136.

7 Civil works

7.1 General requirement

7.1.1 The design of the building and structure shall ensure unified planning, coordinated styling, good integrity, convenient production and living; meanwhile the structure type and material type shall be reasonable and simplified, to facilitate material preparation, processing, construction, maintenance.

7.1.2 The main control communication building (room) should be completed once in accordance with the planning requirements. The outdoor and indoor power distribution devices and other building (structure) shall be built once or in phases according to the characteristics of the project.

7.1.3 The bearing capacity, stability, deformation, crack resistance, seismic resistance, durability of substation's buildings and structures shall comply with the requirements of current national standards "Load code for the design of building structures" GB 50009, "Code for design of building foundation" GB 50007, "Code for design of concrete structures" GB 50010, "Code for seismic design of buildings" GB 50011, "Code for design of steel structures" GB 50017.

7.1.4 The design of the building structure shall, according to the loads that may occur at the same time in the structure during use, be subjected to load (effect) combination based on the load capacity limit state and the normal use limit state, respectively. Meanwhile the design shall be carried out by the use of the most unfavorable effect combination.

7.1.5 The safety grade of the main structure of the substation of 500kV and above (main control communication building, 500kV and 750kV power distribution device structure, etc.) should adopt the grade-1; the rest structure should adopt the grade-2. The structural importance factor γ_0 of grade-1 and grade-2 is 1.1 and 1.0, respectively.

7.2 Loads

7.2.1 Loads are divided into three types: permanent load, variable load, accidental load.

1. Permanent loads include structural weight, weight of fixed device, soil weight, earth pressure, water pressure, tension of the conductor and lightning conductor.
2. Variable loads include wind loads, ice loads, snow loads, temporary loads during installation and maintenance, seismic action, action of temperature

1. Maximum wind condition: Take the design maximum wind load and corresponding tension of lead and self-weight as occurred once in 50 years.
2. Operating load condition: Take the maximum operating load and the corresponding tension of lead and self-weight under the corresponding wind load conditions.
3. Earthquake condition: Horizontal earthquake action and corresponding wind load, tension of lead, self-weight. The structural resistance (anti-pulling, anti-overturning, etc.) or the bearing capacity adjustment factor under earthquake conditions use the values as specified in the current national standard "Design code for antiseismic of special structures" GB 50191.

7.2.4 Short-circuit electric power: For flexible conductors, it may not take into account of the impact of short-circuit electric power on the structure and the bracket. However, the strength of the line-hanging plate and node of the combined conductor shall meet the requirements of short-circuit electric power. Generally, it may take 3 times the tension of conductor as the verification conditions for the line-hanging plate and node. The load partial factor is taken as 1.0. For the hard tube busbar, it shall be based on the data as provided by the electrical specialty to carry out calculation.

7.2.5 The standard value of the live load of the platform and the walkway of the power distribution device is 1.5kN/m^2 (for the assembled walkway plate, it shall take the concentrated load for verification). When calculating the beam, column, or foundation, the live load may be multiplied by a factor 0.7 (load area is $10\text{m}^2 \sim 20\text{m}^2$) or 0.6 (load area is more than 20m^2).

7.2.6 The standard live load of the outdoor trench cover or tunnel shall be 4kN/m^2 . For the sections where the motor vehicle may pass, it shall meet the requirements for the possible concentrated load of the rear axle pressure from the vehicle. When there is a serious load other than the vehicle, it shall be verified according to the actual situation.

7.2.7 The wind load factor of the foundation design of the structure adopts the values as specified in the current national standard "Code for design of building foundation" GB 50007:

1. When calculating the structural foundation, it does not take into account of the wind vibration.
2. For the foundation action of high-rise structures such as lightning rods, it shall calculate the pulsation of gusts. The wind-induced vibration factor of the upper structure may be multiplied by 0.8, but not less than 1.0.

animal, sand from intrusion.

7.3.11 The doors of transformer room, capacitor room, battery room, oil processing room, cable interlayer, power distribution device room shall be opened in the direction of evacuation. When there is public walkway or other building rooms outside the door, it shall use the solid door which is made of non-combustion or difficult-to-combustion materials.

7.3.12 The battery compartment (valve-controlled battery) shall not be provided with acid conditioning chamber. The wall, ceiling, door & window of battery compartment, exposed part of exhaust fan, other metal parts shall be coated with acid-resistant paint or acid-resistant coating. The floor, wall skirt, buttress should use acid-resistant easy-to-clean finish material. It shall provide an acid-proof isolation layer between the finish and the base layer. The floor shall have a drainage gradient and be discharged to the outside through an acid-resistant drain trench for proper disposal. The window of the battery compartment shall be made of translucent glass.

7.3.13 According to the seismic fortification intensity, geological conditions, use functions, the building may adopt a concrete frame structure, a masonry structure or a light steel structure.

7.3.14 Seismic fortification classification criteria for substation buildings: The main control communication building, power distribution device building, relay room, station service power room of the 330kV ~ 750kV substation and the 220kV important hub substation are key fortification buildings. The remaining production and production supporting and living buildings are standard fortification buildings.

7.4 Structures

7.4.1 Structures such as frames and device support shall, based on the voltage level, scale, construction and operating conditions, manufacturing level, transportation conditions, local climatic conditions of the substation, be appropriately selected. The shape shall be coordinated with each other. The support shall also coordinate with the upper device.

7.4.2 Frame columns of 330kV and above should adopt lattice steel structure or A-column steel tube structure. The frame columns of 220kV and below may use cement rod or A-column steel tube structure. The beam should use a lattice steel beam which has a triangular or rectangular section. When the out-of-plane stability of the A-column is not satisfactory, it shall set end support. In the 500kV and above frame beam, it should provide walkway and connect it to the ladder of the column.

7.4.3 The outdoor structural frame of the substation shall be hot-galvanized,

ground water level, it shall calculate the impact of buoyancy.

Table 7.4.7 -- Foundation's uplifting or overturning stability factor K_S or K_G

K_S	K_G
1.8	1.15

Note:

1. K_S is used to calculate the overturning moment of the foundation according to the ultimate soil resistance and to calculate the uplifting resistance according to the conical soil.
2. K_G is used to calculate the overturning moment or uplifting resistance according to the self-weight of foundation plus the above soil weight.

7.4.8 The depth of the column of the frame and device support as inserted into the foundation cup shall not be less than the value as specified in Table 7.4.8. According to the stability requirements of the lifting work, the depth of the column as inserted in the cup shall also not be less than 0.05 times the height of the column. However, there are no restrictions when the construction takes measures such as temporary stay wire.

Table 7.4.8 -- Minimum depth of column as inserted in the foundation cup

Type of columns		Reinforced concrete column of rectangular or I-shaped section	Cement rod	Steel tube
Minimum depth of insertion in cup	Frame	1.25B	1.25D	1.5D
	Support	1.0B	1.0D	1.0D

Note: B is the long side dimension of the column and D is the diameter of the column.

7.4.9 For the cup of frame and support, when the ratio of the thickness of the cup wall to the height of the cup wall is (when the foundation is stepped and the depth of the cup is deeper than the height of first step, take the ratio of the wall thickness to the wall height of the first step) more than or equal to 0.5 (for frame) or 0.4 (for support), it is allowed not to use reinforcing bar in the cup wall. The thickness of cut wall and the net thickness of the baseplate after deducting the cup depth shall be not less than 150mm.

7.4.10 In the hollow tube structure and the bottom of the support column, it shall take reliable measures to prevent water accumulation: burial of pipe under the bottom of pipe or pouring concrete, with water drainage holes made at the top of concrete; the portion of the column foot under the ground surface shall be wrapped by concrete of lower strength grade (the thickness of the protective layer shall be not less than 50mm). the bottom of the tube is buried or filled with concrete, and the upper part of the concrete is opened with water holes;

8 Heating, ventilation and air conditioning

8.1 Heating

8.1.1 The heating design of the substation shall comply with the current national standard "Code for design of heating ventilation and air conditioning" GB 50019.

8.1.2 In the heating area, the heating facilities shall be provided in the office, living room, the process and device room that needs heating in the attended substation.

8.1.3 The heating method may, based on the location, scale and meteorological conditions of the substation, combined with local conditions, be in the form of distributed electric heating, centralized electric boiler heating, heating by nearby heat source facilities.

8.1.4 Anti-acid flameproof battery compartment shall use the explosion-proof type electric heating.

8.2 Ventilation

8.2.1 The ventilation design of the substation shall comply with the current national standard "Code for design of heating ventilation and air conditioning" GB 50019.

8.2.2 The accidental air replacement of the power distribution device shall not be less than 12 air changes per hour. The accident fan can also be functioned as ventilation fan.

8.2.3 The ventilation capacity of the dry transformer room shall meet the requirements for discharging the heat output of the transformer. The ventilation of the transformer room shall be calculated based on the conditions that the summer exhaust air temperature does not exceeding 45 °C, and the temperature difference between the inlet and exhaust air does not exceed 15 °C. Ventilation of the transformer room shall be set independently.

8.2.4 Sulfur hexafluoride chamber shall be mechanically ventilated; the indoor air is not allowed to be recycled. The content of sulfur hexafluoride of the indoor air shall not exceed 6000mg/m³. The normal ventilation of the sulfur hexafluoride chamber is not less than 2 times per hour; the suction port shall be placed in the lower part inside the chamber. The amount of ventilation during the accident is not less than 4 times per hour, which is guaranteed by the normal ventilation system installed in the lower part and the accidental exhaust system installed at the upper part.

10 Fire protection

10.1 General requirement

10.1.1 The fire protection design of the substation shall implement the principle of "prevention first, prevention and elimination combined", to prevent and reduce fire hazards and ensure personal and property safety.

10.1.2 The design of the substation's fire protection system shall comply with the current national standards "Code of design on building fire protection and prevention" GB 50016 and "Code for design of fire protection for fossil fuel power plants and substations" GB 50229.

10.2 Firefighting facilities

10.2.1 The number of fires that may occur at the same time in a substation is designed as once. The fire water consumption of the substation is calculated according to the maximum amount of fire water used in the event of a fire.

10.2.2 If the building in the substation meets the fire resistance rating of not less than grade-2, the fire hazard is category E, the volume does not exceed 3000m³, it may not provide the fire water supply system.

10.2.3 A single fuel oil-immersion transformer which has a capacity of 125000 kV • A and above shall be equipped with a water spray fire extinguishing system, a synthetic foam spray fire extinguishing system or other fixed fire extinguishing devices. The design of the water spray fire extinguishing device shall comply with the current national standard "Code of design for water spray extinguishing systems" GB 50219.

10.2.4 Each building shall be equipped with an appropriate number of mobile fire extinguishers. The design of mobile fire extinguishers shall comply with the current national standards "Code for design of extinguisher distribution in buildings" GB 50140 and "Code for design of fire protection for fossil fuel power plants and substations" GB 50229.

10.2.5 For oil-containing indoor electrical device with a single oil volume more than 100kg, it shall provide an oil sump. The volume of the oil sump shall be 20% of the oil volume of a single device. It shall also provide facilities to discharge the accident oil to a safe place. When the above requirements are not met, it shall provide an oil sump that can accommodate the entire volume of oil.

10.2.6 For outdoor single oil-containing electrical device with an oil volume of

11 Environmental protection

11.1 General requirement

11.1.1 The site selection of the substation shall comply with the relevant laws and regulations of the state environmental protection, soil and water conservation, ecological environment protection.

11.1.2 In the design of substations, it shall take necessary prevention and control measures for pollution factors such as wastewater, noise, electromagnetic radiation, to reduce their impact on the surrounding environment.

11.2 Control of electromagnetic radiation

11.2.1 The environmental impact of the electromagnetic radiation from the substation and the incoming and outgoing line shall comply with the requirements of current national standards "Controlling limits for electromagnetic environment" GB 8702, "Hygienic standard for environmental electromagnetic waves" GB 9175, "Limits of radio interference from AC high voltage overhead power transmission lines" GB 15707, as well as the requirements of "Technical regulations on environmental impact assessment of electromagnetic radiation produced by 500kV ultrahigh voltage transmission and transfer power engineering" HJ/T 24.

11.2.2 In the design of substation, it shall select the device which has low electromagnetic radiation levels.

11.2.3 The incoming and outgoing lines of the substation shall avoid densely populated areas. The main transformer and high-voltage power distribution device should be arranged away from the residents. In the high-voltage hazard area nearby the substation, it shall provide the corresponding warning sign.

11.3 Control of noise

11.3.1 The impact of substation noise on the surrounding environment shall be in accordance with the current national standard "Emission standard for industrial enterprises noise at boundary" GB 12348 and "Environmental quality standard for noise" GB 3096.

11.3.2 Substation noise shall first be controlled from the sound source and use low noise device. For the production noise which cannot be eliminated from the sound source, it shall take effective noise control measures.

12 Labor safety and occupational health

12.1 General requirement

12.1.1 The design of the substation must implement the laws, regulations, standards and rules on labor safety and occupational health as prescribed by the State; implement the policy of "safety first, prevention foremost".

12.1.2 The design of labor safety and occupational health shall be implemented in the engineering design. The measures shall comply with the relevant current standards, codes and regulations.

12.2 Labor safety

12.2.1 The design of the fire compartment, fire partition, fire separation, safety evacuation, fire exit of the production place, auxiliary building, domestic building, inflammable and explosive hazard place, underground buildings of the substation shall comply with the current national standards "Code of design on building fire protection and prevention" GB 50016 and "Code for design of fire protection for fossil fuel power plants and substations" GB 50229.

12.2.2 The safety evacuation facilities of substations shall have adequate lighting and obvious evacuation signs.

12.2.3 For the design of explosion-hazardous device and related electrical device, process systems and workshops, as well as the civil work design, it shall take corresponding explosion-proof measures based on different types of explosion sources and risk factors. The explosion-proof design shall comply with the provisions of current national standard Electrical installations design code for explosive atmospheres and fire hazard GB 50058 as well as the provisions of relevant national standards and codes such as "Electrical safety regulations for explosive hazardous locations of the People's Republic of China".

12.2.4 The design of anti-electric shock shall comply with the requirements of current national standard "Design code for protection of structures against lightning" GB 50057, meanwhile meet the requirements of the power industry standard "Technical code for designing high voltage electrical switchgear" DL/T 5352, "Overvoltage protection and insulation coordination for AC electrical installations" DL/T 620, "Grounding for AC electrical installations" DL/T 621, "Safety code of electric power industry - Electric part of power plants and transformer substations" DL 408. The arrangement of electrical device shall meet the safety protection distance requirements of live device. Meanwhile it

13 Energy saving

13.1 General requirement

13.1.1 The energy-saving design of the substation shall comply with the relevant national standards in addition to the implementation of this regulation.

13.1.2 The layout and design of the general plane of the substation should use the winter sunshine and avoid the dominant wind direction in winter, use the natural ventilation in summer. The main orientation of the building should choose the best orientation or close to the best orientation of the region.

13.2 Electrical energy saving

13.2.1 Electrical device should select energy-saving products with low loss.

13.2.2 The main transformer's cooling method should adopt natural oil circulation air-cooling or self-cooling. The high-voltage shunt reactor's cooling method should adopt self-cooling.

13.2.3 Reasonably select conductors and reduce power loss.

13.2.4 For the lighting of substation, it should use energy-saving lamps.

13.3 Building and thermal energy saving

13.3.1 The shape factor of buildings in frozen and cold areas should be less than or equal to 0.40. When the provisions of this clause cannot be met, it shall follow the relevant requirements of the current national standard "Design standard for energy efficiency of public buildings" GB 50189 to make trade-off judgment.

13.3.2 The surrounding wall and roof of the building shall adopt new environmentally friendly and energy-saving materials. The insulation and heat insulation performance of the exterior wall and roof shall comply with the requirements of the current national standards "Design standard for energy efficiency of public buildings" GB 50189 and "Thermal design code for civil building" GB 50176 for the thermal insulation of buildings.

13.3.3 The internal surface's temperature of the thermal bridge part of the exterior wall and roof of the building shall not be lower than the indoor air's dew point temperature.

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