KINGDOM OF CAMBODIA

Nation, Religion and King

ELECTRIC POWER TECHNICAL STANDARDS

Specific Requirements for Transmission and Distribution Facilities

Ministry of Industry, Mines and Energy

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Electric Power Technical Standards
Specific Requirements for Transmission and Distribution Facilities

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CHAPTER 1

INTRODUCTION

Article 1 - Definitions

In this Specific Requirements of Electric Power Technical Standards, unless the context otherwise requires, the terms below shall have the following meanings assigned to them:

1. EAC

"EAC" is the acronym for the Electricity Authority of Cambodia.

2. Electrical Line

"Electrical Line" means the part of electric power facilities used to transmit or supply electricity. "Electrical Line" connects power stations, substations, switching stations and user's sites. The "Electrical Line " also includes lines in associated protective devices and switchgears.

3. Electric Power Facility

"Electric Power Facility" means all facilities for generation, transmission and supply of electric power such as power stations, substations, switching stations, electrical lines, dispatching centers etc... in this also including equipment, buildings, dams, waterways, fuel storage yards, ash disposal areas, etc.

4. Electrical Equipment

"Electrical Equipment" means electrically-charged facilities.

5. GREPTS

"GREPTS" is the acronym for the General Requirements of Electric Power Technical Standards of the Kingdom of Cambodia.

6. Guy

"Guy" means a wire to reinforce the foundation of a supporting structure. It is usually installed between the ground and the upper part of the supporting structure.

7. High-voltage Line

"High-voltage Line" means an electrical line of voltage higher than 35kV.

8. IEC

"IEC" is the acronym for the International Electro technical Commission.

9. Insulated Conductor

"Insulated Conductor" means a cross-linked polyethylene (XLPE) insulated conductor for the medium-voltage lines and a XLPE insulated conductor or a polyvinyl chloride (PVC) insulated conductor for the low-voltage line.

10. ISO

"ISO" is the acronym for the International Organization for Standardization.

11. Joint Use

"Joint Use" means a condition that electrical lines and/or communication lines belonging to two or more owners are installed on the same supporting structure.

12. Low-Voltage Line

"Low-voltage Line" means an electrical line having voltage of not more than 600V.

13. Medium-Voltage Line

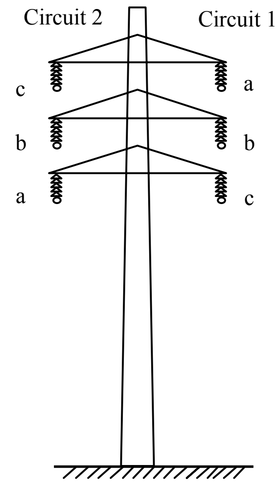
"Medium-voltage Line" means an electrical line having voltage of between 600V and 35kV.

14. National Grid

"National Grid" is the high voltage backbone system of interconnected transmission lines, substations and related facilities for the purpose of conveying bulk power.

15. Reversed phase-formation

"Reversed phase-formation" means a formation of double-circuit overhead-lines where three phase order of one side circuit is different from that of the other circuit as given in the right drawing.



16. RTU

"RTU" is the acronym for "Remote Terminal unit" for the SCADA system, installed at electric power facilities for monitoring and controlling those facilities.

17. SCADA

"SCADA" is the acronym for "Supervisory, Control, and Data Acquisition" and refers to the equipment used for monitoring and receiving data.

18. Side by Side Use

"Side by Side Use" means a condition that electrical lines and/or communication lines of one owner are installed on the same supporting structure.

19. SREPTS

"SREPTS" is the acronym for the Specific Requirements of Electric Power Technical Standards of the Kingdom of Cambodia.

20. Substation

"Substation" means the electric power facilities where voltage of electrical power is transformed and including transformers, lightning arresters, circuit breakers, disconnecting switches, voltage transformers, current transformers, bus bars, protective relay systems, RTU for SCADA system, telecommunication facilities, etc.

21. Supporting Structure

"Supporting structure" means a structure that supports electrical lines, such as wooden poles, iron poles, reinforced concrete poles and steel towers.

22. SWER

"SWER" is the acronym for the Single Wire Earth Return system. "SWER" is an electricity distribution method using one conductor with the return path through the earth.

23. Switching Station

"Switching Station" means the electric power facilities used to change-over the electrical lines, which include disconnecting switches, circuit breakers, bus-bars, protective relay system, the RTU for the SCADA system, etc.

24. The Technical Standards

"The Technical Standards" means the Electric Power Technical Standards in the Kingdom of Cambodia.

25. User's Site

"User's Site" means any place at which machines, apparatus and devices for using electricity are installed.

Article 2 - Purpose

This Specific Requirements of Electric Power Technical Standards for Transmission and Distribution Facilities prescribes the basic requirements necessary to regulate the existing and the planned transmission and distribution facilities in the Kingdom of Cambodia. The requirements in this standard document are mainly for facility security and safety operation of the most important parts for facilities.

Article 3 - Area of Application

All transmission and distribution facilities in the Kingdom of Cambodia shall be in accordance with the requirements prescribed in this Technical Standard.

All persons including licensees, consultants, contractors and consumers who are related to the study, design, construction and operation of transmission and distribution facilities shall follow these Specific Requirements of electric Power Technical Transmission and Distribution Standards.

Article 4 - Applicable Standards

Power transmission and distribution facilities planned to construct and operate in the Kingdom of Cambodia shall be as per the provision of this Technical Standards. In case a matter is not stipulated in the Technical Standards, IEC Standards shall be applied. If it is not covered in the IEC standards, ISO Standards shall be applied. If it is not covered in the ISO Standards, internationally recognized standards shall be applied, subject to the approval by MIME.

Article 5 - Types of Power Transmission and Distribution Facilities

Power transmission and distribution facilities regulated in this Specific Requirements of Electric Power Technical Standards has been divided into 2 types:

1- High Voltage Facilities

2- Medium and Low Voltage Facilities.

CHAPTER 2

GENERALS FOR TRANSMISSION AND DISTRIBUTION

PART 1

General Provisions

Article 6 - Prevention of Electric Power Disasters

The electrical equipment shall be installed in such a manner that does not cause electric shock, fire and other accidents.

Article 7 - Prevention of Accidents Caused by Electric Power Facilities

The electric power facilities shall be installed with proper measures for operators not to touch their moving parts, hot parts and other dangerous parts, and to prevent them from falling accidentally.

Article 8 - Safety of Third Persons

1- Safety of Third Persons at Power Stations, Substations and Switching Stations

Appropriate measures shall be taken to prevent third persons from entering compounds containing power stations, substations and switching stations. These measures shall include:

a. External fences or walls to separate outside from inside compound. The height of external fences or walls shall not be lower than 1,800 mm. Boundary Clearance from these fences or walls to electrical equipment shall not be less than the values described in the following table:

Table 1 - Boundary Clearance from Walls or Fences to Electrical Equipment

Nominal voltage [kV]	A : Height of a wall or a fence [mm]	Boundary clearance [mm]	
		B : Wall	C : Fence
(22)	not less than 1,800	not less than 2,100	not less than 2,600
115	not less than 1,800	not less than 2,100	not less than 2,600
230	not less than 1,800	not less than 2,900	not less than 3,400

b. Signs to alert third persons to danger shall be installed at the entrances/exits. Moreover, where necessary, signs shall also be displayed on walls and fences.

c. Locking devices or other appropriate devices shall be installed at the entrances/exits.

2- Safety of Third Persons at Electric Supporting Structures

Appropriate measures shall be taken to prevent third persons from climbing supporting structures of overhead electrical lines. To prevent danger to third persons related the supporting structures of electrical lines the following measures shall be taken:

- Any metal steps on supporting structures shall be installed more than 1.8m from the ground.
- Warning signs to alert the third persons to danger shall be installed at each supporting structure.
- As for high-voltage lines, appropriate devices shall be installed at all legs of supporting structures to prevent third persons from climbing the supporting structures. However, in case the supporting structures are located at places where third persons seldom approach such as in the mountains or where the supporting structures are surrounded by fences or walls with of an appropriate height, this article shall not be applicable.

Article 9 - Prevention of Failures of Electric Power Facilities from Natural Disasters

Proper measures shall be taken to prevent failures of electric power facilities from anticipated natural disasters such as floods, lightning, earthquakes and strong winds

Article 10 - Prevention of Electric Power Outage

- When any generating facilities have a serious fault, these facilities shall be disconnected from the power system so that the effect of the fault on the system can be minimized and the system could be operated continuously.
- When a power system fault occurs in a system connected to a generating facility, the generating facility shall immediately be disconnected from the system, so that the generator runs continuously with no-load while waiting for the recovery of the system from fault.

- When a power system fault affecting electrical lines occurs, the power cut areas shall be minimized as much as possible by disconnecting the faulty section or by other appropriate methods.

Article 11 - Protection against Over-current

1 General provision

Protection equipment against over-current shall be installed at the appropriate places of electrical circuits to prevent electrical equipment from over-heating due to excessive current and not to cause fire.

2 Properties of Over-current Protection Equipment for High-Voltage Lines and Medium-Voltage Lines

a. Properties of fuses used for protection of over-current on a medium-voltage electrical circuit shall conform to related IEC 60282 (2002-01) [High-voltage fuses].
b. Properties of circuit breakers used for protection against over-current on a medium-voltage electrical circuit shall conform to related IEC 62271[High-voltage switchgear and control gear].
c. An over-current breaker shall have a device to indicate its switching status according to its operation. However, if its switching status can be easily confirmed, it need not have such a device.

Article 12 - Protection against Ground Faults

Protection equipment against ground faults or other appropriate measures shall be provided to prevent damage of electrical equipment, electric shock and fire.

Article 13 - Environmental Protection

1 Compliance with Environmental Standards

To prevent environmental pollution, the electric power facilities shall be constructed in accordance with the environmental laws and regulations of the Kingdom of Cambodia.

2 Prohibition of Installation of Electrical Machines or Equipment Containing Polychlorinated Biphenyls (PCBs)

a. The installation of new electrical equipment using insulating oil that contains greater than 0.005 percent (50ppm) polychlorinated biphenyls (PCBs) shall be prohibited.

b. The use of existing electrical equipment using material containing PCBs, if it was installed before the Specific Requirements of Electric Power Technical Standards came into force, and effective and sufficient measures shall be taken in order to prevent the material containing PCBs from escaping from the oil container, shall be permitted.

c. Once removed from the electrical equipment, the material containing PCBs greater than 0.005 percent (50ppm) PCBs shall not be reinstalled in another electrical facility and shall be safely scrapped as noxious industrial wastes.

Article 14 - Life of Electrical Power Facilities

Electrical power facilities shall be durable for long term usage with efficient and stable operation.

Article 15 - Requirements related to the Design of Electrical Power Facilities

With regard to the design of electrical power facilities, selection of the materials, assembling and installation of the equipment, suitable safety factors against foreseeable stresses, such as insulation strength, thermal stress and mechanical stress shall be considered.

1 Insulation Co-ordination

Taking everything into consideration technically, economically and operationally, the insulation strength of electrical equipment and facilities of an electric power system, including power stations, substations, switching stations, transmission lines and distribution lines, shall be coordinated so that it may be in the most rational conditions. In co-ordination of insulation the following important items shall be considered:

a. Standard Withstand Voltage of Insulation

In selection of electrical equipment, its insulation shall be suitable with the “Standard lightning impulse withstand voltage” and “Standard short-duration power-frequency withstand voltage” given in the table of standard withstand voltage of insulation below.

Table 2 - Standard Withstand Voltage of Insulation

Nominal Voltage	22kV	115kV	230kV
Standard lightning impulse withstand voltage	95,125,145kV	550kV	950kV
Standard short-duration power-frequency withstand voltage	50kV	230kV	360,395kV

b. Installation of Surge Arresters

"Lightning impulse" and "Switching impulse" shall be controlled by installing surge arresters to coordinate them correctly.

c. Insulation Co-ordination of Power Stations, Substations, Switching Stations and Transmission Lines

In order to prevent the lightning impulse invasion to power stations, substations and switching stations from transmission lines as much as possible, the arcing horn gaps of the steel tower near the power stations, substations and switching stations shall coordinate with the standard withstand voltage of electrical equipment in the power stations, substations and switching stations.

2 Dielectric Strength of Electrical Circuits

The dielectric strength of electric circuits shall be examined by dielectric strength test, insulation resistance measurement and so on, to ensure that their performance corresponds to their nominal voltage.

Moreover, before starting operation, the dielectric strength shall be confirmed by charging nominal-voltage to the circuit continuously for 10 minutes.

However, if the nominal voltage of the electrical circuit is low-voltage, it can be tested by insulation resistance measurement or leakage current measurement. In case of the leakage measurement, it is sufficient to keep 1mA or less.

3. Thermal Strength of Electrical Equipment

Electrical equipment to be installed in the substations, switching stations and high-voltage and medium-voltage users' sites shall be able to withstand the heat generated by electrical equipment in normal operations.

4. Mechanical Strength of Electrical Equipment against Short-circuit Current

Generators, transformers, reactive power compensators, switching devices, bus bars and insulators for supporting bus bars to be installed in the substations and high-voltage and medium-voltage users' sites shall be able to withstand the mechanical shock caused by short-circuit current.

5 Prevention of Damage of Pressure Tanks

Gas insulated equipment installed in the substations, switching stations and high-voltage and medium-voltage users' sites shall be designed as following in order to avoid any risk of damage:

a. Materials and structure of the parts receiving pressure shall be able to withstand the maximum operating pressure and shall also be safe.

b. Parts receiving pressure shall be corrosion-resistant.

c. Insulation gas shall not be inflammable, corrosive or hazardous.

d. Tanks shall withstand the gas pressure rising during fault continuous time at internal failure of gas insulated equipment.

Article 16 - Technical Documents of Electrical Power Facility

To secure long term power supply , each facility shall have its drawings, installation records, technical manuals, instruction manuals and operation records necessary for its proper maintenance works . These documents shall be safekept well.

Article 17 - Communication System

To secure the power supply, suitable communication facilities consisted of SCADA systems and voice communication systems shall be provided.

1. SCADA System

SCADA systems are used to monitor and control electric power facilities and consist of RTUs, telecommunication lines and a master station.

1.1 The RTU for the SCADA System shall be installed in electric power facilities so that the state of the National Grid can be monitored and the power facilities can be controlled at the Dispatching Center.

1.2 Necessary SCADA system shall be installed between the Dispatching Center and electric power facilities.

2. Telecommunication Line

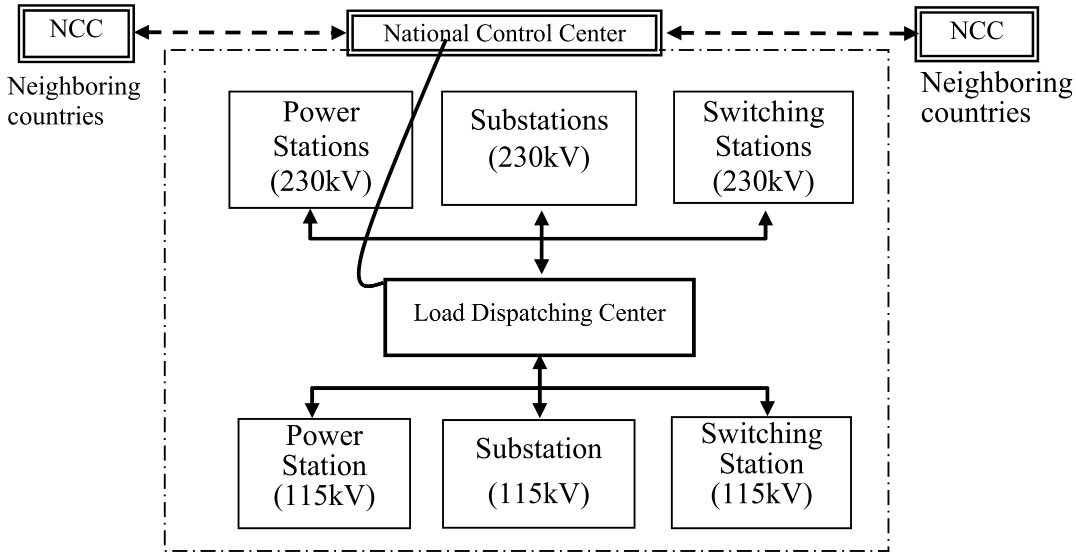
Necessary telecommunication lines for SCADA systems and voice communication systems shall be installed as follows.

2.1 Installation Sites

a. Between the NCC and the Load Dispatching Center;

b. Between the Load Dispatching Center and the power facilities that compose the National Grid.

c. Between the NCC and neighboring countries' NCCs when the power system is connected to a neighboring country. If there are any agreements on these systems with neighboring countries, this may not be applicable.



(Legend)
NCC : National Control Center
⟷ : Lines for domestic telecommunication
⇠ ⇢ : Lines for telecommunication to neighboring countries

Figure 1 - Installation Sites

2.2 Kinds of Lines and Condition of Lines for Domestic Telecommunication line

- At least two different telecommunication lines shall be required for the National Grid.
- Lines for domestic telecommunication systems for the power system shall be provided in accordance with Table 3.

Table 3 - Type of Lines for Facilities Connected to National Grid

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">Between National control center and Load dispatching center</td><td colspan="2">Between Load dispatching center and Power Facilities</td></tr>
<tr><td>Data</td><td>Voice</td><td>Data</td><td>Voice</td></tr>
<tr><td rowspan="6">Type of Line</td><td>Optical fiber</td><td>1 line</td><td>1 line</td><td>1 line</td><td>1 line</td></tr>
<tr><td>Optical fiber</td><td rowspan="5">1 line (selected from 5 types)</td><td rowspan="5">1 line (selected from 5 types)</td><td rowspan="5">1 line (selected from 5 types)</td><td rowspan="5">1 line (selected from 5 types)</td></tr>
<tr><td>Metal cable</td></tr>
<tr><td>Radio</td></tr>
<tr><td>Power line carrier</td></tr>
<tr><td>Microwave</td></tr>
<tr><td colspan="2">Condition of lines</td><td colspan="4">Exclusive line for Power System</td></tr>
</table>

3. Securing means of communication in an emergency

Communication facilities, which are essential to recover the power system when unexpected disasters occur, shall be sufficiently reliable to be secure in an emergency.

Article 18 - Accuracy of Power Meters

Power meters shall be accurate, fair and equitable. The accuracy of a meter shall be generally as follows:

Table 4 - Accuracy of Electro-magnetic Mechanical Power Meters and Electric Power Meters

Type of Customer	*Class
High-voltage customers	0.5
Medium-voltage customers	1.0
Low-voltage customers	2.0

* In accordance with the IEC

PART 2

Grounding

Article 19 - General Requirements for Grounding

Grounding or other appropriate measures shall be provided for electrical equipment to prevent electric shock, danger to human beings, fire, and other trouble to objects.

Grounding for electrical equipment shall be installed to ensure that current can safely and securely flow to the ground.

Article 20 - Classification of Grounding

Grounding for electrical equipment of all electric power facilities can be classified in 4 classes as shown in the following table:

Table 5 - Classification of Grounding Work

Classification of grounding work	Resistance to earth	Conditions for easement of resistance value
Class A	10Ω or less	
Class B	10Ω or less (When $\frac{230}{I^{*1}}$ is less than 10, resistance to earth shall be the value of $\frac{230}{I^{*1}}$ or less.)	In the case where voltage to earth of a low-voltage electrical circuit exceeds 230V due to power contact between the medium-voltage electrical circuit and the low-voltage electrical circuit of the transformer, when an earth leakage breaker that cuts off the electrical circuit within 1 second is installed, $\frac{600}{I^{*1}}$ Ω or less. When $\frac{230}{I^{*1}}$ becomes less than 5Ω, it shall not be necessary to obtain resistance less than 5Ω.
Class C	10Ω or less	In the case where grounding arises in a low-voltage electrical circuit, when an earth leakage breaker that acts within 0.5 seconds is installed, the resistance value shall be 500Ω or less.
Class D	100Ω or less	In the case where grounding arises in a low-voltage electrical circuit, when an earth leakage breaker that acts within 0.5 seconds is installed, the resistance value shall be 500Ω or less.

Remarks:

*1 - I is Single-line ground fault current (A)

Article 21 - Grounding for Electrical Lines

The types of grounding, the places to be applied, installation conditions, and the resistance value to earth of electrical lines shall be as given in the following table.

Table 6 - Kinds of Groundings for Electrical Lines

<table>
<tr><th>Grounding</th><th>Application</th><th>Installation conditions</th><th>Resistance to earth (Ω)</th></tr>
<tr><td>System grounding</td><td>MV/LV transformer</td><td>Low-voltage neutral conductor of TT or TN grounding type</td><td>Value prescribed for Class B grounding work</td></tr>
<tr><td rowspan="4">Safety grounding</td><td rowspan="4">Exposed conductive parts (*1)</td><td>For high-voltage line (*2)</td><td rowspan="2">Value prescribed for Class A grounding work</td></tr>
<tr><td>For medium-voltage</td></tr>
<tr><td>For low -voltage exceeding 300V</td><td>Value prescribed for Class C grounding work</td></tr>
<tr><td>For low-voltage not exceeding 300V</td><td>Value prescribed for Class D grounding work</td></tr>
<tr><td>Arrester grounding</td><td>Surge arrester</td><td>For medium-voltage</td><td>Value prescribed for Class A grounding work</td></tr>
</table>

Remarks:

*1) "Exposed conductive parts" refers to parts such as steel stands, metal case or similar, of apparatus installed in the electrical circuit.

(*2) Groundings for high-voltage substations and switching stations shall be individually designed, depending on the short-circuit capacity.

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Article 22 - Grounding for Power Stations, Substations, Switching Stations and High-voltage and Medium-voltage Users' Sites

1. Grounding for Electrical Facilities

1.1 Safety Grounding

Electrical equipment to be installed in power stations, substations, switching stations and high-voltage and medium-voltage users' sites shall be equipped with the protective groundings listed below so that there is no risk of rise of potential under abnormal conditions, no harm to human bodies and no damage to other objects due to electric shocks and fires caused by high voltage invasion.

1.1.1 Grounding for Exposed Conductive Parts of Electrical Equipment

Exposed conductive parts of electrical equipment such as metal stands and metal case shall be connected with the ground by grounding. Grounding for exposed conductive parts of electrical equipment of different voltage is provided in the table below:

Table 7 - Grounding for Exposed Conductive Parts of Electrical Equipment

Voltage of electrical equipment	Kind of grounding work
High-voltage electrical equipment	Class A
Medium-voltage electrical equipment	Class A
Low-voltage electrical equipment (Over 300V)	Class C
Low-voltage electrical equipment (300V or lower)	Class D

1.1.2 Grounding for other facilities

Other facilities such as outdoor metal structures, external metal fences, protective metal fences and metal stands for operation shall be provided also with grounding work according to the voltage of the electrical facilities or equipment listed in table above.

1.1.3 Grounding for Conductive Parts in Electrical Equipment

At necessary points in electrical circuits, the grounding listed below shall be provided:

a. Grounding of Instrument Transformers (Current or Voltage Transformers)

   Class A grounding work shall be provided at an arbitrarily chosen point in the electrical circuit on the secondary side of a high-voltage or medium-voltage instrument transformer.

   In case where grounding work is provided for the electrical circuit on the primary side of a high-voltage or medium-voltage instrument transformer, Class A grounding work shall be provided.

b. Grounding for Station Service Transformers

In case where grounding is provided for the electrical circuit on the secondary side of transformers connecting a medium-voltage electrical circuit and a low-voltage electrical circuit, Class B grounding work shall be provided.

A "low-voltage electrical circuit" means an electrical circuit that supplies electricity to automatic control circuits, remote control circuits, signal circuits for remote monitoring devices, and the like.

c. Grounding for the Stabilizing Windings in Transformers

In case where the star-star winding high-voltage and medium-voltage transformers have a stabilizing winding for reducing the zero phase impedance which is not connected with outgoing electrical circuit, this winding shall be grounded with Class A grounding.

1.2 Grounding for Neutral Points in High-voltage and Medium-voltage Electrical Circuits

In case where grounding is provided for the neutral point of high-voltage and medium-voltage electrical circuits in power stations, substations, switching stations and high-voltage and medium-voltage users' sites in order to secure reliable operation, to suppress abnormal voltage and to reduce the voltage to ground for protective devices of electrical circuits, the grounding electrode shall be installed to prevent risks of danger to people, domestic animals and other facilities due to the potential difference generated between the pole and the nearby ground when any failure occurs.

1.3 Grounding for Electrical Equipment for SWER

In case where electrical equipment for SWER are installed in power stations and substations, grounding for electrical equipment for SWER shall be provided to prevent risks of danger to people, domestic animals and other facilities due to the potential difference between the electrical equipment and the nearby ground caused by load current and when any failure occurs.

1.4 Grounding for Lightning Guards

The grounding resistance provided for lightning guards such as overhead ground wires and lightning rods to be installed in power stations, substations, switching stations and high-voltage and medium-voltage users' sites shall be not greater than 10 Ω.
However, in case where overhead ground wires are used as SWER, the grounding work shall apply as grounding on earth-return side of SWER provided above.

1.5 Grounding for Surge Arresters

The grounding resistance provided for surge arresters for high-voltage and medium-voltage electrical circuits in power stations, substations, switching stations and high-voltage and medium-voltage users' sites shall be less than 10 Ω as much as possible to prevent hindrance to the functions of the surge arrester

2 Particularities of Grounding Arrangement

2.1 Properties of Grounding Conductors

Grounding conductors to be installed in electrical circuits in power stations, substations, switching stations and high-voltage and medium-voltage users' sites shall be constructed of corrosion-resistant metallic wire and shall be able to carry the current safely during failures.

a. Mechanical Strength of Grounding Conductors
In order to secure necessary mechanical strength, the grounding conductors listed in Table 7 shall be used, depending on the kind of grounding work for which the grounding conductor is used.

Table 8 - Grounding Conductors to be used for Grounding Work

Kind of grounding conductors / Kind of grounding work		Metal wire	Annealed copper wire	Annealed copper twisted wire
		Tensile strength	Diameter	Sectional Area
Class A	Grounding conductors for neutral points of high-voltage and medium-voltage electrical circuits in generators and transformers	not less than 3 kN	not less than 4 mm	not less than 14 mm^2
	Others	not less than 2 kN	not less than 3 mm	not less than 6 mm^2
Class B	Low-voltage side neutral points of transformers transforming medium-voltage into low voltage	not less than 2 kN	not less than 3 mm	not less than 6 mm^2
Class C		not less than 1 kN	not less than 2 mm	not less than 4 mm^2
Class D		not less than 1 kN	not less than 2 mm	not less than 4 mm^2

b. Thermal Strength of Grounding Conductors

Grounding conductors in which grounding current flows when any abnormality occurs, such as those for neutral points of electrical equipment and high-voltage and medium-voltage electrical circuits, shall have also enough thermal strength against the heat from grounding current during the occurrence of such abnormality or failures in addition to mechanical strength.

2.2 Installation of Grounding Conductors

Grounding conductors for instrument transformers, neutral points, surge arresters and SWER to be installed in power stations, substations, switching stations and high-voltage and medium-voltage users' sites shall be grounded directly to the ground without being connected to stands of equipment. Bare live parts of grounding conductors shall be installed so that there is no risk of operators easily coming into contact with them.

2.3 Neutral Grounding Devices

Resistors and reactors to be connected to grounding conductors in power stations, substations, switching stations and high-voltage and medium-voltage users' sites shall be suitable and safe for the flows of electric current when any failure occurs.

Bare live parts of resistors, reactors and other neutral grounding devices shall be installed so that there is no risk of operators easily coming into contact with them.

2.4 Prohibition against Installation of Switching Devices on Grounding Conductors for Neutral

No switching device and power fuse, excluding switching devices to be installed to switch neutral resistors and neutral reactors, shall be installed on grounding conductors for neutral in power stations, substations, switching stations and high-voltage and medium-voltage users' sites.

2.5 Connection between Grounding Conductors

Grounding conductors of earth-return side of SWER to be installed in power stations and substations shall not be connected to the grounding conductors of other electrical equipment.

Article 23 - Grounding for Distribution Lines and Low-Voltage Users' Sites

1. Particularities of Grounding Arrangement

Grounding for distribution lines and low-voltage users' sites shall be installed according to the following.

1.1 Grounding Electrodes

1.1.1 Materials and dimensions of the grounding electrodes shall be selected for corrosion resistance and adequate mechanical strength.

1.1.2 The following are examples of grounding electrodes which may be used:

a. Metal plates

b. Metal rods or pipes

c. Metal tapes or wires

d. Underground structural networks embedded in foundations (foundation grounding)

e. Other suitable underground metalwork approved by MIME

1.2 Grounding Conductors and Protective Conductors

Protective conductors in this provision mean the conductors used for connecting electrical equipment to the grounding system.

a. Grounding conductors and protective conductors shall be constructed of corrosion-resistant metallic wire and shall be able to carry the current safely at failures.

b. Grounding conductors shall comply with paragraph c and, where buried in the soil, their cross-sectional areas shall be in accordance with Table 9A.

Table 9A - Minimum Cross-sectional Areas of Grounding Conductors Buried in the Soil

Conditions	Mechanically protected	Mechanically unprotected
Protected against corrosion	2.5 mm^2 Cu (Copper) 10mm^2 Fe (Iron)	16mm^2 Cu (Copper) 16mm^2 Fe (Iron)
Not protected against corrosion	25mm^2 Cu 50mm^2 Fe	

c. The cross-sectional area of protective conductors shall be selected in accordance with Table 9B or paragraph d.

Table 9B - Minimum Cross-sectional Area of Protective Conductors

Cross-sectional area of line conductor S (mm^2)	Minimum cross-sectional area of the corresponding protective conductor (mm^2)	
	If the protective conductor is the same material as the line conductor	If the protective conductor is not the same material as the line conductor
S≤16	S	k × S
16<S≤35	16	k × 16
S>35	S/2	k × S/2

*k is selected from Table 9C.

Table 9C - Factor k, for Table 9B

Materials of line conductors	Conductor insulation	Materials of protective conductors					
		Aluminum		Copper		Steel	
		PVC	Rubber	PVC	Rubber	PVC	Rubber
Aluminum	PVC <300mm^2	-	-	0.58	0.48	1.56	1.32
	PVC >300mm^2	-	-	0.52	0.43	1.39	1.18
	EPR / XLPE	-	-	0.71	0.60	1.92	1.92
Copper	PVC<300mm^2	1.31	0.73	-	-	2.45	1.99
	PVC >300mm^2	1.18	0.65	-	-	2.11	1.78
	EPR/ XLPE	1.63	0.90	-	-	2.92	2.47

*Note: Factor k provided here is used only for insulated protective conductors not incorporated in cables and not bunched with other cables. In case of other protective conductors, the factor shall follow IEC60364-5-54.

d. The cross-sectional area of every protective conductor which does not form part of the cable or which is not in a common enclosure with the line conductor shall be not less than the size given in Table 9D.

Table 9D - Cross-sectional Area of Protective Conductors (IEC60364-5-54)

Mechanically protected	Mechanically unprotected
$2.5mm^2$ Cu $16mm^2$ Al	$4mm^2$ Cu $16mm^2$ Al

1.3 Installation of Grounding Electrodes and Conductors

In case there is any danger of persons touching grounding conductors, electrodes and conductors for Class A and Class B shall be installed as described below:

a. Grounding electrodes shall be installed at depths of not less than 75cm underground.

b. Grounding conductors shall be covered in the section from 75cm underground to 2.0 m above ground by a synthetic resin pipe or another shield of equivalent or higher insulating effect and strength.

c. If the grounding electrode is installed along iron poles or other metallic objects, insulated conductor or cable shall be used for the full length of the grounding conductor.

d. If the grounding electrode is installed along iron poles or other metallic objects, the grounding electrode shall be buried with a clearance of not less than 1m from those metallic objects.

   In case where the grounding electrode is installed along iron poles or other metallic objects, the clearance between the top of the electrode and the bottom of iron poles or other metallic objects shall be not less than 30 cm.

2. Class B Grounding Resistance

Single-line ground fault current (I) of an electrical circuit in the medium-voltage side used for calculation of resistance of Class B grounding provided in Article 20 of these SREPTS shall conform to an actual value, or the following:

2.1 Medium-voltage Electrical Circuit of Isolated Neutral System

Class B grounding resistance for isolated neutral systems shall be determined by the following:

a. Electrical circuits using an electric conductor other than a cable

   For electrical circuits using an electric conductor other than a cable, Class B grounding resistance shall be not more than ten 10 Ω.

b. Electrical circuits using a cable for an electrical conductor

For electrical circuits using a cable for an electrical conductor, Class B grounding resistance shall be determined by Table 9E and Table 9F according to the total length of medium-voltage circuit (limited to that using a cable for an electrical conductor) connected to the same bus.

Table 9E - In Case Class B is Decided by 230/I

L	<3km	3km≤
Class B grounding resistance (Ω)	10	5

Table 9F - In Case Class B is Decided by 600/I*

L	<4.5km	4.5km≤
Class B grounding resistance (Ω)	10	5

* In case of an earth leakage breaker that cuts off the electrical circuit within 1 second

Where:

L: the total length of medium-voltage circuit (limited to that using a cable for an electrical conductor) connected to the same bus.

c. Electrical circuits using an electrical conductor other than cable and also a cable for an electrical conductor

In this case, Class B grounding resistance shall be determined by Table 9E and Table 9F according to the total length of medium-voltage feeders (limited to that using a cable for an electrical conductor) connected to the same bus.

2.2 Medium-voltage Electrical Circuit of Solidly Grounded Neutral System

Single-line ground fault current (I_2) of an electrical circuit in the medium-voltage side used for calculation of grounding resistance in Class B grounding provided in Article 20 of these SREPTS shall conform to an actual value, or the following formula.

$$I_2 = \sqrt{I_1^{\,2} + \frac{V^2}{3R^2} \times 10^6}$$

* Any fraction less than the decimal point shall be rounded up.

Where:

I_2: Single-line ground fault current (A);

I_1: Single-line ground fault current of the electrical circuit in case of no solidly system grounding which is calculated by a theoretical formula (A);

V: Nominal system voltage of the electrical circuit (kV);

R: Electric resistance value of the resistance used in the neutral point (including the resistance to ground value of the neutral point) (Ω);

3. Grounding Systems for Low-voltage Lines

Grounding systems for low-voltage lines have 2 types: TT and TN. These grounding works shall comply with IEC 60364-1.

a. The TT system has one point directly grounded and the exposed-conductive parts of the installation are connected to ground that are electrodes electrically independent of the ground electrodes of the power system.

b. The TN system has one point directly grounded and the exposed-conductive parts are connected to the point by protective conductors. Two types of TN system are considered according to the arrangement of neutral and protective conductors, as follows:

  - TN–S system: in which, throughout the system, a separate protective conductor is used;
  - TN-C system: in which neutral and protective functions are combined.

c. Low-voltage electrical equipment to be installed at users' sites shall be installed according to the IEC 60364 series. If it is directly connected to a power supplier, the grounding system shall be the same as that of the supplier's equipment involved in the supply of low-voltage electricity.

   Low-voltage electrical equipment shall not be installed in such a manner that the grounding systems are different from those used at the same user's site.

(LEGEND)

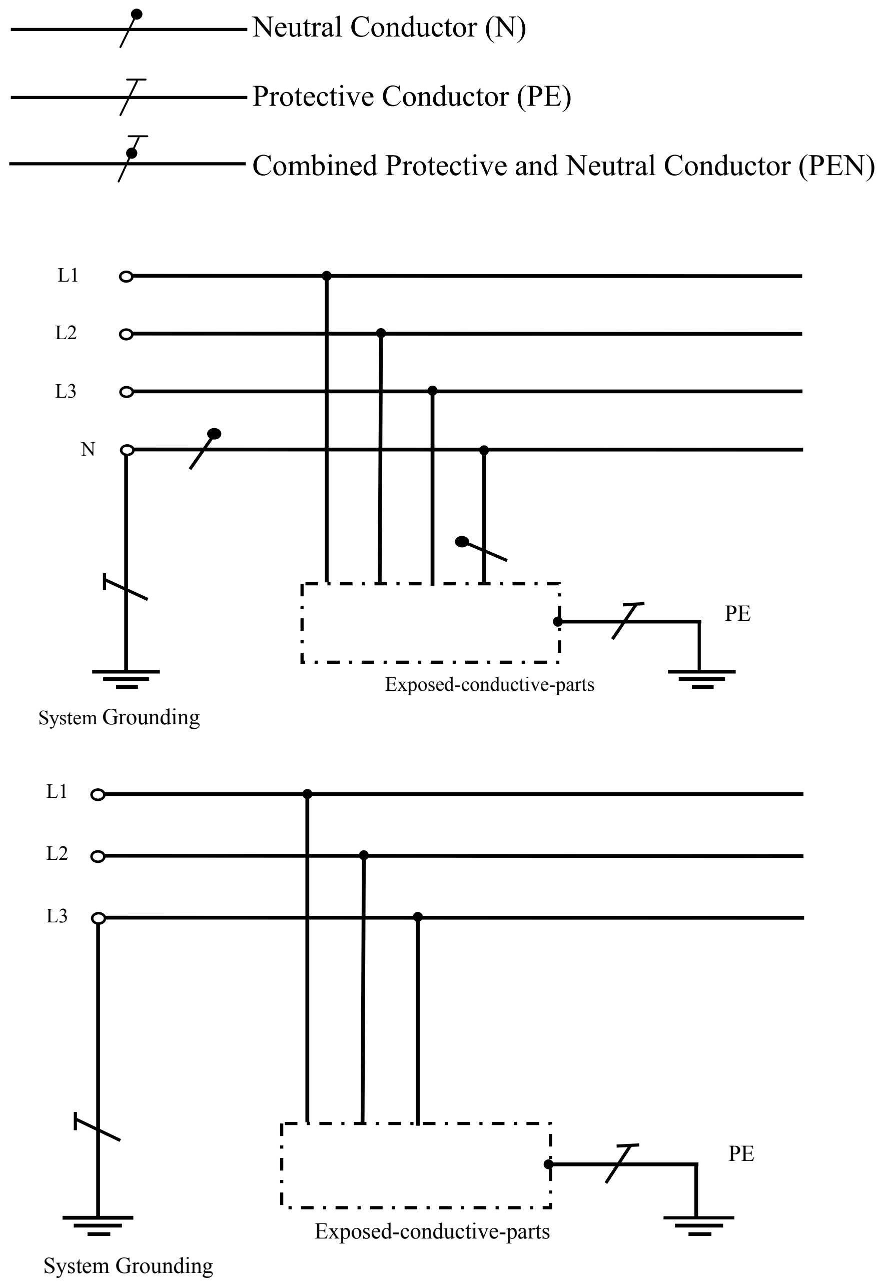
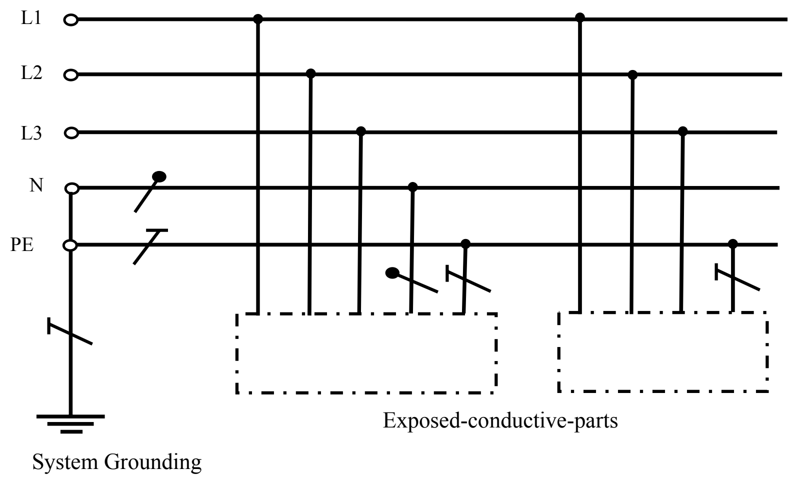


Figure 2 - TT System



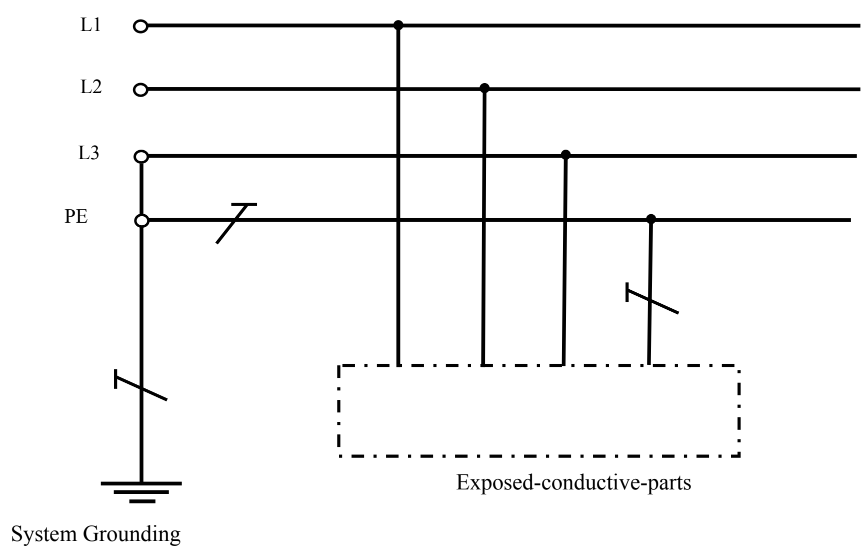
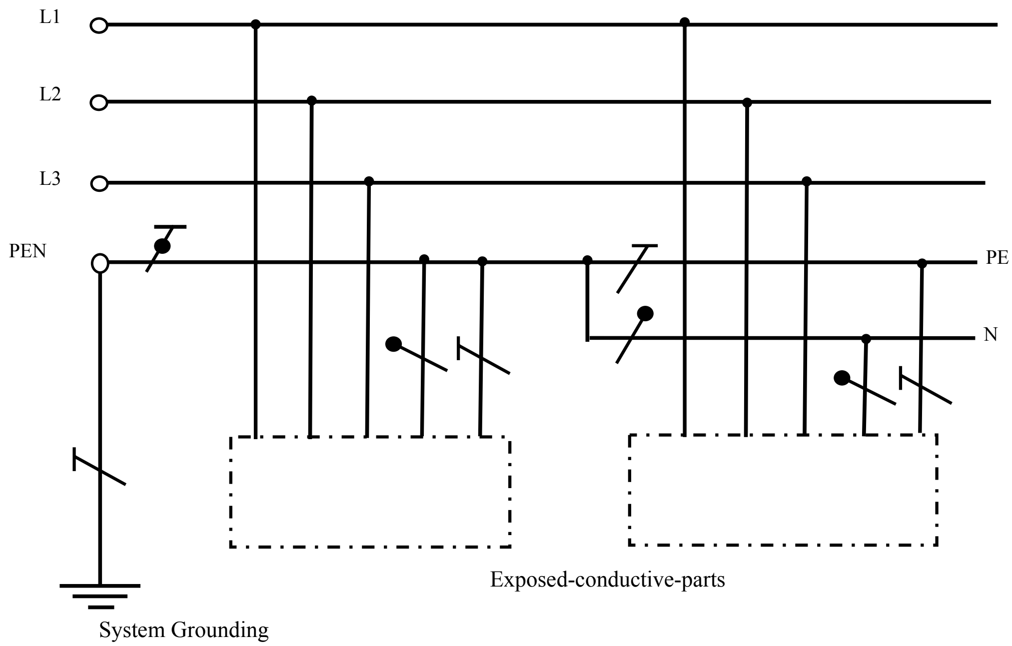


Figure 3 - TN-S System



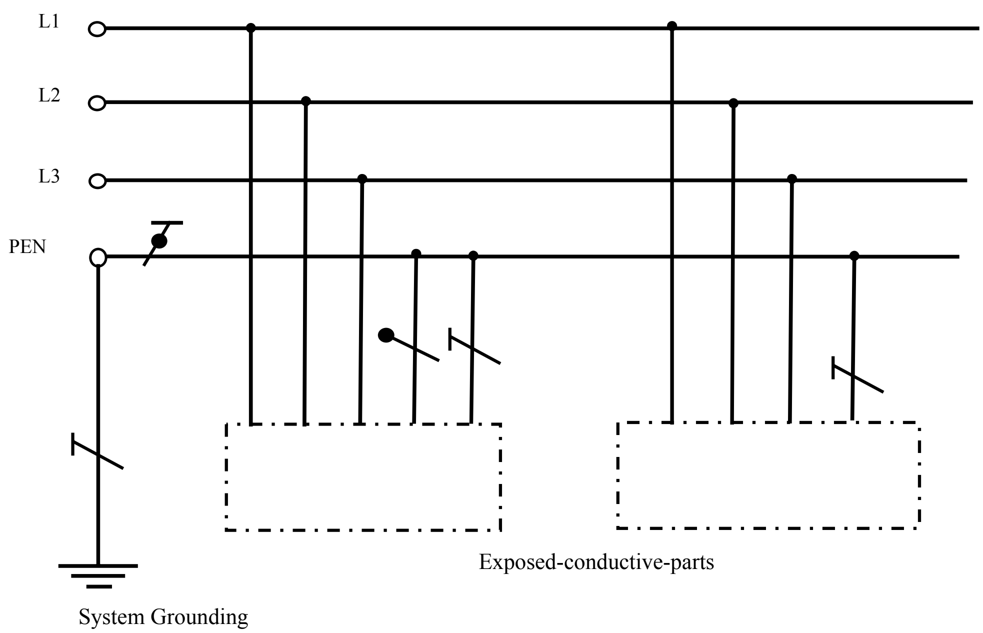


Figure 4 - TN-C System

PART 3

Conductor

Article 24 - Conductors for Transmission and Distribution Facilities

1- Generals

The conductors for transmission and distribution facilities shall be cables, insulated conductors or bare conductors. Bare conductors shall not be used for low-voltage lines.

Cables and insulated conductors shall have sufficient insulation capacity appropriate for the conditions of the applied voltage.

2- Property of Conductors

2.1- The conductors shall withstand temperatures under ordinary use.

2.2- The structure of the conductors

a. **Insulated Conductors**
   The structure shall be an electric conductor covered with insulating material.

b. **Cables used in Low-voltage Line**
   The structure shall be such that an electric conductor is covered with insulating material that is protected with armor.

c. **Cables used in Medium-voltage Line**
   The structure shall be such that an electric conductor is covered with insulating material that is protected with armor, and that has a metal electric shielding layer made of metal provided on the cable core in a single-core cable, and on the cable cores bundled together, or on each cable core in a multi-core cable.

2.3 The conductors, the completed product to be used in a transmission line, or in a distribution line shall pass an appropriate AC withstand voltage test.

2.4 The tensile strength per unit area (MPa) of hard-drawn aluminum wires used for single conductors in an overhead line shall be not less the value given in Table 10 conforming to the related IEC standards.

Table 10 - Tensile Strength of Hard-drawn Aluminum Wires (IEC 60889)

Nominal diameter		**Minimum tensile strength (MPa)**
Over (mm)	**Up to and including (mm)**	
-	1.25	200
1.25	1.50	195
1.50	1.75	190
1.75	2.00	185
2.00	2.25	180
2.25	2.50	175
2.50	3.00	170
3.00	3.50	165
3.50	5.00	160

Article 25 - Connection of Conductors

Conductors shall be connected as per following methods:

a. Conductors shall be connected firmly and the resistance of conductors shall not increase more than the resistance of conductors without connection.

b. Conductors shall be connected so that the insulating capacity of cables and insulated conductors shall not decrease less than the insulating capacity without connection.

c. With regard to connecting conductors of different kind of materials, electrochemical corrosion shall be prevented.

Article 26 - Safety Factor of Bare Conductors and Ground Wires of Overhead Electrical Lines

1- Generals

As for tensile strength of conductors and ground wires for overhead electrical lines except for cables, the safety factor shall be 2.5 or more.

2- Loads on Conductors for Overhead Transmission Lines

2.1- Assumed Load and Safety Factor

Overhead transmission conductors and overhead ground wires (excluding cables, the same applies hereafter in this clause) shall be installed with the tension to allow a safety factor specified in the following Item 2.1.2 when they are subject to the assumed load specified in the following Item 2.1.1 below at the average temperature in the area.

2.1.1- Assumed Load

The assumed load for the calculation of tension of overhead transmission conductors and overhead ground wires shall be the composite load of the vertical loads specified in the following item a and the horizontal loads specified in the following item b.

a. The vertical load shall be the weight of the electrical conductor.
b. The horizontal load shall be the horizontal maximum wind pressure load of the electrical conductor's vertical projected area.

2.1.2 Safety Factor

A safety factor of 2.5 or more shall be applied to the tensile strength (ultimate tensile strength; breaking strength) of overhead transmission conductors and overhead ground wires.

2.1.3 Reference Wind Velocity

Reference wind velocity to design overhead lines shall be as given in Table 11.

Table 11 - Reference Wind Velocity

Yearly maximum of 10-minute average wind velocity (50 year return period)	32 m/sec

In the following circumstances, the above reference wind velocity can be changed.

a. When sufficient observed data have been accumulated.

b. When greater reliability is especially needed.

c. When the design is needed to cooperate with the designs of neighboring countries.

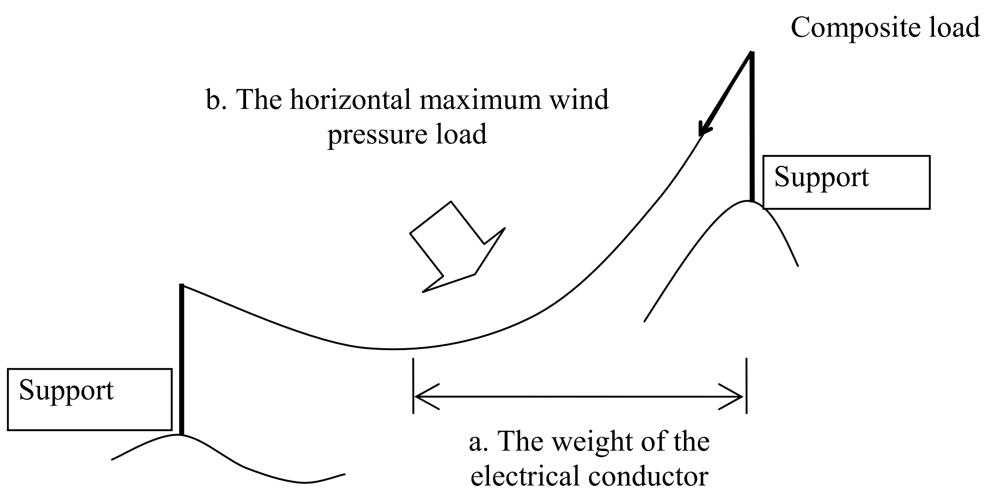


Figure 5 - Assumed Load

Article 27 - Side-by-Side Use and Joint Use of Electrical Lines or Communication Lines

1- High-Voltage Lines, Medium-Voltage Lines and Low-Voltage Lines

Side-by-side use and joint use of electrical lines shall be done by the following methods.

1.1- High-voltage Lines and Medium-voltage Lines

a- When a high-voltage line and a medium-voltage line are installed at the same supporting structure, the medium-voltage line shall be installed under the high-voltage line and on separate crossarms.

b- The clearance between any overhead high-voltage line conductors and any overhead medium-voltage line conductors shall under no circumstances be less than the values specified in Article 36 of these SREPTS at any point in the span.

c- The overhead high-voltage line conductor shall be stranded wire with a tensile strength of at least 30kN, unless they are cables.

d The nominal voltage of the high-voltage electrical lines in side-by-side use or joint use shall be not more than 115kV.

1.2- Medium-voltage Lines and Low-voltage Lines

1.2.1 When a medium-voltage line and a low-voltage line are installed at the same supporting structure, the low-voltage line shall be installed under the medium-voltage line and on separate cross arms.

1.2.2 The conductor of the low-voltage line shall be conformed with following provisions, except in cases where cables are used:

a- In case the span of the low-voltage line is shorter than 50m, the tensile strength shall be not less than 5kN.

b- In case the span of the low-voltage line is 50m or over, the tensile strength shall be not less than 8kN.

1.2.3 The low-voltage line in a part installed on the same supporting structure of an overhead high-voltage line shall be grounded with class B grounding and its resistance shall be not more than 10Ω.

1.2.4 The clearance between any overhead medium-voltage line conductors and any overhead low-voltage line conductors shall under no circumstances be less than the values specified in Article 47 of the SREPTS at any point in the span.

1.3- High-voltage Lines and Low-voltage Lines

1.3.1 No low-voltage line shall be installed at the same supporting structure where a high-voltage line is installed.

1.3.2 Exception of Side-by-side Use of High-voltage Lines and Low-voltage Lines

Side-by-side use of high-voltage lines and low-voltage lines is permitted only if all following measures are taken to intensify the facilities.

(1) The conductor of the low-voltage line shall be conformed with following provisions, except in cases where cables are used:

a- In case the span of the low-voltage line is shorter than 50m, the tensile strength shall be not less than 5kN.

b- In case the span of the low-voltage line is longer than 50m, the tensile strength shall be not less than 8kN.

(2) The low-voltage line in a part installed on the same supporting structure of an overhead high-voltage line shall be grounded with Class B grounding and its resistance shall be not more than 10Ω.

(3) The clearance between any overhead high-voltage line conductors and any overhead low-voltage line conductors shall under no circumstance be less than 4.5m at any point in the span.

(4) The overhead high-voltage line conductor shall be stranded wire with a tensile strength of at least 30kN unless they are cables.

(5) The nominal voltage of the high-voltage line shall be not more than 115kV. In case the high-voltage line has double circuits, reversed phase-formation shall be adopted.

(6) The distance of side-by-side use of high-voltage lines and low-voltage lines shall be decided taking the assumed induction voltage into consideration.

(7) Exception can be allowed in the following unavoidable circumstances:

a- There is no suitable space to install a low-voltage line in urban areas, because houses stand close together and the only appropriate low-voltage line route is along a road but a high-voltage transmission line has been already installed there.

b- Other special circumstances approved by the EAC.

2- Electrical Lines and Communication Lines

Side-by-side use and joint use of electrical lines and communication lines shall be done by the following methods. If communication lines consist of optical fibers and they are tied to electrical lines or ground wires, this may not be applicable.

a. When a medium-voltage or a low-voltage line and a communication line are installed on the same supporting structure, the medium-voltage or the low-voltage line shall be installed above the communication line and on separate cross arms.
b. No communication line shall be installed at the same supporting structure where a high-voltage line is installed.

Article 28 - Underground Lines

1- Conductors of Underground Lines

Cables shall be used for underground electrical lines.

2- Draw-in Conduit System and Culvert System

a- In case underground lines are installed with a draw-in conduit system, tubes of the draw-in conduit system shall have sufficient strength to withstand the pressure of vehicles and other heavy objects.

b- In case the strength of the tubes cannot be verified, they shall be installed not less than 1.2 m in depth to prevent a danger due to the pressure from vehicles and other heavy objects.

c- In case underground lines are installed with a draw-in culvert system as shown in Figure 6 B, culverts shall be capable of withstanding the pressure of vehicles and other heavy objects.

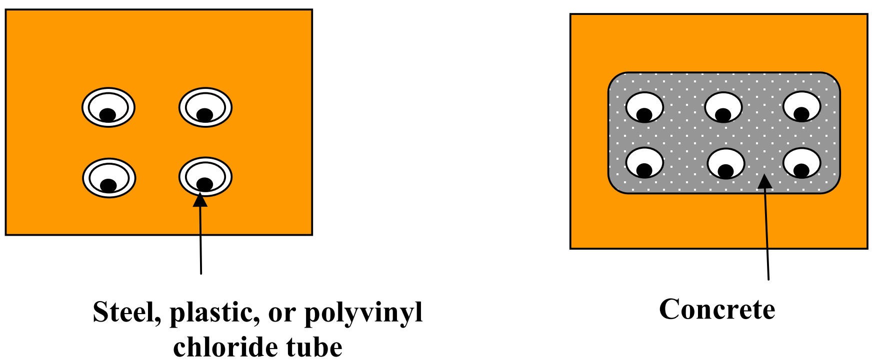


Figure 6A - Example of Draw-in Conduit System

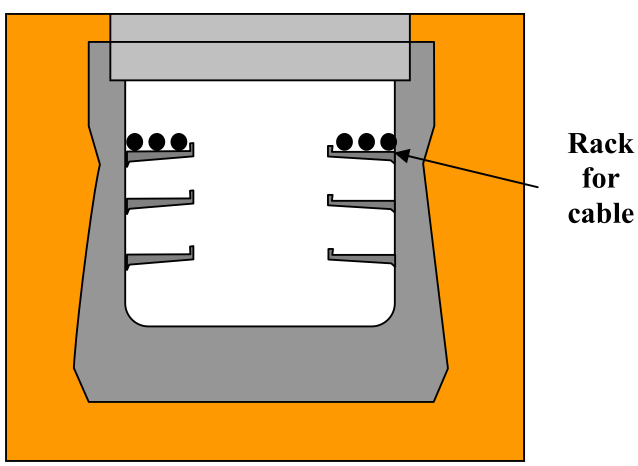


Figure 6B - Example of Draw-in Culvert System

3- Direct Burial System

3.1 In case underground lines are installed with a direct burial system, they shall be installed in accordance with the following methods.

a. Installation of proper plates above the underground lines or other proper measures shall be taken to protect the underground lines against mechanical shocks.

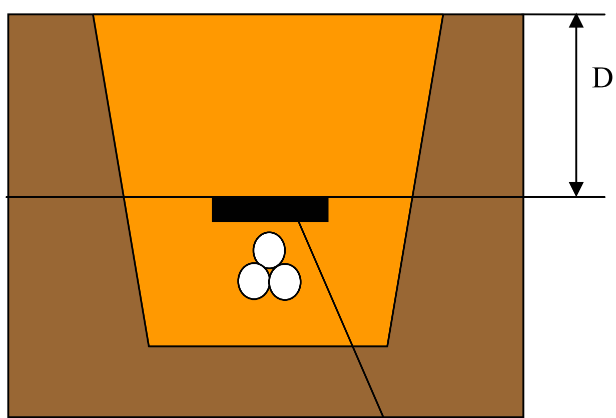
b. The installed position of underground facilities shall be not less than 1.2 m in depth at a place where there is a danger of receiving pressure from vehicles or other objects, and not less than 0.6 m at any other place.

3.2 The depth of underground facilities described in 3.1.b above signifies the depth of such facility measured from the plate to protect cables.

3.3 The following places shall be included among the 'any other place' of 3.1.b above.

a. The sidewalk of a road.

b. A road where no cars pass.



Brick, warning tape etc.

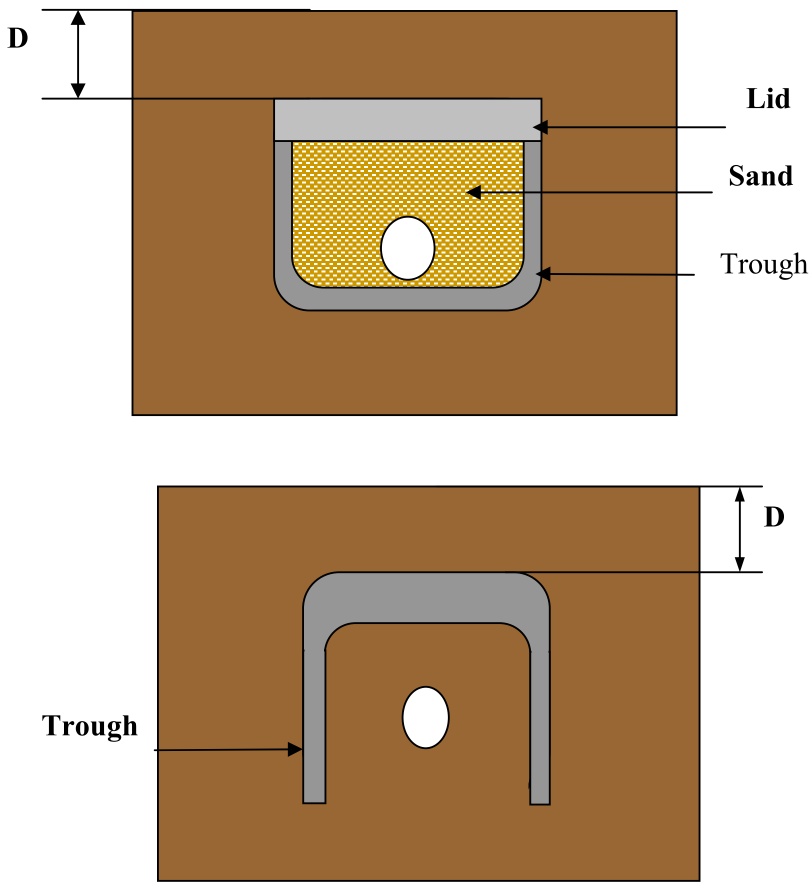


Figure 6C - Explanation of the Depth of the Direct Burial System

Table 12A - Depth in case of Direct Burial System

At a place where there is a danger of receiving pressure from vehicles or other objects	D = Not less than 1.2 m
Other place	D = Not less than 0.6 m

4- Clearance between Multiple Underground Lines

4.1 Minimum clearance between a new underground line and other electrical lines shall be as shown in the following table:

Table 12B - Clearance between Multiple Underground Lines

(Unit: m)

New line	Other electrical lines		
	Low voltage	Medium voltage	High voltage
Low-voltage	0.15	0.3	0.3
Medium-voltage	0.3	0.3	0.3
High-voltage	0.3	0.3	0.3

4.2 In case one of two electrical lines is installed in an incombustible stout tube, the minimum clearance shall not be required.

5- Clearance between Underground Lines and Other Facilities

a- Minimum clearance between a new underground line and other facilities shall be as shown in the following table:

Table 12C - Clearance between Underground Lines and Other Facilities

(Unit: m)

New line	Other facilities			
	Communication line	Gas	Water	Sewerage
Low voltage	(*0.1) 0.3	Shall not make direct contact		
Medium voltage	(*0.1) 0.6	1.0	0.3	0.3
High voltage	0.6	1.0	0.3	0.3

* The approval of the owner of the communication line shall be required.

b- In case the electrical line is installed in an incombustible stout tube and the tube does not come into direct contact with other facilities, the minimum clearance shall not be required.

c- In case communication lines are united with electrical lines, the minimum clearance shall not be required.

6- Connection of Underground Cables

The connection of underground cables shall be implemented with the following methods, in addition to Article 25 of these SREPTS.

a The connecting device shall be able to withstand the external forces that will be extended under the expected conditions.

b The connected cables shall be in good order for the permissive current of the original cables.

c The connected cables shall have same waterproof performance.

7- Structure of Underground Boxes

In case underground boxes are installed, their structure shall be as follows:

a- The underground boxes shall be able to withstand the pressure of vehicles and other heavy objects.

b- When there is some possibility that explosive gases or combustible gases are filled in the box and the capacity of the box is $1m^3$ or more, a device such as a ventilator to exhaust the gases shall be installed.

c- The lids of underground boxes shall be so installed that third persons are unable to open them easily.

8- Grounding for Underground Facilities

Safety grounding of Class D shall be installed at the metallic part of such facilities as the tube, culvert and joint box, and the metallic shield tape of a cable.

CHAPTER 3

HIGH-VOLTAGE TRANSMISSION FACILITIES

Article 29 - Protective Devices for Electrical Equipment

1. Measures for protecting Conductors and Electrical Equipment against Over-current

At necessary points in electrical circuits, over-current circuit breakers that protect against heating damage by over-current and prevent outbreaks of a fire shall be installed.

2. Protection and Alarm Devices for Transformers and Reactive Power Compensators

Transformers and reactive power compensators to be installed in stations and high-voltage and medium-voltage users' sites shall be equipped with devices to automatically cut off the transformer and the reactive power compensator from the electrical circuit when any abnormality that might cause significant damage and serious trouble to the supply of electric power occurs, in addition to other appropriate protection systems, as shown in Table 13.

Table 13 - Protection Systems for Transformers and Reactive Power Compensators

Classification		Abnormality	Protection and alarm device	
			Automatic shutdown device	Alarm device
Main transformer	Common	Over current	○	---
		Internal fault	○	---
		Significantly rise in temperature	---	○
	Transformer with cooling system (A cooling system in which the coolant is sealed-in to directly cool the windings and iron core of the transformers, and is forcibly circulated)	When the cooling system fails or when there is a significant rise in the temperature of the transformer	---	○

Power capacitor	Common	Over current or over voltage or internal fault	○	---
Shunt reactor	Common	Over current	○	---
		Internal fault	○	---
		Significant rise in temperature	---	○
	Shunt reactor with cooling system (A cooling system in which the coolant is sealed-in to directly cool the winding and iron core of the shunt reactor, and is forcibly circulated)	When the cooling system fails or when there is a significant rise in the temperature of the Shunt reactor	---	○

Notes- ○ **: Equips**

-- **: No need**

Article 30 - Design of Supporting Structures of Overhead High-voltage Lines

1. Basic Conditions

a. Supporting structures of overhead lines shall be designed, taking into account the following loads.

Table 14A - Type of Loads

Type of Load	Components of Load
Vertical loads	Weight of the supporting structure
	Weight of the conductors and the ground wires and the accessories supported by the supporting structure
	Weight of the insulator strings and the fittings supported by the supporting structure
	A vertical component of the maximum tension of the guy wires supporting the supporting structure, if any

Horizontal transverse loads	Wind pressure on the supporting structure under the maximum wind velocity
	Wind pressure on the conductors and the ground wires supported by the supporting structure under the maximum wind velocity
	Wind pressure on the insulator strings and the fittings supported by the supporting structure
	A horizontal transverse component of the maximum tension of the conductors and the ground wires supported by the supporting structure and the guy wires supporting the supporting structure, if any
Horizontal longitudinal loads	Wind pressure on the supporting structure under the maximum wind velocity
	A horizontal longitudinal component of the unbalanced maximum tension of the conductors and the ground wires supported by the supporting structure and the maximum tension of the guy wires supporting the supporting structure, if any

b. Supporting structures and foundations of overhead high-voltage lines shall be designed, taking the value of wide pressure based on the reference wind velocity prescribed in Article 26 of these SREPTS into consideration.

c. Supporting structures and foundations of overhead high-voltage lines shall be designed to withstand the maximum loads, taking appropriate safety factors into consideration.

d. In case overhead high-voltage lines are installed at places with the worst conditions, such as inside river areas, windy areas, and so on, the supporting structures and the foundations shall be designed to withstand such severe conditions.

2. Components of Supporting Structures

Components of supporting structures shall satisfy the following or shall have an equivalent strength to these items.

2.1 Fundamental Properties of Components of Supporting Structures

Flat steel, shaped steel, steel pipes, steel plates, steel bars and bolts which compose a steel tower or an iron pole used for overhead transmission lines shall be appropriate ones as specified in the ISO (International Organization for Standardization) standards or other standards equivalent to these standards.

2.2 Thickness of Steel Members, etc.

Shaped steel, steel pipes and steel plates to be used for a steel tower or an iron pole for overhead transmission lines shall have the thickness and other dimensions specified below.

2.2.1 Minimum Thickness of Shaped Steel

a. Those to be used as a main post member of an iron pole (in which a main member of a cross arm is included. The same shall apply hereafter in this article) shall have a thickness of 4 mm.
b. Those to be used as a main post member of a steel tower shall have a thickness of 5 mm.
c. Those to be used as other structural members shall have a thickness of 3 mm.

2.2.2 Minimum Thickness of Steel Pipes

a. Those to be used as a main post member of an iron pole shall have a thickness of 2 mm.
b. Those to be used as a main post member of a steel tower shall have a thickness of 2.4 mm.
c. Those to be used as other structural members shall have a thickness of 1.6 mm.

2.2.3 Slenderness Ratio of Steel Members

The slenderness ratio of a steel member is an indicator showing the state of tallness of its form. Slenderness Ratio of steel member is a division of its length to its section turning radius. More slenderness ratio means longer length or smaller section, so the form of steel member is more slim and weaker. Lesser slenderness ratio means shorter length or bigger section, so the form of steel member is more rotund and stronger.

The slenderness ratio of a compression member shall be not more than 200 for those to be used as the main post members, not more than 220 for compression members other than main post members (excluding those used as auxiliary members) and not more than 250 for those used as auxiliary members.

2.2.4 Minimum Thickness of Steel Plates

The thickness shall be not less than 1 mm.

2.3 Strength of Steel Members and Bolts

Steel members and bolts to be used for a steel tower or an iron pole of overhead transmission lines shall have the strength as specified in Table 14B.

Table 14B - Strength of Steel Members and Bolts

Classification of strength		Strength
Tensile strength	When $\sigma Y \leq 0.7\sigma B$	σY
	When $\sigma Y > 0.7\sigma B$	$0.7\sigma B$
Compression strength		σY
Flexural strength		σY
Shearing strength	When $\sigma Y \leq 0.7\sigma B$	$\sigma Y / \sqrt{3}$
	When $\sigma Y > 0.7\sigma B$	$0.7\sigma B / \sqrt{3}$
Bearing strength		$1.65\sigma Y$
Buckling strength	$0 < \lambda_k < \Lambda$	$\sigma Y\left[K_0 - K_1\left\{\lambda_k \Big/ \left(\pi \big/ \sqrt{(E/\sigma Y)}\right)\right\} - K_2\left\{\lambda_k \Big/ \left(\pi \big/ \sqrt{(E/\sigma Y)}\right)\right\}^2\right]$
	$\Lambda \leq \lambda_k$	$1.5\pi^2 E / 2.2\lambda_k^2$

Where:

σY: Yield point strength of steel members and bolts

σB: Tensile strength of steel members and bolts

λ_k: Effective slenderness ratio ($= L_k / r$)

L_k: Effective buckling length of steel members

r: Turning radius of a steel member cross section

E: Elastic modulus (20.6×10^2 N/m^2)

Λ: $\pi\sqrt{(1.5E / 2.2K\sigma Y)}$

K, K_0, K_1, K_2: Refer to Table 14C.

Table 14C - K,Ko,K_1,K_2, for Table 14B

	K	K_0	K_1	K_2
Structural members with little decentering (steel pipe, cruciform section steel, etc.)	0.6	1	0	0.352
Structural members with some decentering (angle steel used for a main post member, etc.)	0.5	0.945	0.0123	0.316
Structural members with significant decentering (angle steel used for a web member with one side flange joint, etc.) (*)	0.3	0.939	0.424	0

(*)Note that the buckling strength shall be not more than 0.6σY for structural members with significant decentering.

2.4 Strength of Foundation Components used for Steel Poles or Steel Towers

Foundation components of a steel pole or steel tower for overhead transmission lines shall have the strength specified below:

a. Strength of Concrete

The strength of concrete at yield point shall be based on the design standard strength (4-week strength; Fc) of concrete and conform to Table 14D.

Table 14D - Strength of Concrete

Kind of strength	Strength of concrete [$\times 10^6 N/m^2$]
Compression strength	Fc/2
Tensile strength	Fc/20
Shearing strength	Fc/20 and 0.74+1.5Fc/100

b. Bond Strength of Concrete

The bond strength of concrete at yield point shall be based on the design standard strength (4-week strength; Fc) and conform to Table 14E.

Table 14E - Bond Strength of Concrete

[$\times 10^6 N/m^2$]

	Member		Fixative joint
	Upper edge round bar	Normal round bar	
Round bar	6Fc/100 and not more than 1.32	9Fc/100 and not more than 1.99	6Fc/100 and not more than 1.32
Deformed round bar	Fc/10 and not more than 1.32+3Fc/75	3Fc/20 and not more than 1.99+3Fc/50	Fc/10 and not more than 1.32+3Fc/75
Shaped steel			3Fc/100 and not more than 0.66

c. Strength of Shaped Steel, Flat Steel and Steel Bars

The strength of shaped steel, flat steel and steel bars at yield point shall conform to Table 14F.

Table 14F - Strength of Shaped Steel, Flat Steel and Steel Bars

		Yield tensile strength (N/mm^2)	Yield compression strength (N/mm^2)
Round bar		σY and not more than 234	σY and not more than 234
Deformed round bar	Diameter ≥ 29 mm	σY and not more than 294	σY and not more than 294
	29 mm > Diameter > 25 mm	σY	σY
	25 mm ≥ Diameter	σY and not more than 322	σY and not more than 322
Others		σY and not more than 0.7σB	σY

σY: Strength of material at yield point

σB: Tensile strength of material

d. Strength of Bolts

The strength of bolts shall conform to Table 14B.

3. Wind Pressure Load

3.1 Wind Pressure Values

The wind pressure load shall be the value obtained by calculation based on the wind pressure specified in the following Table 14G.

This shall not apply when calculation is made based on values obtained by a wind pressure (wind duct) test using a wind at a velocity of not less than 32 m/s.

The wind receiving area shall be the vertical projected area of the structural member. For crossarms of a concrete pole, an iron pole except a columnar pole, and a steel tower, the wind receiving area shall be the vertical projected area of the front structures that receive the wind.

Table 14G - Wind Pressure to calculate the Wind Pressure Load

Subject to the wind pressure				**Wind pressure to 1 m^2 of the vertical projected area of the structural member (N)**
Supporting structure	Iron pole	Columnar pole		520
		Triangle or rhombic pole		1,220
		Square pole consisting of steel pipes		970
		Others		1,540
	Reinforced concrete pole	Columnar pole		520
		Square pole		1290
	Steel tower	Shaped steel tower		2,350 *
		Steel pipe tower		1,340 *
		Single pole	Columnar pole	520
			Hexagonal or octagonal pole	970

Electrical conductors and other wires	Electrical wires forming multiple conductors (limited to those in which two compositional conductors are arranged horizontally and the distance between such electrical conductors is not more than 20 times their outer diameter)	610
	Others	680
Insulator device		900
Crossarms for an iron pole (limited to a columnar pole) and a reinforced concrete pole		1,030 when it is used as a single member
		1,410 in other cases

* This value shall be applied to 115kV high-voltage towers which are less than 40m high.

3.2 Wind Pressure Load at an Oblique Wind

When the wind blows to the electrical line at an angle of 60°, the wind pressure load in an assumed normal load of a common type steel tower shall be that calculated by the wind pressure load multiplier (in case of a square tower) in Table 14H.

Table 14H Multiplier to Wind Pressure Load

Classification of wind pressure load			The multiplier to the wind pressure load when the wind blows perpendicular to the electrical line (in case of a square tower)
Wind pressure load to steel tower	Wind pressure load to body	Shaped steel tower	1.6
		Steel pipe tower	1.4
	Wind pressure load to cross arm		0.5 (for the wind pressure in the direction of the electrical line)
Wind pressure load to wire			0.75

4. Loads on Supporting Structures and Safety Factors

Loads on supporting structures and safety factors shall satisfy the following items or shall have an equivalent performance to these items.

4.1 Types and Combinations of Assumed Loads

The types and combinations of assumed loads to be used for calculating the strength of supporting structures for overhead transmission lines shall conform to the following provisions.

The assumed loads on supporting structures shall be classified as the loads specified in Table 14I. The combination of these loads on the supporting structures shall be in accordance with Table 14J depending on the classification and type of supporting structures.

Table 14I - Classification of Assumed Loads on Supporting Structures

Type of Load	Contents	Symbol
Vertical loads	Weight of the supporting structure	Wt
	Weight of the conductors and the ground wires and the accessories supported by the supporting structure	Wc
	Weight of the insulator strings and the fittings supported by the supporting structure	Wi
	A vertical component of the maximum tension of the conductors and the ground wires	Va
	A vertical component of the maximum tension of the guy wires supporting the supporting structure, if any	Ws
Horizontal transverse loads	Wind pressure on the supporting structure under maximum wind velocity	Ht
	Wind pressure on the conductors and the ground wires supported by the supporting structure under the maximum wind velocity	Hc
	Wind pressure on the insulator strings and the fittings supported by the supporting structure	Hi
	A horizontal transverse component of the maximum tension of the conductors and the ground wires supported by the supporting structure and the guy wires supporting the supporting structure, if any	Ha Hs
	A torsional load due to the unbalance of the maximum tension of conductors of any phase	q
Horizontal longitudinal loads	Wind pressure on the supporting structure under the maximum wind velocity	Ht'
	A horizontal longitudinal component of the maximum tension of the guy wires supporting the supporting structure, if any	Ws'
	The unbalance of the maximum tension of the conductors of all phases and the ground wires	P1
	The unbalance of the maximum tension of the conductors of any phase	P2
	A torsional load due to the unbalance of the maximum tension of the conductors of any phase	q1

Table 14J - Combination of Loads on the Supporting Structures

Classification of supporting structure	Type	Design cases		Combination of assumed loads													
		Load condition	Wind direction	Vertical load				Horizontal transverse load					Horizontal longitudinal load				
				W_t	W_c Wi	V_a	W_s	H_t	H_c Hi	H_a	H_s	q	H'_t	P1	P2	q1	W'_s
Concrete pole	Tension& Suspension Type Tower	Normal	Horizontal transverse	○	○	○	○	○	○	○	○						
			Horizontal longitudinal	○	○	○	○			○			○				○
Steel pole	Dead-end Type Tower	Normal	Horizontal transverse	○	○	○	○	○	○		○			○			
			Horizontal longitudinal	○	○	○	○						○	○			○
Steel tower	Tension& Suspension Type Tower	Normal	Horizontal transverse/60°	○	○	○	○	○	○	○	○						
			Horizontal longitudinal	○	○	○	○			○			○				○
		Abnormal	Horizontal transverse	○	○	○	○	○	○	○	○	○			○	○	
			Horizontal longitudinal	○	○	○	○			○		○	○		○	○	○
Single steel pole	Dead-end Type Tower	Normal	Horizontal transverse	○	○	○	○	○	○		○			○			
			Horizontal longitudinal	○	○	○	○						○	○			○
		Abnormal	Horizontal transverse	○	○	○	○	○	○		○	○		○		○	
			Horizontal longitudinal	○	○	○	○					○	○	○		○	○

Where:

Dead-end type: Supporting structure with a large unbalanced load in the horizontally longitudinal direction, e.g. the first tower from a substation.

Abnormal Condition: An assumption for tower design where any one or two of conductors and ground wires will be broken down

Notes: Circles "○" indicate the assumed loads to be considered at the same time that can combine together.

The wind direction that brings the bigger assumed load should be selected.

Where strung wires are arranged asymmetrically on the supporting structure, the assumed vertical eccentric load shall be added to the load in Table 14J and the load by normal torsional load shall also be added for the dead-end type.

4.2 Unbalanced Maximum Tension and so on

Unbalanced maximum tension and so on used in 4.1 shall conform to the following requirements:

4.2.1 The unbalanced maximum tension and torsional force shall conform to Table 14K.

Table 14K - Unbalanced Tension and Torsional Force

Classification of supporting structure	Type of supporting structure	Unbalanced tension and torsional force	
		Assumed normal load	Assumed abnormal load
Steel tower	Tension & Suspension Type Tower	No specification	Horizontal longitudinal component of force of the unbalanced tension and torsional force generated by cutting strung wires
	Dead-end Type Tower	Horizontal longitudinal component of force of the unbalanced tension equal to the assumed maximum tension for each strung wire	
Iron reinforced concrete pole and iron pole	Tension & Suspension Type Tower	No specification	No specification
	Dead-end Type Tower	Horizontal longitudinal component of force of the unbalanced tension equal to the assumed maximum tension for each strung wire	

4.2.2 For steel towers, the strung wires shall be cut according to the following requirements, depending on the total number of phases of electrical conductors (which mean phases for each circuit. The same shall apply hereafter).

a. The overhead ground wire shall not be cut at the same time as the electrical conductors and only one wire shall be cut;

b. Where the total number of phases of electrical conductors is not more than twelve (12), one phase that maximizes the stress generated in each structural member (two electrical conductors from one phase in case of multiple conductors for steel towers other than dead-end type);

c. Where the total number of phases of electrical conductors is over twelve (12) (excluding the case specified in the following Item d.), two phases in different circuits that maximize the stress generated in each structural member (two electrical conductors from one phase in case of multiple conductors for steel towers other than dead-end type);

d. Where electrical conductors are arranged so that nine or more phases are in a longitudinal row and two phases are in a transverse row, one of the top six phases in the longitudinal row (two electrical conductors from one phase in case of multiple conductors for steel towers other than dead-end type) and one phase from the other phases (two electrical conductors from one phase in case of multiple conductors for steel towers other than dead-end type) that maximize the stress generated in each structural member.

4.2.3 The unbalanced tension generated by cutting the strung wire shall be equal to the assumed maximum tension.

Provided, however, that the unbalanced tension may be 0.6 times the assumed maximum tension if, depending on the mounting method of the strung wire, the supporting point of the strung wire shifts when the wire is cut or the strung wire slides at the supporting point.

4.3 Safety Factor of Supporting Structure

The yield strength of the structural members of reinforced concrete poles, iron poles and steel towers used for overhead transmission lines shall satisfy the safety factor listed in Table 14L for the assumed loads specified in 4.1 to 4.2.

Table 14L - Safely Factors of Supporting Structures

Classification of supporting structure	Load condition	Safety factor
Reinforced concrete pole Iron pole	Assumed normal load	2.0
Steel tower	Assumed normal load	1.5
	Assumed abnormal load	1.0(1.5 for crossarms)

5 Loads on Foundations of Supporting Structures and Safety Factors

5.1 Loads on the Foundation of a Supporting Structure

The loads applied to the foundation of a supporting structure for overhead transmission lines shall be calculated from combinations of the assumed loads of the supporting structure specified in paragraph 4 and the resulting maximum values shall be the assumed normal and abnormal loads for the foundation.

5.2 Safety Factor of the Foundation

The safety factor of the foundation of a supporting structure for overhead transmission lines shall satisfy the value listed in Table 14M for its yield strength.

Table 14M - Safety Factors of the Foundations

Classification of supporting structure	Safety factor	
	Assumed normal load	Assumed abnormal load
Reinforced concrete pole and iron pole	2.0	-
Steel tower	2.0	1.33

5.3 Treatment of the Weight of the Foundation

The weight of the foundation used for calculating the safety factor shall be treated in accordance with the following provisions:

a. For a foundation that is subject to a lifting load, not more than two-thirds of the weight of the foundation (or the weight of the foundation of a steel tower to an abnormal load) may be included in the lift bearing power.

b. For a foundation that is subject to a compressive load, the weight of the foundation shall be included in the compressive load.

Article 31 - Design of Fittings for Conductors and/or Ground Wires of Overhead High-voltage Lines

1. Safety Factor of Fittings for Conductors and/or Ground Wires of Overhead High-voltage Lines

1.1 The safety factor for the tensile strength (the maximum tensile strength or breaking strength) of fittings of conductors and ground wires for overhead high-voltage lines shall be 2.5 or more.

1.2 The safety factor mentioned in 1.1 shall be obtained as follows:

a. Tension insulator device (insulator device that anchors electrical conductors)
[Safety factor] = [Tensile break strength] / [Assumed maximum tension at a support point];

b. Suspension insulator device (Insulator device from which electrical conductors are hung)
[Safety factor] = [Tensile break strength] / [Composite load of vertical load and horizontal transverse load];

c. Supporting insulator device
[Safety factor] = [Bending break strength] / [Horizontal transverse load or vertical load applied perpendicular to the axis of the insulator device].

2 Mechanical Strength of Insulators for Overhead Transmission Lines

2.1 Assumed Load

The assumed loads to be used for calculating the strength of insulator devices for overhead transmission lines shall conform to the following requirements.

a. Vertical Load

The vertical load shall be the sum of the weight of electrical conductors, the weight of insulator devices and the vertical component of the force generated by the assumed maximum tension of the electrical conductors.

b. Horizontal Transverse Load

The horizontal transverse load shall be the sum of the wind pressure loads of electrical conductors and insulator devices and the horizontal component of load generated by the assumed maximum tension of the electrical conductors. The wind pressure loads shall be calculated based on the values listed in Table 14G.

c. Assumed Maximum Tension of Conductors

The assumed maximum tension of conductors shall be the tension of the transmission conductor under the composite load of the vertical load generated by the weight of the electrical conductor, and the horizontal load generated by the horizontal wind pressure stipulated in Table 14G at the average temperature in the area.

Article 32 - Protection against Lightning for Overhead High-voltage Lines

The following measures shall be taken for overhead high-voltage lines to decrease the number of electrical faults and to protect equipment from damage caused by the faults.

a. Installation of ground wires for overhead high-voltage lines;

b. Installation of arcing horns for both ends of insulator assemblies of overhead high-voltage lines;

c. Installation of armor rods to wrap conductors in a clamp of suspension insulator assemblies of overhead high-voltage lines.

Article 33 - Bare Conductors of Overhead High-voltage Lines

1. Vibration Dampers

An appropriate type and number of dampers shall be installed to prevent fatigue of bare conductors and ground wires for overhead high-voltage lines due to their aeolian vibration.

2. Connection

In case bare conductors and ground wires are jointed with each other or with insulated conductors or cables, the connection shall conform to the following requirements in addition to Article 25 of these SREPTS.

a. Bare conductors and ground wires shall be connected with compression type sleeves or compression type devices.

b. The tensile strength of connection of bare conductors and ground wires shall be not less than 95 % of the tensile strength of the connected bare conductors and ground wires. This requirement, however, shall not be applied to cases where the maximum tension to be designed is substantially less than the ultimate strength of the bare conductors and ground wires such as jumper conductors, the end span to substations and others.

Article 34 - Clearance between Bare Conductors and Supporting Structures of Overhead High-voltage Lines

Clearance between bare conductors and supporting structures, arms, guy wires and/or pole braces of overhead high-voltage lines shall be as follows. The clearances shall be secured, in any cases where the maximum swing of conductors under the maximum wind velocity to be designed.

Table 15 - Clearance between Bare Conductors and Supporting Structures

Nominal Voltage	Clearance
115kV	Not less than 0.70m
230kV	Not less than 1.45m

Clearance between ground wires and the nearest conductor in the same span shall be larger at any point in the span than the clearance of the supporting point at both sides of the span.

Article 35 - Height of Overhead High-voltage Lines

The height of conductors of overhead high-voltage lines shall be as follows:

1. Height in Urban Areas

Height of conductors of overhead high-voltage lines in urban areas shall be not less than the value calculating by adding 0.060 m to a base height 6.5m for every 10kV over 35kV.

Table 16A - Height in Urban Areas

Nominal Voltage	Height
115kV	Not less than 7.0m
230kV	Not less than 7.7m

2. Height in Areas Where Third Persons Hardly Approach

The height of conductors of overhead high-voltage lines in areas where third persons hardly approach shall be not less than the value calculated by adding 0.06 m to a base height of 5.5m for every 10kV over 35kV.

Table 16B - Height in Areas Where Third Persons Hardly Approach

Nominal Voltage	Height
115kV	Not less than 6.0m
230kV	Not less than 6.7m

3. Height over Roads and/or Railways

The height of conductors of overhead high-voltage lines crossing over roads and/or railways shall be not less than the value calculated by adding 0.060 m to a base height of 13m for every 10kV over 35kV.

Table 16C - Height over Roads and/or Railways

Nominal Voltage	Height
115kV	Not less than 13.5m
230kV	Not less than 14.2m

4. Height over Rivers and/or Seas

The height of conductors of overhead high-voltage lines crossing rivers and/or seas shall be as follows:

Table 16D - Height over Rivers and/or Seas

At places with no vessel passage		At places with vessel passage	
From the highest water level		From the highest point of vessels on the highest water level(*1)	
Not less than the value calculated by adding 0.06 m to a base height of 5.5m for every 10kV over 35kV		Not less than the value calculated by adding 0.06 m to a base height of 3m for every 10kV over 35kV	
Nominal Voltage	Height	Nominal Voltage	Clearance
115kV	Not less than 6.0m	115kV	Not less than 3.5m
230kV	Not less than 6.7m	230kV	Not less than 4.2m

(*1) The highest point of vessels shall be decided taking into account any future possible changes.

5. Note

All the heights described above shall be secured in any cases of the maximum sagging of conductors in the maximum temperature to be designed.

Article 36 - Clearance between Overhead High-voltage Lines and Other Facilities or Trees

1 Generals

The clearance between each conductor of overhead high-voltage lines and other facilities or trees shall be as follows:

a. Clearance to Other Facilities

The clearance between each conductor of overhead high-voltage lines and other facilities shall be not less than the value calculated by adding 0.06 to a base height of 3m for every 10kV over 35kV.

Table 17A - Clearance to Other Facilities

Nominal Voltage	Height
115kV	Not less than 3.5m
230kV	Not less than 4.2m

b. Clearance to Trees

The clearance between each conductor of overhead high-voltage lines and trees shall be not less than the value calculated by adding 0.06 m to a base height of 2m for every 10kV over 35kV.

Table 17B - Clearance to Trees

Nominal Voltage	Height
115kV	Not less than 2.5m
230kV	Not less than 3.2m

c. Note

The clearances described above shall be secured in any cases of the maximum sagging of conductors in the maximum temperature and/or the maximum swing of conductors under the maximum wind velocity to be designed.

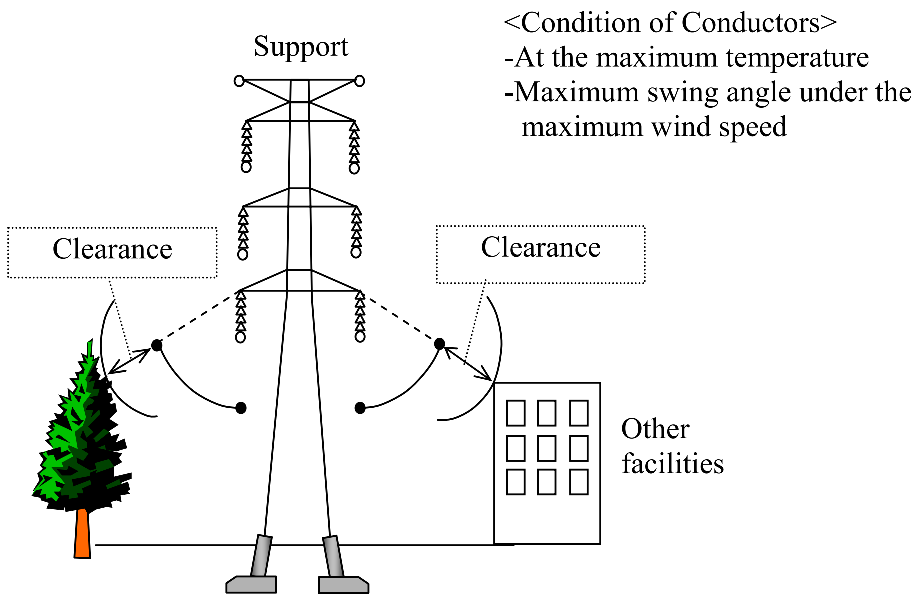


Figure 7 - Direct Proximity

2 Proximity to and Crossing with Buildings

2.1 230kV Overhead High-voltage Line

Overhead transmission conductors with a nominal voltage 230kV shall be installed not less than 3 meters away in a horizontal distance above or to the side of buildings.

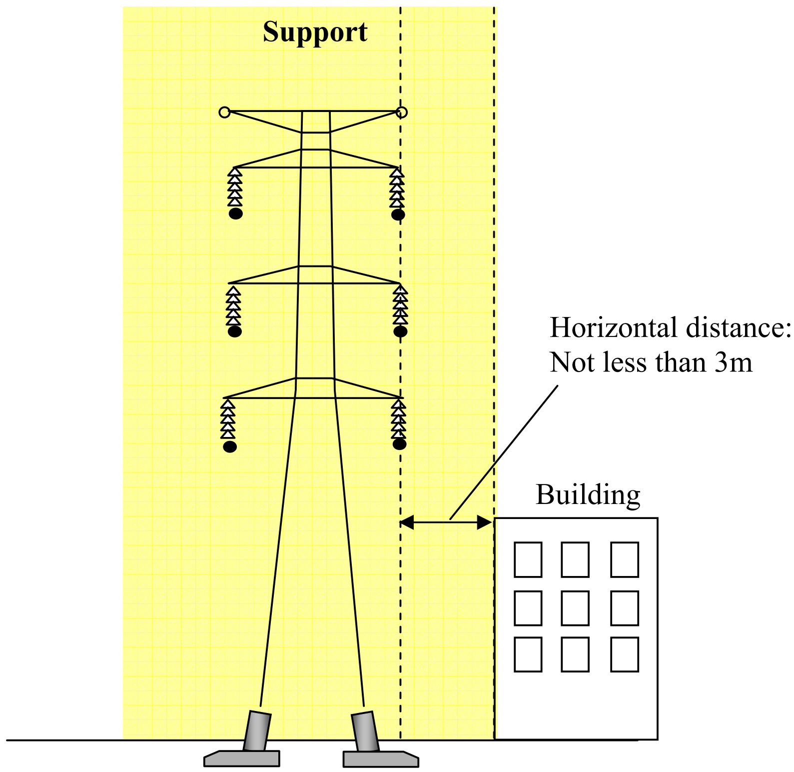


Figure 8 - Proximity to Buildings (230kV)

2.2 115kV Overhead High-voltage Line

Overhead transmission conductors with a nominal voltage of 115kV shall be installed not less than 6 meters from the top of buildings when the 115kV overhead high-voltage line is adjacent laterally within 3m or crossing with buildings.

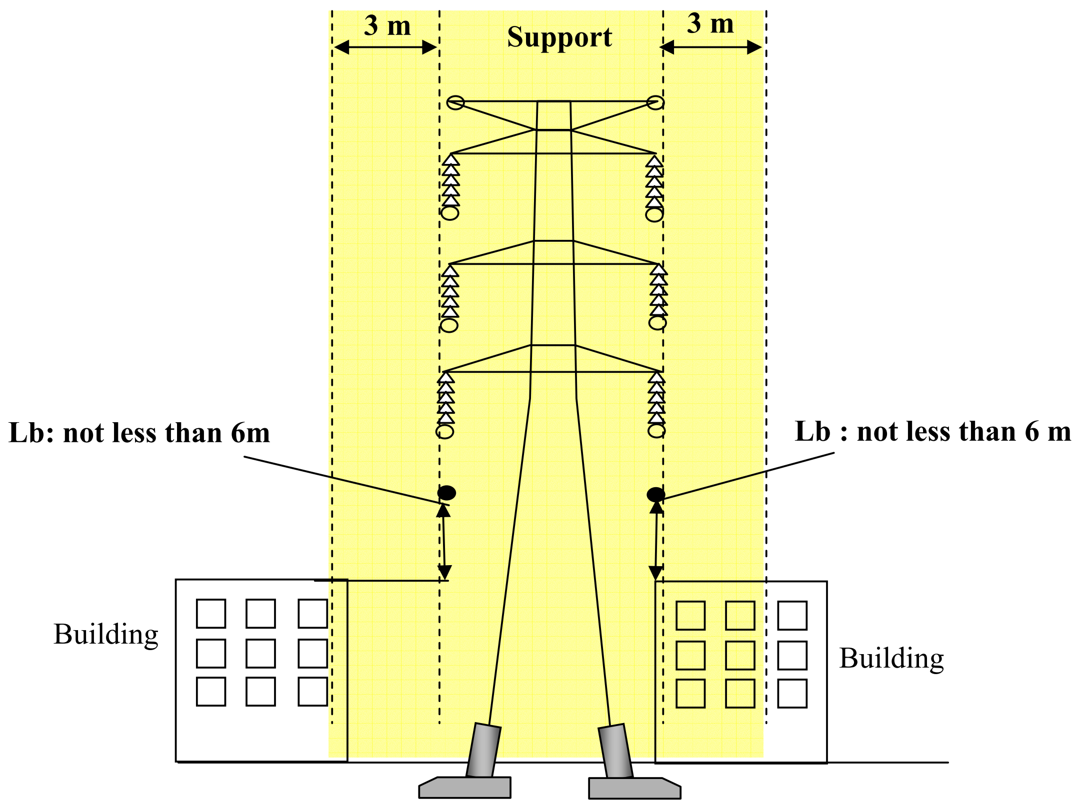


Figure 9 - Crossing with Buildings (115kV)

3. Proximity to and Crossing with Medium-voltage Lines and High-voltage Lines

The clearance between each conductor of overhead high-voltage lines and other medium-voltage lines or high-voltage lines shall be not less than the value calculated by adding 0.06m to a base height of 2m for every 10kV over 35kV.

Table 18 - Clearance between Conductors

	Nominal Voltage[kV]	Clearance[m]
Clearance (Ll*)	115	Not less than 2.5
	230	Not less than 3.2

* Refer to Figure 10.

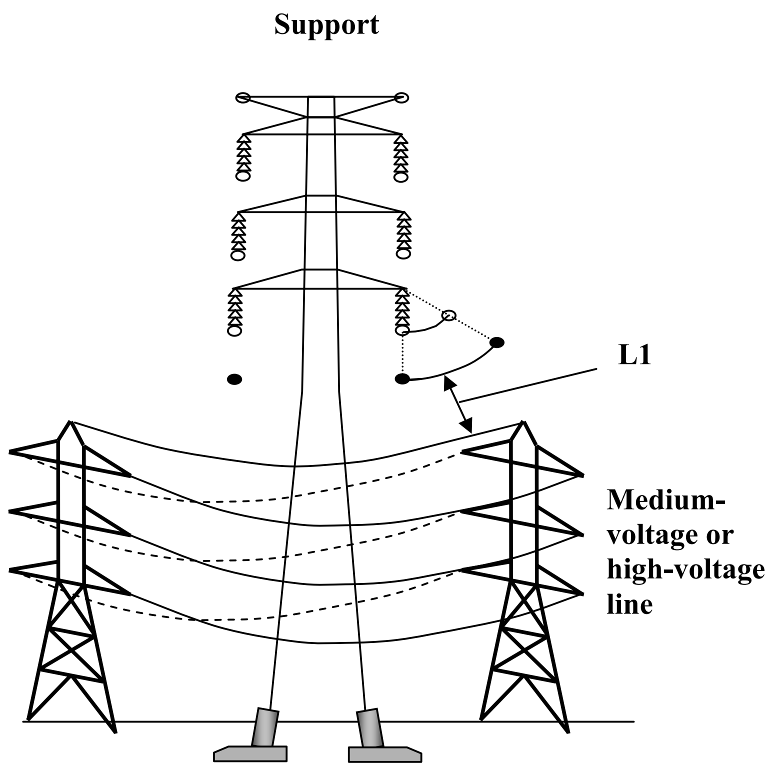


Figure 10 - Proximity and Crossing with Medium-voltage Lines and High-voltage Lines

Article 37 - Prevention of Danger and Interference due to Electrostatic Induction and Electromagnetic Induction

1. Electrostatic Induction

High-voltage lines shall be installed to prevent danger to persons and/or interference on communication lines installed near the high-voltage lines caused by electrostatic induction, taking appropriate measures including the following items a, b and Article 27 of these SREPTS into consideration.

a. The electrical field caused by overhead high-voltage lines shall be 3kV/m or less at 1 m above the ground surface, except for overhead high-voltage lines in places where third persons hardly approach, such as in mountains, on farming land and so on.

b. Conductive materials on the surface of the buildings under overhead high-voltage lines shall be grounded with the Class D grounding in accordance with Article 21 of these SREPTS.

2. Electromagnetic Induction

High-voltage lines shall be installed to prevent danger to persons and/or interference on communication lines caused by electromagnetic induction on the low voltage lines and/or communication lines installed near the high-voltage lines, taking appropriate measures including Article 27 of these SREPTS.

Article 38 - Surge Arresters

1. Generals

Surge arresters shall be installed at the appropriate places on electrical lines.

2. Installation of surge arresters

2.1 Installation Points for Surge Arresters

In high-voltage and medium-voltage electrical circuits surge arresters shall be installed at the points listed below or at locations close to such points, in order to prevent damage to be electrical equipment installed in electrical circuits in the power stations, substations and switching stations and high-voltage and medium-voltage users' sites, by over-voltage.

However, the same shall not apply in cases where there is no risk of damage to such electrical equipment.

a. Receiving and outgoing points on overhead electrical lines in the power stations, substations and switching stations;

b. Receiving points on the high-voltage and medium-voltage users' sites to which power is supplied from high-voltage and medium voltage overhead electrical lines;

c. Locations where there is a risk that the protective effects of surge arresters installed in accordance with the above provisions may not be achieved.

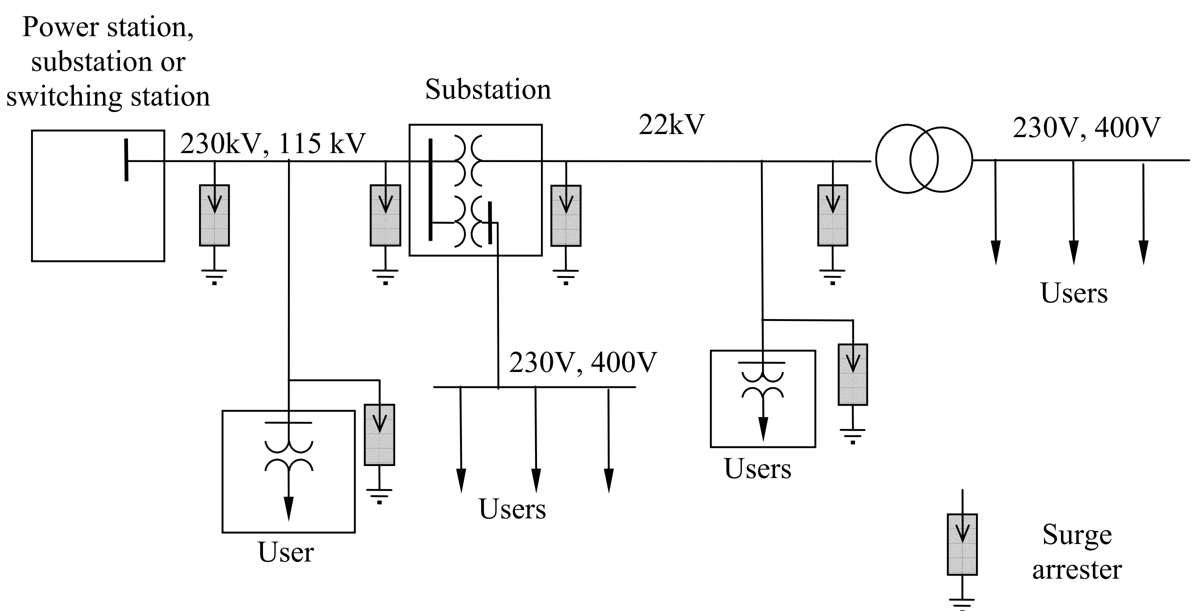


Figure 11 - Installation Points for Surge Arresters

2.2 Grounding of Surge Arresters

Grounding of surge arresters shall be installed in accordance with Article 21 and 22 of these SREPTS.

The grounding resistance provided for surge arresters in high-voltage and medium-voltage electrical circuits in power stations, substations, switching stations and high-voltage and medium-voltage users’ sites shall be as much lower than 10 Ω as possible in order to prevent hinder to the functions of the surge arrester.

CHAPTER 4

MEDIUM AND LOW-VOLTAGE DISTRIBUTION FACILITIES

Article 39 - Supporting Structures

1. Loads on Overhead Distribution Lines

Supporting structures of overhead medium-voltage and low-voltage lines shall be designed taking into account the loads shown in Table 19A.

Table 19A - Kinds of Loads

Type of Load	Contents
Vertical loads	Weight of supporting structures
	Weight of the conductors and the ground wires and the accessories supported by the supporting structure
	Weight of the insulating devices, the crossarms and the distribution equipment supported by the supporting structure
	A vertical component of the maximum tension of the guy wires supporting the supporting structure, if any
Horizontal transverse loads	Wind pressure on the supporting structure under the maximum wind velocity
	Wind pressure on the conductors and the ground wires supported by the supporting structure under the maximum wind velocity
	Wind pressure on the insulator, the crossarms and the distribution equipment supported by the supporting structure under the maximum wind velocity
	A horizontal transverse component of the maximum tension of the conductors and the ground wires supported by the supporting structure and the guy wires supporting the supporting structure, if any
Horizontal longitudinal loads	Wind pressure on the supporting structure under the maximum wind velocity
	A horizontal longitudinal component of the unbalanced maximum tension of the conductors and the ground wires supported by the supporting structure and the maximum tension of the guy wires supporting the supporting structure, if any

By calculating, firstly, the load when wind pressure is applied in a horizontal transverse direction to the distribution line, and secondly, the load when wind pressure is applied in the horizontal longitudinal direction of the distribution line, the one of these two loads which generates greater stress on the structural member shall be adopted for the assumed normal load.

2. Safety Factor of Foundations of Supporting Structures

- The safety factor of the foundations of supporting structures for low-voltage lines shall be 2 or more to the wind pressure.

- The safety factor of the foundations of supporting structures for medium-voltage lines shall be 2 or more to the load prescribed in Table 19A.

- If wooden poles, iron-poles and iron-reinforced concrete poles are installed at other than soft ground in accordance with Table 19B, this article may not be applicable.

Table 19B

	Design load of poles	**Length of poles**	**Setting depth**	**Span**
Wooden pole	----	15m or less	1/6 of overall length or more	Medium-voltage lines in an urban area: Not more than 75m
		More than 15m, and 16m or less	2.5m or more	
Iron pole	----	15m or less	1/6 of overall length or more	Low-voltage lines in an urban area: Not more than 40m Other: Not more than 150m
		More than 15m, and 16m or less	2.5m or more	
Iron-reinforced concrete pole	6.5kN or less	15m or less	1/6 of overall length or more	
		More than 15m, and 16m or less	2.5m or more	
		More than 16m, and 20m or less	2.8m or more	

3. Strength of Iron-reinforced Concrete Pole

- Iron-reinforced concrete poles for low-voltage lines shall have the strength to withstand wind pressure.
- Iron-reinforced concrete pole for medium-voltage lines shall have the strength to withstand the load prescribed in Article 31 of these SREPTS.
- Iron-reinforced concrete pole shall have the strength to withstand two times of the design load.

4. Safety Factor

4.1 Conductor

A safety factor of 2.5 or more shall be applied to the tensile strength (ultimate tensile strength; breaking strength) of overhead distribution conductors and overhead ground wires.

4.2 Supporting Structure

(1) Supporting structures for overhead low-voltage lines shall have the strength to withstand a load of 1.2 times the wind pressure for wooden poles, and a load equal to the wind pressure for others.

(2) Wooden poles to be used as the supporting structures for overhead medium-voltage lines shall be installed in accordance with the following items:

   a. The safety factor against a wind pressure shall be 1.3 or more; and

   b. The thickness shall be not less than 12 cm in diameter at the top end.

(3) Iron-reinforced concrete poles and iron poles to be used as supporting structures for overhead medium-voltage lines shall have the strength to withstand the assumed normal load.

5. Reference Wind Velocity

Reference wind velocity used in the calculation of wind loads on overhead distribution lines shall be as follows:

Table 19C - Reference Wind Velocity

Yearly maximum of 10-minute average wind velocity (50 year return period)	32m/sec

In the following circumstances, the above reference wind velocity shall be changed:

a. When sufficient observed wind velocity data have been accumulated.
b. When greater reliability is particularly needed.
c. When a terrain has the effect to decrease the wind velocity.

6. Reinforcement for Supporting Structures by Guys

Supporting structures shall be guyed to share strength with the guys according to Table 19D. In such case, the strength of the supporting structure itself shall be such that it bears at least half of the wind load.

6.1 Installation and Safety Factor of Guys

a. Installation of Guys

Guys shall be installed in order to reinforce the foundation of a supporting structure if the calculated result of the safety factor of supporting structure's foundation is less than 2.0 under the following conditions.

Table 19D - Conditions of Installation of Guys

Conditions	Installation method	Safety factor of the guy
a. Supporting structures lacking strength against wind pressure	Guys that withstand wind pressure shall be installed at right angle to the lines.	2.5 or more
b. Supporting structure of which spans on both sides are too different	Guys that withstand the force caused by unbalanced tension shall be installed on both sides in the direction of the line.	1.5 or more

c. Supporting structure of which lines on both sides make an angle of more than 5 degrees	Guys that withstand the force caused by the assumed maximum tension of each line shall be installed at the opposite side of the line.	
d. Supporting structure which supports the end of a line	Guys that withstand the assumed maximum tension of the line shall be installed at the opposite side of the line.	

b. Section near the Ground of the Guy

For the section near the ground, that is, from the underground portion of the guy to 30cm above the ground, a galvanized iron rod or similar rod equal or superior to it in strength and corrosion resistance shall be used.

c. Foundation of the Guy

The guy anchor shall be installed firmly so that it can adequately bear the tensile load from the guy. A guy anchor installed with a supporting structure shall be of such a material that it hardly corrodes.

d. Globe Insulator

If a guy is installed on an overhead distribution line that is in danger of touching an electrical conductor, a globe insulator shall be inserted in the upper part of the guy.

A globe insulator, however, need not be inserted if the guy is installed on a low-voltage overhead distribution line in a place other than a rice field or other swamp area.

e. Height of Guy

A guy crossing a road shall have a height of not less than 6.5 m from the road surface.

If this is impossible for technical reasons, a height of not less than 4.5m (not less than 2.5m, if a sidewalk) is allowed if there is no danger of interfering with traffic.

f. Strut

A strut that has equivalent or higher effect than a guy can be substituted for a guy.

Article 40 - Overhead Medium-voltage and Low-voltage Lines

1. Cables for Overhead Lines

a. When cables are used for overhead lines, the cables shall be installed using messenger wires or other appropriate measures so that they bear no tensile strength. The messenger wires shall be installed in accordance with the provision of Article 31 of these SREPTS.

b. When cables are installed along a building or another object, the cables shall be supported so that they are not damaged by contacting the building or the object.

2. Connecting Methods of Overhead Conductors

The tensile strength of the conductors shall not be reduced by 20% or more, when electric conductors are connected. If the tension on the conductors is distinctly less than the general tensile strength of conductors, this may not apply.

3. Branching of Overhead Lines

Branching of overhead lines shall be made at the supporting point of the lines. If branching can be done in a way that does not to inflict tension on the conductor at the branch point, this may not be applicable.

Article 41 - Mechanical Strength of Insulators

1. Generals of Mechanical Strength of Insulators

The insulator to support medium-voltage lines shall be installed in such a manner that it has sufficient strength to attain the safety factor of at least 2.5 based on the assumption that the following loads are exerted on the insulators.

a. For the insulators to anchor lines, the load is the assumed maximum tension of the lines.

b. For the insulators to support lines, the load is the horizontal lateral load or vertical load exerted perpendicular to the axis of the insulators.

2. Safety factor of Insulators

The safety factor of insulators for medium-voltage lines shall be calculated using the following equations.

a. Tension insulator (Insulator that anchors electrical conductors)

$$\text{[Safety factor]} = \frac{\text{[Tensile break strength]}}{\text{[Assumed maximum tension of the lines]}}$$

b. Supporting insulator

$$\text{[Safety factor]} = \frac{\text{[Tensile break strength]}}{\text{[Horizontal transverse load or vertical load applied perpendicular to the axis of the insulator device]}}$$

3. Assumed Load

The assumed loads to be used for calculating the strength of insulator for medium-voltage lines shall conform to the following requirements.

a- Vertical load

The vertical load shall be the sum of the weight of electrical conductors and the weight of insulator devices.

b- Horizontal transverse load

The horizontal transverse load shall be the sum of the wind pressure loads of electrical conductors and insulator devices and the horizontal component of a load generated by the assumed maximum tension of the electrical conductors. The wind pressure loads shall be calculated based on the values listed in Table 20.

Table 20 - Wind Pressure Loads

Segment of an object receiving wind pressure	Wind pressure to $1m^2$ of the vertical projected area (Pa)
Electrical conductor and other strung conductor	680
Insulation device	900

*The wind pressures are obtained from 32m/s wind velocity as same as Table 19C.

4. Assumed Maximum Tension of the Lines

The assumed maximum tension of the lines shall be the tension of the medium-voltage line conductor under the composite load of:

a. The load generated by the weight of the electrical conductor, and
b. The horizontal load generated by the horizontal wind pressure stipulated in Table 20.

Article 42 - Medium-voltage/Low-voltage (MV/LV) Transformers

MV/LV transformers, including medium-voltage conductors other than cables, shall be installed so that they are not in danger of electrical shock using either of the following methods.

1. MV/LV transformers shall be installed in an exclusive cabin that is locked.

2. MV/LV transformers shall be installed at a height of not less than 5.0m above the ground in order that persons can not touch them easily.

3. Appropriate fences shall be installed around the MV/LV transformers in order that persons can not touch them easily and warning signs to indicate the danger shall be displayed. Otherwise MV/LV transformers, the charged parts of which are not exposed shall be installed so that persons can not touch them easily.

Article 43 - Installation of Distribution Transformers for Single Wire Earth Return (SWER) Systems

1. Grounding Arrangement for SWER

Grounding on the primary side of distribution transformers for SWER shall be installed by the following methods, in order to avoid risk of danger to persons, domestic animals and other facilities due to the potential difference between the grounding conductor and the ground caused by load current, when any failure occurs.

a. The grounding resistance shall be not more than 5ohms.
b. The cross-sectional areas of grounding conductors shall be not less than 16mm^2.
c. The grounding conductors placed up to a depth of 75cm underground or up to a height of 2.0 m above ground shall be covered by a synthetic resin pipe or another shield of equivalent or higher insulating effect and strength.

2. Load Current of Distribution Transformers

The load current in any earth-return circuits shall be not more than 8 amperes.

3. Isolating Transformer

SWER circuits shall be supplied from double-wound transformers (isolating transformers).

4. Safety of Third Persons

Warning signs to alert third persons' attention shall be installed near the grounding point.

Article 44 - Protective Devices

1. Installation of Medium-Voltage Over-current Circuit Breakers

a. On medium-voltage lines, an over current circuit breaker shall be installed at the outgoing point of a substation or similar location and on the primary side of a transformer.

b. Over current breakers for short circuit protection shall have the ability to break the short circuit current that passes the breakers.

2. Installation of Medium-Voltage Ground Fault Circuit Breakers

A ground fault breaker that breaks circuit automatically when an earth fault happens in the lines shall be installed at an outgoing point of substation or similar locations.

3. Installation of Surge Arresters

To prevent electrical equipment from being damaged by lightning, surge arresters shall be installed at the places of lines stated below or their surrounding areas. If electric power facilities are not damaged by lightning, this may not be applicable.

a. A lead-out of overhead line from power station, substation, and equivalent places.
b. The connecting point of overhead medium-voltage lines with a main transformer.

4. Exceptions to Installation of an Over Current Breaker for Medium-voltage and Low-voltage Lines

No over current circuit breaker shall be installed at the following places:

a. Grounding conductor of grounding work.
b. Neutral conductor of an electrical conductor. An over-current circuit breaker, however, may be installed if all the poles are shut off simultaneously.
c. Grounding conductor of a low-voltage overhead electrical conductor whose circuit is provided with class B grounding work in part.

Article 45 - Height of Overhead Medium-voltage and Low-voltage Lines

1. Regulations for Medium and Low-voltage Overhead Distribution Conductors

The height of medium and low-voltage overhead lines shall be no less than the values in the following table:

Table 21 - Height of Medium and Low-Voltage Overhead Lines

(Unit: meter)

	Low-voltage	Medium-voltage		
		Urban area		Other area
		Cable	Others	
Crossing a road	6.5	8.0	8.0	6.5
Others	5.5	5.5	6.5	5.5

2. Urban Areas to be Included

The following areas shall be included in the urban area.

a. Area

- Phnom Penh city and other cities
- Provincial towns

b. Road

-The National Road
- The Provincial Roads

3. Exclusions for Road Crossings

The conductor is not regarded as crossing a road in the followings:

- The road is so narrow that cars can not pass through it.
- The road is on private land.

4. Mitigation of Height for Low-voltage Conductors

The minimum height of the low-voltage conductor is mitigated up to 4.0 m on the place other than a road.

Article 46 - Clearance between Overhead Medium-voltage and Low-voltage Lines and Other Objects

1. Clearance between Overhead Lines and Buildings/Plants

The minimum clearance between a line and another object shall be the values shown in the Table 22A.

Table 22A - Clearance between Overhead Lines and Other Objects

(Unit: meter)

				Low-voltage	Medium-voltage
Structures of buildings	Up side proximity	With the possibility for persons to climb on	Bare conductor	-	3.0
			Insulated conductor	2.0	2.5
			Cable	1.0	1.2
		Others	Bare conductor	-	3.0
			Insulated conductor	1.2	1.5
			Cable	0.4	0.5
	Lateral and downside proximity		Bare conductor	-	3.0
			Insulated conductor	1.2	1.5
			Cable	0.4	0.5
Plants			Bare conductor	-	2.0
			Insulated conductor	Shall not contact directly	
			Cable	Shall not contact directly	

Low-voltage cable including ABC (Aerial Bundle Conductor) type cable may be installed directly on a wall of a building by using a clip and clamp in such a way that in normal circumstances a person cannot reach the cable.

2. Clearance between Overhead Distribution Lines and a Road

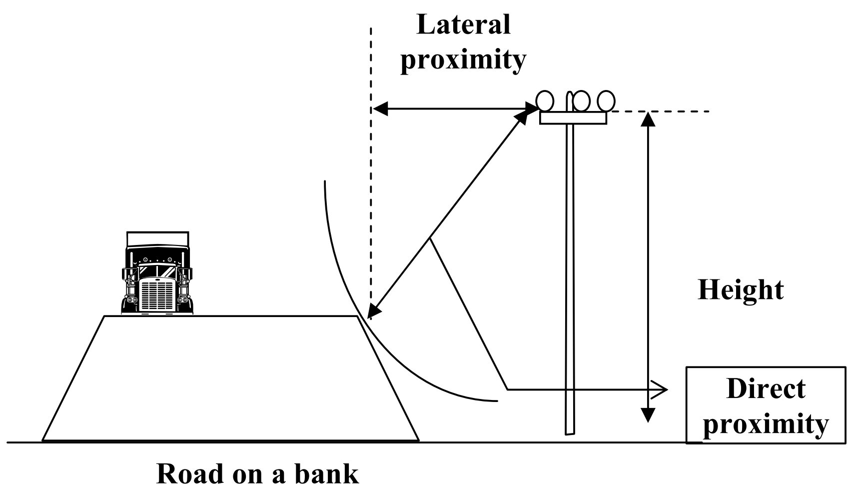
When a supporting structure is installed below a road, the minimum clearance between a line and a road shall be the values shown in Tables 22B and 22C.

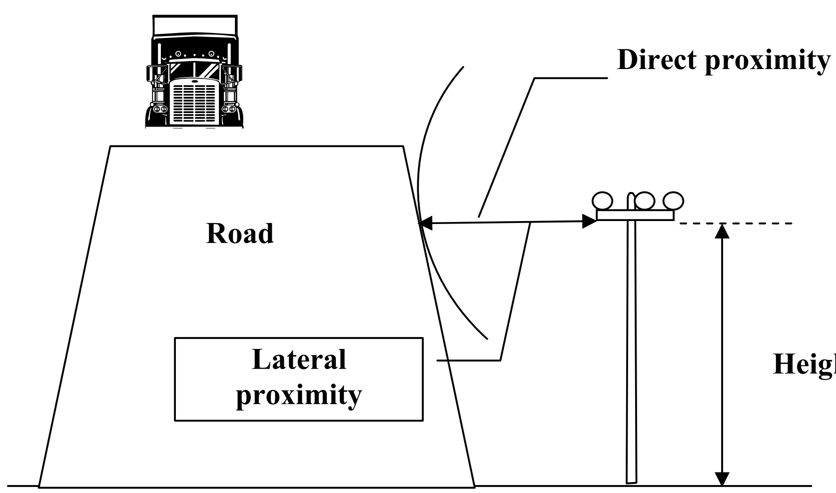
Table 22B - Clearance between a Line and a Road on a Bank

(Unit: m)

	Type of wire	Low-voltage	Medium-voltage
Direct proximity	Bare conductor	Do not install	3.0
	Insulated conductor	3.0	3.0
	Cable	3.0	3.0
Lateral proximity	Bare conductor	Do not install	3.0
	Insulated conductor	1.0	1.5
	Cable	1.0	1.2

* If the lateral proximity is equal to the direct proximity, the lateral proximity required the same value as the direct adjacency.





* If the lateral proximity is equal to the direct proximity, the lateral proximity required the same value as the direct proximity.

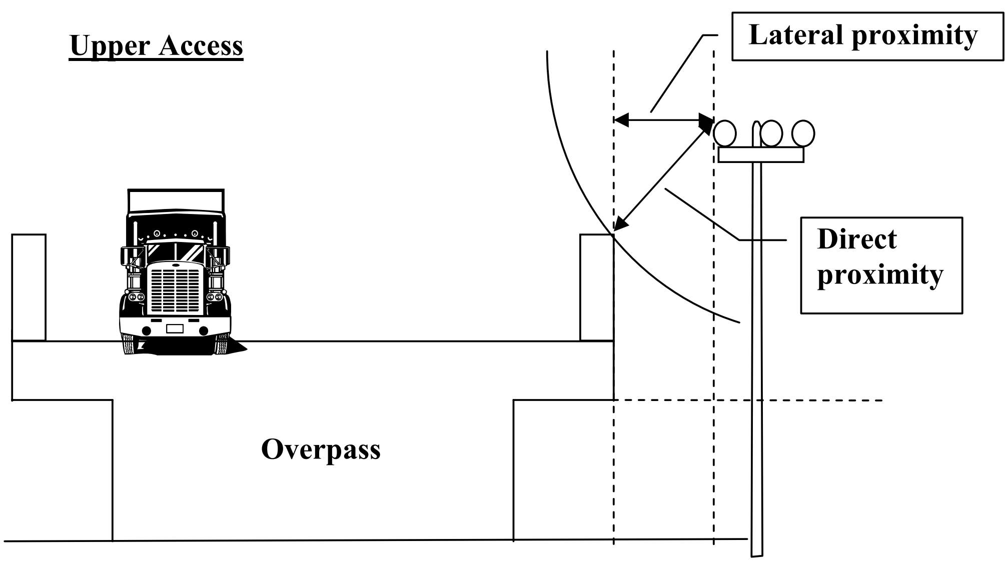
Figure 12 - Explanation of Direct Proximity and Lateral Proximity (Road on a Bank)

Table 22C - Minimum Clearance between a Line and an Overpass

(Unit: m)

	Type of wire	Low-voltage	Medium-voltage
Upper access	Bare conductor	Do not install	Direct proximity:3.0
	Insulated conductor	Direct proximity:3.0 or Lateral adjacencu:1.0	Direct proximity:3.0 or Lateral proximity:1.5
	Cable	*Direct proximity:3.0 or Lateral adjacencu:1.0	*Direct proximity:3.0 or Lateral proximity:1.2
Lower access	Bare conductor	Do not install	Lateral proximity:3.0
	Insulated conductor	Direct proximity:0.6	Direct proximity:1.5
	Cable	Direct proximity:0.3	Direct proximity:0.5

* Either direct proximity or lateral proximity shall be required.



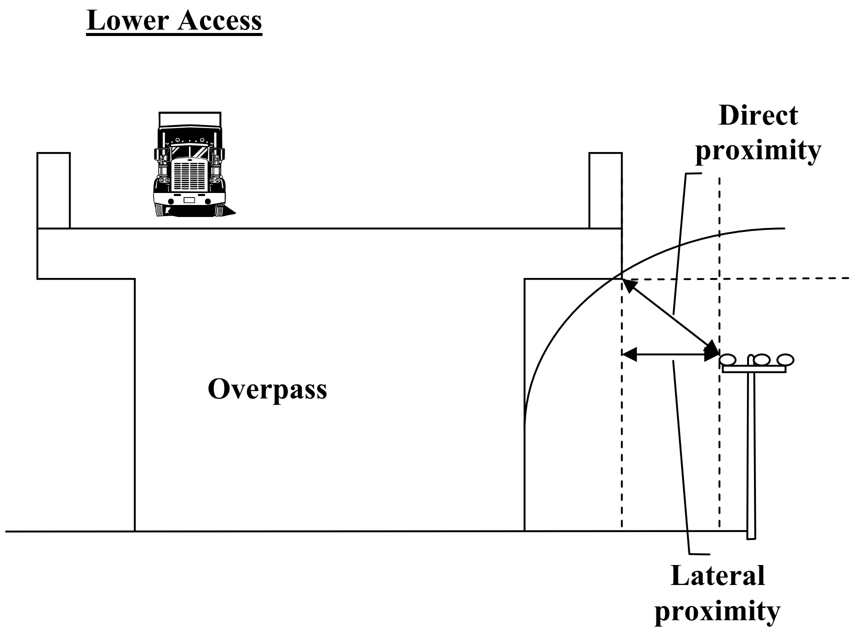


Figure 13 - Explanation of Direct Proximity and Lateral Proximity (Overpass)

Article 47 - Proximity and Crossing of Overhead Medium-voltage and Low-voltage Lines

1. Multiple Medium-voltage Line

When a medium-voltage line is installed adjoining or crossing another medium-voltage line, the clearance between the two medium-voltage lines shall be not less than 2.0m. If one is a cable and the other is a cable or an insulated conductor, the clearance shall be not less than 0.5m.

2. Medium-voltage Lines and Low-Voltage Lines

When a medium-voltage line and a low-voltage line are installed so that they adjoin or cross each other, they shall be installed in the following manners.

- The medium-voltage line shall not be installed under the low-voltage lines. If the medium-voltage line maintains a horizontal clearance of not less than 3.0m from the low-voltage line, and the low-voltage line does not come in contact with the medium-voltage line when the support structure of the low-voltage line collapses, this may not be applicable.

- The clearance between the medium-voltage line and the low-voltage line shall be not less than 0.5m when the medium-voltage line is a cable, not less than 1.0m when it is an insulated conductor, and not less than 2.0m when it is a bare conductor.
- The medium-voltage line shall not cross under the low-voltage line. If the medium-voltage line is a cable and the clearance between the medium-voltage line and the low-voltage line is not less than 0.5m, this may not be applicable.

3. Multiple Low voltage Lines

When a low-voltage line is installed adjoining or crossing other low-voltage lines, the clearance between the two low-voltage lines shall be not less than 0.6m. When one is a cable and the other is a cable or an insulated conductor, the clearance shall be not less than 0.3m.

4. Medium-voltage Lines and Communication Lines

When a medium-voltage line is installed adjoining or crossing a communication line, the medium-voltage line shall be installed in the following manners.

- The medium-voltage line shall not be installed under the communication line. If the medium-voltage line maintains a horizontal clearance of not less than 3.0m from the communication line, and the communication line does not come in contact with the medium-voltage line when the support structure of the communication line collapses, this may not be applicable.

- The clearance between the medium-voltage line and the communication line shall be not less than 0.5m when the medium-voltage is a cable, not less than 1.0m when it is an insulated conductor, and not less than 2.0m when it is a bare conductor.

- The medium-voltage line shall not cross under the communication line. If the medium-voltage line is a cable and the clearance between the medium-voltage line and the communication line is not less than 0.5m, this may not be applicable.

5. Low-voltage Lines and Communication Lines

When a low-voltage line is installed adjoining or crossing a communication line, the low-voltage line shall be installed in the following manners.

- The low-voltage line shall not cross under the communication line. If other methods are not technically realistic, this may not be applicable.

- The clearance between the low-voltage line and the communication line shall be not less than 0.3m when the low-voltage line is a cable, and not less than 0.6m when conductor is insulated.