DL

POWER INDUSTRY STANDARD OF

THE PEOPLE'S REPUBLIC OF CHINA

ICS 27.100

P 62

Registration number: J173-2016

P **DL/T 5155-2016**

Replacing DL/T 5155-2002

Technical code for design AC station service of 220kV ~ 1000kV substation

220kV ~ 1000kV 变电站站用电设计技术规程

Issued on: August 16, 2016 **Implemented on: December 01, 2016**

Issued by: National Energy Administration

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Technical code for design AC station service of 220kV ~ 1000kV substation

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Main drafting organization: Electrical Planning and Design Institute

Approved by: National Energy Administration

Date of implementation: December 01, 2016

2016 Beijing

Announcement of National Energy Administration

2016 No.6

According to the relevant provisions of the "Notice of the National Energy Administration on Printing and Distributing the Industrial Standardization Management Measures for Energy Sector (Trial) and Detailed Rules of Implementation" (GNJKJ [2009] No.52), after review, the National Energy Administration approved 144 industrial standards such as "Specification on quality acceptance of construction of conventional island and supporting facilities of nuclear power plant - Part 8: Thermal insulation and paint", including 75 energy standards (NB) and 69 power standards (DL), which are now released.

Attachment: Industry standards catalog

National Energy Administration

August 16, 2016

Attachment:

Industrial standard catalog

No.	Standard No.	Standard name	Replaced standard	Adopted standard No.	Date of approval	Date of implementation
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Foreword

According to the requirements of the "Notice of National Energy Administration on the Issuance of the Compilation/Revision Plan for the first batch of Energy Industry Standard in 2010" (GNKJ [2010] No.320), the compilation team conducted extensive investigations and studies, carefully summarized the design experiences on the station service for 220kV and above substations, absorbed the latest technological development results, solicitated extensive opinions, to revise the original "Technical code for design AC station service of 220kV ~ 500kV substation" DL/T 5155-2002.

This standard has 10 chapters and 5 appendixes. The main technical contents include general provisions; terms; station service system wiring; station service load analysis; choice of station service transformer; short-circuit current calculation and choice of electrical equipment and conductor; station service equipment arrangement; maintenance power supply; protection against electric shock; control, signaling, metering and automatic devices of station service system.

The main contents of this revision are:

1. The original standard applies to the substation which has a voltage ranging from 220kV to 500kV. In this revision, it includes the requirements for the station service of 750kV and 1000kV substations, changes the standard name to “Technical code for design AC station service of 220kV ~ 1000kV substation"

2. The original standard has 8 chapters. This revision adds two separate chapters of "terms" and "protection against electric shock"; in addition, the chapter 5 "Selection of station service transformers" in the original standard is divided into two chapters "Station service load analysis" and "Choice of station service transformer"; move the clause 7.5 "maintenance power supply" from chapter 7 of the original standard out to form an independent chapter; the other chapter contents are adjusted accordingly. After this revision, this standard has 10 chapters, which increases 2 chapters as compared with the original standard;

3. In the choice of station service transformer, add the requirements for voltage regulation and wiring;

4. Some substations are difficult to connect external power supply due to special geographical conditions. This revision adds the requirements for self-provided emergency power supply in the station;

5. Add the principle requirements for the application of clean energy;

6. Supplement the requirements for station service power metering devices.

From the date of implementation, this standard replaces the "Technical code for design AC station service of 220kV ~ 500kV substation" DL/T 5155-2002.

For this standard, the National Energy Administration is responsible for its management; the Electrical Planning and Design Institute proposes it; the Energy Industry Power Grid Design Standardization Technical Committee is responsible for daily management; the China Power Engineering Consulting Group Huadong Electric Power Design Institute Co., Ltd. is responsible for the interpretation of specific technical contents. If you have any comments or suggestions during the implementation, please send it to the Electrical Planning and Design Institute (Address: 65 Ande Road, Xicheng District, Beijing, Zip code: 100120).

The main drafting organizations, the main drafters, the main reviewer of this standard:

The main drafting organizations: China Power Engineering Consulting Group Huadong Electric Power Design Institute Co., Ltd.

The main drafters: Wang Xiaojing, Wang Xiangping, Yu Zheng, Hu Wenhua, Le Dangjiu, Chen Yue, Cao Sheng, Chao Qiong, Pan Yihua, Wang Weihua, Deng Ming, Zhang Jingfeng, Wang Weiying, Zheng Yi

Main reviewers: Li Baojin, Fang Jing, Yan Shihai, Chen Zhirong, Li Zhenghong, Yu Kewu, Shen Aimin, Chen Hongming, Zhang Yuming, Pu Hao, Wu Mianqiong, Kong Zhida, Qian Feng, Chen Ping, Tang Hongde

Technical code for design AC station service of 220kV ~ 1000kV substation

1 General provisions

1.0.1 In order to make the station service design of the substation meet the national technical and economic policies, safe, reliable, economical, in line with national conditions, it hereby develops this standard.

1.0.2 This standard is applicable to the design of the AC station service system for the newly built, extended, reconstructed 220kV ~ 1000kV substation, switch station, series compensation station.

1.0.3 Station service design shall use energy-saving, environmentally friendly, safe, reliable electrical products which are in line with national standards.

1.0.4 The design of the station service system shall be based on the characteristics and scale of the project, combining the recent period and future, to meet the short-term needs while meeting the long-term requirements.

1.0.5 In addition to complying with the provisions of this standard, the design of station service power shall also comply with the relevant national standards.

2 Terms

2.0.1

Power supply

AC power supply for long-term supply for the working load in the substation.

2.0.2

Standby supply

AC power supply which supplies power only when the power supply in the substation is cut off.

2.0.3

Emergency power supply

An AC power supply that supplies power to the load which, in case of power failure within a limited period of time, may affect the safety of the person or cause the significant decrease of power delivery of the substation.

2.0.4

AC uninterruptible power supply

A power supply device consisting of a rectifier and an inverter, which cooperates with a battery pack of a substation's DC power supply, to provide an uninterrupted AC power supply that meets the requirements.

2.0.5

Station service switchboard

The station service low-voltage switchboard which is powered by the station service transformer or the external low-voltage AC power supply, meanwhile distributes power to the load in the station.

3 Station service system wiring

3.1 Station service power supply

3.1.1 The station service power supply for the 220kV substation should be 2 circuits of equal-capacity and mutual-standby power supply from the low-voltage side of different main transformers, respectively. When there is only one main transformer in the initial stage, in addition to connecting 1 circuit of power supply from it, it shall also connect 1 circuit of reliable power supply from outside of the station.

3.1.2 The station service power supply for the 330kV ~ 750kV substation shall be 2 circuits of equal-capacity and mutual-standby power supply from the low-voltage side of different main transformers, respectively, as well as 1 circuit of reliable station service standby power from outside of the station. When there is only one (set) main transformer in the initial stage, in addition to connecting 1 circuit of power supply from it, it shall also connect 1 circuit of reliable power supply from outside of the station.

3.1.3 The station service power supply for the 1000kV substation shall be 2 circuits of equal-capacity and mutual-standby power supply from the low-voltage side of different main transformers, respectively, as well as 1 circuit of reliable station service standby power from outside of the station. When there is only one (set) main transformer in the initial stage, it should also connect 2 circuits of reliable power supply from two different substations.

3.1.4 The switchyard should connect 2 reliable power supplies from the outside of the station. When there is a high-voltage shunt reactor in the station, one circuit may use a high anti-extraction power supply. The configuration of the power supply for the series compensation station shall be carried out in accordance with the relevant provisions of the current power industry standard "Technical code for design of series compensator station" DL/T 5453.

3.1.5 The capacity of the station service power supply for each circuit shall meet the needs of the load power consumption of the entire station.

3.1.6 When there is no condition to connect the reliable power supply from outside of the station, it may provide a self-provided emergency power supply in the station, the capacity of which shall meet the power consumption requirements of the type-I loads of the whole station and some type-II loads (including the load of 2 main transformers and the cooling load of high-voltage reactor of whole station).

3.1.7 The power supply voltage outside the station may use the voltage grade of 10kV ~ 66kV. When the reliability meets the requirements, it should use the power supply of lower power grades.

3.1.8 The emergency power supply in the station may adopt the fast self-starting diesel generator set. The configuration requirements shall be implemented in accordance with the relevant provisions of the current national standard "Specific configuration of power supply and self-emergency power supply for important power users" GB 29328.

3.1.9 When a reliable clean energy power supply is installed in the station, it should give priority to it.

3.2 Load classification

3.2.1 Station service power load may be divided into the following three categories according to the impact of power outage:

Type-I load: The load which, in case of short-term power outages, may affect the safety of the person or equipment, cause the production run to stop or the main transformer to reduce the load;

Type-II load: The load which allows for short-term power outages; however, if the duration of power outage is too long, it may affect the normal production operation;

Type-III load: The load which, in case of long-term power outage, will not directly affect the production operations.

3.2.2 The commonly used station service load characteristics may be selected according to Appendix A of this standard.

3.3 Power supply manner

3.3.1 The station service power load should be directly supplied by the station service switchboard. For the important load, it shall use the double-loop power supply mode which are respectively connected to two busbars, respectively.

3.3.2 When the capacity of the station service transformer is more than 400kV • A, the station service power load which is more than 50kV • A should be directly supplied by the station service switchboard; the small capacity load should be centrally power-supplied locally.

3.3.3 Forced cooling device, loaded voltage-regulating device and its charged oil filtering device of main transformer and high-voltage shunt reactor should adopt the mutual-standby dual power supply according to the following methods, meanwhile the automatic mutual switchover is only achieved in the control box of the cooling device.

1. When using three-phase equipment, it should set separate dual power supplies for each set;

2. When using a group of single-phase equipment, it should set the dual power supply for each group. The power load of each phase transformer is connected to the switched incoming line.

3.3.4 For the main control communication building, comprehensive building, decentralized relay chamber of the 330kV ~ 1000kV substation, it may, according to the load needs, set the dedicated sub-switchboard to supply power to local load. The dedicated sub-switchboard should use the single bus wiring. Where there is type-I load circuit, it shall use dual power supply.

3.3.5 For the operation and heating load of the circuit-breaker and the isolating switch, if it may be classified according to the voltage zone of the power distribution device, it respectively uses the following dual power supplies which are respectively connected to the two segments of station service power busbar, as follows:

1. Set the ring power supply network according to the function zone; meanwhile set the knife switch in the middle of the ring network to achieve open-loop operation;

2. Dual-circuit independent power supply, set dual power supply switchover distribution box in the function zone, to achieve radiated power supply to the interval load;

3. Dual-circuit independent power supply, wherein dual power supply switchover device is provided in the equipment control box.

3.3.6 The station service power supply should be prioritized as the working power supply. When detecting any phase-voltage interruption, it shall, after time delay, switch the load from the working power supply to the standby power supply. When the working power supply returns to normal, it should, after time delay, automatically return from the standby power supply back to the power supply by working power supply.

3.3.7 Maintenance power supply network should adopt a single-loop branch power supply mode as divided by function zone.

3.4 Power supply connection

3.4.1 The station service power supply for the 330kV ~ 750kV substation should use the one-stage voltage-reduction mode. The station service power supply for the 1000kV substation shall, according to the voltage level at the low-voltage side of the main transformer, select the two-stage voltage-reduction mode or one-stage voltage-reduction mode. When using the two-stage voltage-reduction mode, the middle voltage level should be consistent with the voltage level of the power supply outside the station. The high-voltage station service power supply should use the wiring method of independent-wired transformer set.

3.4.2 The rated voltage of the low-voltage system of station service power is 220V/380V. The station service power busbar adopts a single busbar connection as classified by the working transformer, simultaneous power supply by the working busbars of adjacent two segments, as well as split operation. It shall not install the automatic transfer switching device between the two segments of working busbars. When any one working transformer loses power and exits, the standby transformer shall be able to automatically switch to the de-energized working busbar segment to supply power continuously.

3.4.3 For the substation with power supply vehicle access requirements, the station service low-voltage busbar shall be equipped with the mobile power supply lead-in device.

3.5 Application of neutral grounding in auxiliary power system

3.5.1 The high-voltage station service power system in the station should adopt the neutral ungrounding mode. The neutral grounding mode of the externally connected high-voltage station service power system is determined by the system outside the station.

3.5.2 The station service low-voltage central power supply system for the outdoor substation should adopt the three-phase four-wire neutral-point direct grounding method (TN-C). The total indoor substation, the building internal and scattered maintenance power supply may use whole or local three-phase five-wire neutral point direct grounding method (TN-S or TN-C-S).

3.5.3 The protective grounding neutral conductor (PEN) in the three-phase four-wire system (TN-C) as introduced into the building shall be grounded repeatedly. It is strictly forbidden to connect the switch or the isolating appliance in the PEN line.

3.6 AC uninterruptible power supply

3.6.1 AC uninterruptible power supply should adopt the complete set of equipment according to the functional requirements. In case of normal conditions, use the AC input power supply; in case of AC power loss, quickly switch to the in-station DC battery for power supply.

3.6.2 Uninterruptible power supply devices should be set centrally based on the total load. It may also be set in a scattered manner based on different loads by zones.

3.6.3 Uninterruptible power supply should adopt a voltage-regulated frequency-regulated device. The rated output voltage is single-phase 220V and rated output frequency is 50Hz. The technical requirements for the complete set of uninterruptible power supply shall be implemented in accordance with the current power industry standard "Integrated uninterruptible power supply equipment of DC and AC for power system" DL/T 1074 and "Technical code for designing of electrical secondary wiring in fossil fuel power plants and substations" DL/T 5136.

3.6.4 Uninterruptible power supply system may use single-busbar or single-busbar segmented wiring.

3.6.5 Uninterruptible power supply devices for computer use shall have a margin for their choice of capacity.

4 Station service load analysis

4.1 Principles of load calculations

4.1.1 Equipment that is continuously operated and often short-term operated shall be calculated.

4.1.2 Equipment that is not frequently short-term operated and intermittently operated shall not be calculated.

4.1.3 The electrical load characteristics of the main station service load of the substation shall be selected according to Appendix A.

4.2 Load account procedure

4.2.1 Station service load is calculated by the following formula:

$$S \geqslant K_1 \times P_1 + P_2 + P_3 \tag{4.2.1}$$

Where:

S - Capacity of station service transformer (kV • A);

K_1 - Conversion factor of station service power load, take K = 0.85;

P_1 - Sum of the station service power loads (kW);

P_2 - Sum of the station service electric heating loads (kW);

P_3 - Sum of the station service lighting loads (kW).

5 Choice of station service transformer

5.0.1 The capacity of the station service transformer shall be greater than the maximum calculated capacity of the whole station.

5.0.2 Station service transformers shall use low-loss energy-saving standard series products. The transformer should be oil-immersed type. When the fire protection and layout conditions have special requirements, it may use dry-type transformers.

5.0.3 The station service transformer should adopt the D yn11 connection group. The selection of the connection group of station service transformer should be such that the phase of the output voltage of each station service working transformer and station service standby transformer is the same. The low-voltage system of station service power shall take measures to prevent the transformer from running in parallel.

5.0.4 The impedance of the station service transformer shall be determined according to the ability of the low-voltage electrical appliance to withstand the short-circuit current. It should use a transformer of the standard impedance series.

5.0.5 The rated voltage of the high-voltage side of the station service transformer shall be determined according to the actual operating voltage of the access point. It should take the rated voltage of the main transformer corresponding to the access point.

5.0.6 When the voltage of the high-voltage power supply fluctuates greatly, which always make the voltage deviation of the station service busbar to be more than ±5%, it shall use the loaded voltage-regulated station service transformer. The voltage-regulation calculation of station service power shall comply with the provisions of Appendix B of this standard.

6 Short-circuit current calculation and choice of electrical equipment and conductors

6.1 Short-circuit current calculation

6.1.1 The short-circuit current of the high-voltage side of the station service can be considered according to the three-phase short-circuit current level of the connected busbar. The breaking capacity of the protective device connected behind the device with the finite-current function shall be determined according to the short-circuit current after the current limiting.

6.1.2 The short-circuit current calculation of the station service low-voltage system shall comply with the following principles:

1. Calculate by using the power supply of single station service transformer;

2. It shall take account of the resistance;

3. The system impedance should be determined according to the breaking capacity of the protection device at high-voltage side or the short-circuit capacity at the high-voltage side;

4. It does not consider the feedback current of the asynchronous motor;

5. When the feeder circuit is short-circuited, it shall take into account of the impedance of the feeder;

6. It does not consider the attenuation of the periodic component of the short-circuit current;

7. When the sum of the operating time of the main protection device and the natural opening time of the circuit-breaker is greater than 0.1s, it may not consider the impact of the non-periodic component of the short-circuit current.

6.1.3 The calculation method of 380V short-circuit current shall comply with the provisions of Appendix C of this standard.

6.2 High-voltage switchyard

6.2.1 At the high-voltage side of the station service transformer, it should use the high-voltage circuit breakers as protective device. When the capacity of station service transformer is less than 400kV • A, it may also use fuse protection. When the breaking current of the protective device cannot meet the requirements, it should use the current limiting means which are equipped with the current limiting reactor.

6.2.2 When the high-voltage side of the station service is a neutral point non-effective grounding system, the current transformer that protects the circuit of the D yn station service transformer shall be configured in three phases.

6.2.3 The design of high-voltage electrical appliances and conductors for station services shall be carried out in accordance with the relevant provisions of the current power industry standard "Design technical rule for selecting conductor and electrical equipment" DL/T 5222.

6.2.4 The design of grounding and overvoltage protection for high-voltage power distribution device of the station service shall be in accordance with the relevant requirements of the current national standard "Code for Earthing Design of AC Electrical Installations" GB/T 50065 and "Code for design of overvoltage protection and insulation coordination for AC electrical installations" GB 50064.

6.3 Station service low-voltage equipment

6.3.1 Low-voltage equipment shall be selected according to the environment it is located, based on the conditions of meeting the working voltage, working current, breaking capacity, dynamic stability, thermal stability requirements, according to the relevant provisions of the current national standards "Code for design of low-voltage electrical installations" GB 50054, "Code for design of electric distribution of general-purpose utilization equipment" GB 50055, "Low-voltage switchgear and controlgear" GB 14048. For the selection of rated current of the electrical appliances in the distribution cabinet, it shall also consider the influence of unfavorable heat dissipation. The calculation of the continuous working current of the power supply circuit shall comply with the provisions of Appendix D of this standard.

6.3.2 Station service Low-voltage power distribution should adopt a closed fixed switchboard, or a drawer-type switchboard. When using a drawer-type switchboard, there shall be an electrical or mechanical interlock.

6.3.3 Under the following conditions, the low-voltage electrical appliances and conductors may not be subjected to the verification of dynamic stability or thermal stability:

1. Appliances and conductors protected by a current-limiting fuse or a common fuse which has a rated current of 60A or less may not be verified for thermal stability;

2. Electrical appliances and conductors protected by current limiting circuit breakers may not be verified for thermal stability;

3. When the rated current of the fuse is not more than 2.5 times the rated current of the cable, meanwhile the single-phase short-circuit current at the end of the power supply circuit is more than 5 times of the rated current of the fuse, it may not be verified for thermal stability;

4. For circuit breakers that have met the rated short-circuit breaking capacity, they can no longer be verified for dynamic stability and thermal stability. However, when the relay protection is installed separately, it shall verify the thermal stability of the circuit breaker;

5. Protective magnetic starters and contactors as placed in separate power boxes may not be verified for dynamic stability and thermal stability.

6.3.4 Short-circuit protection appliances shall be installed at the head end of the circuit. When a protective device with current limiting functions is installed in the circuit, the electrical appliance and conductor of the circuit may be verified by the maximum short-circuit current actually passed after the current limit.

6.3.5 The breaking capacity of short-circuit protection appliances shall meet the following requirements:

1. The rated breaking capacity of the protective device shall be greater than the expected effective value of the short-circuit current at the mounting point;

2. When using the instantaneous overcurrent tripper of the circuit-breaker itself as short-circuit protection, the ultimate short-circuit breaking capacity of the circuit-breaker shall be greater than the expected effective value of the short-circuit current at the head end of the circuit;

3. When the delay overcurrent tripper of the circuit-breaker itself is used as the short-circuit protection, use the short-circuit breaking capacity under the corresponding delay of the circuit-breaker for verification;

4. When the relay protection is installed separately, if the action time exceeds the longest delay of the circuit-breaker's delay tripper, the breaking capacity of the circuit-breaker shall be verified according to the manufacturer's specified value;

5. When the power supply is the lower incoming line, it shall consider its influence on the breaking capacity;

6. The rated power factor of the low-voltage protection circuit-breaker shall be lower than the short-circuit power factor value at the installation point. When it is not satisfied, the rated breaking capacity of the electrical appliance should have appropriate margin.

6.3.6 The operating current of the protective appliance shall be matched with the cross section of the circuit's conductor, meanwhile it shall avoid the maximum operating current of the circuit. The sensitivity of the protection action shall be verified according to the minimum short-circuit current at the end of the circuit. The selection of matching method shall comply with the provisions of Appendix E of this standard.

6.3.7 The low-voltage distribution protection should use low-voltage air breakers. In the three-phase power supply circuit, each pole of the three-pole circuit-breaker shall be equipped with an overcurrent tripper. The parameters of the shunt tripper and the voltage-loss tripper as well as the number of auxiliary contacts shall meet the requirements for control and protection.

6.3.8 Isolation electrical appliance shall meet the requirements of dynamic stability and thermal stability of short-circuit current.

6.3.9 The grade and model of AC contactor and magnetic starter shall be selected according to the capacity and working mode of the motor. The parameters of the holding coil and the number of auxiliary contacts shall meet the requirements for control and interlocking.

6.3.10 The combination of low-voltage electrical appliances shall meet the following requirements:

1. The power supply circuit shall be equipped with electrical equipment which has the function of short-circuit protection and overload protection. For the motor circuit that needs to be operated frequently, it shall also be equipped with an operating device. For a circuit that is not frequently operated, the protective device can also be used as an operating device;

2. When a short-circuit fault occurs, all levels of protective device shall meet the requirements of selective action. The low-voltage main circuit-breaker of the station service transformer should have a delay action, the feeder circuit-breaker should be operated before the action of total circuit breaker. The upper and lower fuses shall maintain a selective level difference;

3. It shall provide isolation devices in groups between the protective devices and the busbars that are fixedly installed for more than 4 circuits. For the power supply circuit of the lifting equipment, it shall add the locally installed isolation device;

4. A three-phase motor circuit consisting of a fuse and a contactor shall be equipped with a thermal relay with phase-failure protection or a fuse with contacts as phase-failure protection;

5. The contactor shall be electrically coordinated with the protective devices when passing short-circuit current. When reaching to the requirements for "type-1" coordination, it is allowed to be installed on the central switchboard;

6. For the important circuit used for fire protection in the station, it should appropriately increase the conductor's cross section, be equipped with short-circuit protection, without the need to configure overload protection. If the overload protection is configured, it shall not cut off the line; it may act on the signal;

7. The requirements for the station service power design and equipment procurement: the automatic-control or interlock-control motor shall have the measures of manual control as well as the measures to tripper the automatic control or interlock control; the remote-control motor shall have the measures of local control and releasing remote control; when the sudden startup may endanger the safety of surrounding personnel, it shall provide a startup warning signal and an emergency power off control switch or a self-locking stop button aside the machine.

6.3.11 The type selection of low-voltage motors shall meet the following requirements:

1. The motor shall use an efficient and energy-saving AC motor;

2. The protection type of the motor shall be adapted to the surrounding environmental conditions.

6.3.12 The design of grounding and overvoltage protection of station service low-voltage electrical device shall be in accordance with the relevant requirements of current national standards "Code for earthing design of AC electrical installations" GB/T 50065, "Insulation coordination for equipment within low-voltage systems" GB/T 16935, "Specifications for disposition, erection and acceptance of 220/380V power surge protection in power plant and substation" DL/T 5408.

6.4 Choice of conductor

6.4.1 The design of high-voltage conductors for station services shall be carried out in accordance with the relevant provisions of the current power industry standard "Design technical rule for selecting conductor and electrical equipment" DL/T 5222.

6.4.2 The design of low-voltage conductors for station services shall be carried out in accordance with the relevant provisions of the current national standard "Code for design of low-voltage electrical installations" GB 50054.

6.4.3 The selection of station service cable shall be carried out in accordance with the relevant provisions of the current national standard "Code for design of cables of electric engineering" GB 50217.

6.5 Diesel-engine generators

6.5.1 The diesel generator set shall adopt the fast self-starting emergency type. The time for the first self-starting and restoring the power supply after the power failure may take 15s ~ 20s. The generator set shall have the ability to prepare for self-starting work and can self-start up for three times continuously. The startup mode of the diesel engine shall adopt electric startup; the cooling mode of the diesel engine shall be closed-type circulating water. The generator should adopt a fast-reacting excitation system. The wiring of the generator shall be star-connection. The neutral point shall be able to be led out.

6.5.2 The technical requirements for diesel generators shall be implemented in accordance with the relevant provisions of the current national standard "Reciprocating internal combustion engine driven alternating current generating sets" GB/T 2820.

7 Station service equipment arrangement

7.1 General requirements

7.1.1 The location of the power distribution device room for station service shall be close to the center of the power load. The surrounding environment is dry and free from vigorous vibration.

7.1.2 The layout of the station service electrical device shall be in accordance with the principles of safety, reliability, application, economy. It shall be easy to install, operate, handle, overhaul, testing, monitoring.

7.1.3 The safety clearance of 220V ~ 380V indoor switchboard shall not be less than the values as listed in Table 7.1.3.

Table 7.1.3 -- Safety clearance of 500V below indoor and outdoor switchboard (mm)

Symbol	Scope of application	Place of use	
		Indoor	Outdoor
	Unobstructed bare live part to the surface	2500	
A	Bare live part to grounding and between different phases of bare live parts	20	75
B	Net spacing between bare conductor below 2500 mm to surface and the shield which has a degree of protection of IP2X	100	175
	Horizontal distance between unshielded bare conductors which are not simultaneously maintained after power-failure	1875	2000
	Bare live part to non-porous fixed shield	50	-
C	Bare live part to shield which can only be opened or removed by keys or tools	800	825
	Out-going line casing to outdoor pedestrian walkway floor	-	3650

Note: When the altitude exceeds 1000m, the value under the symbol A in the Table shall be corrected by increasing 1% per every altitude increase of 100m. The values of B and C shall be added by the correction value of item A accordingly.

7.1.4 In the station service switchboard room and station service transformer room, all holes leading to the outdoor or adjacent rooms (including the cable layer) shall be reliably sealed by flame-resistant materials.

7.1.5 In the room where the station service switchboard is provided, except for the pipelines as required by the room, there shall be no other pipeline passing through it. Along the indoor water and steam pipelines, it shall not install valves or intermediate joints. The connection between the water and steam pipelines and the radiators shall be welding. It shall not lay water and steam pipelines above and below the switchboard and within the cable trenches.

7.2 Arrangement of station service transformer

7.2.1 When the station service transformer is arranged indoor, the oil-immersed transformer shall be installed in a separate small chamber. Dry-type transformers may be arranged in the station service switchboard room.

7.2.2 The net clearance between the outer contour of the oil-immersed transformer and the four walls of the transformer chamber shall not be less than the values as listed in Table 7.2.2.

For the station service transformers for on-site maintenance, the indoor height may be determined by adding 700mm to the minimum height required by the suspension core, the width can be determined by adding 800mm to each side of the transformer.

Table 7.2.2 -- Minimum net clearance between the outer profile of the transformer and the four walls of the transformer chamber for oil-immersed station (mm)

Transformer capacity (kV • A)	1000 and below	1250 and above
Between transformer and rear wall and side wall	600	800
Between transformer and door	800	1000

7.2.3 The setting of the oil storage or oil retaining facilities of transformers for oil-immersion stations shall be carried out in accordance with the relevant provisions of the current national standard "Code for design of fire protection for fossil fuel power plants and substations" GB 50229.

7.2.4 At the high-low pressure casing sides of the station service transformer or the side of the transformer close to the maintenance door, it should be provided with a mesh shield. The transformer's oil pillow should be placed on the maintenance inlet side.

7.2.5 At the point where the low-voltage hard conductor of the transformer for the oil-immersion station passes through the wall, it may be enclosed by flame-retardant insulation board. At the point where the indoor and outdoor lead line passes through the wall, it shall be subjected to moisture-proof treatment.

7.2.6 When installing the isolation device in the oil-immersed transformer chamber, it shall be installed at the indoor maintenance door of the transformer chamber and shall be shielded.

7.2.7 The transformer chamber shall have a special door or detachable wall for inspection. The width shall be determined by at least adding 400mm to the width of the transformer, the height shall be determined by adding at least 300mm to the height of the transformer. For transformers of 1000kV • A and above, in the course of handling, it may consider removing the oil pillow and the explosion-proof tube. In order to facilitate the operation maintenance, the transformer chamber may be equipped with a maintenance door.

7.3 Arrangement of switchboard

7.3.1 The size of the operation and maintenance channel of the station service switchboard shall comply with the requirements of Table 7.3.1.

Table 7.3.1 -- Minimum width of the channel for switchboards arranged in rows (m)

Type of switchboard		Single-row layout			Double-row face-to-face layout			Double-row back-to-back layout			Multiple-row same-direction layout			Passage aside switchboard
		In front of switchboard	Behind switchboard		In front of switchboard	Behind switchboard		In front of switchboard	Behind switchboard		Between switchboards	Distance between front row and back row of switchboards		
			Maintenance	Operation		Maintenance	Operation		Maintenance	Operation		Front row	Rear row	
Fixed type	Unrestricted	1.5	1.0	1.2	2.0	1.0	1.2	1.5	1.5	2.0	2.0	1.5	1.0	1.0
	Restricted	1.3	0.8	1.2	1.8	0.8	1.2	1.3	1.3	2.0	2.0	1.3	0.8	0.8
Drawer-type	Unrestricted	1.8	1.0	1.2	2.3	1.0	1.2	1.8	1.0	2.0	2.3	1.8	1.0	1.0
	Restricted	1.6	0.8	1.2	2.0	0.8	1.2	1.6	0.8	2.0	2.0	1.6	0.8	0.8

Note:

1. Restricted means that it is limited by the plane of the building and there are local protrusions such as columns in the channel.

2. Behind-switchboard operation channel refers to the channel where the switch device needs to be operated from the back of the switchboard.

3. In case of back-to-back layout, the width of the channel in front of the switchboard may be determined by the size in front of the double-row back-to-back switchboards in this Table.

4. The minimum width of the channel in front of and behind the control panel, control cabinet, floor-standing power distribution box may be determined according to this Table.

5. The width of the operation channel in front of the wall-mounted power distribution box should not be less than 1 m.

7.3.2 The central switchboard room for the station service as set up separately shall be arranged as close as possible to the station service transformer chamber.

7.3.3 The station service switchboard and circuit arrangement in the switchboard shall be beneficial to reduce the cross-laying of the outgoing cable.

7.3.4 When the length of the switchboards arranged in rows is more than 6m, it shall provide two outlets along the channel behind the switchboard, both outlets should be located at both ends of the channel. When the distance between the two outlets is more than 15m, it shall also add another outlet between them.

7.3.5 The height of the bare conductive part of the indoor station service switchboard to the floor shall be in accordance with the provisions of clause 4.2.6 of the current national standard "Code for design of low-voltage electrical installations" GB 50054-2011.

7.3.6 In addition to the spare circuit left in the station service switchboard, the station service switchboard room should have one to two positions for spare switchboards.

7.3.7 The bottom of the floor-standing distribution box shall be raised. The height above the ground shall not be lower than 50mm indoor and 200mm outdoor. It shall take enclosing measures around its base, to avoid small animals such as rats and snakes from entering the box.

7.3.8 Two segments of adjacent busbars in the station service power distribution room shall be fireproofed between the adjacent two busbars and the space below.

7.3.9 When the low-voltage station service switchboard is located in the same room as the high-voltage power distribution cabinet, meanwhile there is bare busbar on the top of the high-voltage cabinet, the net clearance between the two shall not be less than 2m.

7.4 Arrangement of diesel-engine generator

7.4.1 Diesel generators should be arranged in a well-ventilated independent room.

7.4.2 The diesel generator room should be arranged close to the station service power room.

7.4.3 The distance from the diesel generator set to the wall shall meet the requirements for transportation, operation, maintenance. The relevant dimensions in the equipment room shall meet the requirements of Table 7.4.3.

Table 7.4.3 -- Dimensions of diesel generator room (m)

Item \ Capacity (kW)	75～150	200～400	500～1500
Operating surface of unit	1.7	1.8	2.2
Backside of unit	1.6	1.7	2.0
Diesel engine end	1.0	1.2	1.5
Spacing between units	2.0	2.3	2.6
Generator end	1.8	2.0	2.4
Net height of machine room	3.5	4.0～4.3	4.3～5.0

7.4.4 The arrangement of the oil storage facility shall meet the following requirements:

1. When the fuel's source and transportation are inconvenient, it should install an oil storage facility with a fuel consumption of 40h ~ 64h outside the main building;

2. It shall arrange the oil storage room in the equipment room. The total storage capacity shall not exceed the fuel consumption of 8h. Meanwhile it shall take corresponding fireproof measures.

7.5 Clean energy and energy storage device

7.5.1 The arrangement of clean power generation and energy storage devices in the station shall not affect the main function of the substation.

7.5.2 The installation of clean power generation and energy storage devices in the station shall comply with the corresponding technical standards.

7.6 Requirements for constructions

7.6.1 When the length of the station service switchboard room is more than 7m, it shall provide two outlets at both ends of the switchboard room.

7.6.2 The door of the station service switchboard room shall be a fire door that opens outwards, meanwhile a spring lock that can be opened without a key is installed on the inside. The door between adjacent power distribution devices shall be able to open in both directions. The width of the door shall be increased by 200mm ~ 400mm according to the maximum equipment dimensions to be handled. The width of the door shall not be less than 900mm and the height of the door shall not be less than 2100mm. The size of the maintenance door is not less than 750mm x 1900mm.

7.6.3 The ground design elevation of the power distribution device room for station service shall be not more than 0.3m above the outdoor floor. It shall take measures to prevent rainwater from entering the station service transformer room.

7.6.4 The station service switchboard room should use the floor with no dust and a certain hardness.

7.6.5 The switchboard room should not be provided with opening window. However, when the opening window is provided, it shall take measures to prevent rain, snow, small animals, sand, dirty dust from entering.

7.6.6 The construction, fire prevention, ventilation design of the power distribution device for station service shall be carried out in accordance with the relevant provisions of the current power industry standard "Technical code for the design of 220kV~750kV substation" DL/T 5218.

8 Maintenance power supply

8.0.1 Nearby the main transformer, high-voltage shunt reactor, series reactive power compensation device, inside the indoor and outdoor power distribution device, it shall arrange fixed maintenance power supply. The power supply radius of the maintenance power supply should not be greater than 50m.

8.0.2 Special power supply box for maintenance shall meet the following requirements:

1. The power supply box in the power distribution device is equipped with at least two circuits of three-phase feeder and two circuits of single-phase feeder. The circuit's capacity should meet the needs of electric welding and other work;

2. The circuit and capacity of the power supply box near the main transformer and high-voltage shunt reactor shall meet the needs of fuel filtration and injection.

8.0.3 The power supply box for maintenance installed outdoor shall be protected against moisture and to prevent intrusion of small animals. When installing on the floor, the bottom shall be more than 0.2m above the floor.

9 Protection against electric shock

9.0.1 The electric shock protection of the power distribution device for high-voltage station services shall be carried out in accordance with the relevant provisions of the current power industry standard "Technical code for designing high-voltage electrical switchgear" DL/T 5352. The electric shock protection of low-voltage electrical devices shall be in accordance with the current national standard "Code for design of low-voltage electrical installations" GB 50054.

9.0.2 The maintenance power supply for substation and mobile power equipment shall be equipped with residual current action protection device. The rated residual non-operating current of the residual current action protection device shall be more than the expected grounding leakage current when the load is in normal operation.

9.0.3 When the substation is equipped with the residual current action protection single-phase circuit and equipment, it shall select two-pole protection device. For protecting three-phase three-wire circuit and equipment, it may select three-pole protection device. For protecting three-phase four-wire system circuits, it shall use the three-pole protection device. It is strictly forbidden to connect the protective grounding neutral conductor to the switchgear. In the three-phase five-wire system circuit, it shall select the four-pole protective device and disconnect all phase conductors and neutral live conductors.

9.0.4 The circuit's neutral line of the residual current action protection as installed in the substation shall be connected for protection. The neutral line which passes by the leakage protector shall not be used as the protective grounding line. It shall not be repeatedly grounded or connected to the outer casing of the equipment. The circuit must be equipped with a protective grounding conductor.

9.0.5 Between the conductive parts that can be accessed simultaneously in the power distribution room, it shall make equipotential bonding.

10 Control, signaling, metering and automatic devices of station service system

10.1 Station service power relay

10.1.1 The protection of station service transformers and motors shall comply with the requirements of the current national standards "Technical code for relaying protection and security automatic equipment" GB/T 14285 and "Code for design of relaying protection and automatic device of electric power installations" GB/T 50062.

10.1.2 When the station service transformer adopts two-stage step-down mode and there is no circuit-breaker between the two-stage transformers, the two-stage step-down transformer may be considered as a whole for configuring primary protection and backup protection.

10.1.3 The protection of diesel generator shall comply with the following provisions:

1. For the stator winding and the phase-to-phase short-circuit fault of lead-line, it should provide overcurrent protection. The overcurrent protection shall have two functions: quick-break (primary protection) and timed limit (back-up protection). When the sensitivity of current quick-break protection does not meet the requirements, it may be provided longitudinal differential protection;

2. For single-phase grounding short-circuit fault, it should provide single-phase grounding protection. The single-phase grounding protection shall action when it trips;

3. The vehicle diesel generator set shall have lightning protection and anti-static protection measures.

10.1.4 The transformer protection of high-extraction resistance stations shall comply with the following provisions:

1. The range of transformer protection for extraction resistance stations shall include transformer windings, bushings, lead-line of extraction coil. The protection configuration should comply with the current national standard "Technical code for relaying protection and security automatic equipment" GB/T 14285;

2. For the fault between the high-voltage side CT and the high-speed fuse, it should provide separate over-current protection as initiated by the high-voltage side composite voltage. The protection also serves as the backup protection when the fuse can not be blown in case of fault between the two. The protection action is to trip the high-voltage breaker as connected to the high resistance after time delay (including circuit breakers on the opposite side of the long-tripping line).

10.2 Station service power control, signaling and measure device

10.2.1 The design of control, measurement and signal circuit shall comply with the current national standards "Technical code for designing of electrical secondary wiring in fossil fuel power plants and substations" DL/T 5136 and "Code for design of electrical measuring device of power system" GB/T 50063.

10.2.2 The operating conditions and information data of the station service power supply shall be connected to the substation's automation system in a standard format.

10.2.3 For the elements such as the operating device of the circuits of the low-voltage master circuit-breaker of station service transformer and the segmented circuit-breaker of busbar, as well as the loaded voltage-regulation tap switch of the station service transformer should be controlled by the monitoring system.

10.2.4 When the station service transformer adopts two-stage step-down mode and there is no circuit-breaker between the two-stage transformers, if the two-stage transformers are arranged in relative large spacing, it should be able to monitor the grounding fault between the two-stage transformers.

10.2.5 The components of the isolating switch, grounding switch, high-speed fuse that lead from the high-extraction resistance coil to the station service transformer should be monitored by the monitoring system.

10.3 Metering system

10.3.1 The metering of electrical energy shall comply with the current national standards "Code for design of electrical measuring device of power system" GB/T 50063 and "Technical code for designing of electric energy metering system" DL/T 5202.

10.3.2 Each station service transformer should be equipped with an active energy meter that meets the accuracy requirements of class 1.0. The power supply outside the station should be equipped with an active energy meter that meets the requirements of class 0.2S energy metering accuracy.

10.4 Power automatic transfer switching equipment

10.4.1 The automatic transfer switching device for standby power supply shall comply with the requirements of the current national standard "Code for design of relaying protection and automatic device of electric power installations" GB/T 50062.

10.4.2 For the domestic water pump, rain pump, etc., it should follow the process requirements to provide automatic level switchover circuit.

Appendix A

Load characteristic table

Table A -- Characteristics of main power load

No.	Item	Load type	Operation mode
1	Charging device	II	Infrequent, continuous
2	Floated charging device	II	Frequent, continuous
3	Forced oil air (water) cooling device of transformer	I	Frequent, continuous
4	On-load voltage regulator of transformer	II	Frequent, intermittent
5	Charged oil filter device of on-load voltage regulator	II	Frequent, continuous
6	Circuit breaker, operating power supply of isolation switch	II	Frequent, intermittent
7	Circuit breaker, isolation switch, terminal box heating	II	Frequent, continuous
8	Fan	III	Frequent, continuous
9	Accident fan	II	Infrequent, continuous
10	Air conditioner, electric boiler	III	Frequent, continuous
11	Carrier, microwave communication power supply	II	Frequent, continuous
12	Telecontrol device	I	Frequent, continuous
13	Microcomputer monitoring system	I	Frequent, continuous
14	Microcomputer protection, detection device power supply	i	Frequent, continuous
15	Air compressor	II	Frequent, short-term
16	Deep well pump or water feed pump	II	Frequent, short-term
17	Domestic water pump	II	Frequent, short-term
18	Rain pump	II	Infrequent, short-term
19	Fire pump, transformer water spray device	I	Infrequent, short-term
20	Maintenance power supply of power distribution device	III	Infrequent, short-term
21	Electrical maintenance room (driving, electric door, etc.)	III	Infrequent, short-term
22	Domestic electricity in the station	III	Frequent, continuous

Note:

1. Load characteristics refer to the general situation. In the engineering design, the load of the communication, remote control, microcomputer monitoring system, AC accident lighting, etc., which are powered by inverter or uninterruptible power supply device, may also be included in the corresponding charging load.

2. The load classification is as shown in clause 3.2.1 of this standard.

3. “Frequent” and “Infrequent” in the operation mode column distinguish the use of this type of load. “Continuous” “short-term”, “intermittent” distinguish the differences in the time length of each use, that is:

(1) Continuous - It runs continuously for more than 2 hours with load each

time.

(2) Short-term - It runs continuously within 2 hours but more than 10min with load each time.

(3) Intermittent - It runs repeatedly in the cycle from on-load to no-load or stop, the duration of each working cycle is not more than 10min.

(4) Frequent - It is related to the normal production process, generally used every day.

(5) Infrequent - It is normally not used, but used in case of maintenance, accidents or in specific situations.

Appendix B

Voltage-regulation calculation

B.0.1 The voltage-regulation of the non-excitation voltage-regulating transformer may be calculated according to the following formula:

When the voltage at high-voltage side of the station service transformer and the station power load are normally changed, the low-voltage busbar voltage for station service can be calculated according to the following conditions and formula (B.0.1). Where, the reference capacity of the transformer takes the rated capacity Se of the station service transformer; the reference voltage of per-unit value of low-voltage busbar voltage takes 0.38kV.

1. According to the lowest voltage on the high-voltage side and the maximum load for station service, calculate the minimum voltage $U_{m.zd}$ of the low-voltage busbar; it shall satisfy $U_{m.zd} \geq 0.95$ (per-unit value).

2. According to the highest voltage on the high-voltage side and the minimum load for station service, calculate the maximum voltage $U_{m.zd}$ of the low-voltage busbar; it shall satisfy $U_{m.zd} \leq 1.05$ (per-unit value).

The formula for the voltage of low-voltage busbar is as follows:

$$U_m = U_0 - S \times Z_b \qquad \text{(B.0.1-1)}$$

$$Z_b = R_b \times \cos\varphi + X_b \times \sin\varphi \qquad \text{(B.0.1-2)}$$

Where:

U_m - Voltage of low-voltage busbar (per-unit value);

U_0 - No-load voltage at the low-voltage side of the station service transformer (per-unit value), $U_0 = Ug \times U_{2eB} / [1 + (n \times \delta\% / 100)]$;

S - Station service load (per-unit value);

Z_b - Voltage drop impedance of load (per-unit value), $R_b = 1.1 \times P_d/S_e$;

Cosφ - Load power factor, taken as 0.8;

X_b - Reactance of station service transformer (per-unit value), $X_b = 1.1 \times U_d\% / 100$;

U_g - Voltage at high-voltage side (per-unit value), $U_g = U_G/U_{1e}$;

U_G - Voltage at high-voltage side (kV);

U_{1e} - Rated voltage at the high-voltage side of the station service transformer (kV);

U_{2eB} - Rated voltage at the low-voltage side of the station service transformer (per-unit value), $U_{2eB} = U_{2e}/U_j$;

U_{2e} - Rated voltage at the low-voltage side of the station service transformer (kV);

U_j - Reference voltage (kV) of the low-voltage busbar, taken as 0.38kV;

n - The tap position, where n is an integer and a negative in case of negative tap;

δ - The stage voltage of the tap switch (%);

P_d - Rated copper loss of station service transformer (kW);

S_e - Rated capacity of the station service transformer (kV • A);

U_d% - Percentage of impedance voltage of the station service transformer.

The calculation shows that for the station service transformer of 4% ~ 6.5% of the 160kV • A ~ 1000kV • A standard impedance series, when the voltage fluctuation range at the high-voltage side is ±2.5% of the rated high-voltage of the station service transformer, the parameters of the tap switch meet the following conditions, the selection of non-excitation voltage-regulating transformer can meet the allowable fluctuation range of ±5% of the low-voltage busbar.

1) The voltage-regulation range of the tap switch is 10% (from positive tap to negative tap);

2) The level voltage of the tap switch is 2.5%;

3) The rated tap position should be in the middle of the voltage-regulation range.

B.0.2 The voltage-regulation of the on-load voltage-regulation transformer can be calculated according to the following formula:

The calculation of the voltage of low-voltage busbar is as shown as B.0.1 and B.0.2. However, it shall take into account the variable factors of the tap position.

For the station service transformer 4% ~ 6.5% of 160kV • A ~ 1000kV • A standard impedance series, when the voltage fluctuation at the high-voltage side exceeds ±2.5% of the rated high-voltage of the station service transformer, it is difficult to meet the allowable fluctuation range of low-voltage busbar ± 5 by using the non-excitation voltage-regulation. Therefore, it shall select the on-load voltage-regulation transformer. The selection of the tap switch shall meet the following requirements:

1) The pressure-regulation range may be ± (4 x 2.5%);

2) The rated tap position should be in the middle of the voltage-regulation range.

Appendix C

Calculation of short-circuit current in 380V power centers

C.0.1 The initial value of the period component of the three-phase short-circuit current may be calculated as follows:

$$I''=\frac{U}{\sqrt{3}\times\sqrt{(\sum R)^2+(\sum X)^2}} \qquad (C.0.1)$$

Where:

I" - The initial effective value of the period component of three-phase short-circuit current (kA);

U - The linear voltage at the low-voltage side of the transformer, taken as 400V;

ΣR - The total resistance of each phase of circuit (mΩ);

ΣX - The total reactance of each phase of circuit (mΩ).

C.0.2 Three-phase short-circuit surge current may be calculated as follows:

$$i_{ch}=\sqrt{2}\times k_{ch}\times I'' \qquad (C.0.2)$$

Where:

i_{ch} - The short-circuit surge current (kA);

k_{ch} - The surge coefficient of the short-circuit current, which can be found from the ratio of ΣX/ΣR in the circuit from Figure C.0.2, or calculated from $k_{ch} = 1 + e^{-0.01/T}$; where Ta = L/R is the time constant s of the circuit.

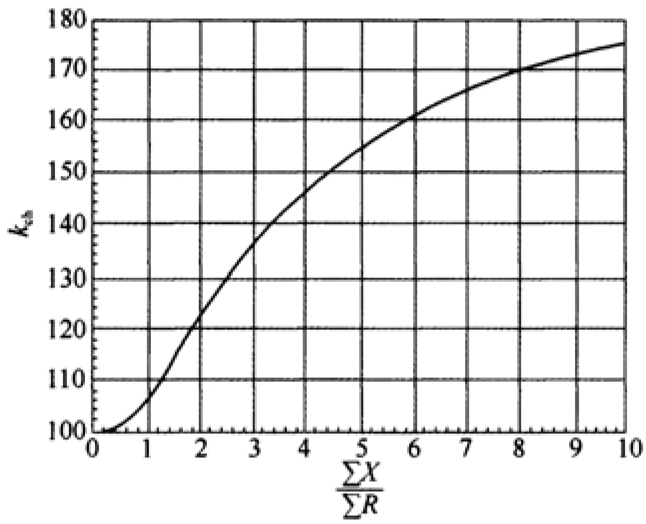

Figure C.0.2 -- k_{ch} = f(X/R) curve

C.0.3 The calculation results of the three-phase short-circuit current of the 380V busbar powered by the commonly used station service transformer are as shown in Tables C.0.3-1 and C.0.3-2.

Table C.0.3-1 -- Calculation results of three-phase short-circuit current of 6kV~ 10kV/0.4kV transformer

Transformer parameters			Short-circuit of 380V busbar						
S_e kV·A	I_e A	U_d %	$\sum R$ mΩ	$\sum X$ mΩ	Surge coefficient k_{ch}	I'' kA	i_{ch} kA	Ta s	Power factor cosφ
160	231	4.0	23.320	39.200	1.16	5.1	8.4	0.00537	0.51
200	289	4.0	17.267	32.368	1.19	6.3	10.6	0.00579	0.41
250	361	4.0	13.907	25.422	1.18	8.0	13.3	0.00582	0.48
310	455	4.0	10.593	20.724	1.20	9.9	16.8	0.00623	0.46
400	577	4.0	7.733	16.712	1.23	12.5	21.8	0.00688	0.42
500	722	4.0	4.864	13.354	1.32	16.3	30.4	0.00874	0.34
630	909	4.5	3.652	12.224	1.39	18.1	35.6	0.01066	0.29
800	1155	4.5	2.780	9.855	1.41	22.6	45.1	0.01129	0.27
1000	1443	4.5	2.132	8.095	1.44	27.6	56.1	0.01209	0.25

Table C.0.3-2 -- Calculation results of three-phase short-circuit current of 35kV/0.4kV transformer

Transformer parameters			Short-circuit of 380V busbar						
S_e kV·A	I_e A	U_d %	$\sum R$ mΩ	$\sum X$ mΩ	Surge coefficient k_{ch}	I'' kA	i_{ch} kA	Ta s	Power factor cosφ
160	231	6.5	25.195	65.230	1.30	3.3	6.1	0.00825	0.36
200	289	6.5	18.467	53.048	1.34	4.1	7.7	0.00915	0.33
250	361	6.5	14.931	41.805	1.33	5.2	9.8	0.00892	0.34
310	455	6.5	11.399	33.628	1.35	6.5	12.4	0.00940	0.32
400	577	6.5	8.333	26.900	1.38	8.2	16.0	0.01028	0.30
500	722	6.5	5.376	21.349	1.45	10.5	21.6	0.01265	0.24
630	909	6.5	4.096	17.159	1.47	13.1	27.3	0.01334	0.23
800	1155	6.5	3.055	13.709	1.50	16.4	34.7	0.01429	0.22
1000	1443	6.5	2.436	11.112	1.50	20.3	43.1	0.01453	0.21

Appendix D

380V feeder working current calculation

D.0.1 The working current of the incoming line circuit of station service transformer may be calculated as follows:

$$I_g = 1.05 \times I_e = 1.05 \times \frac{S_e}{\sqrt{3} \times Ue} \qquad (D.0.1)$$

Where:

I_g - The working current of the incoming line circuit of station service transformer (A);

I_e - The rated current at the low-voltage side of the station service transformer (A);

U_e - The rated voltage at the low-voltage side of the station service transformer (kV);

S_e - The rated capacity of station service transformer (kV • A).

Consider that the transformer's capacity does not change at 95%U_e. For the on-load voltage-regulation transformers for station service, it shall be calculated according to the actual minimum tap voltage.

D.0.2 The working current of the power supply circuit of the cooling device of main transformer may be calculated as follows:

The working current of the power supply circuit of the cooling device of a single main transformer can be calculated as follows. In case of the power supply circuit of three single-phase main transformers, it shall be calculated as three times the formula below:

$$I_g = n_1 \times (I_b + n_2 \times I_f) \qquad (D.0.2)$$

Where:

I_g - The working current of the power supply circuit of the cooling device of a single main transformer (A);

n_1 - The number of groups of coolers required by the station when a single main transformer is operated at full load;

I_b - The rated current of the oil pump motor in each group of coolers (A);

I_f - The rated current of the motor of a single fan motor in each group of coolers (A);

n_2 - The number of fan motors in each group of coolers.

D.0.3 The working current of the operation and heating power supply circuits of the circuit-breaker may be calculated as follows:

$$I_g = \sum I_c + \sum I_r \quad \text{(D.0.3)}$$

Where:

I_g - The working current of the operation and heating power supply circuits of the circuit-breaker (A);

ΣI_c - The sum of the rated currents of the operating motor of the circuit breakers or isolation switch that can operate simultaneously in the circuit (A). When there is no data, the current of a single motor may be estimated as follows: when it is not more than 3kW, it takes 2.5A/kW; when it is more than 3kW, it takes 2A/kW;

EI_r - The sum of the rated currents of the circuit-breakers and isolation switch heaters in the circuit. Single-phase heaters shall be evenly distributed in three phases.

D.0.4 The working current of the lighting circuit may be calculated as follows:

$$I_g = \frac{3 \times P_m \times (1 + \Delta P)}{\sqrt{3} \times U_e \times \cos\varphi} \quad \text{(D.0.4)}$$

Where:

I_g - The working current of the lighting circuit (A);

P_m - The capacity of the lighting device of the maximum phase (kW);

ΔP - The percentage of power loss of ballast component to the light tube, as shown in Table D.0.4;

$\cos\varphi$ - Power factor of illuminator, as shown in Table D.0.4;

U_e - Rated line voltage, taken as 0.38kV.

Table D.0.4 -- Percentage of power loss of ballast component power to light tube

Characteristics of light sources and ballast components	Cosφ	ΔP
Gas discharge lamp without compensation capacitor (inductive ballast)	0.5	20
Gas discharge lamp with compensation capacitor (inductive ballast)	0.9	20
Gas discharge lamp (electronic ballast), LED lamp	0.96	15

D.0.5 The working current of the circuit of DC charging device may use the rated current of the charging device.

D.0.6 The working current of the circuit of maintenance power supply may be calculated as follows:

The maintenance power supply of main transformer is considered according to the long-term working current of the maintenance device of main transformer (oil filtration, heating).

When the circuit of inspection box is considered using a single-phase AC welding machine:

$$I_g = \frac{S_e}{U_e} \times \sqrt{ZZ} \times 1000 \qquad (D.0.6)$$

Where:

I_g - The working current of maintenance circuit (A);

S_e - The rated capacity of single-phase welding machine (kV • A);

U_e - The rated voltage (V);

ZZ - The duty cycle of AC welding machine, which usually takes 65% for domestic welding machine.

D.0.7 The working current of the circuit of fan and pump motor may be calculated as follows:

$$I_g = \sum I_d \qquad (D.0.7)$$

Where:

I_g - Working current of circuit of motor (A);

I_d - The rated current of a single motor, (A), which can be estimated as follows when the data is lacking: when it is not more than 3kW, it takes 2.5 A/kW; when it is more than 3kW, it takes 2A/kW.

Appendix E

Selection and verification of protect device and conductor

E.0.1 The operating characteristics of the short-circuit protection device of low-voltage circuit shall meet the following requirements:

The thermal stability of the insulated conductor shall be verified according to its cross-sectional area and shall comply with the following provisions:

1. When the short-circuit duration is ≤ 5s, the cross-sectional area of the insulated conductor shall comply with the requirements of formula (E.0.1):

$$S \geqslant \frac{I}{k} \times \sqrt{t} \tag{E.0.1}$$

Where:

S - The cross-sectional area of the protective conductor (mm^2);

I - The expected fault current or short-circuit current (A. rms) which passes the protective device;

t - The action time of the protective device that automatically cuts off the current (s);

k - Determined according to the provisions of Appendix A of the current national standard "Code for design of low voltage electrical installations" GB 50054.

Table E.0.1 -- Initial and final temperatures and coefficients of cable cores or protective conductors as laid in bundles with other cables or insulated conductors (GB 50054 Table A.0.4)

Insulated conductor	Temperature (°C)		Coefficient of conductor materials k		
	Initial	Final	Copper	Aluminum	Steel
70 °C polyvinyl chloride	70	160 (140)	115 (103)	76 (68)	42 (37)
90 °C polyvinyl chloride	90	160 (140)	100 (86)	66 (57)	36 (31)
90 °C thermosetting material	90	250	143	94	52
60 °C rubber	60	200	141	93	51
85 °C rubber	85	220	134	89	48
Silicone rubber	180	350	132	87	47

Note: The values in parentheses apply to PVC insulated conductors which have a cross-sectional area of more than 300 mm^2.

2. When the short-circuit duration is less than 0.1s, the cross-sectional area of the verified insulated conductor shall take into account of the impact of the non-periodic component of the short-circuit current. When it is greater than 5s, the cross-sectional area of the verified insulated conductor shall take into account of the heat dissipation.

3. When the short-circuit protection device is a circuit-breaker, the short-circuit current at the end of the protected line shall not be less than 1.5 times the setting current of the instantaneous or short-delay overcurrent tripper of the circuit-breaker.

4. Selective cooperation of protection

The protection of circuit-breaker at the load side actions instantaneously. The protection at the power supply side shall action after a time delay of 0.15s ~ 0.2s. The total power protection should have an action delay of 0.3s ~ 0.4s.

E.0.2 The action characteristics of the overload protection device of low-voltage circuit shall meet the requirements of the following formula:

$$I_B \leqslant I_n \leqslant I_Z \qquad (E.0.2-1)$$

$$I_2 \leqslant 1.45 \times I_Z \qquad (E.0.2-2)$$

Where:

I_B - The calculated current of circuit (A);

I_n - The rated current of fuse or the rated current or setting current of circuit-breaker (A);

I_Z - The allowable continuous current carrying capacity of conductor (A);

I_2 - The current that ensures the reliable action of the protective device (A). When the protection device is a circuit-breaker, I_2 is the agreed action current within the agreed time; when it is a fuse, I_2 is the agreed blowing current within the agreed time.

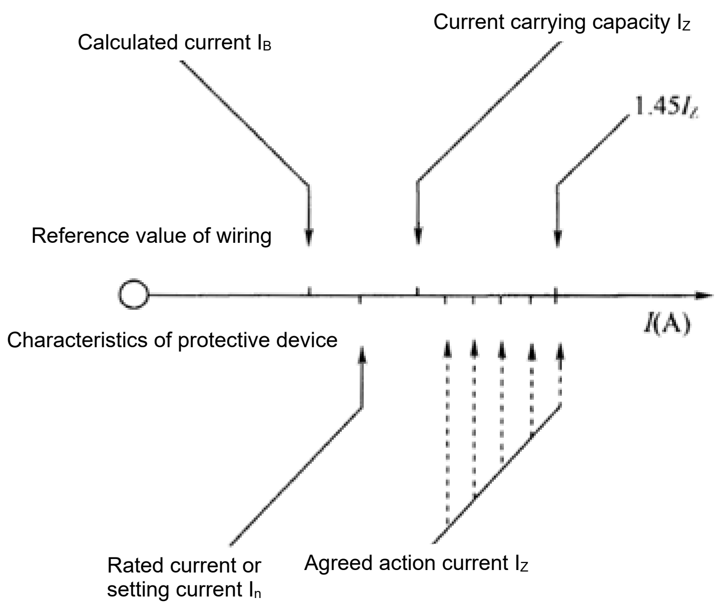

Figure E.0.2 -- Characteristic relationship of overload protective device

E.0.3 The selection and verification of the overcurrent tripper of the circuit-breaker of the motor circuit shall meet the following requirements:

The setting current of overcurrent tripper is calculated according to Table E.0.3.

Table E.0.3 -- Setting current of overcurrent tripper

Circuit of single motor	Feeder trunk	
$I_Z \geqslant K \times I_Q$	Self-start of group motors	$I_Z \geqslant 1.35 \times \sum I_Q$
	Start of the largest one in the group	$I_Z \geqslant 1.35 \times \left[I_{Q1} + \sum_2^n I_{Gi}\right]$

Note:

I_Z - The setting current of tripper (A), which takes the larger one of the two formulas.

K - The reliability factor, which usually takes 1.35 for the circuit-breaker with action time of more than 0.02s, and 1.7 ~ 2.0 for the circuit-breaker with action time of not more than 0.02s.

I_{Q1} - Startup current of the maximum motor (A).

$\sum_{i=2}^{n} I_{Gi}$ - The sum of the working currents of other motors, except for the maximum motor (A).

ΣI_Q - The sum of the currents of all the self-startup motors as powered by the feeder trunk (A).

E.0.4 The selection and verification of the fuse of the motor circuit shall meet the following requirements:

1. The verification of the rated current of fuse according to the startup conditions of the motor is as shown in Table E.0.4.

Table E.0.4 -- Rated current of fuse for verification of motor startup

Single motor	Feeder trunk	
$I_e \geqslant \frac{I_Q}{\alpha_1}$	Self-start of group motors	$I_e \geqslant \frac{\sum I_Q}{\alpha_2}$
	Start of the largest one in the group	$I_e \geqslant \frac{I_{Q1} + \sum_2^n I_{Gi}}{\alpha_2}$

Note:

I_e - The rated current of the fuse (A), which takes the larger one of the two formulas.

I_{Q1} - Startup current of the maximum motor (A).

$\sum_2^n I_{Gi}$ - The sum of the working currents of other motors, except for the maximum motor (A).

ΣI_Q - The sum of the currents of all the self-startup motors as powered by the feeder trunk (A).

α_1 - The selection factor of the fuse of motor circuit; which takes 2.5 for RTP type fuse and 3 for NT type fuse.

α_2 - The selection factor of the fuse of trunk circuit, which takes 1.5.

2. When the power supply circuit selects the fuse as protective device, the cooperation of the rated current of fuse with the cross-section of cable as well as the requirements for the single-phase short-circuit current at the end of the power supply circuit.

1) The rated current of the fuse is not more than 2.5 times the rated carrying current of the cable:

$$I_e \leqslant 2.5 \times I_{le} \qquad \text{(E.0.3-1)}$$

Where:

I_e - The rated current of the fuse (A);

I_{le} - The rated current carrying capacity of cable (A).

2) The single-phase short-circuit current at the end of the power supply circuit is more than 5 times the rated current of the fuse:

$$I_d^{(1)} > 5 \times I_e \qquad \text{(E.0.3-2)}$$

Where:

I_e - The rated current of the fuse (A);

$I_d^{(1)}$ - Single-phase short-circuit current at the end of the power supply circuit (A).

If the above conditions are met, it may not verify the thermal stability of the power supply cable (refer to clause 6.3.3 of this specification).

Explanation of wording in this code

1 In order to facilitate making a difference in the implementation of the provisions of this standard, the words with different strictness requirements are described as follows:

1) Indicating very strict and it must be done as such:

Positive words use “must”; negative words use “forbidden”;

2) Indicating strict and it shall be done as such under normal conditions:

Positive words use “shall”; negative words use “shall not”;

3) Indicating that it allows a slight choice and it shall be done as such when conditions permit:

Positive words use “should” or “may”; negative words use “should not”;

4) Indicating that there is a choice and it may be done as such under certain conditions:

Use the word “may”.

2 When it is specified in the provisions that it shall be implemented according to other relevant standards and codes, the wording is “it shall comply with the provisions of ...” or “it shall be implemented according to ...”.

List of quoted standards

Code for design of low-voltage electrical installations GB 50054

Code for design of electric distribution of general-purpose utilization equipment GB 50055

Code for design of relaying protection and automatic device of electric power installations GB/T 50062

Code for design of electrical measuring device of power system GB/T 50063

Code for design of overvoltage protection and insulation coordination for AC electrical installations GB 50064

Code for earthing design of AC electrical installations GB/T 50065

Code for design of cables of electric engineering GB 50217

Code for design of fire protection for fossil fuel power plants and substations GB 50229

Reciprocating internal combustion engine driven alternating current generating sets GB/T 2820

Low-voltage switchgear and controlgear GB 14048

Technical code for relaying protection and security automatic equipment GB/T 14285

Insulation coordination for equipment within low-voltage systems GB/T 16935

Specific configuration of power supply and self-emergency power supply for important power users GB 29328

Integrated uninterruptible power supply equipment of DC and AC for power system DL/T 1074

Technical code for designing of electrical secondary wiring in fossil fuel power plants and substations DL/T 5136

Technical code for designing of electric energy metering system DL/T 5202

Technical code for the design of 220kV~750kV substation DL/T 5218

Design technical rule for selecting conductor and electrical equipment DL/T 5222

Technical code for designing high-voltage electrical switchgear DL/T 5352

Specifications for disposition, erection and acceptance of 220/380V power surge protection in power plant and substation DL/T 5408

Technical code for design of series compensator station DL/T 5453

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------ The End ------