

UDC

National Standard of the People's Republic of China



P

GB 50217 — 2007

Code for Design of Cables of Electric Engineering

Issue Date: October 23, 2007

Implementation Date: April 1, 2008

Ministry of Construction of the People's Republic of China
Jointly Issued by: General Administration of Quality Supervision, Inspection and
Quarantine of the People's Republic of China

GB 50217—2007

ISBN 978-7-5123-4418-1



上架建议：规程规范/
电力工程/输配电

National Standard of the People's Republic of China

P

GB 50217 — 2007

Code for Design of Cables of Electric Engineering

Translation sponsored by: China Electric Power Planning & Engineering Association

Translated by: SUNTHER Consulting Co., Ltd.

Reviewed by: Southwest Electric Power Design Institute

CHINA ELECTRIC POWER PRESS

BEIJING, 2013

Announcement of Ministry of Construction of the People's Republic of China

No.732

Announcement of Issuing the National Standard of *Code for Design of Cables of Electric Engineering*

The *Code for Design of Cables of Electric Engineering* has been approved as a national standard with a serial number of GB 50217—2007 and implemented on April 1, 2008, where Article 5.1.9 and article 5.3.5 are compulsory provisions and must be enforced strictly. The original *Code for Design of Cables of Electric Engineering* GB 50217—1994 will be abolished from then.

This code will be published and distributed by China Planning Press as authorized the Research Institute of Standards and Norms, Ministry of Construction of the People's Republic of China.

Ministry of Construction of the People's Republic of China

October 23, 2007

Foreword

This code was revised from GB 50217—1994 *Code for Design of Cables of Electric Engineering*, by Southwest Electric Power Design Institute of China Power Engineering Consulting Group Corporation and the interests concerned in response to the *Notice on Printing and Distributing the Preparation and Revision Plan of National Standards for Engineering Construction from 2001 to 2002* (JB [2002] No. 85) issued by the Ministry of Construction.

The technical contents involved in this revision mainly include:

1. Supplementing the requirements on selection of the number of cores of MV and HV cable.
2. Supplementing the requirements on selection of cable insulation, while deleting the contents related to adhesive impregnated paper insulated cables.
3. Supplementing the requirements on selection of the permissible minimum cross-section of protective ground wire in case of a main core cross-section of $400\text{ mm}^2 < S \leq 800\text{ mm}^2$ and $S > 800\text{ mm}^2$.
4. Supplementing the requirements on the cross-section and material of cables in cases where power supply circuit of large current loads consists of multiple parallel-connected cables.
5. Supplementing the general requirements on selection of cable terminals.
6. Supplementing the contents on directly cutting and insulating the metallic layer of cables.
7. Supplementing the requirements on grounding of the metallic layer of three-core cables of AC systems.

8. Supplementing the requirements on the permissible distance between cables and conduits in urban cable systems.

9. Supplementing the requirements on arranging maintenance access of overhead cable trays.

10. Supplementing the requirements on placement interval of safety holes along cable tunnels.

11. Supplementing Appendix B and Appendix F.

Articles in bold in this code are compulsory and must be observed strictly.

This code is administered and explained by the Ministry of Construction of the People's Republic of China in respect of compulsory articles. The daily management of it is the responsibility of the Standardization Center of China Electricity Council. And Southwest Electric Power Design Institute of China Power Engineering Consulting Group Corporation is responsible for the interpretation of the specific technical issues therein. During the implementation of the code, the interests concerned are expected to seriously summarize the experiences and collect the relevant information based on the project practices and at any time refer any comments and suggestions to Southwest Electric Power Design Institute of China Power Engineering Consulting Group Corporation at the address: No.18 Dongfeng Road, Chengdu City, Sichuan Province, Postcode: 610021, for reference in the future revision of the code.

This code is drafted by Southwest Electric Power Design Institute, China Power Engineering Consulting Group. The participants in the development of this regulation also include Northeast Electric Power Design Institute, and HILTI (China) Ltd.

The leading authors of this code: Li Guorong, Xiong Tao, Zhang

GB 50217 — 2007

Tianze, Qi Chun, Tao Qin, Wan Lining, Wang Xin and Wang Conghui.

This code is translated by SUNTHER Consulting Co., Ltd.
under the authority of China Electric Power Planning & Engineering
Association.

Contents

Foreword	II
1 General	1
2 Terms and Definitions	2
3 Selection of Cable Type and Cross-section	5
3.1 Material of Cable Conductor	5
3.2 Number of Power Cable Cores	5
3.3 Cable Insulation Level	7
3.4 Type of Cable Insulation	9
3.5 Type of External Sheath of Cable	11
3.6 Control Cable and Metal Shielding	14
3.7 Cross-section of Power Cables	17
4 Selection and Configuration of Cable Accessories	25
4.1 General Provisions	25
4.2 Oil Supply Systems of Self-contained Oil-filled Cables	34
5 Cable Laying	38
5.1 General Provisions	38
5.2 Selection of Laying Mode	44
5.3 Underground Direct Burying	47
5.4 Laying of Protection Conduits	50
5.5 Cable Structures Laying	53
5.6 Cable Laying in Other Utilities	59
5.7 Underwater Cable Laying	60
6 Cable Supports and Fixings	62
6.1 General Provisions	62
6.2 Cable Supports and Trays	65

7	Fire Protection and Retardation of Cables.....	70
Appendix A	Maximum Allowable Temperature of Common Power Cable Conductor.....	77
Appendix B	Section Selection Methods for Economic Current of Power Cable Rated 10 kV and below	78
Appendix C	Allowable 100% Continuous Ampacity of Common Power Cables Rated 10 kV and below	83
Appendix D	Correction Factors of Allowable Continuous Ampacity of Cables Under Different Laying Conditions	92
Appendix E	Methods for Calculation of Allowable Minimum Cross-section of Cable Conductor Based on the Short-circuit Thermal Stability Conditions	96
Appendix F	Calculation Formula of Normal Induced Potential of Metallic Layer of Single-core Cables of AC System.....	100
Appendix G	Additional Length of Cables Rated 5 kV and Below During Laying Measurement	103
Appendix H	Calculation Methods for Maximum Allowable Length of Conduits in case of Putting Cables through Conduits.....	104
	Explanation of Wording in This Code.....	107

1 General

1.0.1 This code is prepared for the purpose of designing cables that are to be safe, reliable, technically advanced, cost effective and easily operational and maintainable.

1.0.2 This code is applicable to the selection and laying design of power cables of 500 kV or below and control cables in newly built or expanded electric projects.

1.0.3 In addition to this code, the design of cables of electric engineering shall comply with relevant national standards in force as well.

2 Terms and Definitions

2.0.1 Fire Resistance

The ability of a specimen to resist burning in fire for a certain period of time under specified test conditions while maintaining its normal operation.

2.0.2 Fire Resistant Cable

Cables characterized by fire resistance.

2.0.3 Flame Retardancy

The characteristic of a test specimen that, after being burned under the specified test conditions and following the removal of the test fire source, the flame spread is confined within the specified scope and the resulting residual flame or residual matters can extinguish by itself within a limited period of time.

2.0.4 Flame Retardant Cable

Cable characterized by flame retardancy.

2.0.5 Dry-type Cross-linked

A cross-linking process whereby the amount of water used in the production of cross-linked polyethylene insulation is significantly reduced.

2.0.6 Water Tree

A brief term to describe the phenomenon of dendritic tiny cracks occurring in the insulation layer of XLPE cables during operation.

2.0.7 Metallic-plastic Composite Water Barrier

A water barrier consisting of a composite tape surrounding cables longitudinally, which is composed of a thin metallic layer (such as aluminum or lead foil) sandwiched in plastics layers.

2.0.8 Thermal Resistance

A physical quantity defined by the thermal ohm law for the one-dimensional heat dispersion process using the thermal network analytic method to calculate the current-carrying capacity of cables.

2.0.9 Auxiliary Ground Wire

Conductor laid in parallel with HV single-core cable line and grounded at both ends to establish a circuit for induced current.

2.0.10 Direct Burying

A cable laying method where cables are laid down on cushions at the bottom of the underground trenches and covered with a overburden layer, followed by placing protection slabs and then leveling the ground.

2.0.11 Channel

A covered trough structure without brackets intended to contain small quantity of cables.

2.0.12 Manhole

A covered pit-type cable structure that can be accessible for installation of accessories such as cable joints or for pulling cables.

2.0.13 Cable Buildings

Structures including cable troughs, channels, ducts, tunnels, mezzanines, shafts and manholes exclusively intended for laying cables or installing accessories.

2.0.14 Slip Fixing

A fixing method that allows cables to experience axial angle change or slight transverse displacement at the attachment point attributable to thermal expansion and contraction of cables.

2.0.15 Rigid Fixing

A clamping fixing method by which cables will not displace as a result of thermal expansion and contraction.

2.0.16 Snaking of Cable

A cable laying method by which cables are rendered to be in the form of a snake, which contributes to decreased axial cable thermal stress and increased free expansion and contraction consistent with the requirements of quantitative parameters.

3 Selection of Cable Type and Cross-section

3.1 Material of Cable Conductor

3.1.1 The control cable shall use copper as the conductor material.

3.1.2 In the following occasions, copper-core power cables shall be applied:

1 The circuits of generator exciters, major power supplies and mobile electrical devices which need to have highly reliable connections.

2 A severe working environment where intense vibration, explosion danger, or corrosion to aluminum exists.

3 Fire resistant cables.

4 Power cables close to the high-temperature equipment.

5 When used in public facilities requiring high security; and

6 When more power cables are needed due to considerable working current.

3.1.3 The cable conductor can be of either copper or aluminum except where the relevant products use only copper conductor or where only copper conductor is allowed to be used according to Articles 3.1.1 and 3.1.2.

3.2 Number of Power Cable Cores

3.2.1 Where the neutral of power source of 1 kV or below is solidly grounded, the number of cable cores for the three-phase circuit shall be determined in accordance with the following requirements:

1 Where the protective wire is grounded by connecting with the exposed conductive parts of energized equipment, the following

requirements shall be met:

- 1) If the protective wire and the neutral line share the same conductor, four-core cables shall be used.
- 2) If the protective wire is independent of the neutral line, five-core cables should be used; however, four-core cables together with an additional protective conductor may be used provided that the requirements of Article 5.1.16 of this code are met.

2 Where the earth of exposed conductive parts of energized equipment is independent of that of the power supply system, four-core cables shall be used.

3.2.2 Where the neutral of power supplies of 1 kV or below is solidly grounded, the number of cable cores for single-phase circuits shall be selected in accordance with the following requirements:

1 Where the protective wire is grounded by connecting with the exposed conductive parts of energized equipment, the following requirements shall be met:

- 1) If the protective wire and the neutral line share the same conductor, two-core cables shall be used.
- 2) If the protective wire is independent of the neutral line, three-core cables should be used; however, two-core cables together with an additional protective conductor may be used provided that the requirements of Article 5.1.16 of this code are met.

2 Where the earth of exposed conductive parts of energized equipment is independent of that of the power supply system, two-core cables shall be used.

3.2.3 The number of cable cores for 3 kV-35 kV three-phase power supply circuits shall be selected according to the following

requirements:

1 For circuits with a large working current or cables laid underwater, three single-core cables may be used for each circuit.

2 In other cases, three-core cables of ordinary belted type shall be used, or alternatively, three single-core cables in stranded configuration may be used.

3.2.4 For 110 kV three-phase power supply circuits, three single-core cables may be used for each circuit, except for cables laid underwater in lakes or seas and with small cable cross sections, in which case three single-core cables may be used.

For three-phase power supply circuits of 110 kV or above, three single-core cables shall be used for each circuit.

3.2.5 For HV AC single-phase power supply circuits such as that for electric railways, two-core cables or two single-core cables shall be used for each circuit.

3.2.6 The number of cable cores for DC power supply circuits shall be selected according to the following requirements:

1 For LV DC power supply circuits, two-core cables should be used, and single-core cables may be used as an alternative.

2 For HV DC transmission systems, single-core should be used, and coaxial two-core cables may be used when laid underwater in lakes and seas.

3.3 Cable Insulation Level

3.3.1 The rated phase-to-phase voltage of power cable conductor in an AC system shall not be lower than the working line voltage of the circuit in which it is used.

3.3.2 The selection of the rated voltage between the power cable's core and the insulation shielding or the metal sheath in an AC system

shall comply with the following requirements:

1 In systems where neutral-point is grounded solidly or through low resistance, at least 100% of the working phase voltage of the circuit shall be used if the fault is cleared within one minute.

2 The power supply systems other than that described in Item 1 should not use the voltage less than 133% of the circuit's working phase voltage; 173% of the circuit's working phase voltage should be used when a single-phase-to-ground fault may last for more than 8 hours or high security is required in the generator circuit.

3.3.3 The withstand voltage level of cables in AC systems shall meet the requirements on insulation coordination of the system.

3.3.4 The insulation level of DC transmission cables shall be able to withstand voltage tests by application of impulse voltage superimposed on DC voltage with reversal of direction with polarity, and the XLPE cables shall be able to suppress space charge accumulation and to avoid local high field strength suitable for the operation of DC electric field.

3.3.5 The rated voltage of control cables shall be selected to be not lower than the working voltage of the circuit and meet the following requirements:

1 The rated voltage of control cables (pilot cables) laid in parallel with HV cables shall meet the requirements for this arrangement.

2 The rated voltage of control cables for HV distribution devices of 220 kV or above shall be 450/750 V.

3 In other cases, the rated voltage of control cables should be 450/750 V and may be lower if the external electrical interference is less.

3.4 Type of Cable Insulation

3.4.1 The type of cable insulation shall be selected in accordance with the following requirements:

1 The service life of cable insulation under working voltage, current and characteristic and ambient conditions shall not be less than the normally expected life.

2 The cable insulation shall be selected by considering factors including reliable operation, easy construction and maintenance and highest permissible working temperature as well as manufacturing costs.

3 The cable insulation shall meet the requirements on fire protection and ensure safety.

4 Where it is explicitly specified that the cable insulation is in harmony with environmental protection, the cable insulation used shall be environmentally friendly.

3.4.2 The type of insulation of ordinary cables shall be selected according to the following requirements:

1 The type of insulation of LV and MV cables shall be selected according to Articles 3.4.3-3.4.7 of this code. In addition, for LV cables, extruded PVC or XLPE insulation should be used, and for MV cables, XLPE insulation should be used.

Where it is explicitly specified that the cable insulation is in harmony with environmental protection, the use of polyethylene insulated cables is not allowed.

2 The insulation of cables used in HV AC systems should be of XLPE type. In areas where rich operation experiences are available, self-contained oil-filled cables may be used.

3 For HVDC transmission systems, self-contained oil-filled

cables with non-draining impregnated paper insulation may be used. Where high transmission capacity is required, the insulation should be of semi-synthetic paper type.

For DC transmission systems, ordinary XLPE cables should not be used.

3.4.3 In circuits where frequent bending occurs or requirements on high flexibility is placed, such as those of mobile electrical equipment, rubber insulated cables shall be used.

3.4.4 At locations under the action of radiation rays, cables with high radiation resistance, such as those with XLPE or EPR insulation, shall be selected according to the requirements on insulation type.

3.4.5 At 60°C or above high temperature locations, heat resistant cables with PVC, cross-linked PE or EPR insulation shall be selected based on the high temperature they experience and the duration of the high temperature as well as the requirements on insulation type; in high temperature environments of above 100°C, mineral insulated cables should be used.

At high temperature locations, ordinary polyethylene insulated cables should not be used.

3.4.6 In low temperature environment below -15°C, cables with XLPE, polyethylene or cold-resistant rubber insulation shall be selected according to the temperature they experience and the requirements on insulation type.

PVC insulated cables should not be used under low temperature.

3.4.7 In public facilities that are densely populated and at locations where cables are required to be fire retardant and low toxic, XLPE or EPR insulated cables free of halide can be used.

Where low toxic fire protection is required, PVC cables should not be used.

3.4.8 For circuits of below 6 kV, PVC insulated cables may be used unless otherwise clearly specified in Articles 3.4.5-3.4.7 of this code.

3.4.9 For major 6 kV circuits or XLPE cables of above 6 kV, the process of co-extruding the inner semi-conductive layer, outer semi-conductive layer and insulation layer together shall be adopted.

3.5 Type of External Sheath of Cable

3.5.1 The selection of the external sheath of cable shall comply with the following requirements:

1 For single-core power cables used in AC systems, if the resistance to external force of cables is required to be increased, the external sheath of nonmagnetic metal armouring rather than steel armouring not subjected to effective nonmagnetic treatment shall be used.

2 For cables used in damp or chemically corrosive environment or at places susceptible to water immersion, PE sheath shall be applied on the metallic shield, reinforcement layer as well as the armouring of cables; the thick steel wire armouring of cables used underwater shall be wrapped with extruded sheath.

3 In public facilities that are densely occupied and at locations where cables are required to be fire retardant and low toxic, external sheath of PVC or ethylene-propylene rubber free of halogen may be used.

If the low-toxic fire protection is required, the external sheath of PVC should not be used.

4 The extruded sheath of PVC may be used, except for those used in the low-temperature environment below -15°C , or the places immersed in medicinal chemical liquid or the situations where the requirements on low toxicity and flame retardancy are placed, in

which cases, extruded sheath of polyethylene should be used.

5 6 kV-35 kV important cables used in places immersed in water or chemical liquid and XLPE cables above 35 kV shall be provided with radial water-resistant configuration, such as metallic-plastic composite water barrier or metallic sheath.

The MV and HV XLPE cables laid underwater shall be structured to ensure that they are water resistant along longitudinal direction.

3.5.2 The reinforcement layer of self-contained oil-filled cables shall be of such a type that, where lines are not provided with stop joints, the elevation difference between the highest and lowest points complies with the following requirements:

- 1 If the cables are merely equipped with a reinforcement layer such as copper tape along radial direction, the permissible elevation difference shall be 40 m; while for important circuits, it should be 30 m.

- 2 If the cables are equipped with reinforcement layer such as copper tape in both radial and longitudinal directions, the permissible elevation difference shall be 80 m; but for important circuits, it should be 60 m.

3.5.3 In case of direct burial cable, the external sheath shall be selected according to the following requirements:

- 1 Where cables carry a large pressure or are exposed to mechanical damage risk, reinforcement layer or steel tape armouring shall be used.

- 2 When buried in drift sand layer or backfilled zone with a likelihood of displacement, the cables shall be provided with steel wire armouring.

- 3 For extruded cables used in areas exposed to serious termite

damage, the external sheath with a large hardness shall be used; alternatively, it is allowed that a thin layer of large-hardness sheath of nylon or special poly olefin copolymer is wrapped onto ordinary sheath. Alternatively, the cables may be armored with a metallic sheath or steel band.

4 For the cables buried in the areas where the underground water level is high, polyethylene sheath shall be used.

5 Except for the situations described above, armouring absent sheath may be used.

3.5.4 In the case cable fixed in the air, the external sheath of cables shall be selected in accordance with the following requirement:

1 If cross-section extruded insulated cables are directly laid on arm-type brackets, they should be armored with steel tape.

2 At locations requiring high safety but being severely endangered by rodents, such as underground passenger transportation stations and commercial facilities, plastic insulated cables shall be provided with metallic band or steel band armouring.

3 Where forces are exerted on cables due to a large elevation difference, multi-core cables shall be provided with steel wire armouring; AC single-core cables shall comply with Clause 1 of Article 3.5.1 of this code.

4 For cables laid on cable trays thus being densely supported, cable armouring may be eliminated.

5 Where it is explicitly specified that the external sheath of cables is in harmony with environmental protection, the use of PVC sheath is not allowed.

6 In addition to Clauses 3 and 4 of Article 3.5.1 and Clause 5 of this Article, the heat resistant sheath of polyethylene shall be used for cables used in 60°C or above high-temperature locations. In other

cases, the sheath of PVC should be used.

3.5.5 For cables used in the circuits where frequent bending occurs or the requirements on high flexibility is placed, such as those used in mobile electrical equipment, rubber sheath shall be used.

3.5.6 For cables used at locations under the action of radiation rays, the sheath highly resistant to radiation, such as those of PVC, chlorine butyl rubber, or chlorosulfonated polyethylene shall be used.

3.5.7 The cables laid in protective tubes shall be provided with extruded sheath.

3.5.8 The sheath of cables laid underwater shall be selected according to the following regulations:

1 For cables laid in channels and rivers not open to navigation where it is not required for the armouring layer to carry any tension, steel tape armouring may be used.

2 For cables laid underwater in lakes and seas, the selected steel wire armouring shall meet the stress conditions. Where the laying conditions necessitates the measures against mechanical damage, the sheath of increased safety and corrosion resistance shall be used.

3.5.9 When the cable routes pass through various laying conditions, the selection of sheath shall meet the following requirements:

1 If the total line length does not exceed the manufacturing cable length, only one type of sheath or more types that do not vary greatly should be used across the line.

2 If the total length of line exceeds the manufacturing length of cable, suitable types of sheath may be used for the corresponding sections respectively.

3.6 Control Cable and Metal Shielding

3.6.1 Two systems requiring increased reliability that provide dual

protection for current, voltage, DC power supply and trip control circuit shall employ independent control cables.

3.6.2 The circuits described below shall not share the same control cable:

- 1 Weak current signal, control circuit and heavy current signal, control circuit.

- 2 Low and high level signal circuits.

- 3 Weak current control circuit of each phase of AC phase segregated breaker.

3.6.3 Each pair of bi-directional conductors of weak current circuit shall belong to the same control cable.

3.6.4 The phase and neutral lines of each secondary winding of current transformer and voltage transformer shall be arranged in the same cable.

3.6.5 For control cables of heavy current circuits, except for those located at HV switchgear or run parallel with and close to HV cables for a long distance thus requiring disturbance suppression, they may be free from metallic shielding.

3.6.6 The control cables of weak current signal and control circuit should be provided with a metallic shielding when they are routed in an environment affected by interference and no effective anti-interference measures are available.

3.6.7 The metallic shielding of control cables shall be selected based on potential electrical interference together with the comprehensive interference suppression measures and shall be able to satisfy the requirements in terms of reducing interference or overvoltage. In addition, the following requirements shall be met:

- 1 The weak current control cables of the switchgear rated above 110 kV should employ overall shielding or double-layer

overall shielding.

2 The control cables intended for current, voltage and signal circuits of integrated circuit and microprocessor-based protection shall be of shielded type.

3 The shielding of control cables of signal circuit of computer monitoring & control system shall be selected in accordance with the following requirements:

- 1) The overall shielding may be used for binary signal.
- 2) For high-level analogue signals, twisted core pairs should use overall shielding; if necessary, twisted core pairs may use separate shielding instead.
- 3) For low-level analogue signals or pulse signals, twisted core pairs should employ separate shielding; if necessary, twisted core pairs may use separate shielding plus overall shielding.

4 In other cases, the type of shielding shall be properly selected considering the influential factors such as electromagnetic induction, electrostatic induction as well as earth potential rise.

5 If cables are provided with steel armouring and metallic sheath, shielding function.

3.6.8 For control cables requiring decreased electrical interference, a grounded standby core may be added, which shall be grounded at one point at the control room side.

3.6.9 Grounding mode for metallic shielding of control cables shall comply with the following requirements:

1 The shielding layer of control cables of analogue signal circuits of computer monitoring & control system shall be grounded at one point centrally, and grounding via two or more than two points shall not be used.

2 The shielding layer of current, voltage and signal cables of integrated circuit and microprocessor-based protection shall be grounded at both switch installation location and control room.

3 The shielding layer of control cables other than those described in the foregoing should be grounded at two points if the interference caused by electromagnetic induction is strong and at a single point if the interference caused by electrostatic induction is strong.

For double-layer shielding or overall composite shielding, the internal and external shielding should be grounded respectively via one point and two points.

4 The selection of two-point grounding of the shielding should ensure that the shielding layer will not melt when transient current flows through it.

3.6.10 The cross-section of conductors of strong and weak current control circuits shall not be smaller than 1.5 mm^2 and 0.5 mm^2 respectively.

3.7 Cross-section of Power Cables

3.7.1 The cross-section of conductor of power cable shall be selected in accordance with the following requirements:

1 Under the effects of the maximum working current, the temperature of cable conductor shall not be higher than the permissible limit corresponding to the service life of cable. The working temperature of cable conductor of continuous working circuit shall be in compliance with Appendix A of this code.

2 Under the effects of the maximum short-circuit current and time, the temperature of cable conductor shall be in compliance with Appendix A of this code.

3 Under the effects of the maximum working current, the voltage drop across the connecting circuit must not exceed the permissible limit of the circuit.

4 In addition to the requirements in Clauses 1-3, the cross section of power cable of 10 kV and below should be selected comprehensively considering the initial investment and the operating costs during the service life of cables. The economical current cross-section of power cable of 10 kV and below should be selected in accordance with Appendix B of this code.

5 For copper and aluminum conductors of multi-core power cables, the minimum cross-section should not be less than 2.5 mm^2 and 4 mm^2 respectively.

6 For cables laid underwater, if the conductor is required to carry a reasonable tension, the cross-section thereof may be selected according to the requirements in terms of tension resistance.

3.7.2 The minimum permissible cross-section of conductors for commonly-used cables of 10 kV and below shall be determined based on 100% of continuous working current and should comply with the regulations in Appendix C and D. By applying a correction factor due to the difference in operating conditions stated below, the actual permissible limit of cable ampacity shall be greater than the working current of the circuit.

1 Ambient temperature difference.

2 Difference of thermal resistance coefficient of soil in case of direct burying.

3 Mutual effects between multiple cables when routed in parallel; and

4 Impact of solar radiation on cables when routed overhead indoors without sun-shading measures.

3.7.3 Except for the conditions specified in Article 3.7.2 of this code, when determining the minimum permissible cross-section of cable conductor based on 100% continuous working current, the minimum cross-section shall be verified through calculation or test, and the calculation or parameter selection shall be in compliance with the following requirements:

1 For cables of power supply circuit containing high-order harmonic loads or non-coaxial cables for circuit with medium frequency loads, the impact of additional heating caused by increased skin and proximity effects shall be taken into account.

2 For HV single-core cables grounded in cross connection mode, if the three cable sections in a unit system are not equally long, the impact of additional heating resulting from metallic layer loss shall be taken into account.

3 For cables laid in protection tubes, the impact of thermal resistance shall be considered; for cables routed through different holes of cable duct bank, the impact of mutual heating of cables shall be considered respectively.

4 For cables laid in enclosed, semi-enclosed or permeable fire-proof cable trays, the effect of material, thickness and dimensions of the trays on increased thermal resistance shall be taken into account.

5 If the cable covering layer, such as fire protection coating and tapes, has a thickness of more than 1.5 mm, its contribution to thermal resistance shall be considered.

6 If the cable trench is filled with sand and no moisture is frequently added therein, the effects on increased cable thermal resistance shall be considered assuming a thermal resistance coefficient of above $2.0 \text{ K}\cdot\text{m}/\text{W}$ depending upon the sand conditions.

3.7.4 For cables where the working temperature of conductor is higher than 70°C , the permissible continuous ampacity shall be calculated in accordance with the following requirements:

1 Where a number of such cables are laid in tunnels and shafts not mechanically ventilated, the effects on ambient temperature rise shall be taken into account.

2 Where cables are directly buried in dry or damp soil, the thermal resistance coefficient of soil should not be less than $2.0\text{ K}\cdot\text{m}/\text{W}$, except for the situation where soil is replaced to prevent migration of moisture.

3.7.5 The ambient temperature corresponding to continuous permissible cable ampacity shall be determined according to the average climatic temperature over years in the area where the cables are routed and shall comply with the regulations in Table 3.7.5.

**Table 3.7.5 Ambient Temperature of Continuous
Permissible Ampacity of Cable ($^{\circ}\text{C}$)**

Cable Laying Place	Mechanical Ventilation Equipped	Ambient Temperature Selected
Direct burying in soil		Average ground temperature of the hottest month of the location where the cable is buried
Underwater		Average of daily maximum water temperature of the hottest month
Outdoor air and cable trench		Average of daily maximum temperature of the hottest month
Buildings with heat source equipment	Yes	Design ventilation temperature
	No	Average of daily maximum temperature of the hottest month plus 5°C

Table 3.7.5 (continued)

Cable Laying Place	Mechanical Ventilation Equipped	Ambient Temperature Selected
Common building and indoor	Yes	Design ventilation temperature
	No	Average of daily maximum temperature of the hottest month
Indoor cable trenches	No	Average of daily maximum temperature of the hottest month plus 5°C *
Tunnel	Yes	Design ventilation temperature
Note: If the item marked with an asterisk(*) is among the conditions described in Clause 1 of Article 3.7.4 of this code, the method of adding only 5°C is not applicable.		

3.7.6 The cross-section of conductor of cables running through sections with varying heat dissipation conditions shall be selected in accordance with the following requirements:

1 If the total length of the circuit does not exceed the manufacturing length of cable, the following requirements shall be complied with:

- 1) For major circuits, the cross-section selected for the section with poor heat dissipation condition should be determined to be applicable to the whole length.
- 2) For non-important circuit, the cross-section can be selected respectively for each section longer than 10 m according to the relevant heat dissipation conditions. The number of cross-sections for each circuit should not be more than three.
- 3) If the cross-section is required to be increased for

underwater cables in response to the mechanical strength requirements, the same cross-section may be used for the circuit over the total length.

2 If the total length of a circuit exceeds the manufacture length of cable, the cross-section of cable conductor should be selected on section basis.

3.7.7 For non-fused circuit, the minimum permissible cross-section of cable conductor shall be determined based on short-circuit thermal stability conditions and shall be calculated in accordance with Appendix E of this code.

3.7.8 The short-circuit calculation conditions shall be selected in accordance with the following requirements:

1 System connection used for calculation shall be in compliance with the normal operation mode and should be planned based on 5-10 years' development plan after the completion of the project.

2 The selected short-circuit point shall be the place where the maximum short-circuit current possibly flows through the cable circuit.

3 The calculation should be carried out under three-phase short-circuits condition.

4 The duration of short-circuit current shall be the protection action time plus the circuit breaker's breaking time. For direct feeder used for motor, the main protection time shall be taken; in other cases, the standby protection time should be taken.

3.7.9 If the neutral of power supply of 1 kV and below is solidly grounded, the cross-section of neutral line of cables for three-phase four-wire system shall not be smaller than the minimum cross-section needed by the continuous operation under the maximum line imbalanced current; for circuits affected by harmonic current, the

following requirements should be complied with:

1 For circuits where gas discharge lamps are the main loads, the cross-section of neutral line should not be smaller than that of phase core wire.

2 Except for the above conditions, the cross-section of neutral line should not be smaller than 50% of that of phase core wire.

3.7.10 If the neutral of power supply of 1 kV and below is solidly grounded, the cross-section of cable conductor with protective ground wire and neutral line or protective ground neutral line system shall be selected according to the following regulations:

1 The cross-section of neutral line and protective grounding neutral line shall comply with Article 3.7.9 of this code; if single-core cable is used as protective ground neutral line for main power distribution line, the cross-section shall comply with the following requirements:

- 1) Copper conductor, not smaller than 10 mm^2 .
- 2) Aluminum conductor, not smaller than 16 mm^2 .

2 The cross-section of protective ground wire shall satisfy the requirements of circuit protection electrical appliance on reliable operation and shall comply with the provisions stated in Table 3.7.10.

Table 3.7.10 Permissible Minimum Cross-section of Protective Ground Wire Required Based on Thermal Stability (mm^2)

Cross-section of Phase Core Conductor of Cable	Minimum Permissible Cross-section of Protection Ground Wire
$S \leq 16$	S
$16 < S \leq 35$	16
$35 < S \leq 400$	$S/2$
$400 < S \leq 800$	200
$S > 800$	$S/4$

3 For trunk line consisting of multi-core cables, the cross-section of conductor acting as both neutral line and protective ground wire shall not be smaller than 4 mm^2 .

3.7.11 If the AC power supply circuit consists of multiple parallel-connected cables, each cable should have the same length and shall employ conductors of the same material and cross-section. In case of cables provided with metallic sheath, the metal material and structure cross-section thereof shall be the same as well.

3.7.12 The effective cross-section of metallic shielding of power cables shall ensure that the temperature rise of the metallic shielding as a result of potential short-circuit current will not exceed the average permissible short-circuit maximum temperature of insulation and external sheath.

4 Selection and Configuration of Cable Accessories

4.1 General Provisions

4.1.1 The types of cable terminals shall be selected according to the following regulations:

1 Where cables are directly connected to SF₆ enclosed composite apparatus, enclosed GIS terminals shall be used.

2 Where cables are directly connected to HV transformers, trunk-type terminals shall be used.

3 Where cables are connected to electrical apparatus and provided with integrated plug-in feature, detachable (plug-in) terminals shall be used.

4 Except for the above, where cables are connected to other electrical apparatus or conductors, open-type terminals shall be used.

4.1.2 The construction of cable terminals shall be determined considering such factors as reliability requirements, easy installation and maintenance and cost effectiveness, and the following requirements shall be satisfied:

1 The terminals connected to oil-filled cables shall be able to withstand the maximum working oil pressure.

2 For terminals connected to SF₆ enclosed composite apparatus, their interfaces shall match with each other; GIS terminals shall have a structure completely isolated from SF₆ gas.

3 For cable terminals used in combustible and explosive locations where the use of flame source is prohibited, they shall be

structured to avoid open flame operation.

4 The terminals selected for XLPE cables rated 220 kV and above shall pass the standard qualification test designed for the assembly of the terminals and cables.

5 Cable terminals used in rainy areas polluted or with heavy salt fog should be provided with silicon rubber or composite bushings.

6 Outdoor terminals for XLPE cables rated 66 kV-110 kV should be full-dry type prefabricated terminals.

4.1.3 The insulation characteristics of cable terminals shall comply with the following regulations:

1 The rated voltage and insulation level of terminals shall not be lower than the rated voltage and required insulation level of cables to which they are connected.

2 External insulation of terminals must accommodate the requirements of the specific creepage distance required by the elevation and polluted environmental conditions prevailing at locations where it is applied.

4.1.4 The mechanical strength of cable terminals shall be able to withstand the pulling tension of leads, wind force and seismic force at their installation locations.

4.1.5 The cable joints shall be selected according to the following requirements:

1 Where the elevation difference of self-contained oil-filled cable lines exceeds the regulations specified in Article 3.5.2 of this code and the oil passages need to be separated, stop joints shall be used.

2 Where the distance of cable line exceeds the manufacturing length of cables, straight-through joints shall be used except for the

situations described in Clause 3 of this Article.

3 At the cross connection grounding points of metallic shields of long single-core cable lines, insulated joints shall be used except for the situations where the metallic shields may be effectively broken and insulated.

4 At locations where cable branches are led out, T-type joints shall be used, except for trunk cables with branches or the situations where branch boxes and ring main cubicles are provided for cable networks.

5 At locations where three-core cables are directly connected to single-core cables, transition joints shall be used.

6 At locations where extruded plastic insulated cables are connected to self-contained oil-filled cables, transition joints shall be used.

4.1.6 The construction type of cable joints shall be selected by comprehensively taking into account the factors such as the project reliability requirements, easy installation and maintenance and cost effectiveness and the following requirements shall be satisfied:

1 The joints of submarine cables or other underwater cables shall maintain the longitudinal continuity of steel armoured layers and have sufficient mechanical strength. Flexible splices should be used.

2 At installation locations susceptible to water immersion, the joints of XLPE cables rated 6 kV and above shall be provided with an outer waterproof layer.

3 At locations where the use of flame source is prohibited, heat shrinkable cable joints should not be used.

4 For the joints selected for XLPE cables rated 220 kV and above, they shall be subject to standard tests when connected to the cables as a whole.

5 The 66 kV-110 kV XLPE cable lines on which high reliability requirements are placed should not use taped joints.

4.1.7 The insulation characteristics of cable joints shall conform to the following requirements:

1 The rated voltage and insulation level of joints shall not be lower than the rated voltage and the required insulation level of cables to which they are connected.

2 The withstand voltage across insulation rings of insulated joints shall not be lower than twice the insulation level of cable sheaths to which they are connected.

4.1.8 The layout of cable terminals and joints shall satisfy the requirements of space for installation maintenance, as well as the requirements of arrangement for expansion joints with the permissible radius of cables, and shall also comply with the following provisions:

1 Terminal supports shall be formed to facilitate the installation of cables and components thereof; where the operating current is greater than 1500 A, the supports should be so constructed that additional heating measures are made available to prevent the closure of transverse magnetic circuits.

2 In areas where neighboring electrified transportation lines have erosive effects on the metallic shields of cables, joints should be provided in a manner that facilitates supervision and maintenance of them.

4.1.9 The metallic shields of power cables must be directly grounded. The metallic shields of three-core cables in AC systems shall be grounded at both terminals and joints of cables.

4.1.10 The normal induced potential at any non-directly grounded point on the metallic shields of AC single-core power cables should

be calculated in accordance with the regulations in Appendix F of this Code. The maximum induced potential of cable lines shall comply with the following requirements:

1 It shall not be larger than 50 V if no effective safety protection is take into account to avoid any touch with the metallic shields.

2 Besides Item 1, it shall not be larger than 300 V.

4.1.11 Grounding modes for metallic shields of AC single-core power cables shall be selected according to the following requirements:

1 Where cable lines are not so long and the requirements specified in Article 4.1.10 can be satisfied, single point direct grounding at one end or at the midpoint of lines shall be used (Refer to Fig. 4.1.11-1).

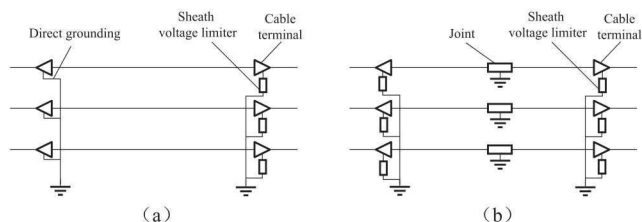


Fig. 4.1.11-1 Single Point direct Grounding at One End or in the Middle of Lines

(a) Single point direct grounding at one end of lines;

(b) Single point direct grounding in the middle of lines

Note: Sheath voltage limiters are applicable to be installed for cables rated 35 kV and above; they may be provided for 35 kV cables if necessary and are not required for 35 kV and below cables.

2 For underwater cables, cables rated 35 kV and below and cables rated 35 kV and above with small transmission capacity, where cable lines are rather long and the single point direct grounding mode cannot meet the requirements specified in Article 4.1.10, direct

grounding at both ends of lines can be used (Refer to Fig. 4.1.11-2).

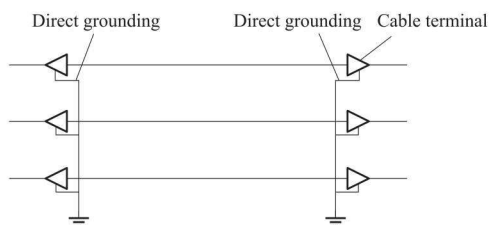


Fig. 4.1.11-2 Direct Grounding at Both Ends of Lines

3 Except for the lines described above, long lines should be divided into appropriate number of units each containing three sections with the same length as practical as possible. The cable lines shall be provided with insulated joints or insulated separation of metallic shields and shall be grounded in a cross connection mode (Refer to Fig. 4.1.11-3).

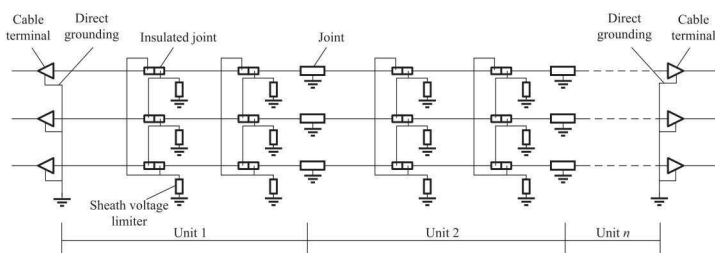


Fig. 4.1.11-3 Cross Connection Grounding

Note: The exemplary sheath voltage limiters are configured in Y_0 wiring.

4.1.12 At external sheath insulation of single-core power cables and their accessories of AC systems, overvoltage protection shall be provided and the following requirements shall be satisfied:

1 If the voltage withstand level of external sheaths of single-core power cables rated 35 kV and above, insulating cylinders of

straight GIS terminals of cables and that at location where metallic shield insulation of insulating joints is separated is lower than the possible transient overvoltage, protective measures shall be taken, and the following requirements should be observed:

- 1) For cable lines directly grounded at a single point, sheath voltage limiters shall be provided at the ends of electrical passages of their metallic shields.
- 2) For cable lines employing cross connection grounding mode, sheath voltage limiters shall be provided at each insulated joint. Where line terminals are not directly grounded, sheath voltage limiters shall be provided at the terminals.
- 3) Sheath voltage limiters or capacitors should be installed across the insulating cylinders of GIS terminals.

2 Where metallic shields of 35 kV single-core power cables use single point direct grounding, and there are requirements to strengthen the insulating protection for sheath insulation, sheath voltage limiters may be installed at the ungrounded terminals of lines.

4.1.13 The parameters for sheath voltage limiters shall be selected according to the following requirements:

1 The residual voltage of sheath voltage limiters as a result of the effects of possible maximum surge current shall not be greater than the value of withstand voltage of cable sheaths divided by 1.4.

2 Sheath voltage limiters shall be able to withstand the maximum power frequency induced overvoltage due to system short circuiting within the possible longest fault clearance time which is considered to be five seconds.

3 Sheath voltage limiters shall not be damaged after the occurrence of the possible maximum surge current accumulates up to

20 times.

4.1.14 The installation and connection of sheath voltage limiters shall observe the following requirements:

1 The installation mode of sheath voltage limiters shall be determined by comprehensively taking into account the effect of transient overvoltage suppression, matching of parameters under power frequency induced overvoltage and easy supervision and maintenance. Also, the following requirements shall be satisfied:

- 1) Sheath voltage limiters at insulated joints of cross connection lines may be installed and connected by means of three-phase wiring modes such as bridge ungrounded delta connection and Y_0 connection or bridge grounded connection.
- 2) For ungrounded cable terminals of cross connection lines and cable lines grounded at single point, sheath voltage limiters should be installed in Y_0 wiring mode.

2 The circuits of sheath voltage limiters shall observe the following regulations:

- 1) The connection wires are required to be as short as possible, and their cross-sections shall satisfy the requirements for thermal stability when the system maximum transient current passes through.
- 2) The insulation characteristics of insulated conductors, disconnecting knife switches or other devices that connect with the circuits shall not be less than the insulation level of cable external sheaths.
- 3) The material and protection class of grounding boxes of sheath voltage limiters shall satisfy the requirements of the operating environment thereof.

4.1.15 Where metallic shields of single-core cables rated 110 kV and above in AC systems use single point direct grounding mode, auxiliary ground wires shall be run in parallel with and close to cables under any of the following conditions:

- 1 The power frequency induced voltage occurring at metallic shields of cables as a result of system short-circuiting exceeds the withstand strength of insulation of cable sheath or the power frequency withstand voltage of sheath voltage limiters.

- 2 The electrical interference of weak power lines in the vicinity of cables needs to be suppressed.

4.1.16 The selection and installation of auxiliary ground wires shall comply with the following requirements:

- 1 The impedance of auxiliary ground wires and earthing resistance at both ends thereof shall be able to suppress the power frequency induced overvoltage of metallic shields of cables, and the cross section of the auxiliary ground wires shall satisfy the thermal stability requirements under the maximum transient current.

- 2 Auxiliary ground wires shall be arranged to ensure the minimum loss during cable operation.

- 3 Where any terminals of cable lines are installed in power plants or substations, auxiliary ground wires shall be connected to the grounding network where the neutral line of power sources is grounded.

4.1.17 Temperature measuring devices should be provided for important circuits and HV cable lines with probably overheated portions.

4.1.18 Where metallic shields of important AC single-core HV cables apply single point direct grounding or cross connection grounding, these cable lines should be provided with monitoring

devices for sheath insulation.

4.2 Oil Supply Systems of Self-contained Oil-filled Cables

4.2.1 Self-contained oil-filled cables must be provided with oil supply devices, which shall be selected to ensure that the variation of working oil pressure of cables complies with the following regulations:

1 Under no-load condition at the lowest temperature in winters, the oil pressure at the highest position of cable lines shall not be less than the permissible minimum working oil pressure.

2 Under full load condition at the highest temperature in summers, the oil pressure at the lowest position of cable lines shall not be greater than the permissible maximum working oil pressure.

3 Where the load rises abruptly to the rated full load at the highest temperature in summers, the oil pressure at the lowest position of cable lines or at the midpoint of oil supply device section should not be greater than the allowable maximum transient oil pressure.

4 Where the full load is abruptly removed at the lowest temperature in winters, the oil pressure at the highest position of cable lines or at the midpoint of oil supply device section shall not be less than the allowable minimum working oil pressure.

4.2.2 The allowable minimum working oil pressure of self-contained oil-filled cables must be able to maintain the electrical performance of cables; the allowable maximum working and transient oil pressure shall accommodate the ability of cables to withstand mechanical strength while observing the following requirements:

1 The allowable minimum working oil pressure shall not be less than 0.02 MPa.

2 For cables reinforced radially with lead sheaths and copper tapes, the allowable maximum working oil pressure shall not be greater than 0.4 MPa, when used in important circuits, it should not be greater than 0.3 MPa.

3 For cables reinforced radially and longitudinally with lead sheaths and copper tapes, the allowable maximum working oil pressure shall not be greater than 0.8 MPa, when used in important circuits, it should not be greater than 0.6 MPa.

4 The allowable maximum transient oil pressure can be 1.5 times the allowable maximum working oil pressure.

4.2.3 Oil supply devices shall be selected to ensure that the potential oil supply flow is greater than that required by cables and the following requirements shall be met:

1 Pressure oil tanks may serve as oil supply devices. The potential oil supply flow of pressure oil tanks should be determined based on the maximum oil pressure variation range under possible cable operating conditions, such as full load at high temperature in summer and no load at low temperature in winter.

2 The oil supply flow required by cables shall consider the overall oil supply flow variation of cable lines and their accessories caused by changes in load current and ambient temperature.

3 40% margins should be considered for the oil supply of oil supply devices.

4 When oil supply of cable lines is performed at one end thereof and only one working oil supply tank is provided for each phase, a standby oil supply tank shall be provided in case of important circuits; and the standby oil supply tank may be eliminated when two or more working oil supply tanks are equipped for each phase.

4.2.4 The installation of oil supply tanks shall conform to the following regulations:

- 1 They should be separately installed on phase basis.
- 2 If oil supply is performed at one end and there is a great elevation difference between two ends of cable lines, the oil supply tanks should be installed at the higher ends.
- 3 Where the length of cable lines is large and the oil supply is performed at one end, resulting in the inability of the oil supply tanks to meet the permissible transient oil pressure requirements, they may be installed at both ends of cable lines or at both ends of oil passage sections.

4.2.5 Oil supply systems and their arrangement shall allow for short pipelines and compact arrangement of components, and the following regulations shall be observed:

- 1 Where several oil supply tanks are provided on phase basis, they shall be connected in parallel.
- 2 The oil supply pipes shall not have a diameter less than that of cable oil passages and should be copper pipes with plastic or rubber insulating jackets.
- 3 Oil supply pipes shall run through a length of oil resistant insulated pipe with insulation strength not less than that of cable sheath before being connected to terminals or stop joints.
- 4 In places where uneven settlement or displacement of soil may occur, the foundation of oil supply tanks shall be integral with that of terminals.
- 5 Outdoor oil supply tanks should be provided with sun-shading measures. If the ambient temperature is lower than the permissible minimum working temperature of oil supply tanks, heating or other improving measures shall be taken.

4.2.6 Oil supply systems shall be equipped with monitoring devices on phase basis to alarm excessively low and high oil pressure (exceeding the specified limits) and ensure that oil pressure accident alarm signals are transmitted reliably to operation duty offices.

5 Cable Laying

5.1 General Provisions

5.1.1 Cables shall be routed so as to:

1 Avoid hazards to cables such as external mechanical forces, excessive heat and corrosion.

2 Ensure that the routing of cables is reduced to the minimum on the premise of satisfying the safety requirements.

3 Ease laying and maintenance.

4 Be kept clear of sites to be excavated for construction as practical as possible; and

5 Ensure reasonable arrangement of oil supply devices where oil-filled cable lines run through undulant terrain.

5.1.2 Under any laying modes, the change in location of cables from side to side and from top downwards along all the routes shall meet the requirements of permissible bending radius of the cables.

The permissible bending radius of cables shall meet the requirements of the insulation and structure characteristics of the cables. The permissible bending radius of self-contained lead-sheathed oil-filled cables may be determined to be 20 times the outside diameter.

5.1.3 Where a large number of cables are laid on multi-layer brackets at the same side in the same raceway, the following requirements shall be met:

1 The laying order of cables from top downwards is: power cables (those of the highest voltage level at the highest point), strong current control and signal cables, weak current control and signal

cables and communication cables.

Where there are HV cables rated above 35 kV in a horizontal raceway, or in order to ensure that cables led into cabinets and panels can meet the permissible bending radius requirements, the cables should be laid in an order from bottom to top.

Where cable raceways are in the same project or extended across different projects, the laying order of cables shall be identical.

2 Where the number of layers of cable brackets is confined by access space, power cables of neighboring voltage levels below 35 kV may be arranged on the same layer of brackets; power cables of 1 kV and below may share the same layer of brackets with strong current control and signal cables.

3 Where working and standby cables in the same major circuit are segregated for the purpose of fire proof, they shall be arranged on different layers of brackets.

5.1.4 The arrangement of cables on the same layer of brackets should comply with the following regulations:

1 Control and signal cables may be arranged side by side or stacked in multiple layers.

2 Except that single-core power cables laid in the same circuit of AC systems may be arranged in the form of trefoil, multiple power cables in the same major circuit should not be stacked together.

3 Except for single-core power cables of AC systems, two neighboring cables should be spaced from each other by a cable outside diameter.

5.1.5 The phase sequence configuration and phase-to-phase distance of single-core power cables of AC systems shall ensure that the normal induced voltage of cable metallic sheath will not exceed the permissible value, and should be determined according to the

principle of selecting small cross-section cables based on continuous working current.

Where no less than two circuits of single-core power cables arranged in forms other than trefoil are placed in the same raceway, mutual influence shall be taken into account.

5.1.6 Where single-core power cables of AC systems are close to common communication lines, the cable routing justified technically and economically should be selected, and the following measures can be taken to suppress induced potential when necessary:

1 Cause cable brackets to form an electrical path and allow for other effects of parallel cable in terms of interference suppression.

2 Interconnect reinforced concrete structures of cable tunnels by welding reinforced bars mesh.

3 Properly add parallel metallic shield wires or enclosures along cable routes.

5.1.7 Exposed cables laid should not be placed above the top of thermal piping in parallel therewith. Where no separation plate is placed between cables and piping, the permissible distance between them shall comply with Table 5.1.7, except that the cables and piping routed at urban public places shall observe the current national standard GB50289, *Code of Comprehensive Planning of Urban Engineering Pipeline*.

Table 5.1.7 Permissible Distance between Cables and Piping without Separator Plate Protection (mm)

Routing of Cable and Piping		Power Cable	Control and Signal Cable
Thermal pipe	Parallel	1000	500
	Crossing	500	250
Other piping	Parallel	150	100

5.1.8 In addition to Articles 3.6.6-3.6.9 of this code, the measures described below shall be taken to suppress electrical interference for control and signal cables of weak current circuits:

1 When being laid in parallel with power cables, they should be spaced from the latter as practical as possible, let alone high-voltage and large-current power cables.

2 Control and signal cables laid in switchgear should be spaced from earthing points of coupling condenser or capacitor voltage transformer and lightning arrester or rod as practical as possible.

3 Metallic shielding wires may be laid in parallel with control and signal cables, alternatively, the cables may be laid in steel pipes or cases.

5.1.9 It is permitted that thermal piping are laid in closed cable raceways, such as tunnel, trough, channel, shaft and mezzanine, through which piping delivering inflammable gas or liquid are prohibited to run.

5.1.10 Where cables are laid at places exposed to dangerous explosive gases, the following regulations shall be observed:

1 Ensure that cables are kept far away from explosion sources as practical as possible and laid at places with less explosion hazard, and shall observe the following regulations:

- 1) Where inflammable gas is heavier than air, cables shall be buried underground or laid overhead at elevated level, and non-armored cables shall run through conduits or be placed in trays and boxes for the purpose of mechanical protection.
- 2) When inflammable gas is lighter than air, cables shall be laid in ducts and troughs at a lower elevation, and

non-armored cables laid in troughs shall be covered with sand.

2 Where cables are laid in air in parallel with inflammable gas delivering piping, cables shall be arranged at the side of piping that is less dangerous and the following regulations shall be observed:

- 1) When inflammable gas is heavier than air, cables should be arranged above the piping.
- 2) When inflammable gas is lighter than air, cables should be arranged below the piping.

3 The holes made on walls and plates between different areas through which cables and the associated ducts and troughs penetrate shall be tightly blocked with incombustible materials.

4 There shall be no joints in cable lines; where joints have to be used, they must be explosion-proof.

5.1.11 Cables must be protected with conduits or housings with specified mechanical strength when used in the following locations:

1 Within 2 m above the ground and 0.3 m below the ground of areas where electrical personnel do not perform activities frequently.

2 Areas where heavy equipment may travel above cables.

5.1.12 Where cables not for the purpose of outdoor use (except for overhead insulated cables) are routed outdoors, they should be provided with housings and covers to shade sunlight.

5.1.13 Where cables are laid at places subject to periodic vibration, the following measures shall be taken:

1 Cushions made of elastic materials, such as rubber, shall be provided at the places supporting cables.

2 Cables shall be laid in a wavy way, with expansion joints being reserved.

5.1.14 On the ground, dam, bridge surface, road of underground

commercial facilities or in the tunnels accessible by people, cables shall not be laid on ground or staircase passage in open air.

5.1.15 Open laying of cables is strictly forbidden in air ducts of plants and buildings, mechanical lifting type inclined shaft ventilating tunnels mechanically lifted (except for those accessible by conveyors) in coal mines or shafts disposed with wooden brackets.

5.1.16 In systems of above 1 kV where power supply is solidly earthed and separate neutral wire and protection ground wire independent of each other are provided, if the protection ground wire is independent from the phase core wire and neutral wire, the two cables in the same circuit shall be routed in accordance with the following regulations:

- 1 In explosive gas environment, they shall be laid in the same structural pipe, trench or box along the same route.

- 2 Except for the above cases, the cables should be laid along the same route in the same structure.

5.1.17 The calculated length of cables shall include actual routing length and additional length. For the additional length, the following factors should be taken into account:

- 1 Altitude difference change of terrain along cable laying route, reserved length for expansion joints or bypass spare margin.

- 2 Increased length due to snaking of cables rated 35 kV and above.

- 3 Reserved cable length to be peeled for making terminal or connector, and length required for leading cable to equipment or devices. The additional length for cables rated 35 kV and below shall be in accordance with Appendix G to this code.

5.1.18 The order length of cables shall be in compliance with the following regulations:

1 For long-distance cable lines, the calculated length should be used as the order length.

For single-core cables rated above 35 kV, the order length shall be calculated on phase basis; in cases where cable lines are connected by sections, such as by using cross connection method, the order length shall be listed by sections.

2 For short-distance cables rated 35 kV and below, bearing in mind that the residual cables resulting from cutting a complete reel of cables can not be used, the order length of the cables of the same type and specifications should be taken to be the calculated length plus 5%-10% margin.

3 The length of each reel of cables laid underwater should not be less than the length of cable section to be laid underwater. If it is impracticable, flexible connectors fabricated may be used.

5.2 Selection of Laying Mode

5.2.1 Laying modes of cables shall be selected according to engineering conditions, environmental characteristics and cable type and quantity, ensuring reliable operation, easy maintenance as well as technical and economic viability.

5.2.2 If direct burying method of cables is selected, the following regulations shall be observed:

1 If fewer than six power cables of 35 kV and below are arranged in the same raceway and run from power plant area to remote auxiliary facilities or sections in suburbs where excavation is seldom carried out, direct burying mode should be used; where such cables run under street pavements in downtown areas where excavation and repair is readily conducted or run along road edges, direct burying mode may be adopted as well.

2 Direct burying mode should not be used at sections where underground pipe networks are dense or at places with a potential of leakage of fused metal and high-temperature liquid or at places susceptible to frequent excavation for development.

3 Cables shall not be buried directly in soils subjected to chemical corrosion or stray current corrosion.

5.2.3 In selecting a method of laying cables in conduits, the following regulations shall be observed:

1 Cables shall be laid by penetrating through conduits if they are routed in open air in places exposed to explosive risks, or they extend beyond the ground thus necessitating protection measures, or if they are laid underground and cross roads or railways.

2 Underground cables should be laid by penetrating through conduits if they run through houses and squares or are laid at sections which are planned to serve as roads.

3 Cables may be laid by penetrating through conduits if a number of them run through plant areas where underground pipe networks are dense, narrow urban roads with heavy traffic or roads hard to evacuate.

5.2.4 The method of laying cables in channels should be used at the following places:

1 Places with high underground water level.

2 Cable accesses where the number of power cables is small and the installation locations of outdoor switchgear where heavy-duty vehicles seldom travel through.

5.2.5 In selecting the method of laying cables in troughs, the following regulations shall be observed:

1 Cable troughs shall not be used at places where chemically corrosive liquid or high-temperature fused metal overflows or

heavy-duty vehicles frequently travel through.

2 Cable troughs should not be used in plant buildings with frequent industrial water overflowing and inflammable dust spreading.

3 Cable troughs should be used except for cases where a large number of cables are laid in plant area and buildings without the necessity for the use of tunnels, and it is inconvenient to evacuate urban walkways and cables are required to be laid by phases.

4 Exposed cables placing requirements on explosion proof and fire protection shall be laid in troughs and covered with sands.

5.2.6 In selecting the method of laying cables in tunnels, the following regulations shall be observed:

1 Tunnels shall be used when the number of underground cables laid in a cable access is too large to be contained in a trough.

2 Tunnels should be used when a large number of underground cables are laid in a cable access where corrosive liquid is present or surface water overflows frequently or where high voltage cables above 35 kV cross highways or railways.

3 Cables may be laid in public tunnels when cable laying is constrained by the conditions of urban underground accesses or cables are laid under roads with heavy traffic or when a large number of cables are arranged together with non-high temperature water, gas and communication pipelines along the same route.

5.2.7 Cables running vertically should be laid along walls and columns, and when the number of cables is large or there exists high voltage cables above 35 kV, shafts shall be employed.

5.2.8 Cable mezzanines should be provided at the lower part of rooms, such as control room and relay protection room, where a large number of cables are laid. Cable mezzanines with moveable cover plates may be used when a small number of cables are laid.

5.2.9 In areas where the underground water level is high or chemical corrosive liquids overflows or the areas inside buildings, cables shall be laid overhead by supporting them. If it is not suitable to lay cables underground in buildings or plant areas, they may be laid overhead.

5.2.10 Exposed cables, if not applicable to be laid overhead by supporting, may be laid overhead by means of suspending.

5.2.11 If the conditions are not available for cables running through rivers or reservoirs to be laid with the aid of bridges or dams, they may be laid underwater.

5.2.12 Maintenance access should not be provided where cables are laid overhead on trays in plant buildings, while maintenance access may be provided where urban cables are laid overhead on trays.

5.3 Underground Direct Burying

5.3.1 The routing of cables buried directly should be selected according to the following requirements:

- 1 The routing shall be kept clear of the sections suffering strong acid and alkali corrosion or stray current electrochemical corrosion.

- 2 The routing should be kept clear of the sections suffering termite damage, heat source impact and external forces damage if no protective measures are available.

5.3.2 The direct burying mode of cables shall conform to the following requirements:

- 1 Cables shall be laid in trenches and covered with a layer of soft soil or sand immediately adjacent to the top and bottom of cables along the whole length thereof.

- 2 Cables shall be covered with protection slabs along the total

length thereof having such a width that they extend no less than 50 mm on either side of the cables beyond the cable width. The protection slabs should be made of concrete.

3 Conspicuous marker tapes should be provided at the top of the protection slabs where cables are buried directly in urban areas.

4 In suburb areas or open regions, conspicuous orientation signs or stakes shall be erected at an interval of 100 m along cable routing and at turning points or joints.

5 Where cables are laid in trenches after penetrating through bellows, plain concrete having a thickness of no less than 100 mm and a width extending no less than 50 mm beyond the outside of the bellows at either side shall be poured at the top of the bellows along the total length thereof. The cable may not be provided with armor.

5.3.3 In cases where cables are directly buried in non-frozen soil zones, the burying depth of cables shall conform to the following requirements:

1 the distance from cable sheath to underground structure foundation shall not be less than 0.3 m.

2 the depth from cable sheath to ground level shall not be less than 0.7 m; where cables are located below roadway or farmland, the depth shall be appropriately increased and should not be less than 1 m.

5.3.4 When being directly buried in frozen soil zones, cables should be laid below frozen soil strata. Where it is impractical to bury them deeply, they may be buried in dry frozen soil strata or back-filled soil characterized by good water drainage. Other measures may be taken to protect the cables from damages.

5.3.5 It is prohibited that cables buried directly are situated right above or below underground pipes.

The minimum permissible distance from cables to cables, pipes, roads, buildings and structures shall conform to the requirements in Table 5.3.5.

Table 5.3.5 Minimum Permissible Distance from Cables to Cables, Pipes, Roads, Buildings and Structures (m)

Cables Buried Directly		Parallel	Cross
Between control cables		—	0.5 ^①
Between power cables or from power cables to control cables	Power cables of 10 kV and below	0.1	0.5 ^①
	Power cables of 10 kV and above	0.25 ^②	0.5 ^①
Cables used by different departments		0.5 ^②	0.5 ^①
From cables to underground pipe trenches	Thermal pipe trenches	2 ^②	0.5 ^①
	Oil pipes or combustible gas pipes	1	0.5 ^①
	Other Piping	0.5	0.5 ^①
From cables to railways	Rails of non-DC current electrified railways	3	1.0
	Rails of DC current electrified railways	10	1.0
From cables to building foundations		0.6 ^③	—
From cables to highway edge		1.0 ^③	
From cables to drainage ditches		1.0 ^③	
From cables to tree trunk		0.7	
From cables to overhead line poles below 1 kV		1.0 ^③	
From cables to overhead line tower foundation of above 1 kV		4.0 ^③	
Note: ① This value shall not be less than 0.25 m in cases where partition plates are used or cables penetrate through conduits. ② The value shall not be less than 0.1 m in cases where partition plates are used or cables penetrate through conduits; and ③ In special cases, the decrease in the distance shall not be less than 50%.			

5.3.6 Where cables buried directly cross railway, highway or street, they shall be penetrated through protective conduits which provide a protection for a scope extending at least 0.5 m beyond road bed, either side of street road surface and drainage ditches.

5.3.7 When cables buried directly are led into structures, protective conduits shall be disposed at the holes where cables penetrate through the walls and the conduit openings shall be blocked to resist water.

5.3.8 The joints of cables buried directly shall be arranged according to the following requirements:

- 1 Clear distance between joints and the neighboring cables shall not be less than 0.25 m.

- 2 Joints respectively provided on cables that are run in parallel should be staggered and the clear distance between them should not be less than 0.5 m.

- 3 Joints located at slopes shall be horizontal.

- 4 For cable joints of major circuits, cables should be laid, starting from the location about 1.0 m away from the joints at either side thereof, in such a manner that maintains a reserve of certain length of cables.

5.3.9 Where cables buried directly are backfilled using special soil, the soil quality shall be non-corrosive to the cable sheath.

5.4 Laying of Protection Conduits

5.4.1 Inner wall of cable protection conduits shall be smooth and free from burrs. The selection of conduits shall satisfy the mechanical strength and durability required for operation conditions and shall comply with the following requirements:

- 1 Where control cables are required to be penetrated through conduits to suppress electrical interference, steel conduits shall be

employed.

2 If AC single-core cables are penetrated through conduit on single basis, steel conduits for which no provisions have been made to separate magnetic circuits shall not be used.

5.4.2 The selection of cable conduits exposed to air partially or completely shall observe the following regulations:

1 At locations where high requirements on fire protection or mechanical performance of conduits are placed, steel conduits should be employed, which shall be subjected to anti-corrosion treatment consistent with the environmental endurance requirements, such as painting, galvanizing and plastic covering.

2 Flame retardant plastic conduit may be employed, provided that they satisfy the self-extinguishing requirements under project conditions. Where plastic conduits are partially buried in areas with a certain impact resistance capability, such as in concrete areas, the plastic conduits shall be able to carry a certain pressure, and flexible plastic conduits should be employed.

5.4.3 Conduits buried underground shall meet the requirements on pressure resistance at the buried depth and environmental corrosion resistance. The span of conduit pillows should be determined based on the bending moment when the area at the bottom of conduits is not compacted evenly; where conduits run through backfill sections suffering uneven settlement or the areas with frequent earthquake activities, longitudinal connection of conduits shall be made through flexible connectors.

Ducts bank should be used in cases where a large number of cables are laid in the same cable access.

5.4.4 Diameters of conduits and quantity of cables penetrating through them shall be determined according to the following

requirements:

1 One conduit should be penetrated by only one cable. Except for important sites, such as power plants and substations, for all circuits of a motor or all circuits of LV motors of the same equipment, no more than three power cables or multiple control cables may penetrate through a conduit.

2 Inner diameter of a conduit should not be smaller than 1.5 times the outside diameter of a cable or envelope outside diameter of multiple cables. Inner diameter of bore of duct bank should not be smaller than 75 mm.

5.4.5 The use of single protection conduit should conform to the following requirements:

1 Each cable conduit should not have more than three elbows and more than two quarter bends.

2 Conduits buried underground should not be less than 0.5 m apart from the ground level; where conduits cross railways, they should not be less than 1.0 m apart from the road bed; and where conduits run through drainage ditches, they should not be less than 0.3 m apart from the ditch bottom.

3 A clearance of no less than 20 mm should be reserved between conduits laid in parallel.

5.4.6 The application of duct bank shall comply with the following regulations:

1 A proper number of duct holes should be reserved for future use.

2 Cables whose conductors have greatly different working temperature should be arranged respectively in different duct banks spaced appropriately.

3 The thickness of soil above the top of conduits should not be

less than 0.5 m.

4 Conduits shall be laid on leveled and compacted soil strata and shall be cushioned to ensure they are continuous and flat; the longitudinal drainage slope of conduits should not be less than 0.2%.

5 The curvature of longitudinal connections of conduits shall ensure that cables will not be damaged when being pulled.

6 Measures against cable damage shall be taken at conduit ports.

5.4.7 Manholes shall be provided at the following locations of long cable conduits:

1 The section where cable pulling tension is limited. The calculation methods of the maximum permissible length of conduits for penetrating cables should comply with Appendix H to this code.

2 Branches and joints of cables.

3 The location where great change in running direction of conduits occurs or where cables are shifted from duct bank to directly buried area.

4 The location where the slope of conduit is large necessitating the use of additional fixture to prevent cables from slipping down.

5.5 Cable Structures Laying

5.5.1 The cable structures shall be sized to house all cables. The arrangement of cables therein shall not hamper safety operation and satisfy the requirements on the spaces required for cable laying activities and walk-around maintenance activities, and shall conform to the following regulations:

1 The clear height of cable access running through tunnels should not be less than 1900 mm; where cable access runs through tunnels with a smaller length which cross other ditches, its clear

height may be reduced at some local points, but shall in no case be less than 1400 mm.

2 The clear height of closed manholes should not be less than 1900 mm.

3 Clear height of cable mezzanine shall not be less than 2000 mm but should not be more than 3000 mm. The clear height of cable mezzanine of civil buildings may be reduced slightly, however, the height of spaces within a short distance intended for cable arrangement performed by personnel shall not be less than 1400 mm.

4 Clear width of cable access in cable troughs, tunnels or manholes should not be less than the values in Table 5.5.1.

**Table 5.5.1 Clear Width of Cable Access in Cable Troughs,
Tunnels or Manholes (mm)**

Arrangement Mode of Cable Brackets	Depth of Cable Troughs			Excavated Tunnel or Closed Manhole	Non-excavated Tunnel
	<600	600-1000	>1000		
Both sides	300*	500	700	1000	800
Single side	300*	450	600	900	800
Note: Asterisk(*) indicates that in shallow troughs cable brackets may be eliminated, and cable access is not necessary.					

5.5.2 The distance between adjacent layers of cable brackets, ladders or trays shall ensure convenient laying, fixing of cables and arrangement of cable joints, and shall ensure that when multiple cables are laid in the same layer, any cable or joint thereof can be replaced or added.

Where the cable cross-section or outside diameter of the joints are not large, the minimum distance between adjacent layers of cable

brackets, ladders or trays that meets the requirements stated above may take values listed in Table 5.5.2.

Table 5.5.2 Minimum Distance between Adjacent Layers of Cable Brackets, Ladders or Trays (mm)

Voltage Level, Type and Laying Characteristics of Cables		Ordinary Hangers and Brackets	Trays
Exposed laying of control cables		120	200
Exposed laying of power cable	Up to 6 kV	150	250
	6 kV-10 kV, XLPE	200	300
	35 kV, single-core	250	300
	35 kV, three-core	300	350
	110 kV-220 kV, more than one cable laid at each layer		
	330 kV, 500 kV	350	400
Cables laid in trunks		$h+80$	$h+100$
Note: h refers to the height of outer shell of trunks.			

5.5.3 In case of horizontal laying of cables, the arrangement dimensions of the top and bottom layer of cable brackets shall comply with the following regulations:

1 The permissible minimum clearance from the top layer of brackets to the top slab or beam bottom of cable building shall accommodate the permissible bending radius when cables are connected to upper cabinets and panels and should not be less than the sum of the values listed in Table 5.5.2 plus 80 mm-150 mm.

2 Clear distance from the top layer of brackets to other equipment shall not be less than 300 mm; if conditions do not permit, protection plates shall be provided.

3 The minimum clear distance from the bottom layer of brackets to floor, channel bottoms should not be less than the values in Table 5.5.3.

Table 5.5.3 Minimum Clear Distance from the Bottom Layer of Brackets to Floor, Channel Bottoms (mm)

Cable Laying Places and Their Characteristics		Vertical Clear Distance
Cable trenches		50
Tunnel		100
Cable mezzanine	Place not acting as access	200
	Access with a width of no less than 800 mm at least one side	1400
Cable brackets not fenced in common corridors		1500
Within power house		2000
Outside of power houses	Without vehicles passing by	2500
	With vehicle passing by	4500

5.5.4 Cable buildings shall be able to prevent water entry and seepage form outside and shall conform to the following requirements:

1 In cases where the bottom of cable troughs or tunnels is below underground water level, cable troughs are parallel with and close to industrial water pipe ditches, and cable tunnels cross industrial water pipes ditches, more water-proof measures should be taken for cable buildings.

2 In cases where cable troughs cross industrial water pipes ditches, the former should be situated above the latter.

3 Walls of outdoor cable trough within plant areas should rise slightly higher than the floor provided that water drainage in plant

areas is not compromised.

5.5.5 Cable buildings shall allow unobstructed water drainage and shall comply with the following requirements:

1 Longitudinal drainage slope of cable troughs and tunnels must not be less than 0.5%.

2 Collecting wells and their drainage systems should be disposed at proper interval along water drainage direction. Where necessary, water drainage shall be performed mechanically.

3 Side ditches for water drainage should be provided along longitudinal direction at the bottom of cable tunnel.

5.5.6 Cable trough walls, cover plates and their materials shall fulfill the requirements in respect of loads carrying and environmental durability.

The dead weight of a single piece of removal trough cover plate should not exceed 50 kg.

5.5.7 Cable tunnel and closed manhole shall be provided with safety holes which be disposed according to the following requirements:

1 No less than two holes shall be disposed along the longitudinal direction of tunnel. The safety holes of tunnels in industrial plant areas or substations should be disposed at an interval of no more than 75 m. In urban public areas, the interval between safety holes of excavated tunnels should not be more than 200 m, which may be increased appropriately for non-excavated tunnels and should be determined comprehensively based on the buried depth of tunnels in conjunction with the conditions of cable laying, ventilation and fire protection.

Where no exit is provided at the start and terminal end of tunnel, safety holes should be disposed no more than 5 m away.

2 Two safety holes shall be disposed at the top cover plate for

closed manhole. For manholes situated in public areas, the covers of safety holes should be disposed so that it is difficult for unprofessional personal to open them.

3 There shall be at least one safety hole that suits handling of installation machineries and equipment to be installed. The diameters of safety holes for personnel access shall not be less than 700 mm.

4 Access ladder shall be equipped in safety holes, and the facilities leading to exits, such as walkways or staircase, shall be disposed.

5 In public areas, the safety holes exposed above ground should be kept clear of highway or light railway and should be visually in harmony with the surrounding landscapes.

5.5.8 In cable tunnels located at sections with high level difference, cable access should not be in the form of steps and should have a longitudinal slope of no more than 15° . Cable joints should not be arranged at inclined positions.

5.5.9 Natural ventilation should be adopted for the cable tunnel. Where the operating temperature of a number of cable conductors reaches up to above 70°C continuously or ambient temperature rises significantly due to other factors, mechanical ventilation may be equipped; which, however, shall be able to stop automatically in the event of a fire.

For long tunnels, ventilation systems independent of each other should be appropriately equipped by sections.

5.5.10 Non-detachable cable shafts shall be provided with spaces intended for personnel activities and should comply with the following requirements:

1 If cable shafts are up to 5 m high, access ladders may be provided and the working spaces should not be sized less than 800

mm × 800 mm.

2 If cable shafts are more than 5 m high, staircases should be provided and stair platforms should be disposed at an interval of 3 m.

3 If cable shafts are more than 20 m high and the number of cables is large or the cables are of higher importance, simple elevators may be provided.

5.6 Cable Laying in Other Utilities

5.6.1 Where non-mineral insulated cables for important wooden facilities pass through wooden bridges, wharfs and trestles or other utilities, they shall be laid in incombustible protection pipes or trays.

5.6.2 Cables for bridges, tunnels or underground department stores or other utilities shall be provided with reliable protections against fire hazards and external damages, further in compliance with the following regulations:

1 Cables shall not be laid in exposure on access roads.

2 Self-contained oil-filled cables laid in channels shall be buried with sand. When laid in protection pipes, the pipes shall be made of non-magnetic and incombustible rigid materials.

3 Non-mineral insulated cables used in unsealed raceways should be laid in incombustible protection pipes or trays.

5.6.3 Cables used for bridges on highways and railways shall be protected against fracture of metal sheath due to long-term stress fatigue caused by vibration, heat expansion and contraction and wind, further in compliance with the following regulations:

1 Cables at both ends of bridge piers and expansion joints shall be sufficiently slack. Where there are deflection angles on bridges, cable return compensations should be provided.

2 Cables above 35 kV with large cross-section should be laid

in snake-like arrangements.

3 Straight laying cables subject to frequent vibrations shall be provided with elastic pads such as rubber and sandbags.

5.7 Underwater Cable Laying

5.7.1 The routes of underwater cables shall be determined to meet the following requirements: the cables are invulnerable to mechanical damage, accessible for reliable protection, and the laying construction is both easy and cost-effective. The cable routes shall further comply with the following regulations:

1 Cables should be laid in water areas with steady riverbed, slow flow, shores unlikely to suffer erosion, no stone hills or shipwrecks at seabed, infrequent occurrence of anchoring and trawler activities.

2 Cables should not be laid near wharves, ferries, hydraulic structures or in dredging areas or scheduled port locations.

5.7.2 Underwater cables shall be buried rather than suspended. In navigable waterways and other places where external mechanical damages need to be prevented, cables shall be buried in channels in proper depth and reinforced with covers; the burial depth should be no less than 0.5 m in shallow area and 2 m in deep area.

5.7.3 Crossing and overlapping of underwater cables are not allowed. Closely arranged cables shall keep adequate safety spacing, and the following regulations shall be observed:

1 The spacing of cables in main waterways should be no less than 1.2 times the average max water depth, which can be properly reduced towards the shore.

2 In non-navigable small rivers with a flow rate below 1 m/s, the spacing of single core cables shall not be less than 0.5 m in a

same circuit and 5 m in different circuits.

3 Moreover, other factors such as water flow rate and burial depth of cables shall also be considered.

5.7.4 The horizontal distance between underwater cables and industrial pipelines, should be no less than 50 m and shall be no less 15 m where confined.

5.7.5 In sections where underwater cables are lead to shores, protections that are suitable for laying shall be taken, and the following regulations shall be observed:

1 In the case of stable shores, cables shall be laid using protection pipes and trenches and working shafts may be provided for connection when necessary. The lower end of pipes or trenches should be located at least 1 m below the lowest water level.

2 In the case of unstable shores, cables should be laid in a return form to reserve an appropriate length as spare.

5.7.6 Bold warning signs shall be provided on both banks of underwater cables.

6 Cable Supports and Fixings

6.1 General Provisions

6.1.1 In case of exposed laying of cables, they shall be supported and fixed along the total length thereof with cable supports, trays, hooks or slings. The maximum spans shall be such that:

1 the bearing capabilities of cable supports and hangers will not be exceeded and cable sheath and conductors will not be damaged.

2 cables are arranged neatly.

3 the requirements on arrangement of cables under engineering conditions are satisfied.

6.1.2 The permissible span of ordinary supports (arm type supports) that provide direct support for cables should comply with the values listed in Table 6.1.2.

**Table 6.1.2 Permissible Spans of Ordinary Supports
(Arm Type Supports) and Hangers (mm)**

Cable Specification	Laying Mode	
	Horizontal	Vertical
Full plastic small-section cables without metal sheath and armoring	400*	1000
Medium-voltage and low-voltage cables other than the above ones	800	1500
High-voltage cables rated above 35 kV	1500	3000
Note: Asterisk(*) indicates that where the cable is laid flat and straight, this value may be doubled.		

6.1.3 In case of exposed laying of cables rated 35 kV or below, fixing locations shall be arranged properly and the following regulations shall be complies with:

1 Horizontal laying: the fixings shall be arranged at the starting, ending and turning points of cable lines and at both ends of connections, and should be arranged at an interval of at least 100 m in straight segment of the line.

2 Vertical laying: the fixings shall be arranged at upper end, lower end and at proper number of points between them.

3 Laying on slopes: the fixings shall be arranged with reference to the above Clauses 1, 2, based on the local actual conditions.

4 If cables are required to be apart from each other, the fixings should be arranged at an interval of about 10 m.

5 For single-core AC power cables, the fixed spacing shall also be determined based on the short-circuit electrodynamic force.

6.1.4 In case of exposed laying of high-voltage cables rated 35 kV or above, in addition to the regulations of Article 6.1.3, the fixings shall comply with the following regulations as well:

1 At least one rigid fixing shall be respectively arranged at terminal, connections or turning points.

2 At least two rigid fixings should be arranged at higher elevation of vertical or sloped cable line; where steel wire armored cables are employed, the armored steel wire should be capable of bearing the tensile force caused by the cable's self weight.

3 Slip fixings should be used at each pitch in snaking of cable. Rigid fixings should be used at the locations where snaking of cables is shifted to straight routing.

6.1.5 For high-voltage cables rated 35 kV or above, expansion

joints should be arranged at cable terminals, joints and connections. The radius of the expansion joints shall be larger than the allowable bending radius of the cable and shall ensure that the strain of metallic sheath will not exceed the allowable value. Rigid fixings or snaking of cable within an appropriate length shall be employed at both sides of the joints not provided with expansion joints.

6.1.6 The selection of parameters for snaking of cables shall be such that it ensures the axial thermal stress of cables resulting from changes in temperature would not damage the paper insulation of oil-filled cable, and would not lead to strain fatigue fracture of cable metallic sheath after a long time of operation. The parameters should also be determined based on the permissible constraint forces.

6.1.7 For high-voltage lead-sheathed cables rated 35 kV or above that are supported on horizontal or inclined supports, the locations where cables shift from an elevation to another and where stress are placed on both sides of connections should be supported in a manner that suits for the change in cable orientation and avoid the presence of sharp corners. Brackets may be disposed on the supports.

6.1.8 Components used to fix cables, such as clamps, ties, binding yarn or brackets, shall be characterized by smooth surfaces, easy installation, sufficient mechanical strengths and durability suitable for the operating conditions.

6.1.9 The selection of components used for cable fixture shall comply with the following regulations:

- 1 Anti-corrosion treated flat steel clamps, nylon ties or plastic-plating metal ties may be used to fix cables (except for single-core AC power cables). Nylon ties or plastic-plating metal ties shall be employed in strong corrosive environment.

- 2 The clamps made of the materials that do not form closed

magnetic loops, such as aluminum alloys, should be used for rigid fixing of single-core AC power cables; as far as other fixing means are concerned, nylon ties or slings may be used.

3 Cables shall not be bound directly with bare iron wires.

6.1.10 The mechanical strength of fixing parts of single-core AC power cables shall be checked and calculated under the short-circuit electrodynamic force, and should satisfy the following relational expressions:

$$F \geq \frac{2.05i^2LK}{D} \times 10^{-7} \quad (6.1.10-1)$$

For clamps with rectangle sections:

$$F = bh\sigma \quad (6.1.10-2)$$

Where:

F —tensile strength of fixings such as clamps, ties (N);

i —maximum short-circuit peak current flowing through cable circuit (A);

D —cable phase-to-phase center distance (m);

L —interval between adjacent clamps or ties on the cable (m);

K —safety factor, more than 2;

b —thickness of clamps (mm);

h —width of clamps (mm);

σ —allowable tension force of clamp material (Pa); for aluminum alloy clamps, $\sigma = 80 \times 10^6$.

6.1.11 Where cables are laid in the vicinity of DC-driven electric railways, insulation cushions should be disposed between the metal supports and the cables.

6.2 Cable Supports and Trays

6.2.1 The cable supports and trays shall comply with the following

regulations:

- 1 Their surfaces shall be smooth without burs.
- 2 They shall be durable and firm adaptable to the operating environments.
- 3 They shall have the required bearing capability.
- 4 They shall comply with the fire protection requirements of projects.

6.2.2 The cable supports (except for those intended for supporting single-core AC cables with a working current larger than 1500 A) should be made of steel. In strong corrosive environment, the selection of cable supports of other materials shall comply with the following regulations:

- 1 The ordinary supports (arm type) employed in cable trenches, shall be made of corrosion resistant rigid materials.
- 2 The cable ladder and trays may be made of flame retardant fibreglass reinforced plastic satisfying the requirement of operating conditions of projects.
- 3 Cable trays of aluminum alloy may be used if justified technically and economically.

6.2.3 Metallic cable supports shall be subject to anticorrosion treatment and shall comply with the following regulations:

- 1 Steel cable trays used for major circuits or in areas where equipment are densely arranged, such as large capacity power plants, shall be subject to anti-corrosion treatment in a suitable manner that ensures durability of the one-time anti-corrosion treatment and suits project environments.

In strong corrosive environment, they should be subject to anticorrosion treatment characterized by high durability, such as hot-dip galvanizing.

2 For profile steel arm-type brackets, or cable trays used in mildly corrosive environment or for unimportant circuits, anticorrosion treatment may be carried out by application of paint.

6.2.4 The strength of cable supports shall be sufficient to carry the self weight of cables and their accessories and the forces resulting from installation and maintenance activities, and shall comply with the following regulations:

1 The cable supports shall be able to carry an additional concentrated load of 900 N when occupied by personnel for a short period of time.

2 In cases where mechanical construction is carried out, the longitudinal tensile forces, transverse thrusts and dead weight of pulleys shall be taken into consideration.

3 In case of outdoor installation, additional loads resulting from ice, snow and strong wind shall be taken into consideration.

6.2.5 The structure of cable trays shall meet the requirements in respect of strength, rigidity and stability, and shall comply with the following regulations:

1 The bearing capability of cable trays shall not exceed the value obtained by dividing the maximum load leading to initial permanent deformation of the trays by a safety factor of 1.5.

2 The relative deflection of ladders or trays under the effects of evenly distributed loads should not be larger than 1/200 if they are made of steel and 1/300 if they are made of aluminum alloy.

3 Under the permissible load, the ratio of the inclination of a steel bracket arm to the arm length should not be larger than 1/100.

6.2.6 The types of cable supports shall be selected according to the following regulations:

1 Where there are a number of full-plastic cables employing

exposed laying modes, or the cable runs over a long distance, or snaking of high-voltage cables is used, cable trays should be used.

2 Ordinary supports and hangers may be used except for the above cases.

6.2.7 The types of cable trays shall be selected according to the following regulations:

1 Where it is required to shield external electrical interference, imperforate metal trays together with solid cover plates shall be used.

2 At sites where there exists inflammable dust, ladder supports should be used and the top layer of trays shall be provided with solid cover plates.

3 At sites where there exists high temperature, corrosive liquid or oil thus necessitating necessary protection measures, trays should be used and the top layer of trays shall be provided with solid cover plates.

4 Where it is required to assemble trays in response to the local actual conditions, assembled trays may be used.

5 Ladder supports should be used except for the above cases.

6.2.8 Where ladder supports or trays have a linear section with a length larger than the following values, expansion joints of no less than 20 mm in length each shall be reserved:

1 Steel: 30 m; and

2 Aluminum alloy or fiber glass reinforced plastic: 15 m.

6.2.9 Metal tray system shall be provided with reliable electrical connections and shall be grounded. Where trays of fiber glass reinforced plastic are used, a special grounding wire shall be laid along the whole length of the trays.

6.2.10 Cable tray systems used at places that are susceptible to vibration, including bolt connections of grounding parts, shall be

installed with spring washers.

6.2.11 The metal trays placing fire protection requirement shall, in addition to the compliance with the provisions of Chapter 7 of this code, have the external surface of their metal members applied with fire protective coatings which shall comply with the relevant provisions of the current national standard of *General Technical Specifications for Fire Resistive Coating of Cable* (GA 181).

7 Fire Protection and Retardation of Cables

7.0.1 In circuits where cables are prone to fire spreading thus leading to serious accidents and the areas with densely arranged cables that make them more susceptible to a fire triggered by external influences, fire resistance separation shall be appropriately provided and the safety measures shall be taken as follows by comprehensively considering the factors including importance of the project, fire probability and its characteristics as well as economic viability:

- 1 Carrying out flame-retardant protection or prevention of retarded combustion.
- 2 Selecting flame-retardant cables.
- 3 Carrying out fire resistance protection or using fire-resistant cables.
- 4 Applying fire protection structures.
- 5 Equipping automatic alarming device and dedicated fire fighting devices.

7.0.2 The fire resistance separation modes shall be selected according to the following regulations:

- 1 The openings cut on cable building through which cables are lead to electrical cubicles (panels) or control panels (consoles), the holes and openings cut on partition walls and floor slabs for the purpose of cable penetration as well as the openings cut on manholes for cable conduit to penetrate shall all be blocked to retard fire.

- 2 Fire-retardant walls (fire walls) shall be disposed in tunnels or cable trenches of important circuits at the locations below:

- 1) Locations where a common main trough is diverged.

- 2) Locations where a cable trench corresponding to multi-sectional power switchgear is appropriately sectioned.
- 3) Locations at an interval of about 200 m or at ventilation sections in long-distance trench.
- 4) Locations at inlet of control rooms or power switchgear and at boundary walls of plant area.

3 In shafts, fire-retardant separation layer should be disposed at an interval of 7 m.

7.0.3 Technical characteristic of fire-retardant separation shall conform to the following regulations:

1 Fire-retardant blocking and separation shall be effected by using applicable fire-retardant blocking materials or components based on the conditions of cable penetrating through opening and holes. The fire-retardant blocking and separation used for power cables should cause less influences on cable current-carrying capacity; where they are used at openings made in shaft or floor slabs, they shall be able to carry the loads applied by walk-around inspectors.

The fire-retardant blocking materials shall cause no corrosion and damage to cables.

2 The fire-retardant walls shall be constructed of soft materials suitable for cable line conditions, such as fire-retardant modules, fireproof blocking sheet materials and fire protection pillows, which shall be able to survive possible accumulated water immersion or mouse disaster without damage.

3 Except that at the locations where cables are led to main control rooms, boundary walls of plant areas, or at fire-resistant walls separating ventilation sections in long-distance tunnels, fire doors shall be disposed, at other locations fire doors may be eliminated provided that measures against flame spreading are taken. The measures against

flame spreading may include application of fire-resistant coatings or wrapping tapes on all the cables within not less than 1 m of fire retardant walls at either side thereof or disposing fire stops.

4 The construction of fire-retardant walls, fire-retardant separation layers and fire-retardant blocking shall be tested in accordance with the standard established for equivalent project conditions and shall ensure fire-resistant integrity and thermal insulation for 1 h under the limit fire conditions.

If the construction of fire-retardant separation is not covered within the assembly features of tested parts consisting of materials passing the standard test, special tests and demonstrations shall be conducted or additional measures shall be taken. If the thickness of fire-resistance separation is insufficient, the cables within 1 m of the fire-resistance separation at blocking side may be applied with fire-resistant coatings or wrapping tapes.

7.0.4 For exposed laying of non-flame-retardant cables, the following requirements shall be met:

1 At sites susceptible to a fire triggered by external causes, the cables there should be subject to flame retardant protection; for important cable circuits, fire-retardant sections may be disposed at proper locations to achieve flame retardancy.

The flame-retardant protection or fire-retardant sections may be achieved or formed through application of fire-resistant coatings or wrapping tapes on cables. Where there are a large number of cables, the measures such as flame retardancy, use of fire resistant troughs and boxes or fire protection pillows may be employed instead.

2 The cables within about 3 m of a cable joint at either side and other cables close to and run parallel with such cable sections should be subject to flame retardancy through application of

fire-resistance wrapping tapes thereon.

7.0.5 At sites with a high fire probability that may cause significant consequences, exposed-laying cables shall be selected according to the following regulations:

- 1 Flame retardant cables should be used for main power house, coal handling system, fuel oil system and other inflammable and explosive places in fossil-fueled power plants.

- 2 Flame retardant cables with low fume and less toxicity should be used in densely-populated areas, such as underground passenger transports or commercial facilities, necessitating increased fire protection safety of circuits.

- 3 For power supply and distribution circuits of other important industrial and public facilities, if increased fire prevention safety is required, flame-retardant cables characterized by flame retardancy or low fume, less toxicity may be used as well.

7.0.6 Section of flame-retardant cables shall comply with the following regulations:

- 1 Where multiple cables are arranged densely, flame retardancy of such cables shall comply with the relevant regulations of the current national standard GB/T 18380.3, *Tests on Electric Cables under Fire Conditions - Part 3: Combustion Tests on Bundled Wires or Cables*. The flame retardancy level and class of cables shall be selected based on cable arrangement, prevention of catastrophic accidents as well as economic viability.

- 2 Where it is determined that the selected class of flame-retardant cables can achieve effective flame retardancy under the operation conditions, the requirements in Article 7.0.4 of this code may be reduced.

- 3 Non-flame-retardant cables and flame-retardant cables should

not be arranged in parallel in the same cable access.

7.0.7 The exposed-laying cables at the sites or in the circuits as follows for which power supply is required to maintain for a certain period of time after breaking out of an external fire shall be subject to fire resistance protection or shall be of fire-resistant type.

- 1 Important circuits, such as fire fighting, alarm, emergency lighting, DC power supply for breaker operation, safety power supply for emergency shutdown of generators.

- 2 One circuit out of dual circuits which share the same cable access but are not separated from each other, such as computer monitoring, dual relay protection, safety power supply or emergency power supply.

- 3 Flammable sites, such as oil tank area, places susceptible to splattering of melted metal in steel plants.

- 4 One circuit out of the dual-circuit power supply circuits serving important power supply such as pump house, chemical water treatment, coal handling system and oil pump house in the fossil-fueled power plant, which share the same cable access but are not separated from each other.

- 5 Circuits placing fire resistance requirements in other important public building facilities.

7.0.8 Fire resistance protection of exposed cables shall conform to the following requirements:

- 1 Where the number of cables is small, they may be applied with fire retardant coatings, wrapping tapes or penetrated through fire resistant conduits.

- 2 Where the number of cables laid in the same cable access is large, they should be laid in fire-resistant troughs and boxes, which should be of permeable type for power cables and may be of

semi-enclosed type when used in environment free from flammable dust. And fire protection pillows may be used instead where the length of protection section of cables laid in trays is not large.

7.0.9 Where fire resistant cables are used at places, such as power plants, where multiple cables are arranged exposed, or at oil pipes or places prone to spattering of melted metal, their fire resistance property shall conform to requirements on fire-resistant cables of Class A as stipulated in the current national standard GB/T 12666.1, *Test Method on Electric Wires or Cables under Fire Conditions - Part 1: General*. In case of situations other than those described above where the number of cables arranged is small, the fire-resistant cable of Class B stipulated in the current national standard GB/T 12666.1, *Test Method on Electric Wires or Cables under Fire Conditions - Part 1: General*, may be used.

7.0.10 For areas where high requirements are placed on fire resistance, such as oil tank areas, important public wooden buildings, high temperature areas, mineral insulated cables may be used if the laying and installation thereof are economically justified.

7.0.11 Where self-contained oil-filled cables are laid in places requiring fire prevention treatment, such as public corridors, passenger transport tunnels, bridges, they may be laid by being buried in sand.

7.0.12 For cable troughs close to oil-contained equipment, such as HV current, voltage transformers, the trough cover plates of the relevant section should be sealed.

7.0.13 At places imposing high requirements on safety, such as the sites where cables are densely arranged or enclosed raceways, automatic fire detection and alarming devices capable of reliable operation and suitable to the environment should be equipped.

The oil supply system of exposed oil-filled cables should be

provided with automatic fire alarming and blocking devices capable of indicating the oil spraying condition.

7.0.14 At places imposing high requirements on safety, such as underground public facilities with densely arranged cables and multiple-circuit oil-filled cable termination, special fire fighting facilities, such as water spray extinguisher, may be equipped.

7.0.15 The flame-retardant materials used for cables shall be selected according to the following regulations:

1 Flame-retardant materials shall comply with the relevant stipulations in the current national standard GA 161, *Performance Requirements and Test Methods for Fire-proof Sealing Materials*.

2 Fire-retardant coatings and flame-retardant wrapping tapes shall comply with the relevant stipulations in the current national standards GA 181, *General Technical Specifications for Fire Resistive Coating of Cable*, and GA 478, *Flame Retardant Belts for Cables* respectively.

3 In addition to Clause 2 mentioned above, the products used to achieve flame retardancy shall also be capable of effective self-distinguishment when being subjected to combustion test in accordance with the equivalent project conditions.

4 The products used for fire resistance protection shall be able to achieve the fire resistance limit for no less than 1h when being subjected to combustion test in accordance with the equivalent project conditions and should have a fire resistance temperate of no lower than 1000℃.

5 The flame retardant and fire resistant troughs and boxes used for power cables shall have current-carrying capacity or the related parameters determined.

6 The materials and products used shall be reliable, durable and suitable to the engineering environment.

Appendix A Maximum Allowable Temperature of Common Power Cable Conductor

**Table A Maximum Allowable Temperature of Common Power Cable
Conductor**

Cable			Maximum Allowable Temperature (°C)	
Insulation Category	Type Characteristics	Voltage (kV)	Continuous Working	Short-circuit Transient
Polyvinyl chloride	Ordinary	≤ 6	70	160
XLPE	Ordinary	≤ 500	90	250
Self-contained oil filling	Ordinary kraft paper	≤ 500	80	160
	Semi-synthetic paper	≤ 500	85	160

Appendix B Section Selection Methods for Economic Current of Power Cable Rated 10 kV and below

B.0.1 The formula for calculation of the total costs of cables is as below:

The total costs resulting from cable line losses consists of two components, the energy costs of line losses and the costs for supply of additional power capacity to compensate the line losses.

Assuming a load growth rate of a and an energy costs grow rate of b , the formula used to calculate the total cable costs is as below:

$$C_T = C_1 + I_{\max}^2 \cdot R \cdot L \cdot F \quad (\text{B.0.1-1})$$

$$F = N_p \cdot N_c \cdot (\tau \cdot P + D) \Phi / (1 + i/100) \quad (\text{B.0.1-2})$$

$$\Phi = \sum_{n=1}^N (r^{n-1}) = (1 - r^N) / (1 - r) \quad (\text{B.0.1-3})$$

$$r = (1 + a/100)^2 (1 + b/100) / (1 + i/100) \quad (\text{B.0.1-4})$$

Where:

C_T —total cable costs (RMB Yuan);

C_1 —cables proper costs and the installation costs (RMB Yuan), consisting of two components, the cables material costs and the installation costs thereof;

$I_{\max}$ —maximum load current of conductors during the first year (A);

R —apparent AC resistance of unit length (Ω);

L —cable length (m);

F —auxiliary quantity (RMB Yuan/kW) defined by Formula (B.0.1-2);

N_p —number of phase lines per circuit, being taken to be 3;

N_c —number of circuits that are of the same type and transfer

the same load, being taken to be 1;

τ — maximum load loss time (h), in other words, after a lapse of τ hours, the energy losses of lines are equal to the lines losses resulting from the actual loads while maintaining the loads to be always the maximum. The value τ may be calculated approximately by using the maximum load utilization time, $T=0.85 \tau$;

P — power electricity price (RMB Yuan/kW · h), which is taken to be the current price for ultimate users, the generating costs for power plants and the power supplying costs for power suppliers;

D — costs (RMB Yuan/kW · Year) of supply of additional capacity to compensate line loss, may be taken to be 252;

Φ — auxiliary quantity defined by Formula (B.0.1-3);

i — discount rate (%), may be taken to be the current bank loan rate of the country;

N — economic life (Years), being taken to be the cable service life, i.e., the total period of time from cable' being put into use till the service life expires;

r — auxiliary quantity defined by formula (B.0.1-4);

a — load growth rate (%), the load current used to select the cross-section of conductor is the heating current allowed by the cross-section, which may be exceeded as the loads increase. The fluctuation of a has little influence on economic current density, thus may be ignored, a may then be taken to be 0;

b — growth rate of energy costs, being taken to be 2%.

B.0.2 The formula used to calculate economic current section of cables is as below:

1 The formula used to calculate A_1 value of cables with two adjacent sections:

$$A_1 = (S_{1\text{total investment}} - S_{2\text{total investment}}) / (S_1 - S_2) \quad (\text{RMB Yuan/m} \cdot \text{mm}^2) \quad (\text{B.0.2-1})$$

Where:

$S_{1\text{total investment}}$ —initial costs of cables with a section area of S_1 , being the sum of cable prices per unit length and laying costs per unit length (RMB Yuan/m);

$S_{2\text{total investment}}$ —initial costs of cables with a section area of S_2 , being the sum of cable prices per unit length and laying costs per unit length (RMB Yuan/m).

For cables of the same type, the formula used to calculate the average of A is:

$$A = \sum_{n=1}^n A_n / n \quad (\text{RMB Yuan/m} \cdot \text{mm}^2) \quad (\text{B.0.2-2})$$

Where:

n —number of grades of nominal section area for cables of the same type, the range of section area being taken to be 25 mm^2 – 300 mm^2 .

2 The formula used to calculate economic current section area of cables is:

1) The economic current density is calculated from:

$$J = \sqrt{\frac{A}{F \times \rho_{20} \times B \times [1 + \alpha_{20}(\theta_m - 20)] \times 1000}} \quad (\text{B.0.2-3})$$

2) The economic current cross section of cables is calculated from:

$$S_j = I_{\max} / J \quad (\text{B.0.2-4})$$

Where:

J —economic current density (A/mm^2);

S_j —economic cable section area (mm^2);

$B=(1+Y_p+Y_s)(1+\lambda_1+\lambda_2)$, may be taken to be the average value of 1.001 4;

ρ_{20} —resistance rate ($\Omega \cdot mm^2/m$) of cable conductor at $20^\circ C$, 18.4×10^{-9} for copper core and 31×10^{-9} for aluminum core; being taken to be respectively 18.4 and 31 for calculation;

α_{20} —resistance temperature coefficient ($1/^\circ C$) of cable conductor at $20^\circ C$, 0.003 93 for copper core and 0.004 03 for aluminum core.

B.0.3 The section area of cables rated 10 kV and below should be selected by using economic current density method in accordance with the following requirements:

1 The economic current density of the proposed copper- or aluminum-core cables rated 10 kV and below insulated with poly vinyl chloride and XLPE shall be calculated taking into account the work conditions, electricity price, cable costs and discount rate.

2 The section area of cables used for spare circuits, such as those for motor circuit, should be selected based on a half of the normal operating hours, while for some circuits kept idle for a long time, the cable section area should not be selected using the economic current density method.

3 Where the section area of cables calculated with economic current density method is smaller than the values calculated respectively based on thermal stability, allowable voltage drop and continuous ampacity method, the larger of the three values shall be selected; if the section area of cables calculated with economic current density method falls in between the nominal cable section

areas of two neighboring grades, the section area of the grade to which the economic current area is more close should be selected appropriately.

Appendix C Allowable 100% Continuous Ampacity of Common Power Cables Rated 10 kV and below

C.0.1 For the allowable continuous ampacity of common power cable rated 1 kV-3kV, see Table C.0.1-1 to C.0.1-4.

**Table C.0.1-1 Allowable Ampacity of Oilpaper and Poly Vinyl
Chloride Insulated Cables Rated 1-3 kV Laid in Air (A)**

Insulation Category		Non-draining Paper			Polyvinyl Chloride		
Steel armor sleeve		Yes			No		
Maximum operating temperature (°C) of cable conductor		80			70		
Quantity of cores		Single core	Dual cores	Three or four cores	Single core	Dual cores	Three or four cores
Cross section area of cable conductors (mm ²)	2.5					18	15
	4		30	26		24	21
	6		40	35		31	27
	10		52	44		44	38
	16		69	59		60	52
	25	116	93	79	95	79	69
	35	142	111	98	115	95	82
	50	174	138	116	147	121	104
	70	218	174	151	179	147	129
	95	267	214	182	221	181	155
	120	312	245	214	257	211	181
	150	356	280	250	294	242	211

Table C.0.1-1 (continued)

Insulation Category		Non-draining Paper			Polyvinyl Chloride		
Cross section area of cable conductors (mm ²)	185	414		285	340		246
	240	495		338	410		294
	300	570		383	473		328
Ambient temperature (°C)		40					
Note: 1 This table is applicable to aluminum-core cables; and for copper-core cables, the allowable continuous ampacity may be multiplied by 1.29. 2 Single-core cables are only applicable to DC cables.							

Table C.0.1-2 Allowable Ampacity of Directly Buried Oilpaper and Poly vinyl Chloride Insulated Cables Rated 1 kV-3 kV (A)

Insulation Category		Non-draining Paper			Polyvinyl Chloride					
Steel armor sleeve		Yes			No			Yes		
Maximum operating temperature (°C) of cable conductor		80			70					
Quantity of cores		Single core	Dual cores	Three or four cores	Single core	Dual cores	Three or four cores	Single core	Dual cores	Three or four cores
Cross section area of cable conductors (mm ²)	4		34	29	47	36	31		34	30
	6		45	38	58	45	38		43	37
	10		58	50	81	62	53	77	59	50
	16		76	66	110	83	70	105	79	68
	25	143	105	88	138	105	90	134	100	87
	35	172	126	105	172	136	110	162	131	105

Table C.0.1-2 (continued)

Insulation Category		Non-draining Paper			Polyvinyl Chloride					
Cross section area of cable conductors (mm ²)	50	198	146	126	203	157	134	194	152	129
	70	247	182	154	244	184	157	235	180	152
	95	300	219	186	295	226	189	281	217	180
	120	344	251	211	332	254	212	319	249	207
	150	389	284	240	374	287	242	365	273	237
	185	441		275	424		273	410		264
	240	512		320	502		319	483		310
	300	584		356	561		347	543		347
	400	676			639			625		
	500	776			729			715		
	630	904			846			819		
800	1032			981			963			
Thermal resistance coefficient of soil (K·m/W)		1.5			1.2					
Ambient temperature (°C)		25								
Note: 1 This table is applicable to aluminum-core cables; and for copper-core cables, the allowable continuous ampacity may be multiplied by 1.29. 2 Single-core cables are only applicable for DC system.										

Table C.0.1-3 Allowable Ampacity of XLPE Insulated Cables Rated 1 kV-3 kV Laid in Air (A)

Quantity of Cores		Three Cores		Single Core							
Arrangement mode of single-core cables				Delta fashion			Horizontal fashion				
Metal layer grounding point				Single side		Both sides		Single side		Both sides	
Material of cable conductor		Aluminum	Copper	Aluminum	Copper	Aluminum	Copper	Aluminum	Copper	Aluminum	Copper
Cross section area of cable conductors (mm ²)	25	91	118	100	132	100	132	114	150	114	150
	35	114	150	127	164	127	164	146	182	141	178
	50	146	182	155	196	155	196	173	228	168	209
	70	178	228	196	255	196	251	228	292	214	264
	95	214	273	241	310	241	305	278	356	260	310
	120	246	314	283	360	278	351	319	410	292	351
150	278	360	328	419	319	401	365	479	337	392	

Table C.0.1-3 (continued)

Quantity of Cores		Three Cores		Single Core									
Cross section area of cable conductors (mm ²)	185	319	410										
	240	378	483										
	300	419	552										
	400												
	500												
	630												
Ambient temperature (°C)				40									
Maximum operating temperature (°C) of cable conductor				90									
Note: 1 The determination of allowable ampacity shall observe provisions of Article 3.7.4 of this code as well. 2 The centers between cables laid in horizontal fashion shall be twice the outside diameter of cables.													

**Table C.0.1-4 Allowable Ampacity of Directly Buried XLPE
Insulated Cables Rated 1 kV-3 kV (A)**

Quantity of Cores		Three Cores		Single Core			
Arrangement mode of single core cables				Delta fashion		Horizontal fashion	
Metal layer grounding point				Single side		Single side	
Material of cable conductor		Aluminum	Copper	Aluminum	Copper	Aluminum	Copper
Cross section area of cable conductors (mm ²)	25	91	117	104	130	113	143
	35	113	143	117	169	134	169
	50	134	169	139	187	160	200
	70	165	208	174	226	195	247
	95	195	247	208	269	230	295
	120	221	282	239	300	261	334
	150	247	321	269	339	295	374
	185	278	356	300	382	330	426
	240	321	408	348	435	378	478
	300	365	469	391	495	430	543
	400			456	574	500	635
	500			517	635	565	713
	630			582	704	635	796
Temperature (°C)		90					
Thermal resistance coefficient of soil (K • m/W)		2.0					
Ambient temperature (°C)		25					
Note: Centers between cables laid in horizontal fashion shall be twice the outside diameter of cables.							

C.0.2 For the allowable continuous ampacity of common power cable rated 6 kV, see Table C.0.2-1 and C.0.2-2.

**Table C.0.2-1 Allowable Ampacity of Three-core Power
Cable Rated 6 kV Laid in air (A)**

Insulation Category		Non-draining Paper	Polyvinyl Chloride		XLPE	
Steel armor sleeve		Yes	No	Yes	No	Yes
Maximum operating temperature (°C) of cable conductor		80	70		90	
Cross section area of cable conductors (mm ²)	10		40			
	16	58	54			
	25	79	71			
	35	92	85		114	
	50	116	108		141	
	70	147	129		173	
	95	183	160		209	
	120	213	185		246	
	150	245	212		277	
	185	280	246		323	
	240	334	293		378	
	300	374	323		432	
	400				505	
	500				584	
Ambient temperature (°C)		40				
Note: 1 This table is applicable to aluminum-core cables; and for copper-core cables, the allowable continuous ampacity may be multiplied by 1.29. 2 Where working temperature of cable conductor is above 70°C, the allowable ampacity shall also observe the provisions of Article 3.7.4 in this code.						

**Table C.0.2-2 Allowable Ampacity of Directly Buried Three-core
Power Cable Rated 6 kV (A)**

Insulation Category		Non-draining Paper	Polyvinyl Chloride		XLPE	
Steel armor sleeve		Yes	No	Yes	No	Yes
Maximum operating temperature (°C) of cable conductor		80	70		90	
Cross section area of cable conductors (mm ²)	10		51	50		
	16	63	67	65		
	25	84	86	83	87	87
	35	101	105	100	105	102
	50	119	126	126	123	118
	70	148	149	149	148	148
	95	180	181	177	178	178
	120	209	209	205	200	200
	150	232	232	228	232	222
	185	264	264	255	262	252
	240	308	309	300	300	295
	300	344	346	332	343	333
	400				380	370
	500				432	422
Thermal resistance coefficient of soil (K • m/W)		1.5	1.2		2.0	
Ambient temperature (°C)		25				
Note: This table is applicable to aluminum-core cables; and for copper-core cables, the allowable continuous ampacity may be multiplied by 1.29.						

C.0.3 For the allowable continuous ampacity of common power cable rated 10 kV, see Table C.0.3.

**Table C.0.3 Allowable Ampacity of Three-core Power
Cable Rated 10 kV (A)**

Insulation Category		Non-draining Paper		XLPE			
Steel armor sleeve				No		Yes	
Maximum operating temperature (°C) of cable conductor		65		90			
Laying mode		In air	Direct burying	In air	Direct burying	In air	Direct burying
Cross section area of cable conductors (mm ²)	16	47	59				
	25	63	79	100	90	100	90
	35	77	95	123	110	123	105
	50	92	111	146	125	141	120
	70	118	138	178	152	173	152
	95	143	169	219	182	214	182
	120	168	196	251	205	246	205
	150	189	220	283	223	278	219
	185	218	246	324	252	320	247
	240	261	290	378	292	373	292
	300	295	325	433	332	428	328
	400			506	378	501	374
	500			579	428	574	424
Ambient temperature (°C)		40	25	40	25	40	25
Thermal resistance coefficient of soil (K·m/W)			1.2		2.0		2.0
Note: 1 This table is applicable to aluminum-core cables; and for copper-core cables, the allowable continuous ampacity may be multiplied by 1.29. 2 Where working temperature of cable conductor is above 70℃, the allowable ampacity shall also observe provisions of Article 3.7.4 in this code.							

Appendix D Correction Factors of Allowable Continuous Ampacity of Cables Under Different Laying Conditions

D.0.1 For correction factors of ampacity of cables rated 35 kV and below at different ambient temperature, see Table D.0.1.

**Table D.0.1 Correction Factors of Ampacity of Cables Rated
35 kV and Below at Different Ambient Temperature**

Laying Location		In Air				In Soil			
Ambient temperature (°C)		30	35	40	45	20	25	30	35
Maximum working temperature of cable conductor (°C)	60	1.22	1.11	1.0	0.86	1.07	1.0	0.93	0.85
	65	1.18	1.09	1.0	0.89	1.06	1.0	0.94	0.87
	70	1.15	1.08	1.0	0.91	1.05	1.0	0.94	0.88
	80	1.11	1.06	1.0	0.93	1.04	1.0	0.95	0.90
	90	1.09	1.05	1.0	0.94	1.04	1.0	0.96	0.92

D.0.2 The correction factors of ampacity (K) at ambient temperature other than those indicated in Table D.0.1 can be calculated from:

$$K = \sqrt{\frac{\theta_m - \theta_2}{\theta_m - \theta_1}} \quad (\text{D.0.2})$$

Where:

θ_m —maximum working temperature of cable conductor (°C);

θ_1 —reference ambient temperature corresponding to the rated ampacity (°C);

θ_2 —actual ambient temperature ($^{\circ}\text{C}$).

D.0.3 For the correction factors of cable ampacity under different thermal resistance coefficient of soil, see Table D.0.3.

Table D.0.3 The Correction Factors of Cable Ampacity under Different Thermal Resistance Coefficient of Soil

Thermal Resistance Coefficient of Soil ($\text{K} \cdot \text{m/W}$)	Classification Features (Soil Characteristics and Rainfall)	Correction Factors
0.8	Wet soil due to frequent raining, e.g., sandy soil with a humidity larger than 9%; sand-clay with a humidity larger than 10%	1.05
1.2	Humid soil due to regular raining, e.g., sandy soil with a humidity of 7%-9%; sand-clay with a humidity of 12%-14%	1.0
1.5	Relatively dry soil due to small rainfall, e.g., sand - clay with a humidity of 8%-12%	0.93
2.0	Dry soil due to rare raining, e.g., sandy soil with a humidity of 4%-7%; sand-clay with a humidity of 4%-8%	0.87
3.0	Rocky stratum, extremely dry, e.g., sandy soil with a humidity smaller than 4%	0.75
Note: 1 It is applicable to the rough classification when the thermal resistance coefficient of soil obtained through actual measurement is not available. For cable lines rated 110 kV and above, the thermal resistance coefficient of soil should be determined through actual measurement. 2 The above correction factors are applicable to situations where the thermal resistance coefficient of soil is taken to be $1.2 \text{ K}\cdot\text{m/W}$, as described in various tables of Appendix C, but not applicable to HV single-core cables of three-phase AC system.		

D.0.4 When multiple parallel cables are directly buried in soil, please see Table D.0.4 for the correction factors of cable ampacity.

Table D.0.4 Correction Factors for Cable Ampacity When Multiple Parallel Cables are Directly Buried in the Soil

Number of Cables Laid in Parallel		1	2	3	4	5	6
Net spacing between cables (mm)	100	1	0.9	0.85	0.80	0.78	0.75
	200	1	0.92	0.87	0.84	0.82	0.81
	300	1	0.93	0.90	0.97	0.86	0.85
Note: The correction factors are not applicable to the single-core cables of three-phase AC system.							

D.0.5 When multiple parallel cables are laid in the air in single layer, please see Table D.0.5 for the correction factors of cable ampacity.

Table D.0.5 Correction Factors for Cable Ampacity When Multiple Parallel Cables are Laid in the Air in Single Layer

Number of Cable Laid in Parallel		1	2	3	4	5	6
Centers between cables	$s=d$	1.00	0.90	0.85	0.82	0.81	0.80
	$s=2d$	1.00	1.00	0.98	0.95	0.93	0.90
	$s=3d$	1.00	1.00	1.00	0.98	0.97	0.96
Note: 1 s refers to centers between cables and d the outside diameter of cables. 2 The correction factors are determined on the condition that the outside diameters of all cables are the same. When the cables laid in parallel have different diameters, d may take the average of outside diameters of cables. 3 The correction factors are not applicable to the single-core power cables for AC system.							

D.0.6 For the correction factors of ampacity of parallel cables laid side-by-side in multiple layers on cable trays, please see Table D.0.6.

Table D.0.6 Correction Factors of Ampacity of Parallel Cables Laid Side-by-side in Multiple Layers on Cable Trays

Number of Cable Layer		I	II	III	III
Type of tray	Ladder	0.8	0.65	0.55	0.5
	Pallets	0.7	0.55	0.5	0.45
Note: The number of cables laid side-by-side in horizontal fashion shall not be less than 7.					

D.0.7 For the correction factors of ampacity of cables rated 1 kV-6 kV during outdoor exposed laying without sunshade, see Table D.0.7.

Table D.0.7 Correction Factors of Ampacity of Outdoor Exposed Cables Rated 1 kV-6 kV Without Sunshade

Cross-section of Cables (mm ²)				35	50	70	95	120	150	185	240
Voltage (kV)	1	Number of cores	III				0.90	0.98	0.97	0.96	0.94
	6		IV	0.96	0.95	0.94	0.93	0.92	0.91	0.90	0.88
			Single				0.99	0.99	0.99	0.99	0.98
Note: The ampacity for which the correction factors are applied is that of cables laid in indoor air having the outdoor ambient temperature.											

Appendix E Methods for Calculation of Allowable Minimum Cross-section of Cable Conductor Based on the Short-circuit Thermal Stability Conditions

E.1 Allowable Minimum Cross-section of Conductors of Solid Insulated Cables

E.1.1 The allowable minimum cross-section of cable conductor shall be determined from:

$$S \geq \frac{\sqrt{Q}}{C} \times 10^2 \quad (\text{E.1.1-1})$$

$$C = \frac{1}{\eta} \sqrt{\frac{Jq}{\alpha K \rho} \ln \frac{1 + \alpha(\theta_m - 20)}{1 + \alpha(\theta_p - 20)}} \quad (\text{E.1.1-2})$$

$$\theta_p = \theta_0 + (\theta_H - \theta_0) \left(\frac{I_p}{I_H} \right)^2 \quad (\text{E.1.1-3})$$

E.1.2 Except for motor feeder circuits, the value of $\theta_p = \theta_0$ can be taken.

E.1.3 The method for determining Q value shall comply with the following requirements:

1 For feeder circuits of auxiliary motors rated 3 kV-10 kV used in thermal power plants, when the unit capacity is 100 MW and below:

$$Q = I^2(t + T_b) \quad (\text{E.1.3-1})$$

2 For the feeder circuit of auxiliary motors rated 3 kV-10 kV used in thermal power plants, if the unit capacity is above 100 MW, please see Table E.1.3-1 for the expressions of Q .

Table E.1.3-1 Expression of Q Value of Feeder Circuit for Motor Used in Thermal Power Plants with a Unit Capacity Larger Than 100 MW

$T(s)$	$T_b(s)$	$T_d(s)$	Q Value ($A^2 \cdot s$)
0.15	0.045	0.062	$0.196I^2+0.22II_d+0.09I_d^2$
	0.06		$0.21I^2+0.23II_d+0.09I_d^2$
0.2	0.045	0.062	$0.245I^2+0.22II_d+0.09I_d^2$
	0.06		$0.26I^2+0.24II_d+0.09I_d^2$
Note: 1 For reactors or double-winding transformer with a $U_d\%$ less than 10.5, $T_b=0.045$; and in other situations, $T_b=0.06$. 2 T may be taken to be 0.15 s and 0.2 s for medium and low speed breakers respectively.			

3 Except for the feeders for auxiliary motors of 3 kV-10 kV used in thermal power plant:

$$Q = I^2 \cdot t \quad (E.1.3-2)$$

Where:

S —cross-section of cable conductor (mm^2);

J —coefficient of mechanical equivalent of heat, being taken as 1.0;

Q —thermal capacity of unit volume of cable conductor ($J/cm^3 \cdot ^\circ C$), being take as 2.48 and 3.4 for aluminum- and copper-core cables respectively;

θ_m —allowable maximum temperature of cable conductor within short-circuit time ($^\circ C$);

θ_p —maximum working temperature of cable conductor before short circuiting occurs ($^\circ C$);

θ_H —allowable maximum working temperature of cable conductor under rated load of cable ($^\circ C$);

θ_m —maximum ambient temperature to which cables are exposed

(°C);

I_H —rated load current of cables (A);

I_p —actual maximum working current of cables (A);

I —initial effective value of periodic component contributed by system power supply to the short-circuit current (A);

I_d —sum of initial effective value of periodic components contributed by motors to feedback current (A);

t —duration of short circuit (s);

T_b —attenuation time constant of aperiodic component of system supply (s);

α —resistance temperature coefficient of cable conductor at 20°C (1/°C), being taken to be 0.003 93 and 0.004 03 for copper- and aluminum-core conductors respectively;

ρ —resistance coefficient of cables at 20°C ($\Omega\text{cm}^2/\text{cm}$), being taken to be $0.014\,8\times 10^{-4}$ and 0.031×10^{-4} for copper- and aluminum-core conductors respectively;

η —correction factor allowing for the effects of thermal capacity of cable conductor fillings, which should be taken to be $\eta=0.93$ for feeder circuits of motors rated 3 kV-10 kV and $\eta=1$ for other cases;

K —ratio of AC resistance to DC resistance of cable-core conductor, which may be taken according to Table E.1.3-2.

Table E.1.3-2 Selection of K Value

Cable Types		6 kV-35 kV Extruded Cable					Self-contained Oil-filled Cable		
Cross-section of conductor (mm^2)		95	120	150	185	240	240	400	600
Number of cores	Single-core	1.002	1.003	1.004	1.006	1.010	1.003	1.011	1.029
	multi-core	1.003	1.006	1.008	1.009	1.021			

E.2 Allowable Minimum Cross-section of Conductors for Self-contained Oil-filled Cables

E.2.1 The allowable minimum cross-section of cable conductor shall comply with the following formula:

$$S^2 + \left(\frac{q_0}{q} S_0 \right) S \geq \left[\alpha K \rho I^2 t / Jq \ln \frac{1 + \alpha(\theta_m - 20)}{1 + \alpha(\theta_p - 20)} \right] \times 10^4 \quad (\text{E.2.1})$$

Where:

S_0 —insulating oil filling area of cable conductors which are free of insulating oil contained in oil ducts (mm^2);

q_0 —thermal capacity of unit volume of insulating oil ($\text{J}/\text{cm}^3 \cdot ^\circ\text{C}$), which may be taken to be 1.7.

E.2.2 Except for the cables used in transformer circuits where θ_p value may be taken based on the maximum working current; in other cases θ_p should be taken to be equal to θ_H .

Appendix F Calculation Formula of Normal Induced Potential of Metallic Layer of Single-core Cables of AC System

F.0.1 In AC systems where each phase of one or two circuits of single-core cable lines are arranged normally, the normal induced potential at any point on the metallic layer of cable which is not directly grounded can be calculated from:

$$E_s = L \cdot E_{s0} \quad (\text{F.0.1})$$

Where:

E_s —induced potential (V);

L —distance from any position on the electrical path of cable metallic layer to the solid earthing location thereof (km);

E_{s0} —normal induced potential of unit length (V/km).

F.0.2 See Table F.0.2 for the expressions of E_{s0} .

Table F.0.2 Expressions of E_{s0}

Number of Cable Circuits	Arrangement Features when Centers between Neighboring Cables are Equal	Phase A or C (Outer Phase)	Phase B (Intermediate Phase)	Symbol Y	Symbol a (Ω/km)	Symbols b (Ω/km)	Symbol X_0 (Ω/km)
1	Two cables arranged in parallel	IX_0	IX_0				
	Three cables arranged in an equilateral triangle	IX_0	IX_0				
	Three cables arranged in a right triangle	$\frac{1}{2}\sqrt{3Y^2 + \left(X_0 + \frac{a}{2}\right)^2}$	IX_0	$X_0 + a/2$	$(2\omega \ln 2) \times 10^{-4}$		$(2\omega \ln S/r) \times 10^{-4}$
2	Three cables arranged in parallel straight lines	$\frac{1}{2}\sqrt{3Y^2 + \left(X_0 + \frac{a}{2}\right)^2}$	IX_0	$X_0 + a$	$(2\omega \ln 2) \times 10^{-4}$		$(2\omega \ln S/r) \times 10^{-4}$
	Two circuits of cables arranged in parallel with equal distance between neighboring cables (with the same phase sequence)	$\frac{1}{2}\sqrt{3Y^2 + \left(X_0 + \frac{a}{2}\right)^2}$	$I(X_0 + a/2)$	$X_0 + a + b/2$	$(2\omega \ln 2) \times 10^{-4}$	$(2\omega \ln 5) \times 10^{-4}$	$(2\omega \ln S/r) \times 10^{-4}$

Table F.0.2 (continued)

Number of Cable Circuits	Arrangement Features when Centers between Neighboring Cables are Equal	Phase A or C (Outer Phase)	Phase B (Intermediate Phase)	Symbol Y	Symbol α (Ω/km)	Symbols b (Ω/km)	Symbol X_0 (Ω/km)
2	Two circuits of cables arranged in parallel with equal distance between neighboring cables (the two circuits have reverse phase sequence)	$\frac{1}{2}\sqrt{3Y^2 + \left(X_0 + \frac{a}{2}\right)^2}$		$X_0 + a - b/2$	$(2\omega \ln 2) \times 10^{-4}$	$(2\omega \ln 5) \times 10^{-4}$	$(2\omega \ln S/r) \times 10^{-4}$
Note: 1 $\omega=2\pi f$; 2 r—mean radius of cable metallic layer (m); 3 I—normal working current of cable conductor (A); 4 f—working frequency (Hz); 5 S—centers between the adjacent cables; 6 For the circuit cables, it is assumed that I and r of each circuit are equal.							

Appendix G Additional Length of Cables Rated 5 kV and Below During Laying Measurement

Table G Additional Length of Cables Rated 5 kV and Below During Laying Measurement

Item		Additional Length (m)
Fabrication of cable terminal		0.5
Fabrication of cable joint		0.5
Leading from grade level to the terminals of various equipment	Motor (the actual height from junction box to grade level)	0.5-1
	Distribution panel	1
	Power control box of workshop	1.5
	Control panel or protection screen	2
	Auxiliary transformer	3
	Main transformer	5
	Magnetic starter or emergency button	1.5
Note: For directly buried cables that are led to buildings in plant areas, considering the topography and burying requirements, the length of cables reserved at cable terminals and joints allowing the connection with cable ducts, tunnels and hangers shall be 5% of the length of cable laying routes measured according to the drawings.		

Appendix H Calculation Methods for Maximum Allowable Length of Conduits in case of Putting Cables through Conduits

H.0.1 In cases where cables are laid by putting them through conduits, the maximum allowable length of conduits shall be determined according to the following expressions in respect of the allowable tension and lateral pressure of cables.

$$T_{i=n} \leq T_m \text{ or } T_{j=m} \leq T_m \quad (\text{H.0.1-1})$$

$$P_j \leq P_m \quad (j=1, 2 \cdots) \quad (\text{H.0.1-2})$$

Where:

$T_{i=n}$ —force required for pulling cables from the conduit inlet end to the n^{th} straight section, N;

$T_{j=m}$ —force required for pulling cables from the conduit inlet end to the m^{th} bend section, N;

T_m —allowable pulling force of cables, N;

P_j —lateral pressure applied to cables at the j^{th} bend conduit section (N/m);

P_m —allowable lateral pressure of cables (N/m).

H.0.2 The pulling force of cables laid in horizontal conduit can be calculated using the following formulas:

$$1 \quad \text{Straight section: } T_i = T_{i-1} + \mu C W L_i \quad (\text{H.0.2-1})$$

$$2 \quad \text{Bend section: } T_j = T_i \cdot e^{\mu \theta_j} \quad (\text{H.0.2-2})$$

Where:

T_{i-1} —pulling force at inlet of straight-line section (N); the initial pulling force $T_0 = T_{i-1} (i=1)$, which may be calculated by assuming a frictional force generated by cables with a

length of 20 m. For other cable sections, it may be assumed to be equal to the pulling force at the outlet of corresponding bend section;

μ —dynamic friction coefficient between cable and conduit;

W —weight of unit length of cable (kg/m);

C —correction coefficient of cable weight, for two cables, $C_2=1.1$; for three cables arranged in delta fashion,

$$C_3 = 1 + \left[\frac{4}{3} + \left(\frac{d}{D-d} \right)^2 \right];$$

L_i —length of the i^{th} straight conduit section (mm);

θ_j —included angle of the j^{th} bend conduit section (rad);

d —outside diameter of cable (mm);

D —internal diameter of protection tube (mm).

H.0.3 The lateral pressure applied to cables in bend conduit sections may be calculated by using the following formulas:

$$1 \quad \text{One cable:} \quad P_j = T_j / R_j \quad (\text{H.0.3-1})$$

Where:

R_j —internal radius of the j^{th} bend conduit section (m).

$$2 \quad \text{Two cables:} \quad P_j = 1.1 T_j / 2 R_j \quad (\text{H.0.3-2})$$

3 Three cables arranged in delta fashion:

$$P_j = C_3 T_j / 2 R_j \quad (\text{H.0.3-3})$$

H.0.4 The allowable tension of cables shall be determined based on the tensile strength of the tension carrying material in conjunction with a certain safety coefficient. The cables may be pulled by means of pulling head or steel mesh sleeve.

If pulling head is used, the allowable cable tension may be calculated from:

$$T_m = k \sigma q s \quad (\text{H.0.4})$$

Where:

k —correction coefficient, which is taken to be 1 for power cables and 0.6 for control cables;

σ —allowable tensile strength of conductor (N/mm^2), which is 68.6×10^6 and 39.2×10^6 for copper and aluminum cores respectively;

q —number of cable cores;

s —cable conductor cross-section area (mm^2).

H.0.5 For allowable lateral pressure of cables, the following values may be taken:

1 For isolated-phase belted type cables, $P_m=2500\text{N}/\text{m}$.

2 For extruded insulated or self-contained oil-filled cables, $P_m=3000\text{N}/\text{m}$.

H.0.6 For dynamic friction coefficient between cables and conduits, the values listed in Table H.0.6 may be taken.

Table H.0.6 Dynamic Friction Coefficient μ in Case of Penetrating Cables Through Conduits

Characteristic of Conduit Wall and Conduit Materials	Corrugated	Smooth		
	Polythene	Polyvinyl Chloride	Steel	Asbestos cement
μ	0.35	0.45	0.55	0.65
Note: The cable sheath is made from PVC and is applied with lubricant during laying.				

Explanation of Wording in This Code

1 When implementing the clauses in this code, the words of the degree of strictness to be treated differently are explained as follows:

- 1) Words denoting very strict requirement, which must be observed without exception:
“must” is used for affirmation; “must not” is used for negation.
- 2) Words denoting strict requirement under normal condition:
“shall” is used for affirmation; “shall not” is used for negation.
- 3) Words denoting a permission of slight choice, when conditions allow may first be chosen:
“should” is used for affirmation; “should not” is used for negation.
Words denoting of choice, when conditions allow may be chosen, “may” or “can” is used for affirmation.

2 When in some clauses of this code that certain related standards and codes shall be implemented, “be in accordance with” or “be in compliance with” is used for affirmation.
