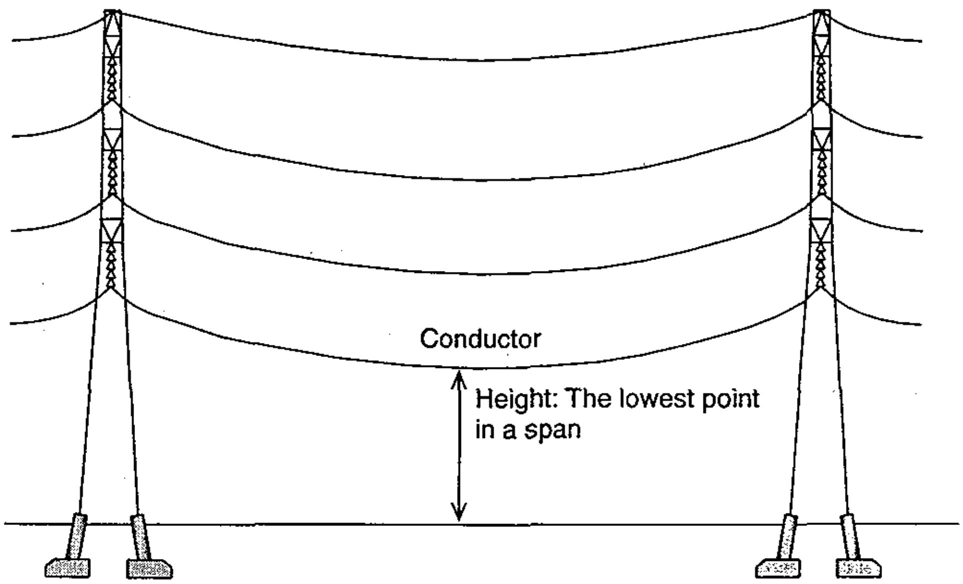
Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL28-1**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	45	Height of Overhead High-voltage Lines	
Title	Height of Conductors (1/4)			

1. Height of Conductors in and around Urban Area

An example of height of conductors of overhead high-voltage lines in and around urban area is as follows.



Voltage [kV]	Height [m]
115	No less than 7.0
230	No less than 7.7

The Heights shall be kept at any points in a span. Furthermore, height of conductors in urban area shall be decided that an electric field at the height of 1 m from the ground is 3kV/m or less in compliance with Clause 47. Normally, the latter height, decided by the electric field, is dominant for extra-high voltage lines.

The Heights have been decided, taking into account foreign countries' standards, and Technical Standards for distribution lines and current conditions in Cambodia. Foreign countries' standards are described below for reference.

Voltage [kV]	Heights [m]			
	Japan	U.S.A(NESC)	France	Germany
115	6.0	6.1	6.6	-
230	6.8	6.8	7.1	7.7

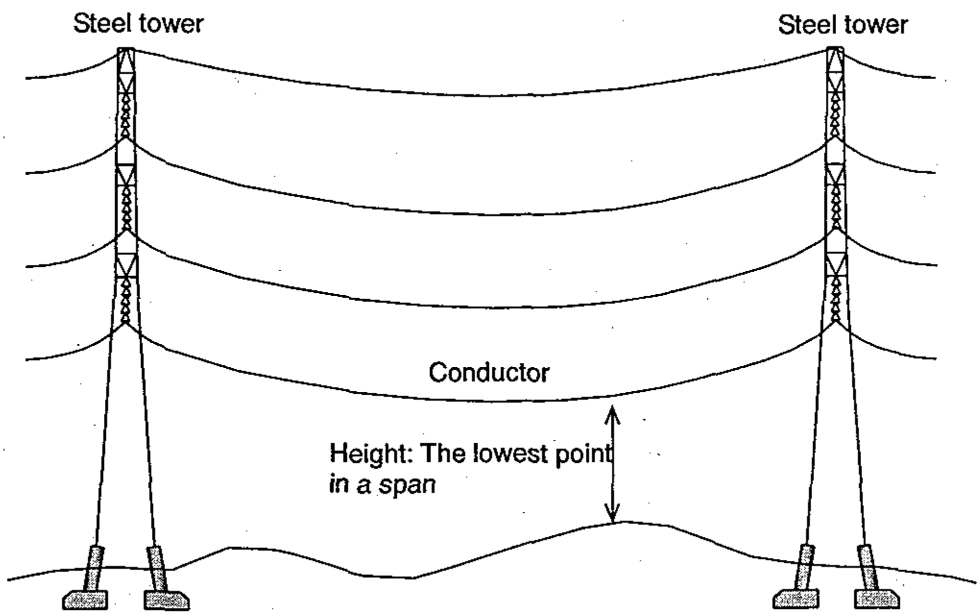
- Remark: Definition of "urban area" is different in the countries.

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No. TL28-2
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	45	Height of Overhead High-voltage Lines	
Title	Height of Conductors (2/4)			

2. Height of Conductors in Areas where Third Persons hardly Approach

An example of height of conductors of overhead high-voltage lines in areas where third persons hardly seem to approach, such as a mountainous area, is as follows.



Voltage[kV]	Height[m]
115	No less than 6.0
230	No less than 6.7

The Heights of conductors shall be kept at any points in a span.

The Heights have been decided, taking into account Japanese standard, and Technical Standards for distribution lines and current conditions in Cambodia. Japanese standard is described below for reference.

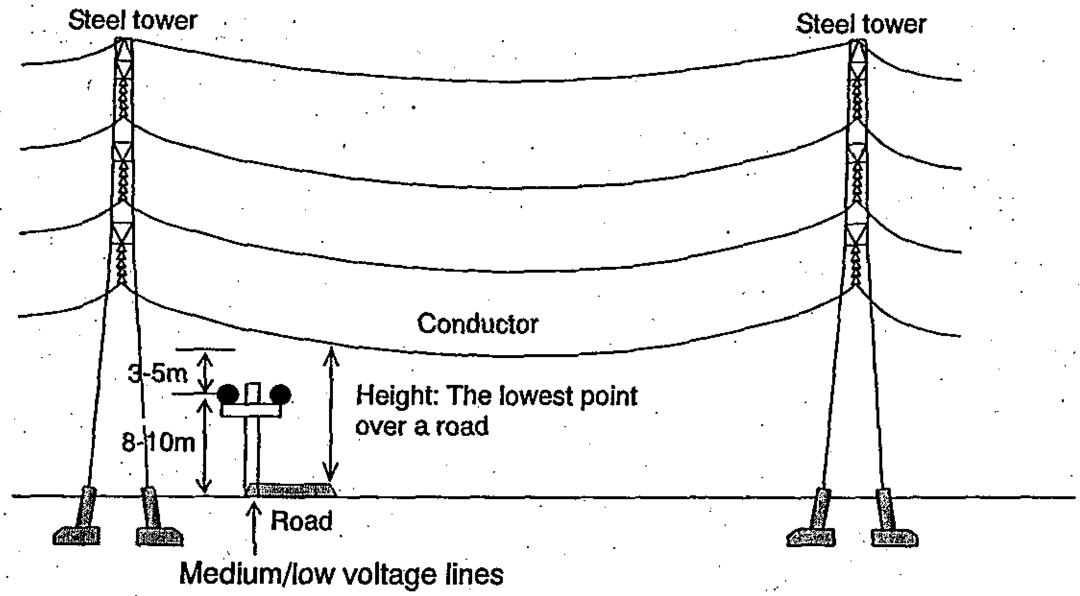
Voltage [kV]	Heights [m]
	Japan
115	5.0
230	5.9

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. TL28-3
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	45	Height of Overhead High-voltage Lines	
Title	Height of Conductors (3/4)			

3. Height of Conductors crossing over Roads and/or Railways

Height of conductors of overhead high-voltage lines crossing roads, such main roads as national roads, and/or railways should be decided taking into account possibility of construction of distribution line along the roads and/or railway, show as below.



Voltage[kV]	Height[m]
115	No less than 13.5
230	No less than 14.2

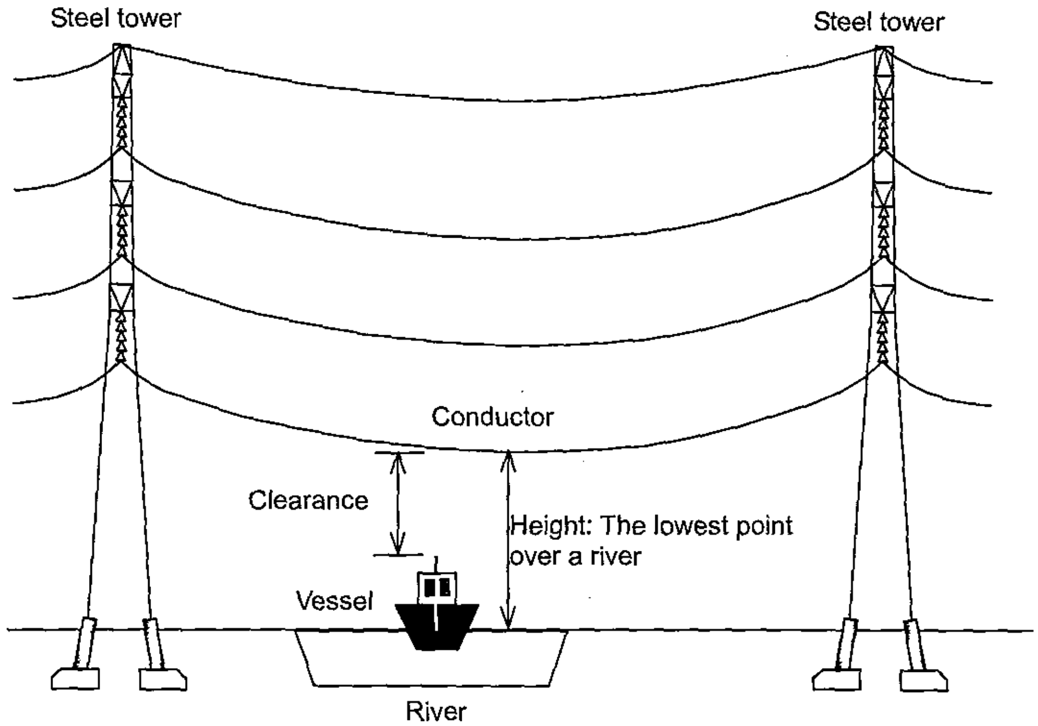
Where a high-voltage line crosses over such a major road as National Roads, the height of the conductors should be decided so that distribution lines and/or houses can be constructed along the roads. Appropriate design as shown in the above figure, in which the line crosses over the road near the supporting structure and not at the biggest sagging point, can make height of the supporting structure not so high.

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No. TL28-4
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	45	Height of Overhead High-voltage Lines	
Title	Height of Conductors (4/4)			

4. Height of Conductors crossing Rivers and/or Seas

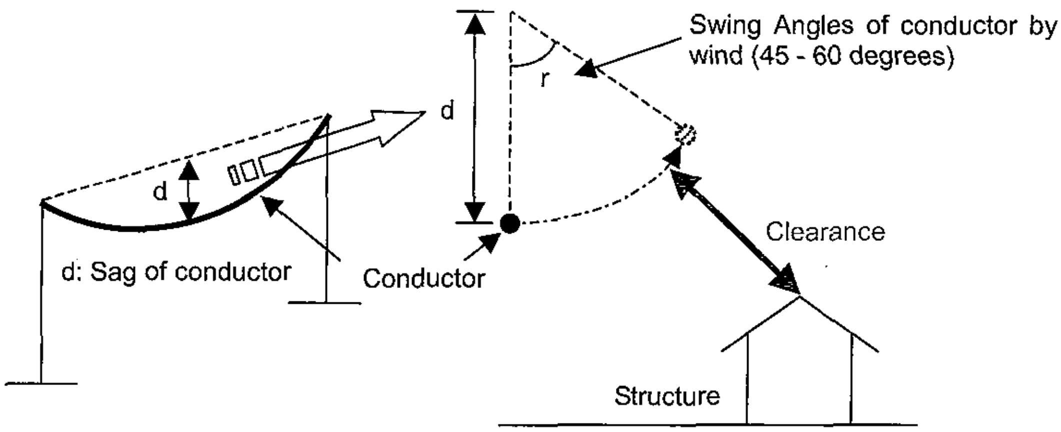
An example of height of conductors of overhead high-voltage lines crossing rivers and/or seas is as follows.



Voltage[kV]	Height or Clearance [m]
115	Height: No less than 6.0 Clearance: No less than 3.5m
230	Height: No less than 6.7 Clearance: No less than 4.2m

Remarks	Revisions	
	2003/Nov.	Original

Category				
Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL29-1**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	46	Clearance among Overhead high-voltage Lines and Other Facilities or Trees	
Title	Clearance among Conductors and Others (1/3)			

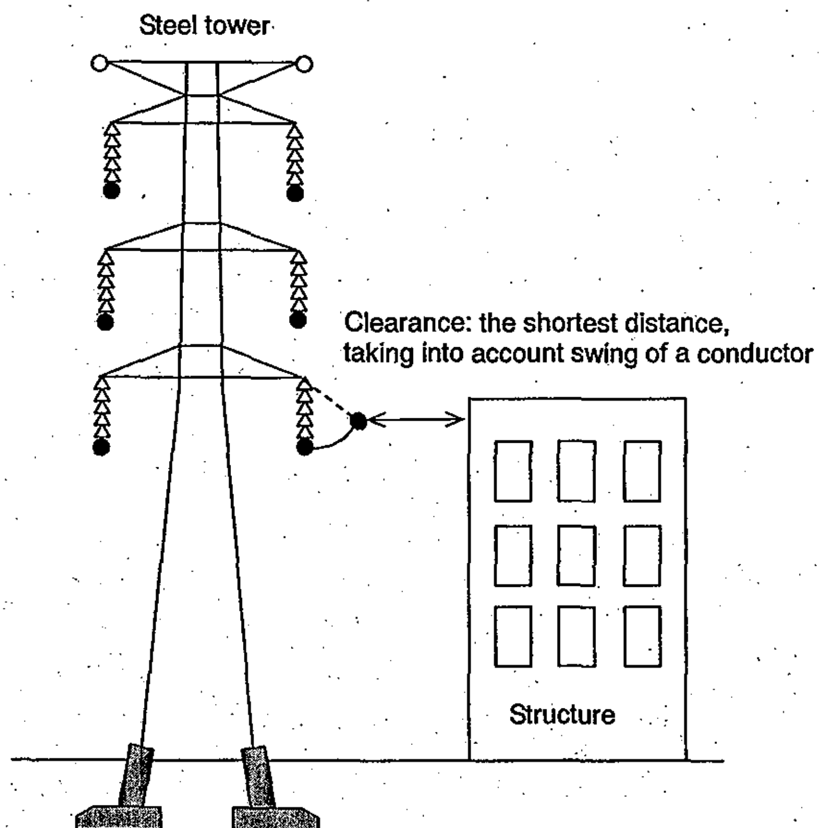


Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. TL29-2
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	46	Clearance among Overhead high-voltage Lines and Other Facilities or Trees	
Title	Clearance among Conductors and Others (2/3)			

1. Clearance among Conductors and Other Facilities

An example of clearance among each conductor of overhead high-voltage lines and other facilities is as follows.



Voltage[kV]	Clearance[m]
115	3.5
230	4.2

The Clearances have been decided, taking into account foreign countries' standards and Technical Standards for distribution lines and current conditions in Cambodia. Foreign countries' standards are described below for reference.

Voltage [kV]	Clearances [m]			
	Japan	France	U.S.A(NESC)	Germany
115	4.2	3.9 (3.6)	4.6 (1.9)	-
230	6.0	4.7 (4.2)	5.3 (2.6)	5.7 (3.7)

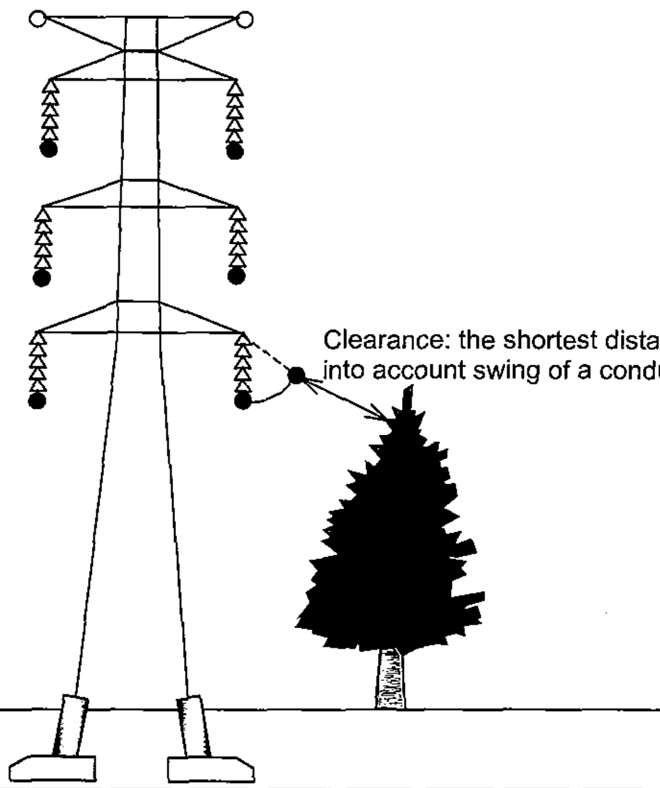
Remark: ( ) is clearance when conductors are swinging.

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL29-3**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	46	Clearance among Overhead high-voltage Lines and Other Facilities or Trees	
Title	Clearance among Conductors and Others (3/3)			

2. Clearance among Conductors and Trees

An example of clearance among each conductor of overhead high-voltage lines and trees is as follows.



Voltage[kV]	Clearance[m]
115	2.5
230	3.2

The Clearances have been decided, taking into account foreign countries' standards, and Technical Standards for distribution lines and current conditions in Cambodia. Foreign countries' standards are described below for reference.

Voltage [kV]	Clearances [m]		
	Japan	France	Germany
115	2.8	1.9 (1.3)	-
230	4.1	2.8 (1.6)	3.2

Remark: ( ) is clearance when conductors are swinging.

Remarks	Revisions	
	2003/Nov.	Original

Category				
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. TL30-1
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	47	Prevention of Danger and Interference due to Electrostatic Induction and Electromagnetic Induction	
Title	Measures for Electrostatic and Electromagnetic Inductive Interference (1/3)			

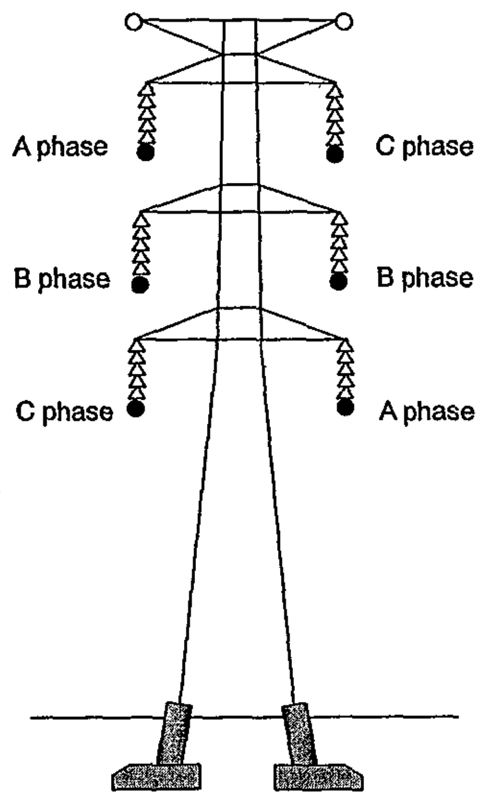
The electric field caused by overhead high-voltage lines at 1m above the ground surface shall be 3kV/m or less. The following table shows the feelings when touching metal materials charged by Electrostatic Induction.

Electric field[kV/m]	The feeling
Less than about 3	No feeling almost
About 3 – 6	Feeling a little
More than about 6	Feeling

Measures for electrostatic inductive interference are as follows.

1.Making height of towers higher

2. Adoption of reversed phase-formation



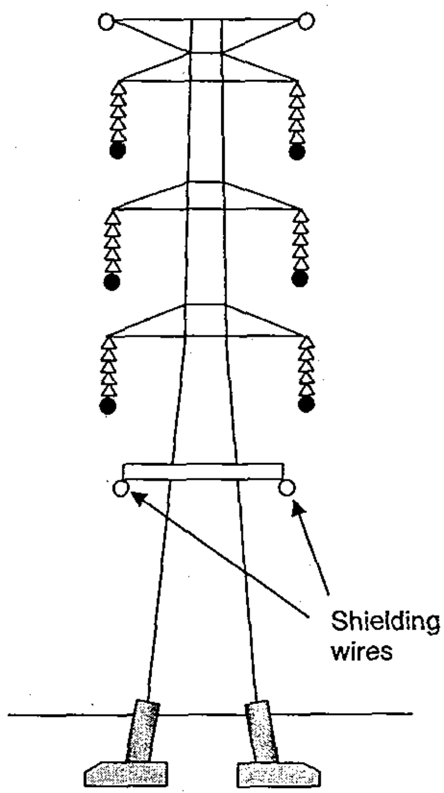
An example of reversed phase-formation

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL30-2**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	47	Prevention of Danger and Interference due to Electrostatic Induction and Electromagnetic Induction	
Title	Measures for Electrostatic and Electromagnetic Inductive Interference (2/3)			

Measures for electromagnetic inductive interference are as follows.

1. Installation of shielding wires
2. Making clearance bigger
3. Adoption of Electromagnetic shielding cables for low-voltage lines and/or communication lines

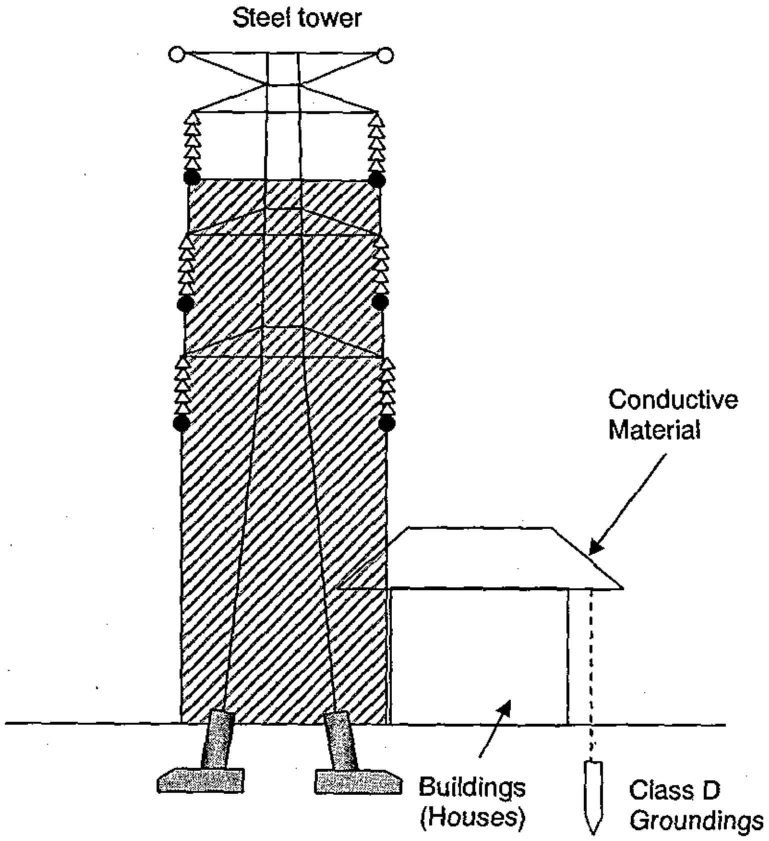


Installation of shielding wires

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL30-3**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	47	Prevention of Danger and Interference due to Electrostatic Induction and Electromagnetic Induction	
Title	Measures for Electrostatic and Electromagnetic Inductive Interference (3/3)			

Basically, Neither buildings nor houses should be constructed under overhead high-voltage lines. However, if the construction is unavoidable, the conductive materials on the surface of the buildings or houses shall be grounded with Class D.



Remarks	Revisions	
	2003/Nov.	Original

JICA

GUIDEBOOK
FOR
POWER ENGINEERS

English Edition

VOL. No.6
MEDIUM & LOW VOLTAGE DISTRIBUTION SYSTEM

Dec. 2003

MINISTRY OF INDUSTRY, MINES AND ENERGY
ELECTRICITY AUTHORITY OF CAMBODIA
ELECTRICITE DU CAMBODGE

Contents of Medium & Low Voltage Distribution System

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DS28	Calculation of Safety Factor of Foundation
DS29	Calculation of Strength of Iron-reinforced Concrete Pole and Steel Pole
DS30	Strength Test for Iron-reinforced Concrete Pole
DS31	Calculation of Strength of Wooden Pole
DS32	Installation of Guy
DS33	Calculation of Strength of Guy
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DS35	Connection Methods of Conductors
DS36	Cables for Overhead Line
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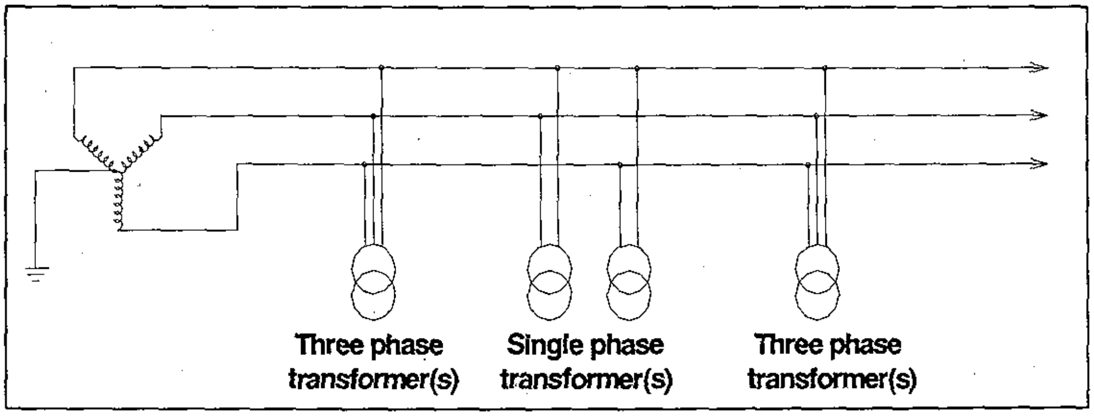
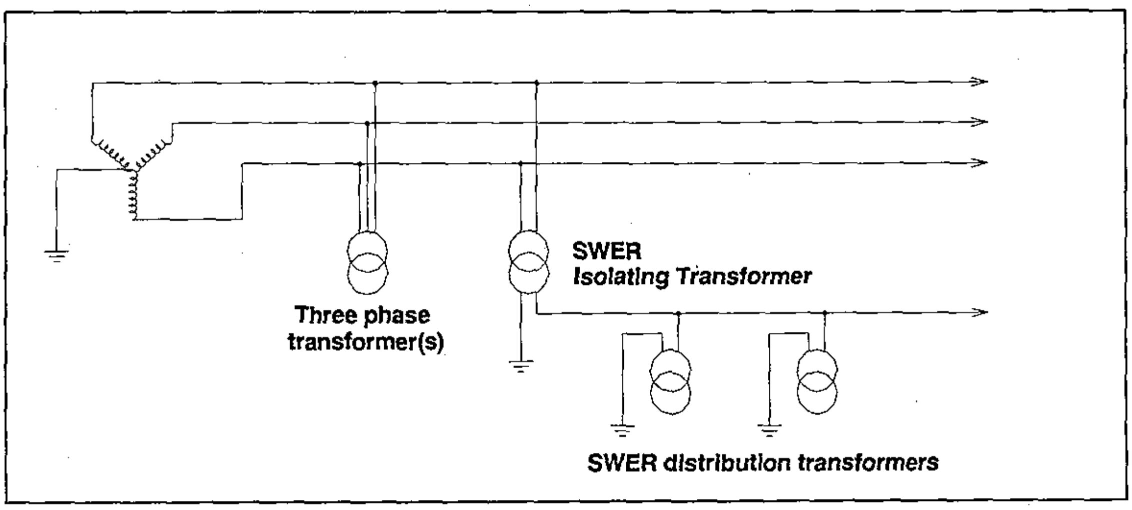
Category				Document No.DS1-1
	Chapter	1	General Provisions	
	Paragraph	3	Quality of Electric Power	
	Clause	6	Voltage	
Title	Distribution System (1/2)			

Three-Phase, Three-wire System



SWER System

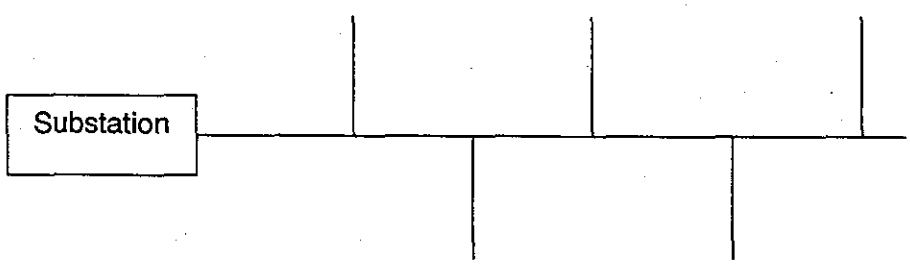


Remarks	Revisions	
Resource: EDC document		
	2003/Nov.	Original

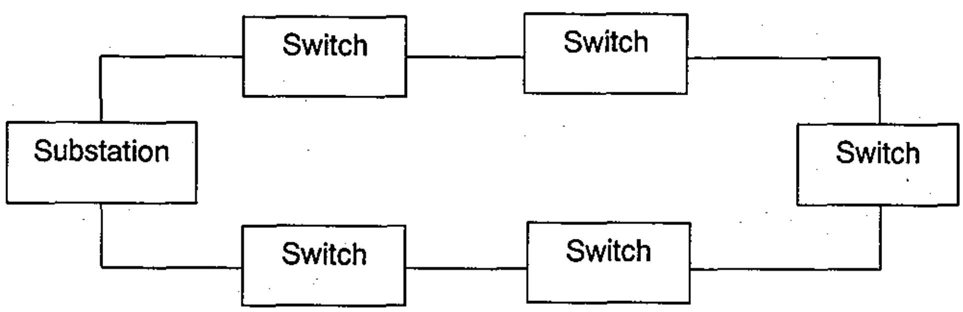
Category	Chapter	1	General Provisions	Document No.DS1-2
	Paragraph	3	Quality of Electric Power	
	Clause	6	Voltage	
Title	Distribution System (2/2)			

Medium-voltage Distribution System

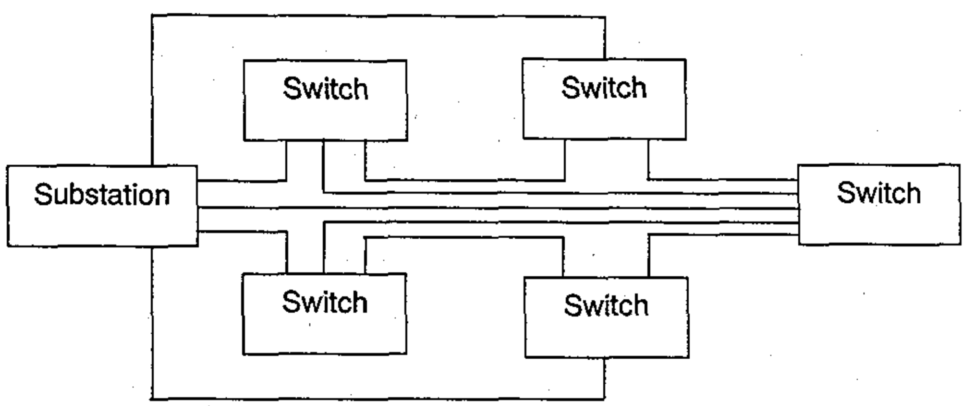
1. Radial Distribution System



2. Ring Distribution System



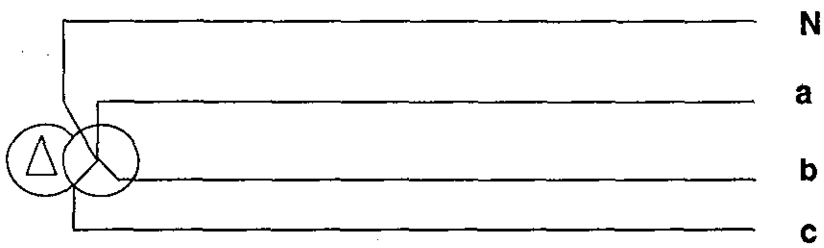
3. Network Distribution System



Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	1	General Provisions	Document No.DS2-1
	Paragraph	3	Quality of Electric Power	
	Clause	6	Voltage	
Title	Low-voltage Supply System (1/3)			

Low-voltage Supply System



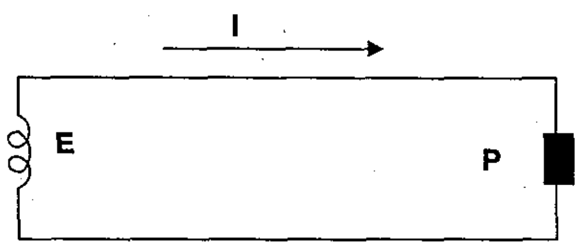
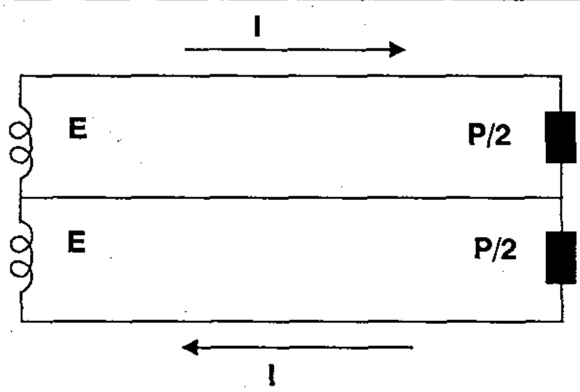
	Nominal Voltage	Variation of Voltage
a-N, b-N, c-N	220V	From 207V to 244V
a-b, b-c, c-a	380V	From 360V to 424V

Nominal voltage is conventional nominal voltage in used in Cambodia. And the variation of voltage is decided considering the conformity with IEC low-voltage standard, *assuming the usage of imported apparatuses.*

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	1	General Provisions	Document No.DS2-2
	Paragraph	3	Quality of Electric Power	
	Clause	6	Voltage	
Title	Low-voltage Supply System (2/3)			

Current of Each Distribution System

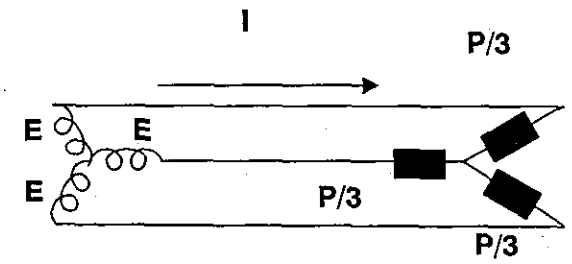
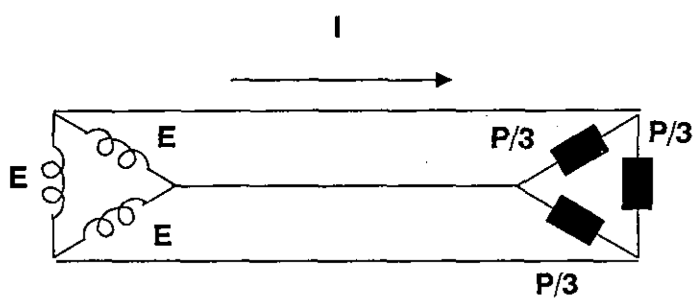
Distribution System	Current in Phase Line
	$I = \dfrac{P}{E \cos\theta}$
	$I = \dfrac{P}{2E \cos\theta}$

*Loads are assumed to be balanced.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	1	General Provisions	Document No.DS2-3
	Paragraph	3	Quality of Electric Power	
	Clause	6	Voltage	
Title	Low-voltage Supply System (3/3)			

Current of Each Distribution System

Distribution System	Current in Phase Line
	$I = \frac{P}{3E \cos\theta}$
	$I = \frac{P}{\sqrt{3} E \cos\theta}$

* Loads are assumed to be balanced.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	1	General Provisions	Document No.DS3
	Paragraph	3	Quality of Electric Power	
	Clause	6	Voltage	
Title	Management of Voltage			

Licensees have to control the supply voltage at the receiving point in accordance with the Electric Power Technical Standard.

As the voltage fluctuates always, the conformity of the supply voltage to the Electric Power Technical Standard shall be certified not just when it is measured, but also anytime.

On the other hand, it is difficult and not realistic to monitor the supply voltage, other than the outgoing voltage at a substation or a power station. Therefore the supply voltages to customers will be managed by assumption of a voltage drop or measuring it in case of necessary.

Generally the voltage of distribution line is managed by the assumption considering electrical characteristics of distribution lines and demand. When distribution facilities are designed, the voltage of the end of the lines based on the assumed demand will be within the target voltage.

To put it concretely, licensees decide the target voltages at the end of medium-voltage lines, the branching point from a main low-voltage line or the primary side of a meter. The designs of facilities will be made considering the voltage to be in conformity with each target voltage. When the voltage at each point will be out of the target by the increase of demand, such countermeasures as the scale up of conductors, the installation of boosters, the change of low-voltage networks, or the change of tap of transformers will be done. In case of the installation of boosters or the change of tap, licensees also have to examine that the voltage at the time of minimum demand will not exceed the maximum voltage regulated the Electric Power Technical Standard.

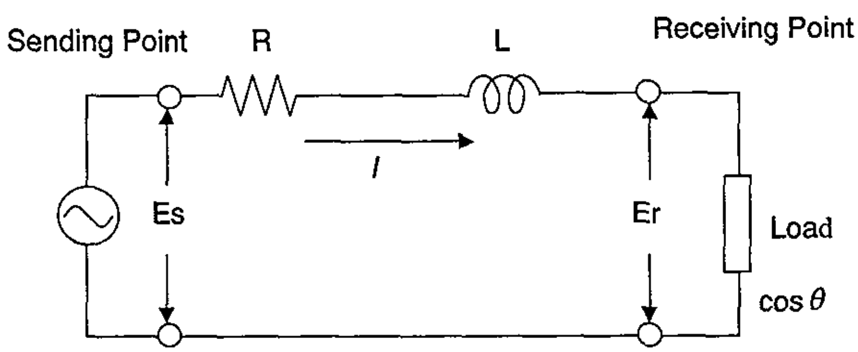
After the expansion of distribution facilities, the change of distribution network, and the supply to bulk customers, licensees should measure voltages of some critical points and examine the conformity with the Electric Power Technical Standard. In addition, the supply voltage should be measured regularly, because the total residential demand will increase gradually. The voltage, fluctuating all the time, should be measured not at a spot but for a long term enough for examination, including both a low demand period and a high demand period.

Even when there are enough capacities in transformers in a substation, conductors and other facilities, for new large customers, if the supply voltages for some customers will be out of regulated voltage taking the new demand into consideration, licensees should not supply to the new large customers before a countermeasure construction works to avoid bad influence to other customers.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	1	General Provisions	Document No.DS4
	Paragraph	3	Quality of Electric Power	
	Clause	6	Voltage	
Title	Ferranti Effect			

Generally the power factor of a load is lagging power factor. Therefore the voltage of receiving point is less than that of sending point (Fig 1). However on the long -distance medium-voltage distribution line the capacitance of the line become larger. When the load is very small at the long-distance line, the power factor may be leading power factor because of the big charging current (Fig 2). In this case, the voltage of receiving point is larger than that of sending point. This phenomenon is called Ferranti Effect and on the occasion of managing voltage, it is necessary to take it into consideration.



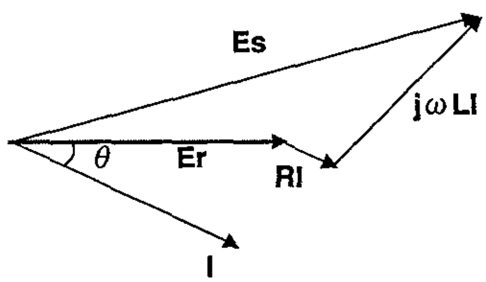


Fig.1 Normal Condition

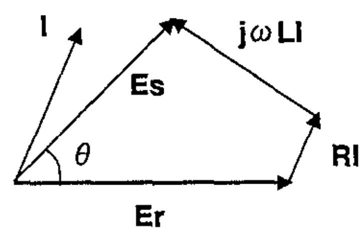
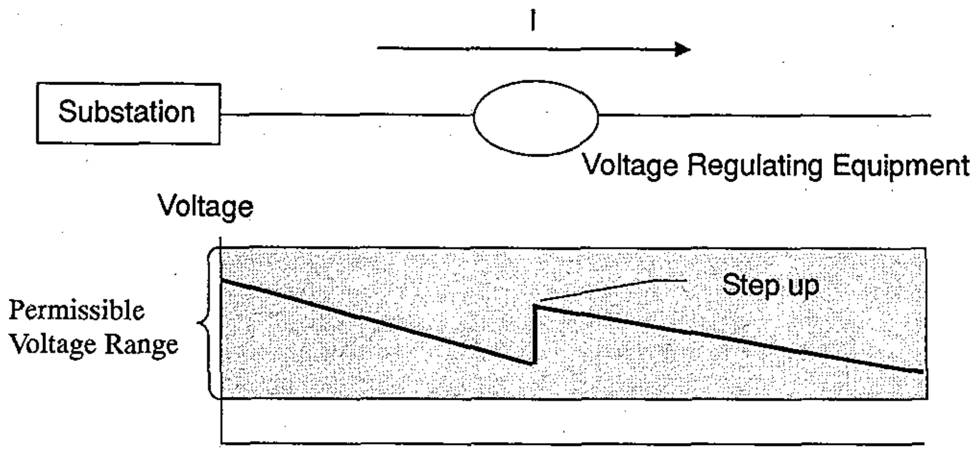


Fig.2 Ferranti Effect

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.DS5
	Chapter	1	General Provisions	
	Paragraph	3	Quality of Electric Power	
	Clause	6	Voltage	
Title	Voltage Regulating Equipment			



Since the voltage will fluctuate by the change of the load, it is difficult to maintain the voltage within the regulated range on the long-distance medium-voltage distribution line. In such case, a voltage regulating transformer is installed to adjust the voltage in accordance with the load. The example circuit of a voltage regulating transformer is shown in Fig 1.

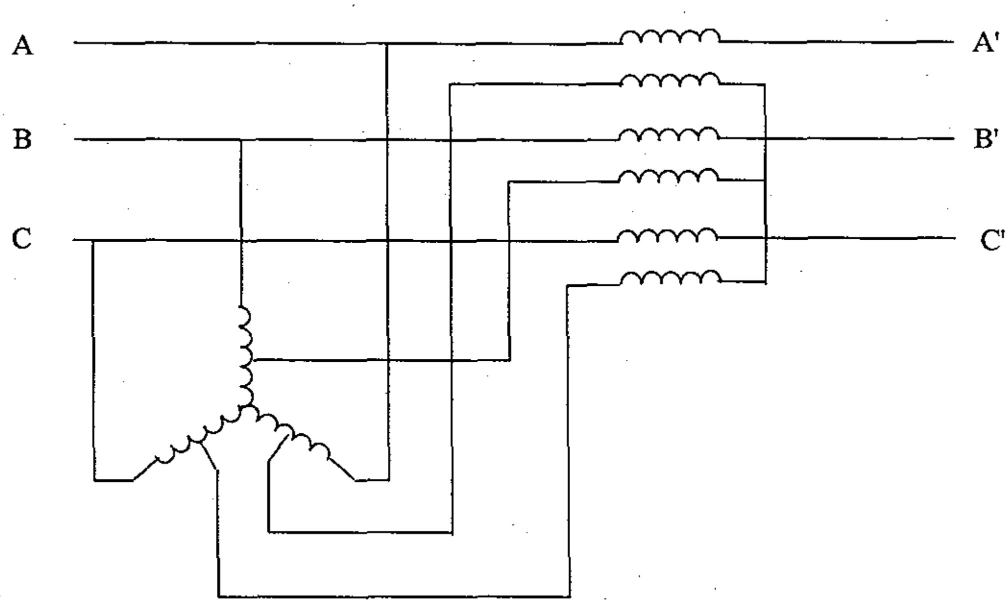


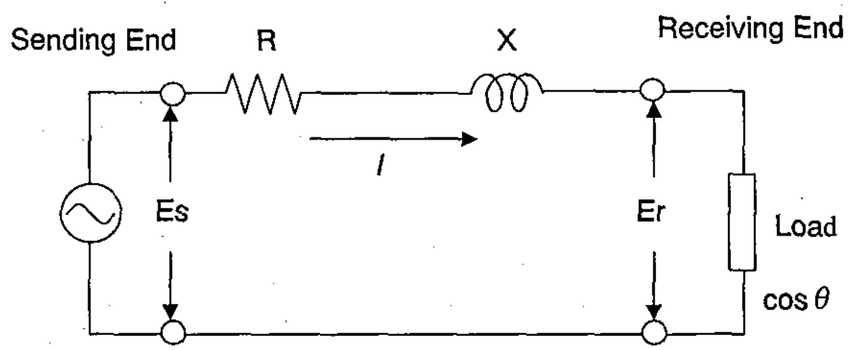
Fig.1 Example of Voltage Regulating Transformer

Remarks	Revisions	
	2003/Nov.	Original

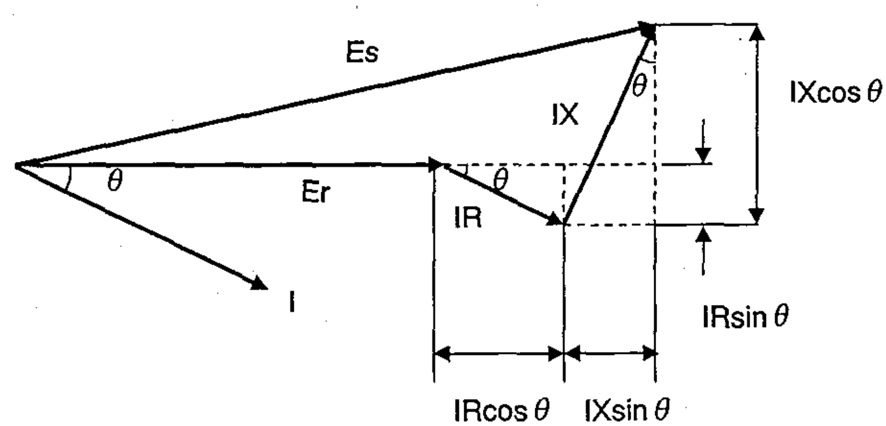
Category	**Chapter**	1	General Provisions	**Document No.DS6-1**
	Paragraph	3	Quality of Electric Power	
	Clause	6	Voltage	
Title	Calculation of Voltage Drop (1/2)			

For the design of distribution network the voltage drop is calculated based on the demand.

The vector diagram of voltage drop for the equivalent circuit is generally shown as follows;



Equivalent Circuit



Vector Diagram

Remarks	Revisions	
	2003/Nov.	Original

Category				Document
	Chapter	1	General Provisions	No.DS6-2
	Paragraph	3	Quality of Electric Power	
•	Clause	6	Voltage	
Title	Calculation of Voltage Drop (2/2)			

$$Es = \sqrt{(Er + IR\cos\theta + IX\sin\theta)^2 + (IX\cos\theta - IR\sin\theta)^2}$$

$$\fallingdotseq Er + IR\cos\theta + IX\sin\theta$$

Therefore the voltage drop is given the following formula.

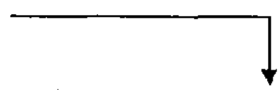
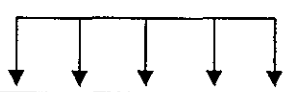
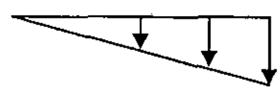
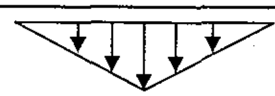
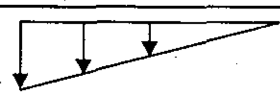
$$e = Es - Er$$
$$= I(R\cos\theta + X\sin\theta)$$
$$= I \times Re$$

Re: Equivalent resistance.

The approximate voltage drop for each load distribution model is as follows;

$$e = f \times IRe$$

f: Dispersal load factor

Model of dispersal load		***Dispersal load***
Concentrating on the end of line		1
Distributing equally on the line		0.5
Increasing, so that it goes to the end of line		0.67 (=2/3)
Becoming the maximum in the middle of line		0.5
Decreasing, so that it goes to the end of line		0.33 (=1/3)

The line voltage drop is given as follows;

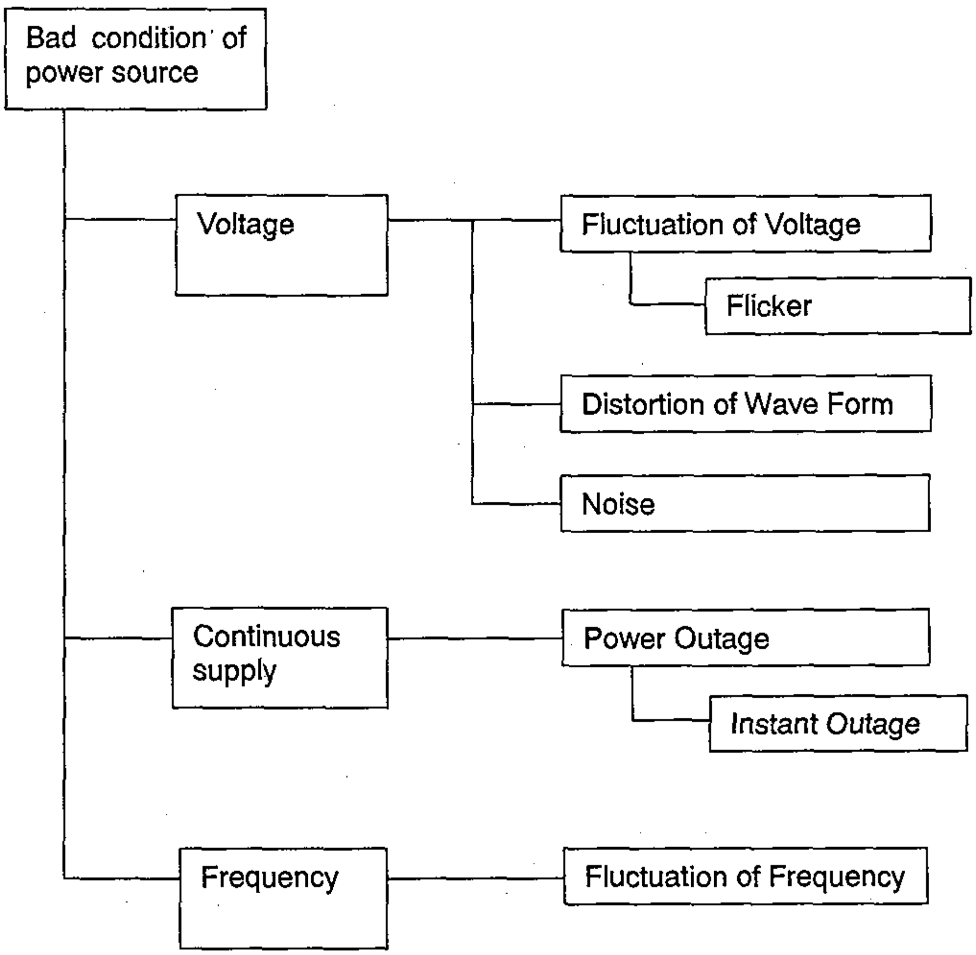
Single phase two wires system: $v = 2e$

Three phases three wires system: $v = \sqrt{3}\,e$

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	1	General Provisions	Document No.DS7
	Paragraph	3	Quality of Electric Power	
	Clause	6	Voltage	
Title	Quality of Power			

The quality of power is evaluated by following items.



Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	1	General Provisions	**Document No.DS8**
	Paragraph	3	Quality of Electric Power	
	Clause	6	Voltage	
Title	Flicker			

When in an instance the demand changes large, the voltage will also fluctuate intensely. If the fluctuation is too intense, the brightness of lamps and fluorescent lights will change, and twinkling will be felt depending on the difference of the voltage and its time of change. This phenomenon is called "flicker" and following influence may happen on apparatuses.

1. Twinkling on lightening apparatuses
2. Damage on electronic apparatuses
3. Noise on communication apparatuses etc.

The typical facilities that generate flicker are a welding machine, an electric furnace, an elevator and a pressing machine.

The sensible annoying is different depending on the voltage and the frequency. "Pst" measured by flicker meters provided in IEC61000-4-15 indicates the digitalization of the annoying. In IEC61000-2-2, there shows a curving line that shows the relation between frequencies and limitations of changes of voltages.
Generally the limitation of flicker is shown as follows;

Pst ≦ 1

Raising the size of conductors or installing an exclusive line for a customer with the source of flicker is an example of countermeasures against flicker.

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	1	General Provisions	**Document No.DS9**
	Paragraph	3	Quality of Electric Power	
	Clause	-	Others	
Title	Planning of distribution facility			

Distribution facilities are installed near the buildings, on the public roads or in the private sites. Therefore when licensees plan distribution facilities, they should consider not only the economy (cost) but also the safety or the efficiency for maintenance,
As far as the economy is concerned, both initial costs and running costs such as maintenance costs and energy losses should be considered.
The reduction of technical losses lead to the reduction of the expansion costs of generation, transmission and distribution facilities as well as the reduction of fuel costs for consolidated licensees, because the reduction of technical loss contributes to the increase of the margin of the capacities of facilities.
As well, for the distribution licensees the reduction of technical loss means the reduction of the expansion costs of distribution facilities and electricity purchase costs from generation licensees.
Technical loss is classified into the resistance loss caused from conductors, and the iron loss and copper loss from transformers.

The resistance loss is given by

$$P = N \times I^2 \times R \ (W)$$

Where
- N: The number of conductor
  (Single phase two wires = 2, Three phases three wires = 3)
- I: Current (A)
- R: Impedance of conductors

The power loss is given by

$$W = P \times T \ (Wh)$$

Where
- T: Hour

Iron loss of transformers with same characteristic is constant, not depending on loads. On the other hand, copper loss, like resistance loss, generated by the current increases in proportion to the square of currents.

Generally, when power companies supply to new low-voltage customers, they are likely to expand low-voltage lines considering only initial costs. However, it is desired that expansion of facilities should be done to meet the increase of demand in the future, and considering the long-term costs.

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	1	General Provisions	**Document No.DS10**
	Paragraph	3	Quality of Electric Power	
	Clause	-	Others	
Title	Demand Forecast by Distribution Licensee			

Licensees should expand their distribution facilities to meet the assumed future demand.

Demand forecasting will be done considering the following items totally.

a. Historical trend of demand
b. Economic index
c. Demand of bulk customers (now and future)

Maximum demand will be decided in consideration of the assumed demand, the demand factor and the diversity factor.

Demand Factor = Maximum Demand / Installed Capacity

Diversity Factor = Σ Maximum Demand of each load / Maximum Demand

Demand factor and diversity factor will be assumed based on the past records regarding real demands or contract demands and installed capacities.

Distribution facilities will be expanded considering both current and voltage at the maximum demand.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	1	General Provisions	Document No.DS11-1
	Paragraph	3	Quality of Electric Power	
	Clause	-	Others	
Title	Power Factor (1/2)			

The power of AC circuit is as follows;

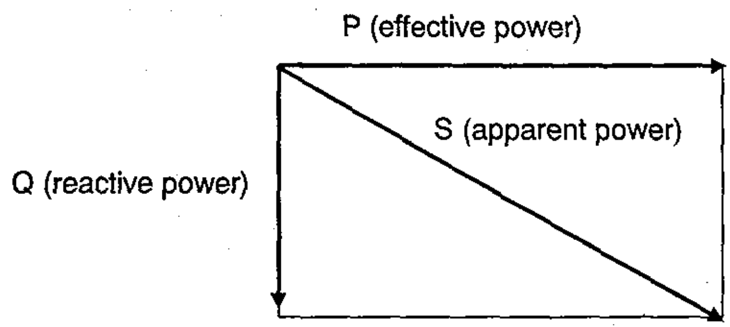
$P = VI \cos\theta$ (W)

P is called effective power. On the other hand, the charged power in reactor is called reactive power and is given by the following;

$Q = VI \sin\theta$ (var)

The composition of P and Q is called apparent power and is given by the following;

$S = VI$ (VA)



θ is the difference of phases on current and voltage. Therefore even when VI is constant, P changes in proportion to $\cos\theta$. $\cos\theta$. is called power factor and the less the power factor is, the more the loss increases. Generally power factor should be no less than 85%.

To improve the power factor, a capacitor is connected to load and parallel (Fig.1 and 2).

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	1	General Provisions	**Document No.DS11-2**
	Paragraph	3	Quality of Electric Power	
	Clause	-	Others	
Title	Power Factor (2/2)			

θ

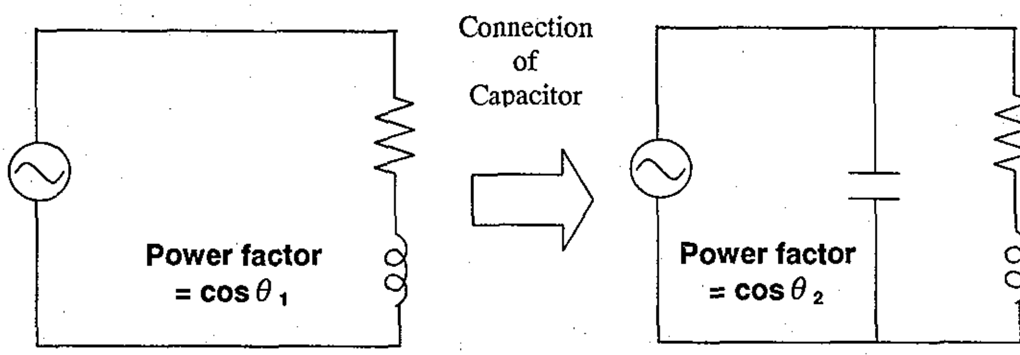
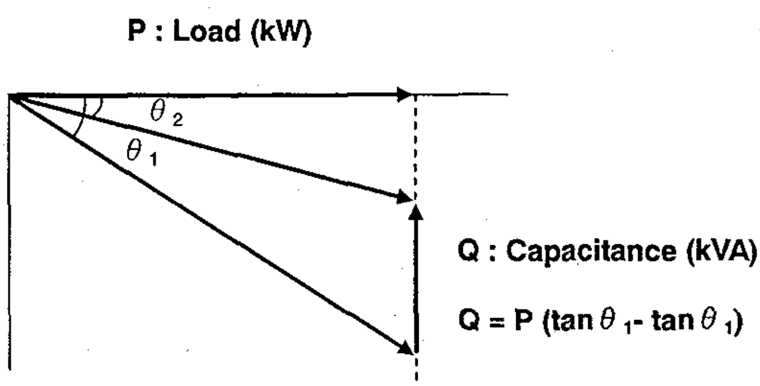


Fig.1 The circuit without capacitance **Fig.2 The circuit with capacitance**



The effects by the improvement of power factor are as follows;

1. Reduction of capacity of facilities
2. Reduction of energy loss
3. Reduction of voltage drop

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.DS12
	Chapter	1	General Provisions	
	Paragraph	4	Prevention of Electric Power Disasters	
	Clause	9	Prevention of Electric Power Disasters	
Title	Medium-voltage Dielectric Tests			

1. Dielectric Tests for Medium-voltage Facilities

Medium-voltage facilities shall be withstand when the test voltage is applied at the parts given in the following table for 10 minutes continuously

Facility		*Applied parts*	*Test Voltage*
Transformer	7000V or less	Between the winding to be tested, and the other winding, the iron core and the case	1.5 times the maximum voltage
	More than 7000V		1.25 times the maximum voltage
Switchgear Circuit breaker Instrument transformer etc.	7000V or less	Between charged part and the ground	1.5 times the maximum voltage
	More than 7000V		1.25 times the maximum voltage

2. Dielectric Test for Medium-voltage Line

Medium-voltage lines shall withstand a test made by impressing the voltage given in following table, between the line and the ground for 10 minutes.

Maximum-voltage	*Test voltage*
7000V or less	1.5 times of maximum-voltage
More than 7000V	1.25 times of maximum-voltage

Remarks	Revisions	
	2003/Nov.	Original

Category				Document
	Chapter	1	General Provisions	Document No.DS13-1
	Paragraph	4	Prevention of Electric Power Disasters	
	Clause	9	Prevention of Electric Power Disasters	
Title	Voltage Tests for 22kV Transformer (1/2)			

1 Lightning impulse test

The primary winding of transformer shall be tested, whether it has sufficient dielectric strength to withstand the definite voltage of positive and negative polarities. This test shall be repeated 3 times. The test voltage is given in following table.

Voltage wave form		1/40 μs
Crest values of voltages	Full wave voltage	150kV
	Chopped wave voltage	165kV

2 Withstand voltage test

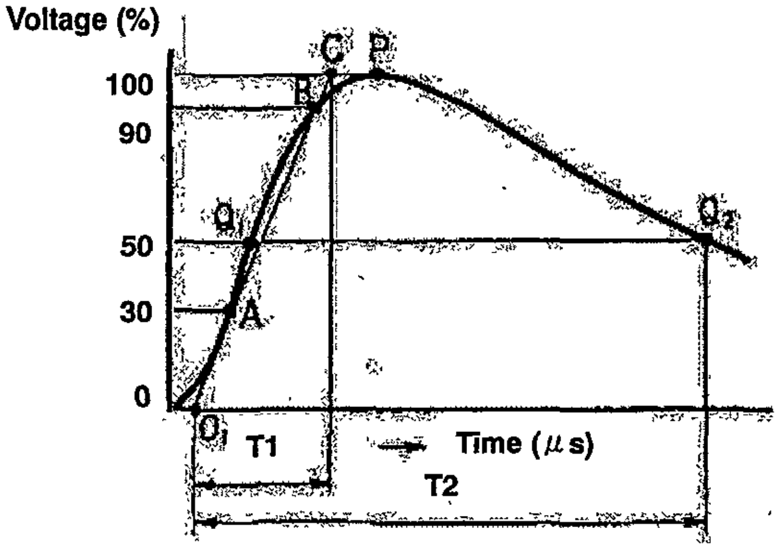
The transformer shall be tested whether it is able to withstand the voltage nearly sinusoidal waveform at 50 Hz for 1 minute. The applied parts and the test voltage are given in following table.

Applied parts	*Test voltage*
Between the primary winding and the ground, the secondary winding and the iron core being connected to the ground	50,000V
Between the secondary winding and the ground, the primary winding and the iron core being connected to the ground	4,000V

Remarks	Revisions	
	2003/Nov.	Original

Category				Document
	Chapter	1	General Provisions	No.DS13-2
	Paragraph	4	Prevention of Electric Power Disasters	
	Clause	9	Prevention of Electric Power Disasters	
Title	Voltage Tests for 22kV Transformer (2/2)			

Impulse Wave Form



T1: Duration of wave front
T2: Duration of wave tail

* Wave form is indicated as T1/T2 μs

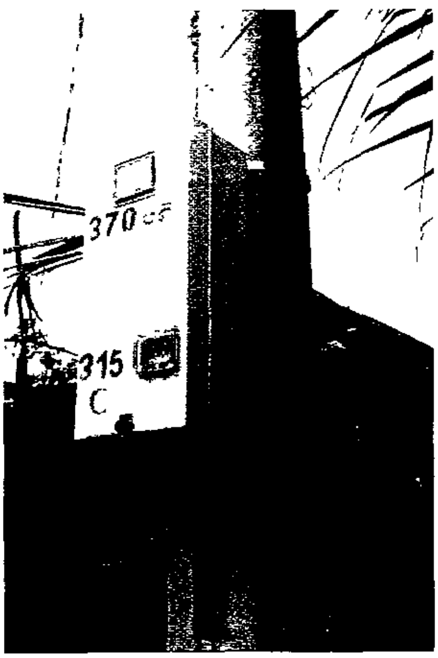
Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DS14**
	Paragraph	1	General	
	Clause	20	Accuracy of Power Meters	
Title	Power Meter			

The accuracy of power meters for trading electricity shall be in conformity with Clause 20 of the Electric Power Technical Standards in Cambodia.
The accuracy shall be confirmed not only when the meter is manufactured but also regularly after it is installed. Power meters shall be sealed for the third person not to handle them.

The power meter shall be installed in manners as follows;

1 It is installed to be measured easily.
2 It is not an obstacle to the third person, when it is installed at a supporting structure on the public street.
3 It is in the water proof boxes, when it is installed outside a house and there is a risk to splash rain on it.



Remarks	Revisions	
	2003/Nov.	Original

Category				
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS15-1
	Paragraph	5	Transmission and Distribution Facilities (Common)	
	Clause	31	Property of Conductors	
Title	Performance of Conductors (1/2)			

1. Abbreviations of Conductors

Name Abbreviation	Conductor Type
Cu	Copper (97% IACS)+
AAC	All Aluminium Conductor
AAAC1120	All Aluminium Alloy (1120) Conductor
AAAC(6201)	All Aluminium Alloy (6201) Conductor *
GZ	Galvanised Steel
AZ	Aluminised Steel
AC	Aluminium Clad Steel

\+ = International Annealed Copper Standard
* = Alloy 6201 is also known as Almelec and Aldrey

2. Properties of Conductor Materials

Code	Conductivity (%IACS)	Resistivity ($\mu\Omega m$)	Temperature Coefficient of Resistance* (per °C)	Modulus of Elasticity (GPa)	Coefficient of Linear Expansion (per °C)
IACS Cu	100	0.01724	0.00393	100	17.0×10^{-6}
Cu	97	0.01777	0.00381	124	17.0×10^{-6}
AAC	60.9	0.0283	0.00403	68	23.0×10^{-6}
AAAC/1120	58.8	0.0293	0.00390	68	23.0×10^{-6}
AAAC/6201	52.5	0.0328	0.00360	70	23.0×10^{-6}
GZ	1.0	0.17	0.0044	193	11.5×10^{-6}
AZ	1.15	0.15	0.0044	193	11.5×10^{-6}
AC	20	0.085	0.0036	162	12.9×10^{-6}

3. Properties of Single Conductors

Single conductors shall have the conductivity and tensile strength equal to the tensile strength per unit area multiplied by its sectional area confirming to related IEC standards. The tensile strength of hard-drawn copper wires shall have properties given in following table.

Diameter of single conductors: d (mm)	Tensile strength (N/mm^2)
0.4 or more, and 12.0 or less	(462-10.8d) or more

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS15-2
	Paragraph	5	Transmission and Distribution Facilities (Common)	
	Clause	31	Property of Conductors	
Title	Performance of Conductors (2/2)			

Copper or Aluminum

The differences on characteristics between copper and aluminum are as follows;

1. The electrical conductivity of the hard drawn copper wire is about 96-98%, and that of hard drawn aluminum wire is about 61%. The resistance per unit area of the aluminum wire is about 1.6 times of that of the copper wire
2. The relative density to water of copper is about 8.9, and that of aluminum is about 2.7. The weight of an aluminum wire is about 50-55% of that of a copper wire with *equivalent electrical performance.*
3. The tensile strength of a copper wire is about 340-470N/mm^2, and that of an aluminum wire is about 160-180N mm^2. Therefore the tensile strength of an aluminum wire is about 75% of that of a copper wire with equivalent electrical performance.

Licensee should choose conductors taking into account their characteristics.

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.DS16
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	5	Transmission and Distribution Facilities (Common)	
	Clause	31	Property of Conductors	
Title	Dielectric Strength and Insulation Resistance of Insulated Conductor			

The insulated conductors shall have the following dielectric strength and insulation resistance.

1. Dielectric strength test of medium-voltage insulated conductors

After immersion in fresh water for 1hour, medium-voltage cross-linked polyethylene (XLPE) insulated conductors shall withstand the test of impressing AC 25,000V between the conductor and the ground for 1 minute.

2. Dielectric strength test of low-voltage insulated conductors

After immersion in fresh water for 1 hour, low-voltage polyvinyl chloride (PVC) insulated conductors shall withstand the test of impressing the AC 3,500V between the conductor and the ground for 1 minute.

3. Insulation resistance

After completion of the dielectric strength test, the insulation resistance of insulated conductors shall be no less than the values given in table, when impressed DC current of 100V for 1 minute.

Type of Insulating Materials	*Insulation resistance (Mega ohms-km)*	*Volume resistivity (ohms-cm)*
XLPE	$R=3.665\times10^{-12}\rho\log_{10}(D/d)$	2.5×10^{15}
PVC		5×10^{13}

Where

ρ :Volume resistivity
D :Outside diameter of the insulator (mm)
d :Inside diameter of the insulator (mm)
When D/d is 1.8 or more, D/d is 1.8 for calculation.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS17
	Paragraph	5	Transmission and Distribution Facilities (Common)	
	Clause	31	Property of Conductors	
Title	Insulator Thickness of Insulated Conductors			

The insulator thickness of low-voltage insulated conductors shall be no less than the values given in following table.

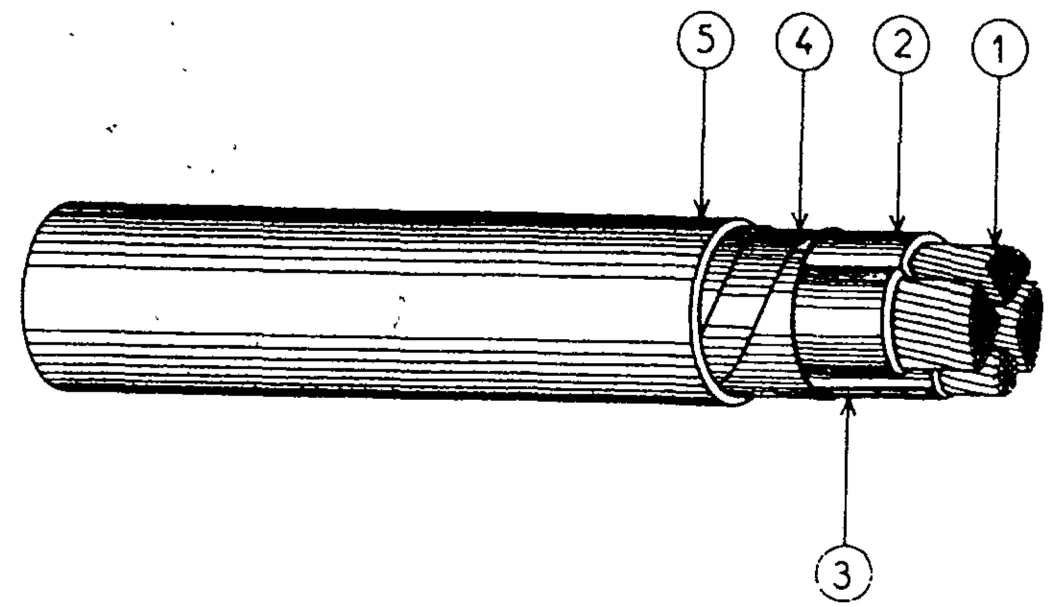
Conductors		***Thickness of insulators (mm)***	
Twisted conductors (Nominal sectional area: mm^2)	Single conductors (Diameter: mm)	PVC insulator	XLPE insulator
0.75 or more, and 3.5 or less	0.8 or more, and 2.0 or less	0.8	0.8
More than 3.5, and 5.5 or less	More than 2.0, and 2.6 or less	1.0	1.0
More than 5.5, and 8 or less	More than 2.6, and 3.2 or less	1.2	1.0
More than 8, and 14 or less	More than 3.2, and 4.0 or less	1.4	1.0
More than 14, and 30 or less	More than 4.0, and 5.0 or less	1.6	1.2
More than 30, and 38 or less		1.8	1.2
More than 38, and 60 or less		1.8	1.5
More than 60, and 80 or less		2.0	1.5
More than 80, and 100 or less		2.0	2.0
More than 100, and 150 or less		2.2	2.0
More than 150, and 250 or less		2.4	2.5
More than 250, and 400 or less		2.6	2.5
More than 400, and 500 or less		2.8	3.0
More than 500, and 725 or less		3.0	3.0
More than 725, and 1000 or less		3.2	3.5
More than 1000, and 1400 or less		3.5	3.5
More than 1400, and 2000 or less		4.0	4.0
More than 2000		4.5	4.5

The insulator thickness of medium-voltage insulated conductors shall be no less than the values given in following table.

Nominal sectional area (mm^2)	***Thickness of insulators (mm)***
22 or more, and 38 or less	2.5
More than 38, and 150 or less	3.0
More than 250, and 500 or less	3.5

Remarks	Revisions	
	2003/Nov.	Original

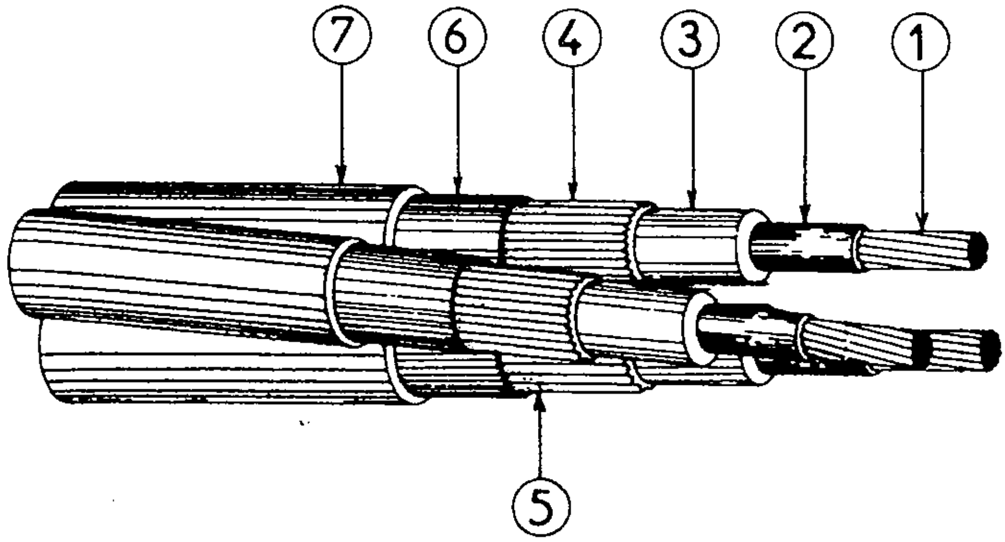
Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DS18**
	Paragraph	5	Transmission and Distribution Facilities (Common)	
	Clause	31	Property of Conductors	
Title	Configuration of Low-voltage XLPE Cable			



① *Conductor*
② XLPE (Cross Linked Polyethylene) insulator
③ Lead cover for neutral line
④ Shield tape layer
⑤ External cover (Poly vinyl chloride)

Remarks	Revisions	
	2003/Nov.	Original

Category				
Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DS19**
	Paragraph	5	Transmission and Distribution Facilities (Common)	
	Clause	31	Property of Conductors	
Title	Configuration of Medium-voltage XLPE Cable			



① Conductor
② Internal semiconductor
Internal semiconductor is for prevention of the corona discharge between the conductor and the XLPE insulator.
③ XLPE (Cross Linked Polyethylene) insulator
④ External semiconductor
External semiconductor is for prevention of the corona discharge between the XLPE insulator and the shield metallic tape layer.
⑤ Waterproof
⑥ Shield metallic tape layer
Shield metallic tape layer is for prevention of the induction and the electrical shock. To prevent the electrical shock shield metallic tape must be grounded.
⑦ Sheath
Sheath is to protect the insulator against the mechanical force.

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.DS20
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	5	Transmission and Distribution Facilities (Common)	
	Clause	33	Safety Factor of Bare Conductors and Ground Wires of Overhead Electrical Lines	

Title	Tensile Strength of Overhead Conductors

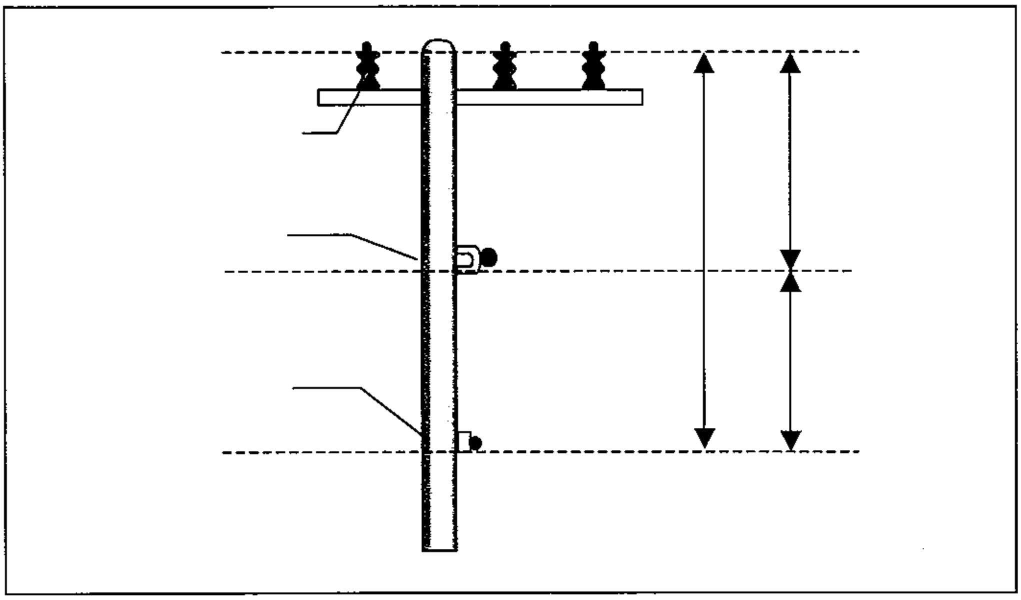
Overhead conductors shall be with a tensile strength no less than the values given in following table.

	Low-voltage		Medium-voltage
	300V or less	More than 300V	
Urban area	3.44kN	8.01kN	21.67kN
Other area	3.44kN	5.26kN	8.71kN

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.DS21
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	5	Transmission and Distribution Facilities (Common)	
	Clause	34	Side by Side use and Joint Use of Lines	
Title	Clearance on Side by Side Use and Joint Use of Lines			

The minimum clearance of each lines at a supporting structure is give by the following figure and table. The clearance is dicided taking working space into consideration.



(Unit: m)

Recommended Minimum Clearance

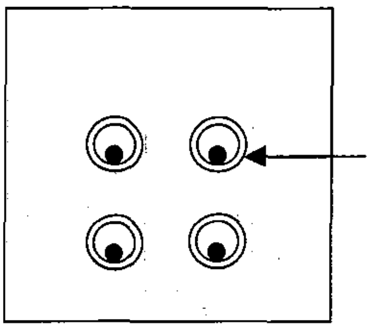
A	*Medium-Voltage Line*	*Cable*	*Low-Voltage Line*	0.5
		Others		1.2
B	*Medium-Voltage Line*	*Cable*	*Communication Line*	0.5
		Others		2.0
C	*Low-Voltage Line*	*Cable*	*Communication Line*	0.3
		Insulated Conductor		0.75

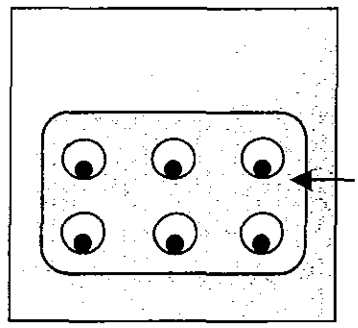
Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS22-1
	Paragraph	5	Transmission and Distribution Facilities (Common)	
	Clause	35	Underground Lines	
Title	Installation Methods of Underground Line (1/3)			

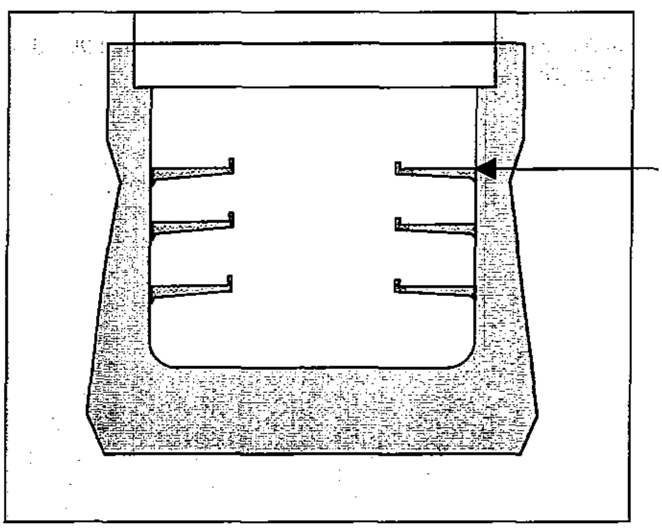
1. Examples of installation method of underground lines

Draw-in conduit system





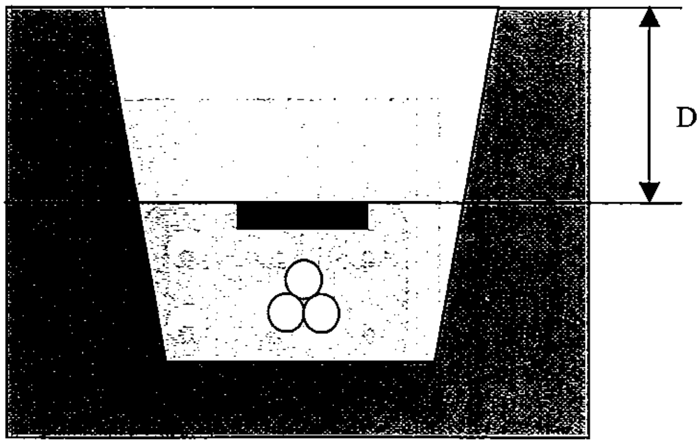
Culvert system



Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.DS22-2
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	5	Transmission and Distribution Facilities (Common)	
	Clause	35	Underground Lines	
Title	Installation Methods of Underground Line (2/3)			

2. The depth of underground lines of direct burial system



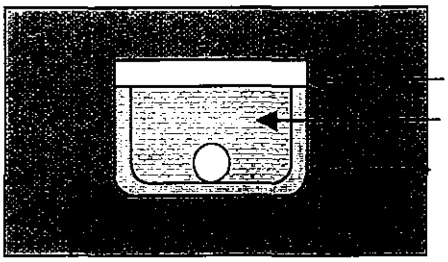
At a place where there is a danger of receiving pressure from vehicles or other objects	D = 1.2 m or more
Other place	D = 0.6m or more

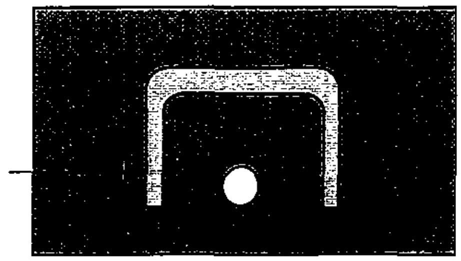
* The value of D is decided considering the present situation of underground lines in Cambodia and the result in other countries.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS22-3
	Paragraph	5	Transmission and Distribution Facilities (Common)	
	Clause	35	Underground Lines	
Title	Installation Methods of Underground Line (3/3)			

Other protection method (Trough type)





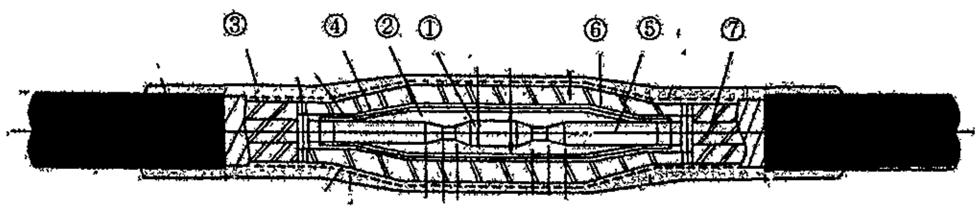
Aside from this, before installation of underground facilities, licensees have to get permission from a local government who manages the road structure to install underground facilities. In this case, licensees should notice the local government regarding the location of facilities including the depth of them.

As "Underground" is shared such utilities as power companies, telecommunication companies, water companies, or gas companies etc.. Each company must manage the location of its underground facilities by drawings or other proper measures.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS20
	Paragraph	5	Transmission and Distribution Facilities (Common)	
	Clause	35	Underground Lines	
Title	Connection of Medium-voltage Cables			

An example of connecting method of Cables



①Connecting pipe
②Adhesive polyethylene tape
③Waterproof tape
④Lead tape
⑤Cross linked polyethylene
⑥Semi-conductive fusion bonding tape
⑦Shied metallic tape

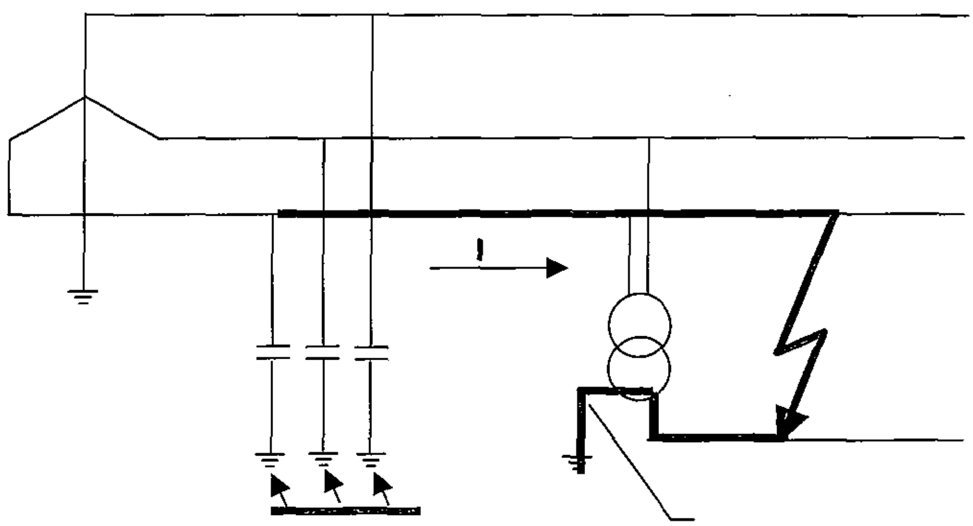
Connecting devices for cables shall be required to have the equivalent performance to the connected cables
In concrete, requirements are as follows;

1. The device shall be to withstand external forces that will be exerted under the use conditions.
2. The device shall be in good order when it is applied the current equivalent to the permissible current of the connected cables.
3. The device shall prevent water and moisture from entering into the connected cables.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS24-1
	Paragraph	5	Transmission and Distribution Facilities (Common)	
	Clause	39	Classification of Grounding for Electrical Lines	
Title	System Grounding (1/2)			

The current will flow to the earth through the system grounding, when a medium-voltage line breaks down and gets in touch with a low-voltage line. In this case the voltage to the earth of low-voltage line will increase in proportion to the single-line earth fault current and the resistance of the system grounding. Therefore, the value of resistance of the system grounding shall be the level to protect low-voltage apparatuses from the damage caused by the increase of the voltage to the earth.



Where

I: Single-line earth fault current

The maximum value of 10 ohms in Class B is decided based on the present condition in Cambodia. And the minimum value of 5 ohms is set up since it is very difficult to get the value less than 5 ohm.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS24-2
	Paragraph	5	Transmission and Distribution Facilities (Common)	
	Clause	39	Classification of Grounding for Electrical Lines	
Title	System Grounding (2/2)			

When a medium-voltage line contacts a low-voltage line, the voltage of the low-voltage line will increase. Therefore if human being gets in touch with the low-voltage line, it is more dangerous compared with the normal situation.
According to some experiment, the relation between he limit charged period and current to a human being is given by following formula.

$$I = 165 / t^{1/2}\ (mA)$$

If human being get in touch with a charged part, the link between the current and the influence to human being is reported as follows;

Current (mA)	Influence to human being
1.2	Human being will feel electrical shock.
3.5	Human being will feel stiff slightly.
8.0	Human being will feel stiff and will not be able to get away from the charged part.
12.0	Human being will feel stiff and will not be able to bear more than 30 seconds.
20.0	Human being will not be able to get away from the charged part and to bear more than 15 seconds.
100.0	Human being will be fatally wounded.

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DS25-1**
	Paragraph	5	Transmission and Distribution Facilities (Common)	
	Clause	39	Classification of Grounding for Electrical Lines	
Title	*Single-line Earth Fault Current (1/2)*			

The single-line earth fault current used for calculation of resistance to earth for class B grounding should be derived from actual measurement in principle. However, it is difficult to measure realistically. In that case, the single-line earth fault current can be calculated by following formula.

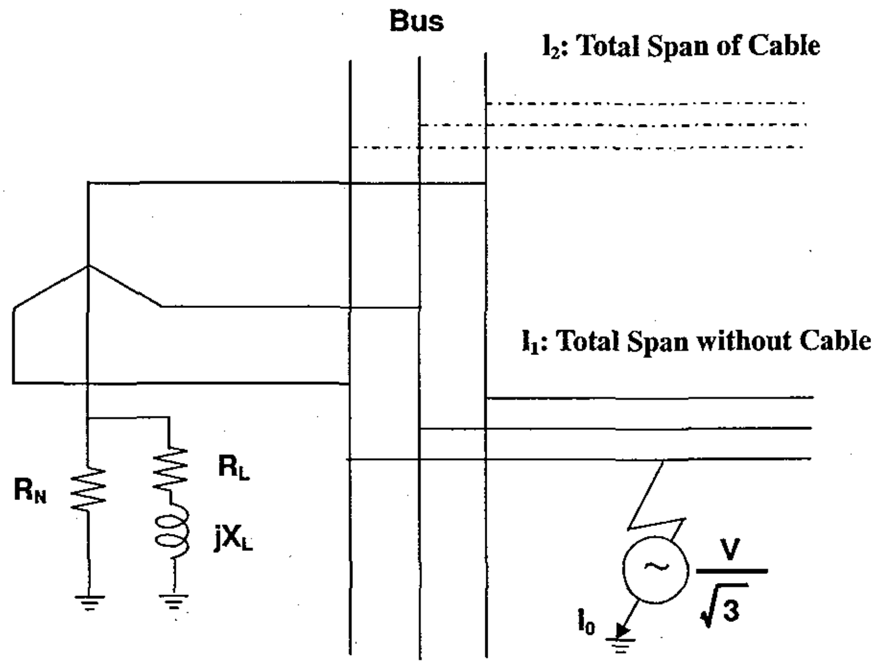
$$I_0 = \frac{V}{\sqrt{3}}\sqrt{\left[\frac{1}{R_N}+\frac{R_L}{R_L^2+X_L^2}\right]^2+\left\{3\omega(C_1l_1+C_2l_2)\times 10^{-6}-\frac{X_L}{R_L^2+X_L^2}\right\}^2}$$

Where

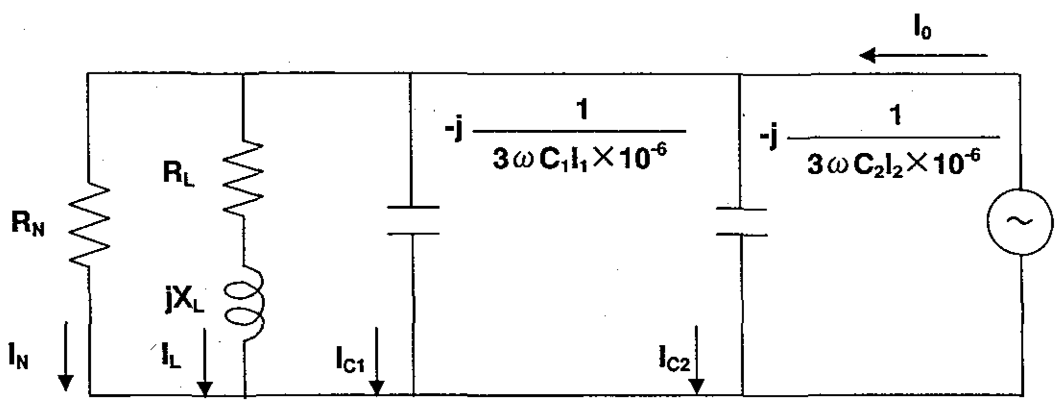
- I_0: Single-line earth fault current (A)
- V: Maximum voltage (V)
- R_N: Value of resistance of resister used for neutral grounding (Ω)
- R_L: Value of resistance of reactor used for neutral grounding (Ω)
- X_L: Value of inductive reactance of reactor used for neutral grounding (Ω)
- ω:Angular frequency (=100π)(rad/s)
- l_1:Total span of medium-voltage lines without cables connected to one bus(km)
- l_2:Total span of medium-voltage lines of cables connected to one bus(km)
- C_1:Electrostatic capacity to ground of l_1 per one phase(μF/km)
- C_2:Electrostatic capacity to ground of l_2 per one phase(μF/km)

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DS25-2**
	Paragraph	5	Transmission and Distribution Facilities (Common)	
	Clause	39	Classification of Grounding for Electrical Lines	
Title	Single-line Earth Fault Current (2/2)			



Medium-voltage Distribution System

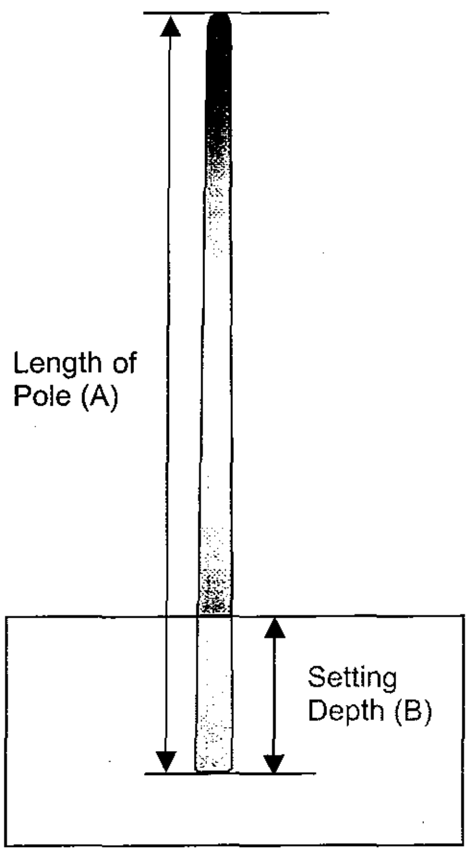


Equivalent Circuit

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DS26**
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	49	Supporting Structures	
Title	Setting Depth of Supporting Structure			

The setting depth of supporting structures defined in Article 49-1 of Technical Standard are as follows;



	A (m)	B (m)
Wooden pole, Iron pole, Iron-reinforced concrete pole	7	1.2
	8	1.4
	9	1.5
	10	1.7
	11	1.9
	12	2.0
	13	2.2
	14	2.4
	15	2.5
	16	
Iron-reinforced concrete pole	17	2.8
	18	
	19	
	20	

* The value of B is decided based on the calculation considering the worst situation of each condition.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS27-1
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	49 51	Supporting Structures Mechanical Strength of Insulators	
Title	Wind Load (1/2)			

Wind load to 1m² of the vertical projected area is calculated by the following formula.

$P = C \times (1/2\,\delta \times V^2)$

Where
C = Resistance coefficient
δ = Density of air
V = Wind speed

The values in the following table will be used for wind load that are applied to the calculation of the strength of iron-reinforced concrete poles, wooden poles and iron poles. The value is calculated under the condition of wind speed of 25m/s and the density of air of 0.121, using the resistance coefficient prescribed in the following table. If a wind speed is assumed more than 25m/s, the wind load shall be calculated individually.
When the wind load is fixed based on wind pressure experiments, It is possible to use other values of wind load when it is decided based on other wind pressures experiments.

Wind Pressure

			Wind pressure to 1m² of the vertical projected area (Pa)
Supporting structure	Wooden pole, Iron pole, Iron-reinforced concrete pole	Columnar pole	450
		Square pole	750
		Others	890
Electrical wire and other strung wire			390
Insulation device			520
Cross arm for medium-voltage lines		Used as single material	600
		Others	820

Remarks	Revisions	
	2003/Nov.	Original

Category				
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS27-2
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	49 51	Supporting Structures Mechanical Strength of Insulators	
Title	Wind Load (2/2)			

Resistance Coefficient

Following resistance coefficient that are decided based on experiments are used for the calculation of the wind pressure.

			Resistance Coefficient
Supporting structure	Wooden pole, Iron pole, Iron-reinforced concrete pole	Columnar pole	1.2
		Square pole	2.0
		Others	2.4
Electrical wire and other strung wire			1.05
Insulation device			1.4
Cross arm for medium-voltage lines		Used as single material	1.6
		Others	2.2

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.DS28
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	49	Supporting Structures	
Title	Calculation of Safety Factor of Foundation			

The safety factor of the foundation of supporting structure is calculated as follows;

$$f \leq \frac{KD_0 t^4}{120P(H+t_0)^2} \quad \text{(without guy anchor)}$$

Where

f: Safety factor of the foundation of the supporting structure.

D_0: Diameter of the supporting structure at the ground level (m)

t: Embedded depth of the supporting structure (m)

H: Height of the point of action of concentrated loads from the ground surface (m)

P: Load converted into a concentrated load at the top of the supporting structure (N)

t_0: Depth of the center of gyration of the supporting structure from the ground surface (m)

$$t_0 = \frac{2}{3}t(m)$$

K: Soil coefficient taking the value given in following table

Classification of soil		***Soil coefficient (N/m⁴)***
Normal soil	[A] Aggregated soil or sand, and soil with plenty of gravel or stone belonging under hard soil	3.9×10^7
	[B] Aggregated soil or sand, and soil with plenty of gravel or stone belonging under soft soil	2.9×10^7
Soft soil	[C] Quicksand (with no soil mixed)	2.0×10^7
	[D] Moist clay, humus, fill and other soft soils (excluding deep rice fields)	0.8×10^7

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS29
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	49	Supporting Structures	
Title	Calculation of Strength of Iron-reinforced Concrete Pole and Steel Pole			

The strength of iron-reinforced concrete pole and steel pole against wind load perpendicular to the distribution line is calculated as follows;

$$\frac{(H-0.25)P}{f} \geq K_1\frac{(2D_1+D_0)H^2}{6}+K_2S(\sum dh)$$

Where

P: Breaking load of the supporting structure (standard design load × 2) (N).
K_1: Wind load per 1 m^2 of vertically projected area of the supporting structure (N/ m^2)
K_2: Wind load per 1 m^2 of vertically projected area of the distribution conductors (N/ m^2)
D_1: Top end diameter of the supporting structure (m)
D_0: *Ground-level diameter of the supporting structure* (cm)
H: Height of the supporting structure above the ground (m).
S: A half of the sum of the spans on the both sides (m).
d: Diameter of the distribution conductor (mm).
h: Height of the supporting structure of
f: Safety factor of the supporting structure (m).

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS30-1
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	49	Supporting Structures	
Title	Strength Test for Iron-reinforced Concrete Pole (1/2)			

Iron-reinforced concrete pole shall not have a crack of more than 0.25 mm width after applied the force equivalent to the design load. And it shall not break when it is applied the force equivalent to 2 times of design load.

(Test method)

Strength Test

1 The iron-reinforced concrete pole is fixed by the method like the following figure.

2 The force equivalent to the strength of the design load is inflicted at the load point vertically to the pole at the same speed. In the same way, the force is inflicted to the opposite direction.

3 Then the pole is examined if there are no cracks of more than 0.25 mm width.

Breakage Test (in succession the Strength Test)

4 The force is inflicted until the pole is broken down.

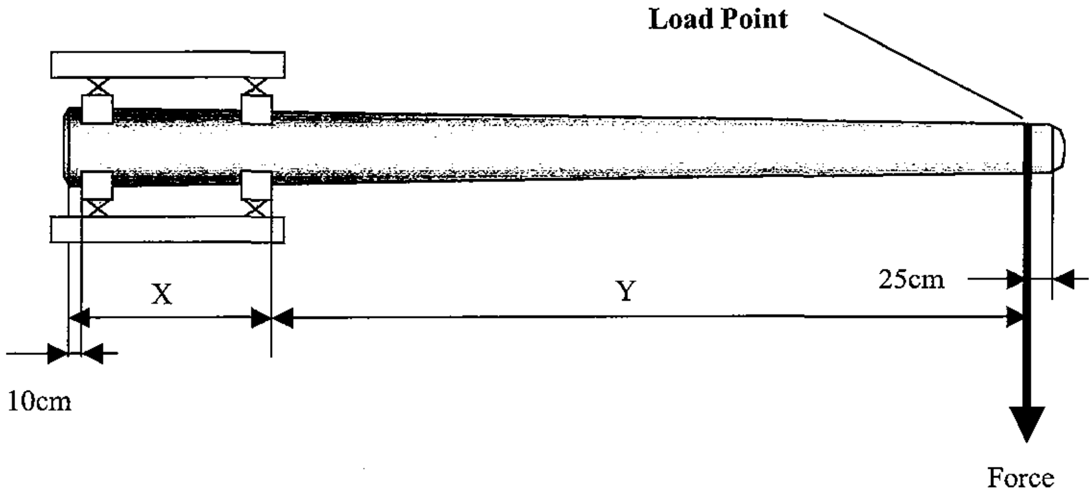
5 Then the maximum strength measured by a load meter is examined to be equal 2 times of design load or more.

6 If the force 2 times of design load is inflicted and the pole is not broken down, this test may be completed.

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DS30-2**
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	49	Supporting Structures	
Title	Strength Test for Iron-reinforced Concrete Pole (2/2)			

Figure: Test Method



(Unit: m)

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS31-1
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	49	Supporting Structures	
Title	Calculation of Strength of Wooden Pole (1/2)			

The wooden pole shall have the strength to withstand the wind load. The safety factor for low-voltage lines shall be no less than 1.2, and that for medium-voltage shall be no less than 1.5.

The calculation of strength of low-voltage wooden poles against the wind load in a direction at the right angle to the direction of overhead lines is made by the following formulas.

1. Single pole without guys

$$\frac{P}{F} \geqq \frac{390D_0H^2-234H^3+S(\Sigma 98dh)}{10(D_0')^3}$$

2. Single pole with guys

$$\frac{P}{F} \geqq \frac{195D_0H^2-117H^3+0.5S(\Sigma 98dh)}{10(D_0')^3}$$

Where

S: The half of the sum of the span on both sides of the pole (m)
d: The outer diameter of each wire (mm)
h: The height of the supporting point of each wire above the ground (m)
H: The height of the pole above the ground (m)
D_0: D+0.9H (The diameter of the pole at the surface of the ground) (cm)
D: The diameter of the pole at the tip of the pole (cm)
D_0': The diameter of the round of which area is equal to the section area of the pole at the surface of the ground that is excluded the corrosion part.
(If there are no corrosion, D_0' equal to D_0)
P: The breaking strength to the bend of the pole.

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.DS31-2
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	49	Supporting Structures	
Title	Calculation of Strength of Wooden Pole (2/2)			

The value will be decided based on the following data.

Type of wood	*Breaking strength*
Cryptomeria	39 N/mm^2
Chestnut tree/ Japanese cypress/	44 N/mm^2
Fir	42 N/mm^2
Oregon pine/ Douglas pine	55 N/mm^2
Others	The values equivalent to the above-mentioned values

F: Safety factor of wooden pole

The calculation of strength for medium-voltage wooden pole is done by the same method. However the wind loads of insulation devices and cross arms will be taken into consideration.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS32-1
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	49	Supporting Structures	
Title	Installation of Guy (1/2)			

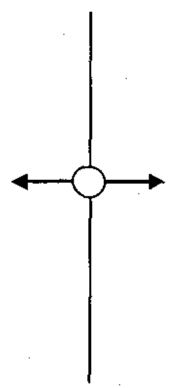
Guys or strut with equal effect shall be installed under the following conditions.

Conditions		***Installation Method***	***Safety Factor***
a. Supporting structures lacking strength against the wind load		When a supporting structure lacks the strength against the wind load, guys shall be installed at right angle to the lines.	2.5 or more
Supporting structures installed in accordance with the table in Clause 49 of Electric Power Technical Standards	b. Supporting structure of which spans on both side are too different	When the difference in spans on both sides of a supporting structure is big, guys that withstand the force caused by unbalanced tension shall be installed on both sides in the direction of line.	1.5 or more
	c. Supporting structure of which lines on both side make an angle more than 5 degrees	When the angle of the lines on both sides of a supporting structure is more than 5 degrees, guys that withstand the force caused by the assumed maximum tension of each line shall be installed.	
	d. Supporting structure supporting the end of a line	When a supporting structure 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.	

Remarks	Revisions	
	2003/Nov.	Original

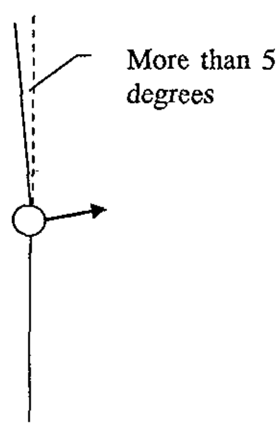
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS32-2
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	49	Supporting Structures	
Title	Installation of Guy (2/2)			

a. Supporting structures lacking strength against the wind load



b. Supporting structure of which spans on both side are too different

c. Supporting structure of which lines on both side make an angle more than 5 degrees



d. Supporting structure supporting the end of a line

Remarks	Revisions	
	2003/Nov.	Original

Category				Document
	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS33-1
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	49	Supporting Structures	
Title	Calculation of Strength of Guy (1/7)			

1. Guys for the wind load lateral to a line (Single Pole)

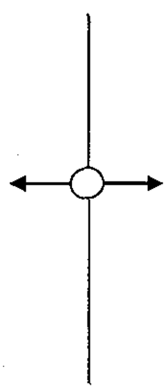
(1)Medium-voltage line

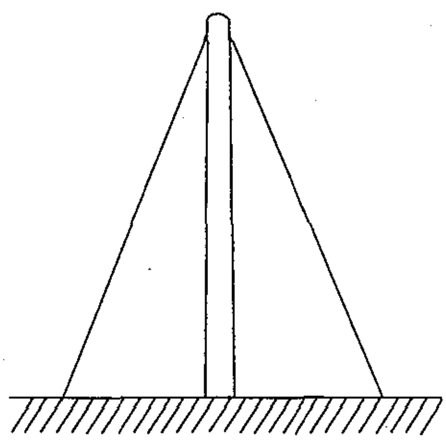
$$P \geqq \frac{K}{h_0}\left\{\frac{12.5}{10^3}(\Sigma 98dh) + 487.5D_0H^2 - \frac{975}{3}k\,H^3 + 12.5(\Sigma 137c_1h_1) + 125(\Sigma 157c_2h_2)\right\}\operatorname{cosec}\theta$$

(2)Low-voltage line

$$P \geqq \frac{K}{h_0 \times 10^3}\{12.5S\Sigma(98dh) + 4{,}875D_0H^2 - \frac{980}{3} \times 10^3kH^3\}\operatorname{cosec}\theta$$

Explanation Drawing





Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.DS33-2
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	49	Supporting Structures	
Title	Calculation of Strength of Guy (2/7)			

Where

- P: Tensile strength of the guy (N)
- h_0: Height of the installed point of the guy (m)
- θ : Angle of the pole and the guy
- S: Span (m) (S is one half of the sum of spans on both sides of the pole If they are not *same length.)*
- c_1: Area of the insulator receiving wind (m^2)
- c_2: Area of the cross arm receiving wind (m^2)
- d: Diameter of the conductor (mm)
- h: Height of the installed point of the conductor (m)
- h_1: Height of the installed point of the insulator(m)
- h_2: Height of the installed point of the cross arm (m)
- H: *Height of the pole (m)*
- D_0: Diameter of the pole at surface of earth (cm)
- k: Increasing rate of the diameter of the pole
- K: Coefficient for the wind load (K=1 is suitable in Cambodia)

Remarks	Revisions	
	2003/Nov.	Original

Category				Document
	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS33-3
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	49	Supporting Structures	
Title	Calculation of Strength of Guy (3/7)			

2. Guys for the wind load lateral to a line (H Type Pole)

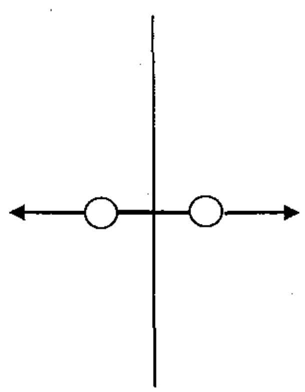
(1)Medium-voltage line

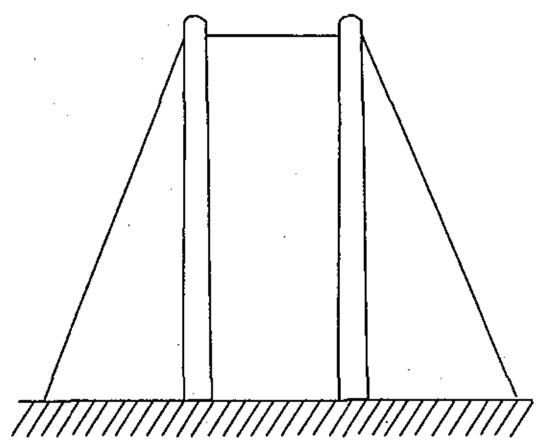
$$P \geqq \frac{K}{h_0}\left\{\frac{12.5}{10^3}(\Sigma 98dh)+975.0D_0H^2-\frac{1{,}950}{3}kH^3+12.5(\Sigma 137c_1h_1)+125(\Sigma 157c_2h_2)\right\}\operatorname{cosec}\theta$$

(2)Low-voltage line

$$P \geqq \frac{K}{h_0\times 10^3}\left\{12.5S\Sigma(98dh)+9{,}750D_0H^2-\frac{1{,}960}{3}\times 10^3kH^3\right\}\operatorname{cosec}\theta$$

Explanation Drawing





Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.DS33-4
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS33-4
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	49	Supporting Structures	
Title	*Calculation of Strength of Guy (4/7)*			

Where

- P: Tensile strength of the guy (N)
- h_0: Height of the installed point of the guy (m)
- θ : Angle of the pole and the guy
- S: *Span (m) (S is one half of the sum of spans on both sides of the pole If they are not same length.)*
- c_1: Area of the insulator receiving wind (m^2)
- c_2: Area of the cross arm receiving wind (m^2)
- d: Diameter of the conductor (mm)
- h: Height of the installed point of the conductor (m)
- h_1: Height of the installed point of the insulator(m)
- h_2: Height of the installed point of the cross arm (m)
- H: Height of the pole (m)
- D_0: Diameter of the pole at surface of earth (cm)
- k: Increasing rate of the diameter of the pole
- K: *Coefficient for the wind load (K=1 is suitable in Cambodia)*

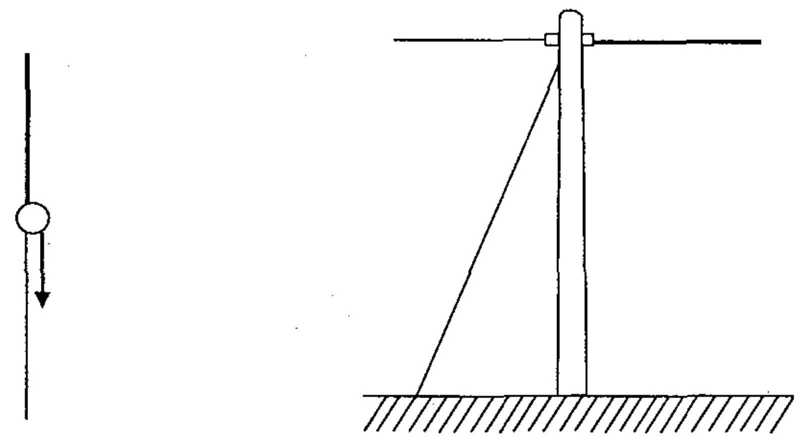
Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS33-5
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	49	Supporting Structures	
Title	Calculation of Strength of Guy (5/7)			

3. Guys for the tension unbalance

$$P \geqq \frac{f}{h_0}(\Sigma Th)\ \mathrm{cosec}\,\theta$$

Explanation Drawing



Where

- P: Tensile strength of the guy (N)
- h_0: Height of the installed point of the guy (m)
- θ : Angle of the pole and the guy
- T: Assumed maximum tension unbalance of a conductor (N)
- S: Span (m) (S is one half of the sum of spans on both sides of the pole If they are not same length.)
- d: Diameter of the conductor (mm)
- h: Height of the installed point of the conductor (m)
- H: Height of the pole (m)
- D_0: Diameter of the pole at surface of earth (cm)
- f: Safety factor
- k: Increasing rate of the diameter of the pole
- K: Coefficient for the wind load (K=1 is suitable in Cambodia)

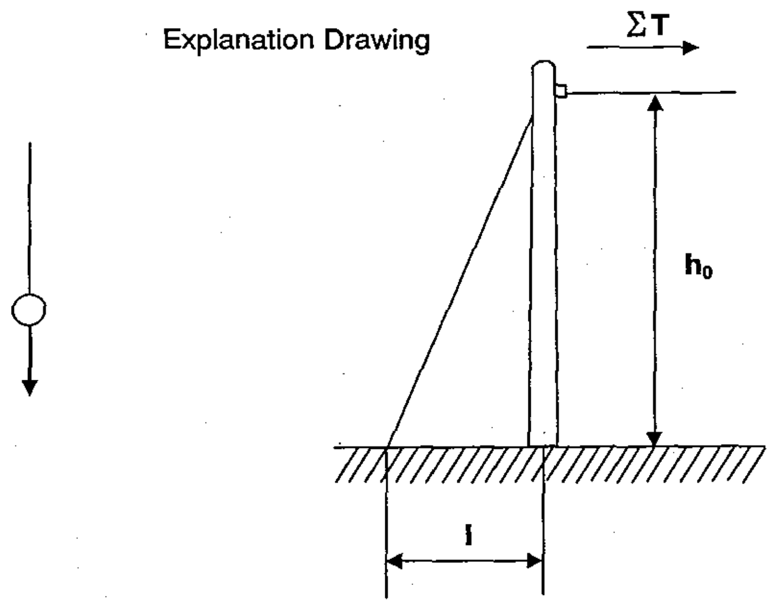
Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.DS33-6
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS33-6
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	49	Supporting Structures	
Title	Calculation of Strength of Guy (6/7)			

4. Guys for the pole supporting the end of a line (Simplified formula)

$$P \geqq f\Sigma T \sqrt{(h_0/l)^2+1}$$

Explanation Drawing



Where

P: Tensile strength of the guy (N)
h_0: Height of the installed point of the guy (m)
T: Assumed maximum tension unbalance of a conductor (N)
l: Length between the pole and the guy at the surface of earth (m)
f: Safety factor

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DS33-7**
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	49	Supporting Structures	
Title	Calculation of Strength of Guy (7/7)			

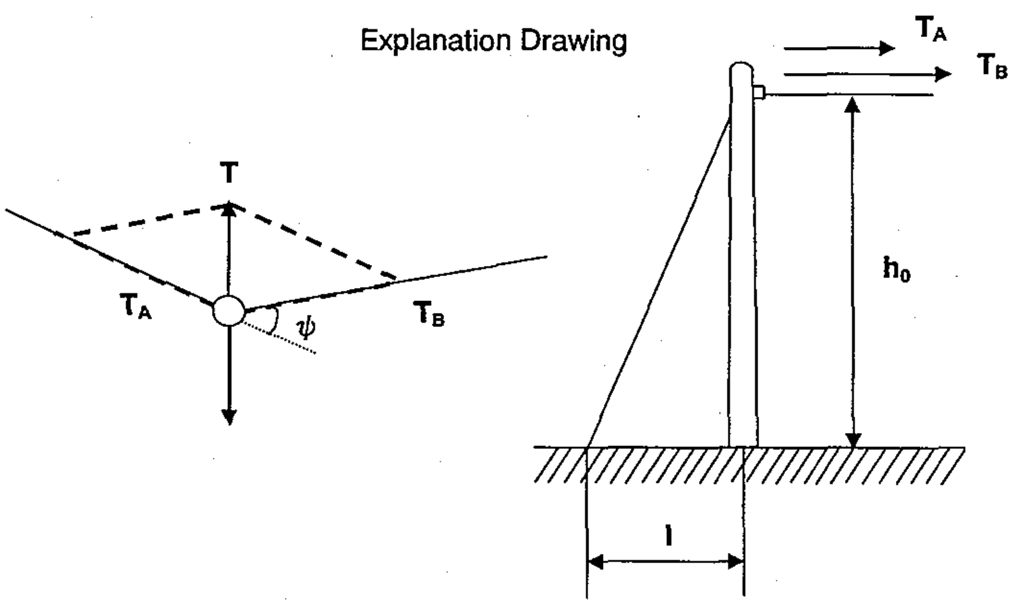
5. Guys for the pole of which line is not strait (Simplified formula)

$$P \geqq f\Sigma T \sqrt{(h_0/l)^2+1}$$

$$T = \sqrt{T_A^2+T_B^2-2T_AT_B\cos\psi}$$

If $T_A=T_B$, then $P \geqq 2f\Sigma T_{As}\sin\frac{\psi}{2}\sqrt{(h_0/l)^2+1}$

Explanation Drawing



Where

P: Tensile strength of the guy (N)
h_0: Height of the installed point of the guy (m)
T: Assumed maximum tension unbalance of a conductor (N)
l: Length between the pole and the guy at the surface of earth (m)
f: Safety factor

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DS34**
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	50	Overhead Lines	
Title	Types of Conductors for Overhead Line			

Under the Electric Power Technical Standards in Cambodia the conductors for overhead lines shall be cables, insulated conductors or bare conductors. The characteristics of these conductors are as follows,

1. Cable

Cables with excellent insulating performance, though they are more expensive than other conductors, will be most preferable conductors for electrical lines so far as the safety is concerned.

2. Insulated Conductor

Insulated conductors do not have such excellent insulating performance compared with cables and the safety against electrical shock by touching them is not perfectly guaranteed. However their costs will be more reasonable and the danger of electrical shock by coming in touch with them accidentally will be expected to decrease drastically compared with bare conductor.

3. Bare Conductor

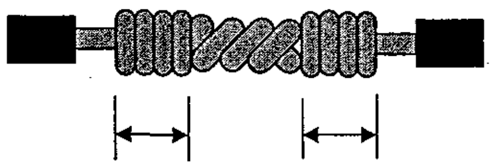
Bare conductors are cheaper compared with other conductors and popular conductors for transmission and distribution lines. However they are inferior to other conductors in safety. Especially it is dangerous to use bare conductors for low-voltage lines, because low-voltage lines will be installed close to houses or buildings and will be supported at the lower position of supporting structures. Therefore under the Electric Power Technical Standards, the use of bare conductors for low-voltage lines is prohibited.

Remarks	Revisions	
	2003/Nov.	Original

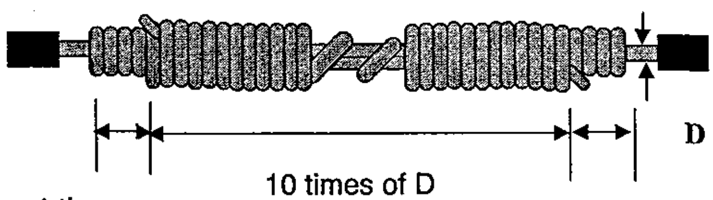
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS35-1
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	50	Overhead Lines	
Title	Connecting Methods of Conductors (1/3)			

1.Single Connection

(1)Twist joint



(2)Britania joint

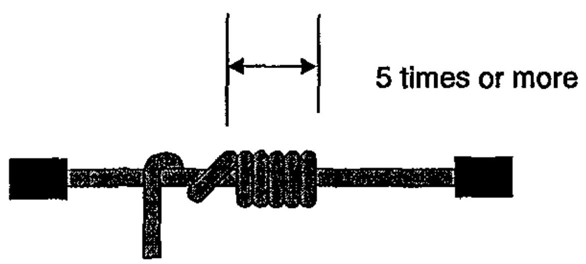


Remarks	Revisions	
	2003/Nov.	Original

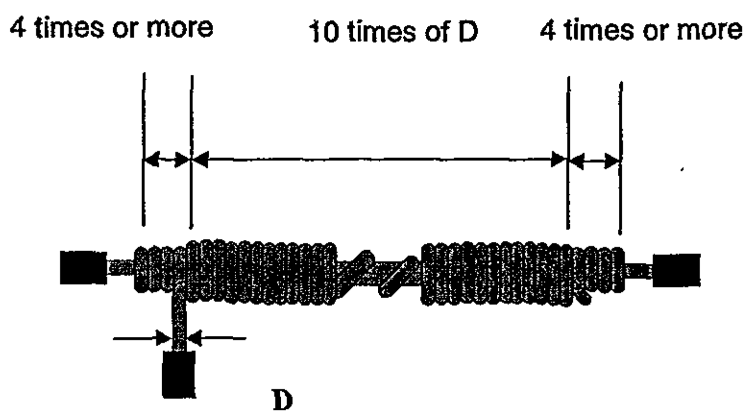
Category				Document No.DS35-2
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS35-2
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	50	Overhead Lines	
Title	Connecting Methods of Conductors (2/3)			

2.Separate Connection

(1)Narrow conductor



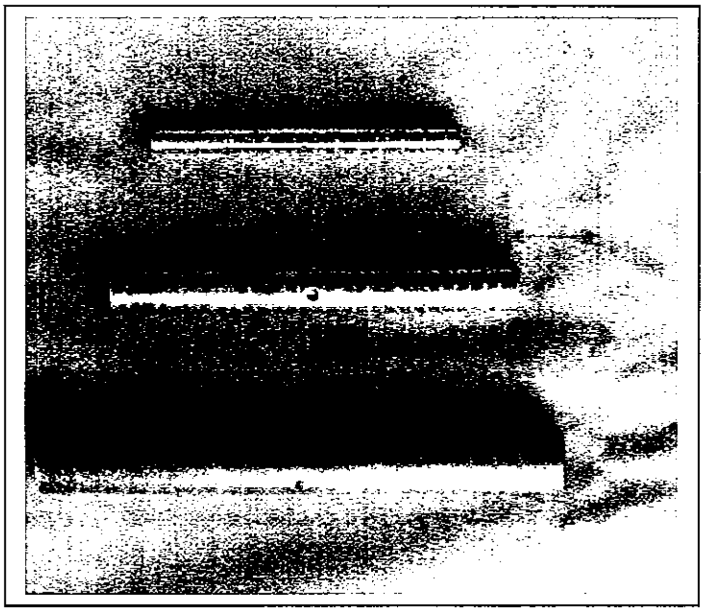
(2)Thick conductor



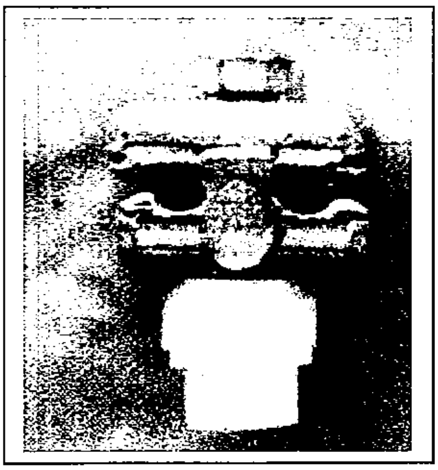
Remarks	Revisions	
	2003/Nov.	Original

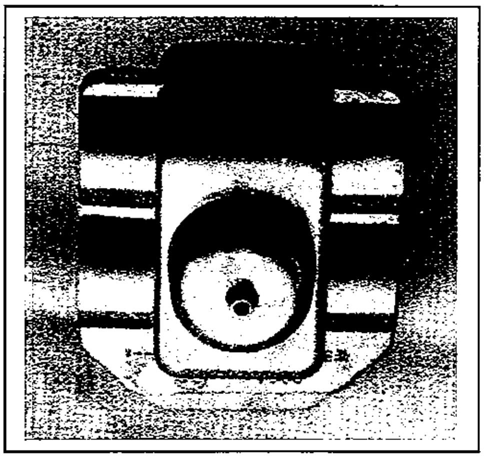
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS35-3
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	50	Overhead Lines	
Title	Connecting Methods of Conductors (3/3)			

1. Straight Sleeve



2. Groove Connector & Cover



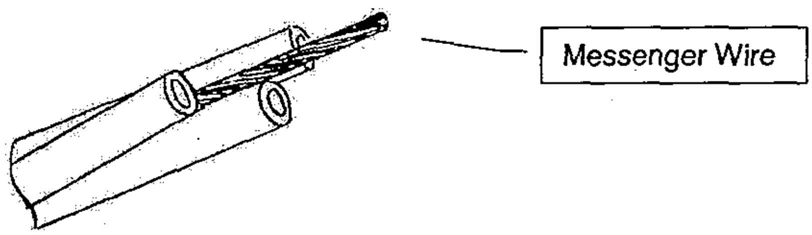


Remarks	Revisions	
	2003/Nov.	Original

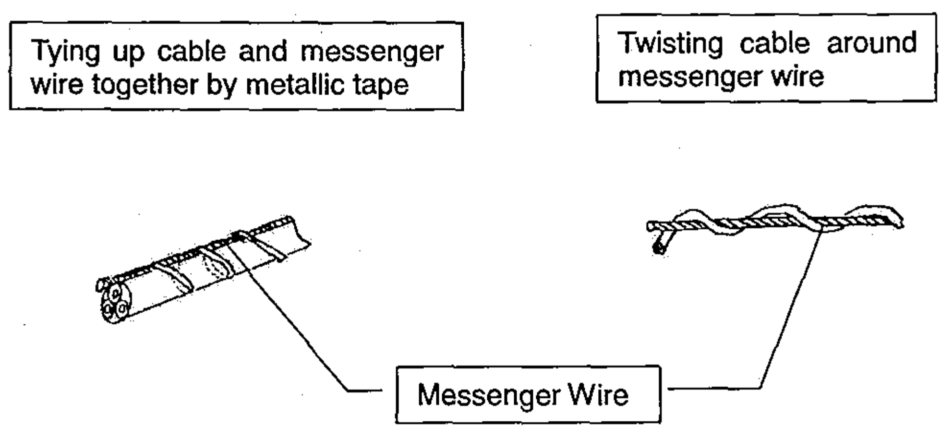
Category	**Chapter**	2	Technical Standards of Electric Power Facilities	***Document* No.DS36**
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	50	Overhead Lines	
Title	Cables for Overhead Line			

When cables are used for overhead lines, cables shall be installed not to inflict tension to cables directly. Generally, cables are installed hanging on a messenger wire. Aerial Bundled Cable (ABC), a cable with a messenger wire, is often used as an overhead conductor.

Aerial Bundled Cable (ABC)



Installation Method using a messenger wire

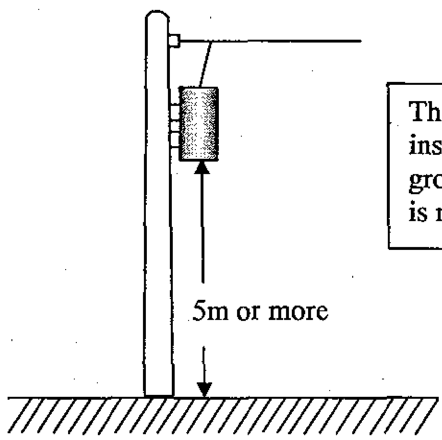


Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DS37**
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	52	MV/LV Transformers	
Title	Installation Conditions of MV/LV Transformer			

The MV/LV transformers shall be installed in either manner of following method if they are not installed in the exclusive cabin with lock.

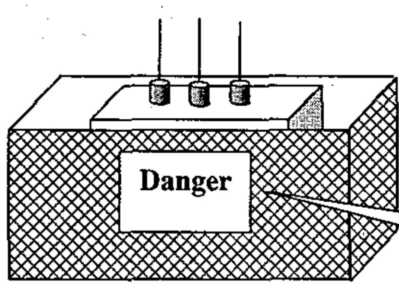
Installation on a pole at the height of 5.0m or more



The medium-voltage facilities shall be installed at a height of 5 m or more from the ground level and in such a manner that there is no danger of persons touching them.

Installation with fence

The medium-voltage facilities shall be installed with an appropriate fence around it to eliminate the danger of persons touching them.



A "DANGER" sign shall be posted.

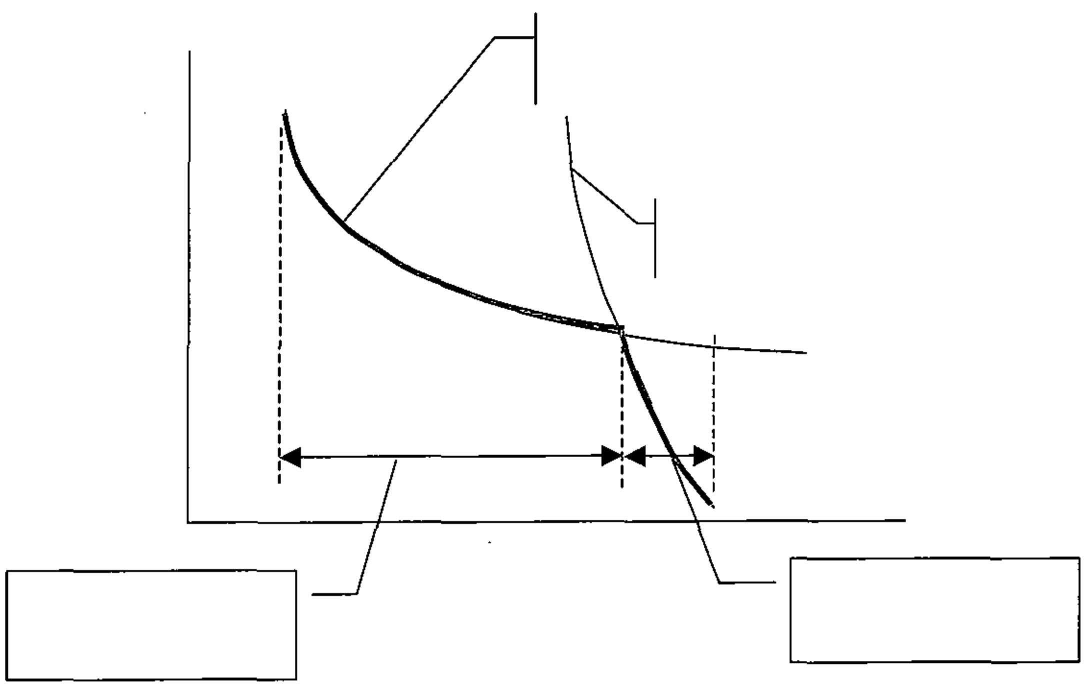
Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DS38**
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	53	Protective Devices	
Title	*Medium-voltage Over Current Circuit Breaker*			

The over current circuit breaker is to protect lines and facilities from the overheat damage caused by current or short-circuit current.

When 2 over current circuit breakers are installed for a medium-voltage line, the coordination of 2 breakers shall be considered.

Coordination of 2 breakers



Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS39
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	53	Protective Devices	
Title	Property of Fuses as Medium-voltage Over Current Circuit Breaker			

1. Covered fuses used on a Medium-Voltage electrical circuit shall withstand a current 1.3 times the rated current and melt within 120 minutes at a 2 times the rated current, or shall conform to related IEC.

2. Open fuses used on a Medium-Voltage electrical circuit shall withstand a current 1.25 times the rated current and melt within 2 minutes at a 2 times the rated current.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS40
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	53	Protective Devices	
Title	Installation Positions of Switchgear			

It is to be desired to install switchgears at the following positions besides the position regulated in the Electric Power Technical Standards.

1. The regular open position of circuits
2. The connecting point between an overhead line and an underground line
3. The connecting point between a cable and another conductor
4. The boundary position between a licensee's facility and a customer's facility
5. The other position which needs a switchgear for maintenance

Remarks	Revisions	
	2003/Nov.	Original

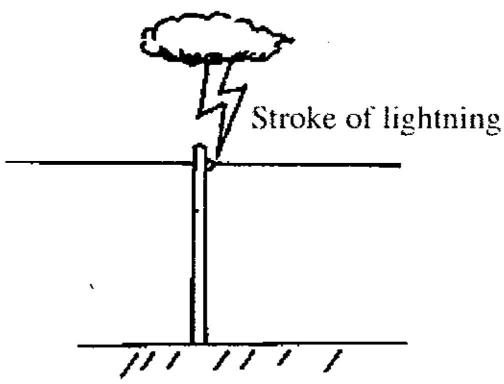
Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DS41-1**
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	53	Protective Devices	
Title	Lightening Damage (1/4)			

1. Lightening

Lightening strikes, both direct stroke lightening and induced stroke lightening, cause a current with high voltage into distribution lines and result in the destruction of facilities.

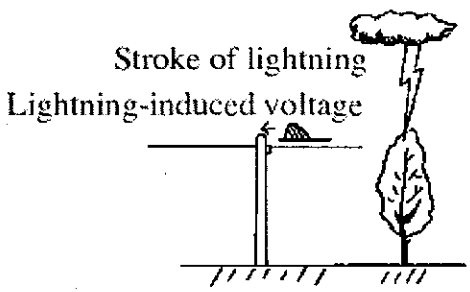
(1) Direct Strike Lightening

Direct strike lightening means lightening that strikes a distribution line directly. Current of 10kA to 120kA with the voltage of several 100kV to several 1000kV flows into medium-voltage lines.



(2)Induced Stroke Lightening

When lightening stroke a tree or a building near distribution lines directly, high voltage is generated at the distribution lines by electromagnet field caused by the lightening current. This is induced lightening and the generated voltage is several 10kV to several 100kV.



Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DS41-2**
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	53	Protective Devices	
Title	Lightening Damage (2/4)			

2. Damage by Lightening

(1) Transformer and Surrounding Facilities

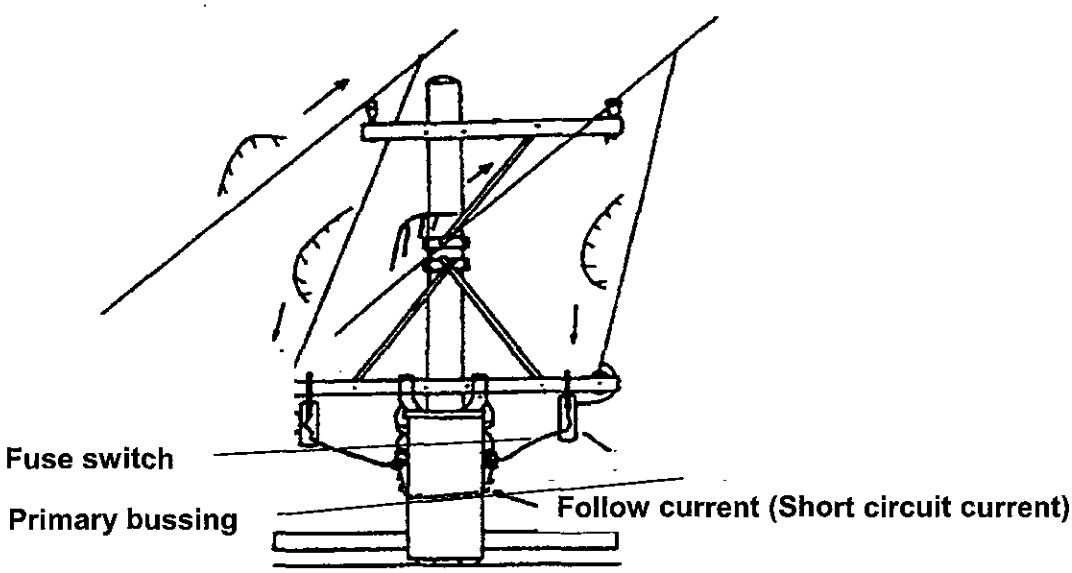
When flashover occurs between primary bushing and case of MV/LV transformer at two phases, a short circuit through the transformer is made and a follow current flows.

In this case, following situation will happen generally.

a. The fuse to protect the transformer will be blown by the follow current.

b. *And the transformer and other facilities around the transformers will be* protected.

However if the follow current is not shut off, fuse switch or primary bussing of transformer are damaged, and in the worst case, the transformer may be broken.



Remarks	Revisions	
	2003/Nov.	Original

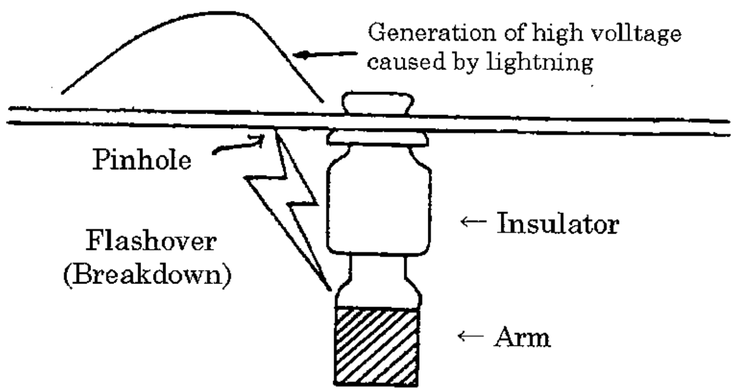
Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DS41-3**
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	53	Protective Devices	
Title	Lightening Damage (3/4)			

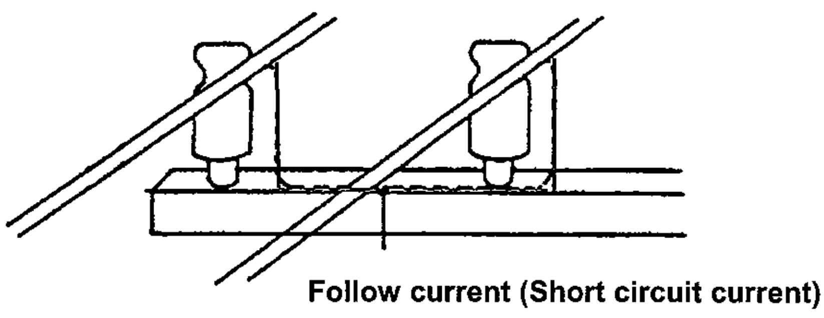
(2) Insulated Conductors

When flashover occurs at a pin insulator a supporting medium-voltage line, a pine hole is made at the insulator covering the conductor.

And if flashovers occur at more than two phases simultaneously, short circuit through a cross arm is made and a follow current flows.

In this case, since the flowing point of follow current at the conductor is fixed to the pine hole, the conductor may be broken by arc heat before the work of an over current breaker.





Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS41-4
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	53	Protective Devices	
Title	Lightening Damage (4/4)			

3. Counter Measure against Lightening Damage

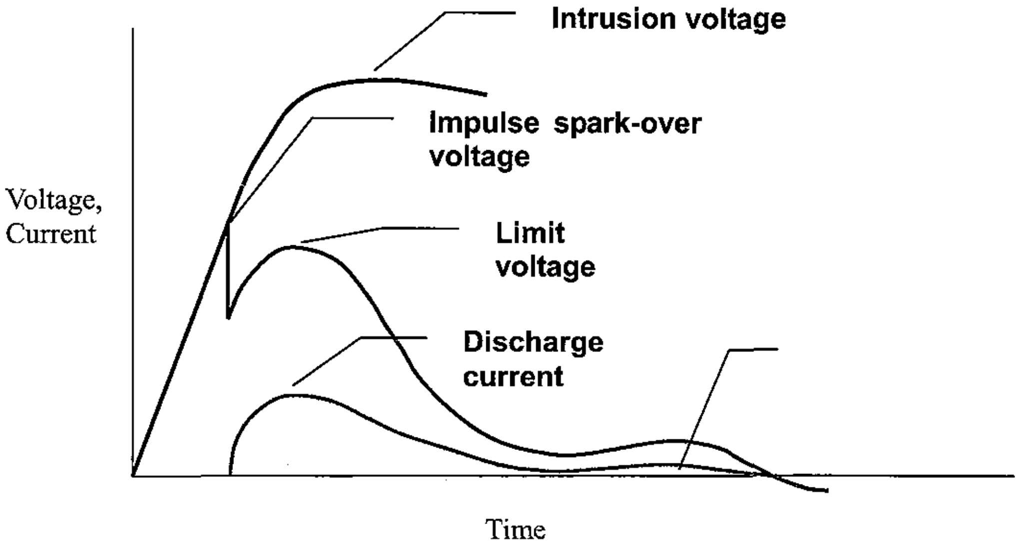
(1) Arrester
Arrester is the most popular countermeasure against lightening. A line and the earth are insulated by the discharge gap at the normal condition. When the lightening strikes, the *induced lightening generated at a medium-voltage line is discharged to the earth* through the arrester, and the induced voltage caused by the lightening strike is suppressed. Also the follow current flowing through the arrester is shut off by the current limiting element and the insulation is recovered.

(2) Grounding Wire
Ground wire avoids the direct strike at the medium-voltage line and suppresses the induced strike. Ground wire is installed above the medium-voltage line.

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DS42**
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	53	Protective Devices	
Title	Installation of Lightning Arrester			

The lightning arrester is to prevent dielectric breakdown of distribution facilities, attributed to intrusion of lighting voltage,



Impulse spark-over voltage:
The highest instantaneous value of terminal voltage which can be attained prior to initiation of terminal voltage drop due to sufficient formation of discharge current, at the first stage of the lightning arrester discharge by the application of impulse voltage across the terminal.

Limit voltage
The impulse voltage that remains across both terminals, when the over-voltage is limited during discharge of a lightning arrester.

Discharge current
The impulse current that flows through a lightning arrester during discharge.

Follow current
The current that flows through a lightning arrester being supplied from a power-frequency supply circuit successively after a discharge phenomenon has substantially finished.

It is to be desired to install arresters at the following positions besides the position stated in the Electric Power Technical Standards.

1. The end of an overhead line
2. The pole on which a switch gear is installed

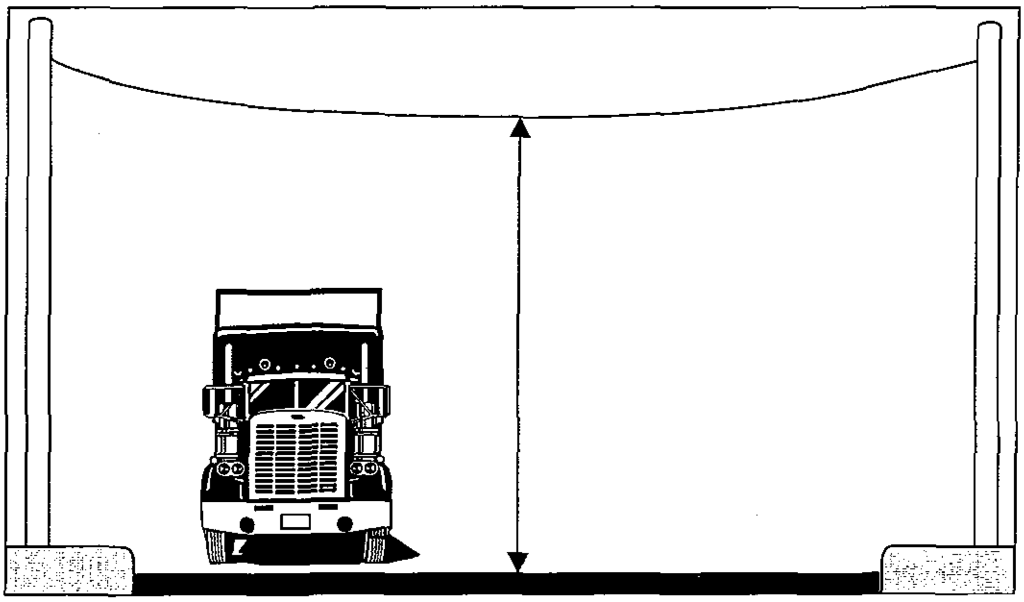
Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS43-1
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	54	Height of Overhead Lines	
Title	Height of Overhead Line (1/2)			

The minimum height of overhead distribution line is as follows;

* The value is decided considering the present situation regarding the installation of *overhead lines in Cambodia*.

1 Crossing a road



Minimum Height

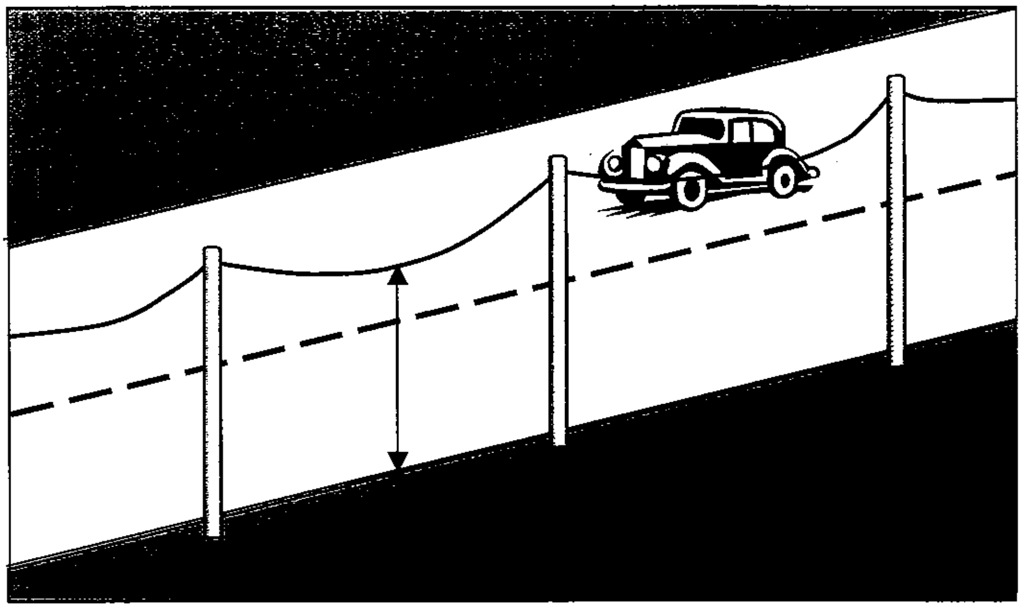
(Unit: m)

Low-voltage	Medium-voltage	
	Urban area	Other area
6.5	8.0	6.5

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.DS43-2
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	54	Height of Overhead Line	
Title	Height of Overhead Line (2/2)			

2 Others



Minimum Height (Unit: m)

Low-voltage	***Medium-voltage***		
	Urban area		***Other area***
	Cable	***Others***	
5.5	5.5	6.5	5.5

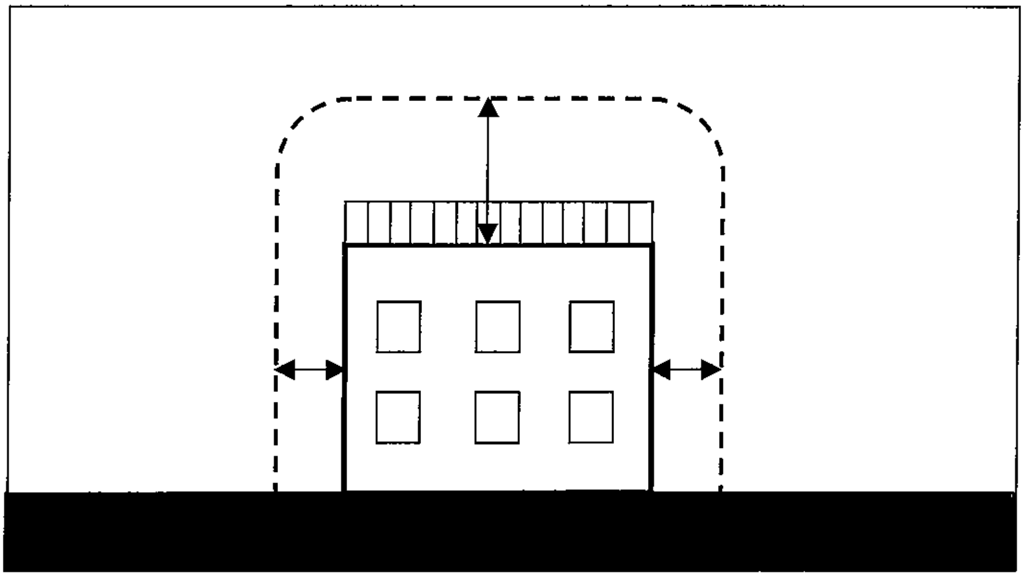
When the medium-voltage line is installed in the urban areas or other areas where many people will gather, the height of the line shall be decided considering the surrounding condition.

Especially it is desired that the height of the line is 10m or more, if bare conductors are used for the medium-voltage line.

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DS44-1**
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	55	Clearance between Overhead Lines and Other Objects	
Title	Clearance between Overhead Line and Structure of Building (1/2)			

1 The clearance between overhead line and Structure of building with the possibility for persons to climb on



Minimum Clearance

(Unit: m)

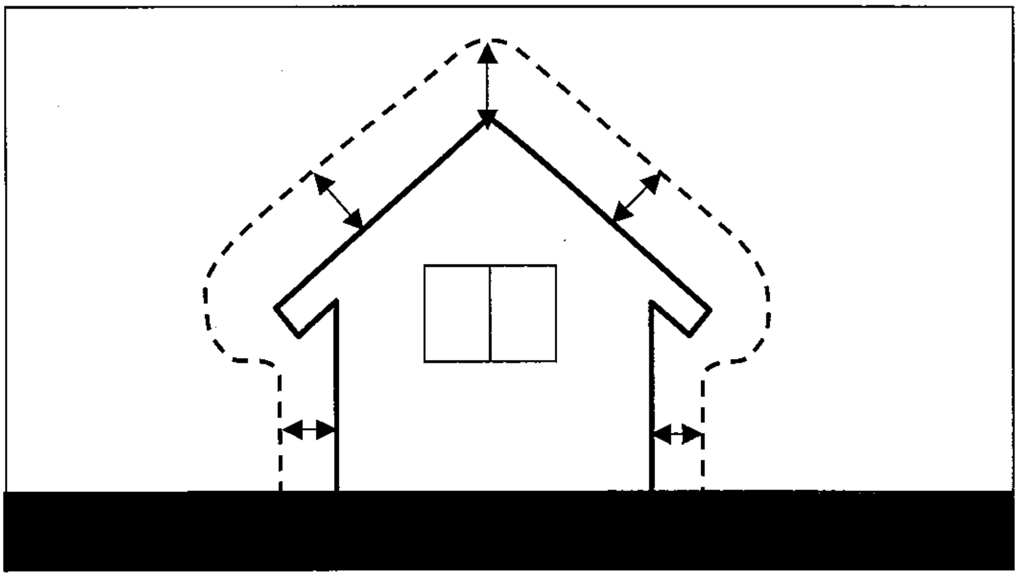
Condition	*Conductor*	*Low-voltage*	*Medium-voltage*
Upside adjacency (A)	Bare Conductor	-	3.0
	Insulated Conductor	2.0	2.5
	Cable	1.0	1.2
Lateral and downside adjacency (B)	Bare Conductor	-	3.0
	Insulated Conductor	1.2	1.5
	Cable	*0.4	0.5

* Except for the special purpose.

Remarks	Revisions	
	2003/Nov.	Original

Category				
Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DS44-2**
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	55	Clearance between Overhead Lines and Other Objects	
Title	Clearance between Overhead Line and Structure of Building (1/2)			

2 The clearance between overhead line and Structure of building with no possibility for persons to climb on



Minimum Clearance

(Unit: m)

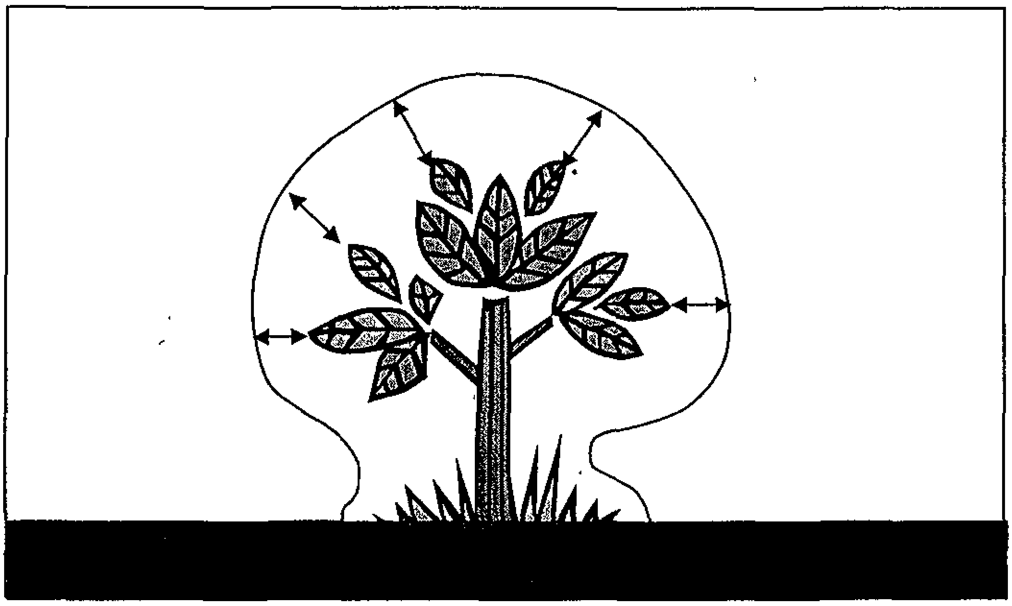
Condition	*Conductor*	*Low-voltage*	*Medium-voltage*
Upside adjacency (A)	Bare Conductor	-	3.0
	Insulated Conductor	1.2	1.5
	Cable	0.4	0.5
Lateral and downside adjacency (B)	Bare Conductor	-	3.0
	Insulated Conductor	1.2	1.5
	Cable	*0.4	0.5

* Except for the special purpose.

The value is decided considering the present situation regarding the installation of overhead lines in Cambodia.

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.DS45
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	55	Clearance between Overhead Lines and Other Objects	
Title	Clearance between Overhead Line and Tree			



(Unit: m)

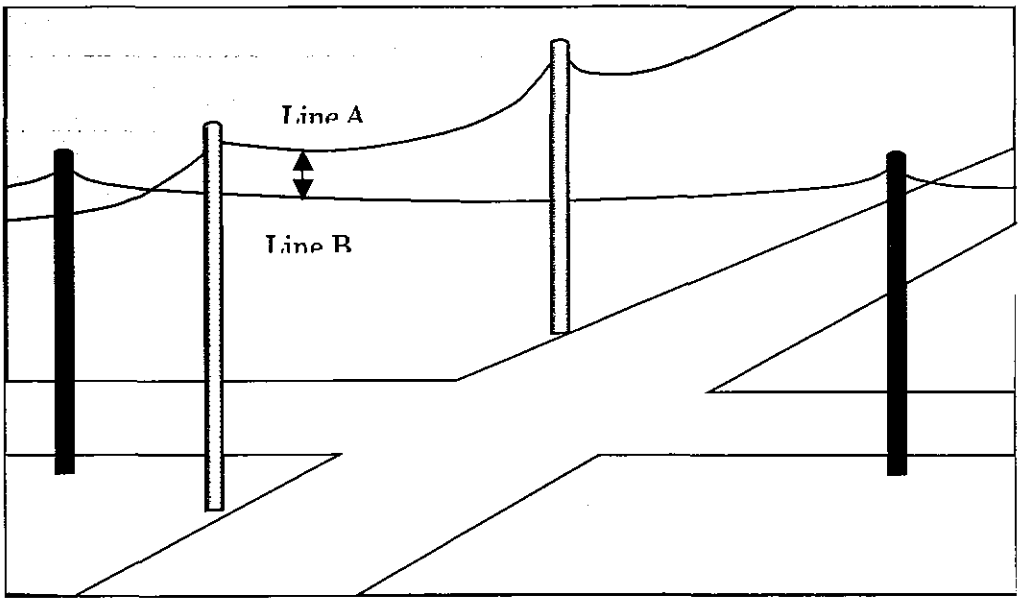
Minimum Clearance

Conductor	Low-voltage	Medium-voltage
Bare Conductor	-	2.0
Insulated Conductor	Not contact directly	
Cable		

The value is decided considering the present situation regarding the installation of overhead lines in Cambodia.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS46-1
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	56	Adjacency and crossing of Overhead Lines	
Title	Adjacency and Crossing of Overhead Lines (1/2)			



Minimum Clearance

(Unit: m)

Line A	*Line B*	*Minimum Clearance*	*Condition*
Medium-voltage Line	Medium-voltage Line	0.5	Line A and B are both cables, or a cable and an insulated conductor.
		2.0	Others
Medium-voltage Line	Low-voltage Line	0.5	Line A is a cable.
		1.0	Line A is an insulated conductor.
		2.0	Line A is a bare conductor.
Low-voltage Line	Low-voltage Line	0.3	Line A and B are both cables, or a cable and an insulated conductor.
		0.6	Others
Medium-voltage Line	Communication Line	0.5	Line A is a cable
		1.0	Line A is an insulated conductor
		2.0	Line A is a bare conductor
Low-voltage Line	Communication Line	0.3	Line A is a cable
		0.6	Line A is an insulated conductor

* The value is decided considering the present situation of overhead lines in Cambodia and the results in other countries.

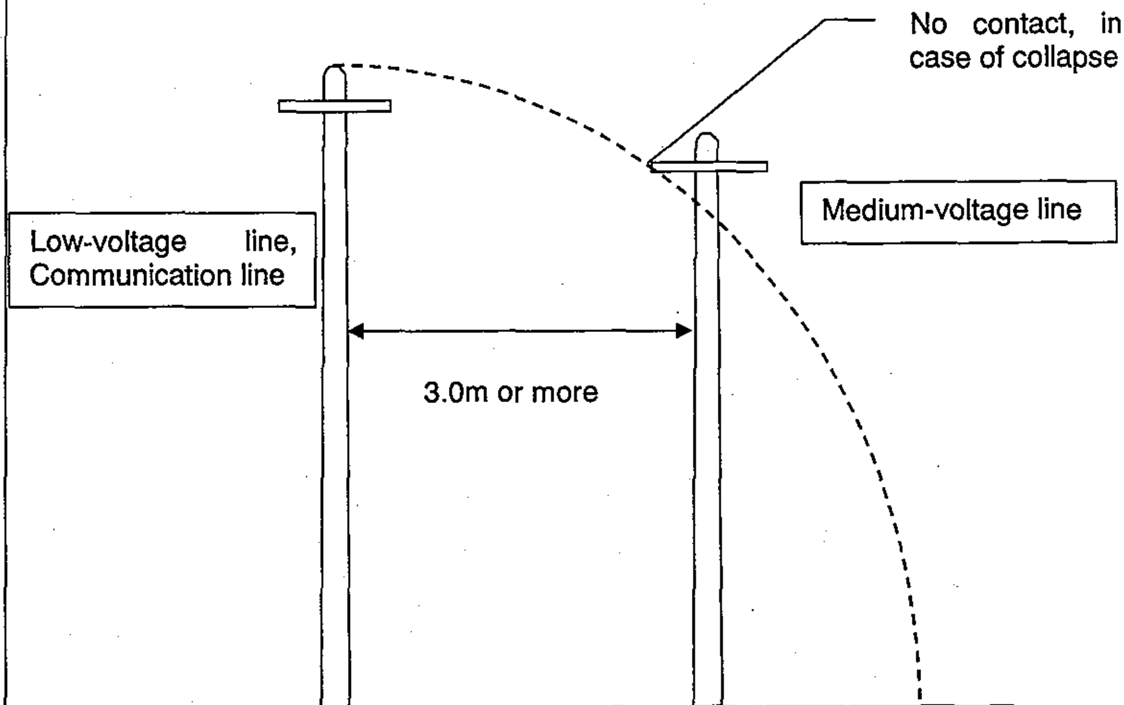
Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.DS46-2
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	56	Adjacency and Crossing of Overhead Lines	
Title	Adjacency and Crossing of Overhead Lines (2/2)			

As a rule, installation of a low-voltage line or a communication line over a *medium-voltage line is prohibited.*
If a low-voltage line or a communication line is installed in accordance with the following manners, the installation over a medium-voltage line is permitted.

1. The horizontal clearance between a low-voltage line or communication line and medium-voltage line is 3.0m or more, and

2. The low-voltage line or communication line does not come in contact with the medium-voltage line when the supporting structure of the low-voltage line or communication line collapse.



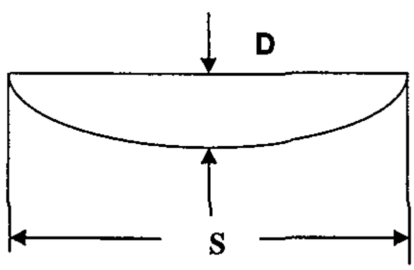
Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS47-1
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	54 55 56	Height of Overhead Lines Clearance between Overhead Lines and Other Objects Adjacency and crossing of Overhead Lines	
Title	Sag of Line (1/2)			

Overhead lines shall be installed with adequate sags in order to keep the safety factors of lines.

Relation between the sag and the tensile strength is given by following formula.

$$D = \frac{W \times g \times S^2}{8T}$$

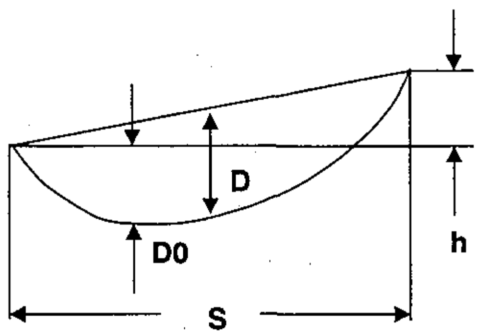


Where
- D: Sag of line (m)
- W: Unit weight of line (kg/m)
- g: G-force (m/s^2)
- S: Spam of line (m)
- T: Horizontal tensile force of line at the bottom point (N)

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS47-2
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	54 55 56	Height of Overhead Lines Clearance between Overhead Lines and Other Objects Adjacency and crossing of Overhead Lines	
Title	Sag of Line (2/2)			

$$D0 = D\left(1 - \frac{h}{4D}\right)^2$$



Where
D: Slant sag of line (m)
D0: Sag of line at the center of span (m)
W: Unit weight of line (kg/m)
g: G-force (m/s^2)
S: Spam of line (m)
T: Horizontal tensile force of line at the bottom point (N)

Generally if the sag is larger and the tensile strength is smaller, there will be following advantages.

1. The safety factor will become higher.
2. The required strength of guys or cross arms will be smaller.

On the other hand, there will be following disadvantages.

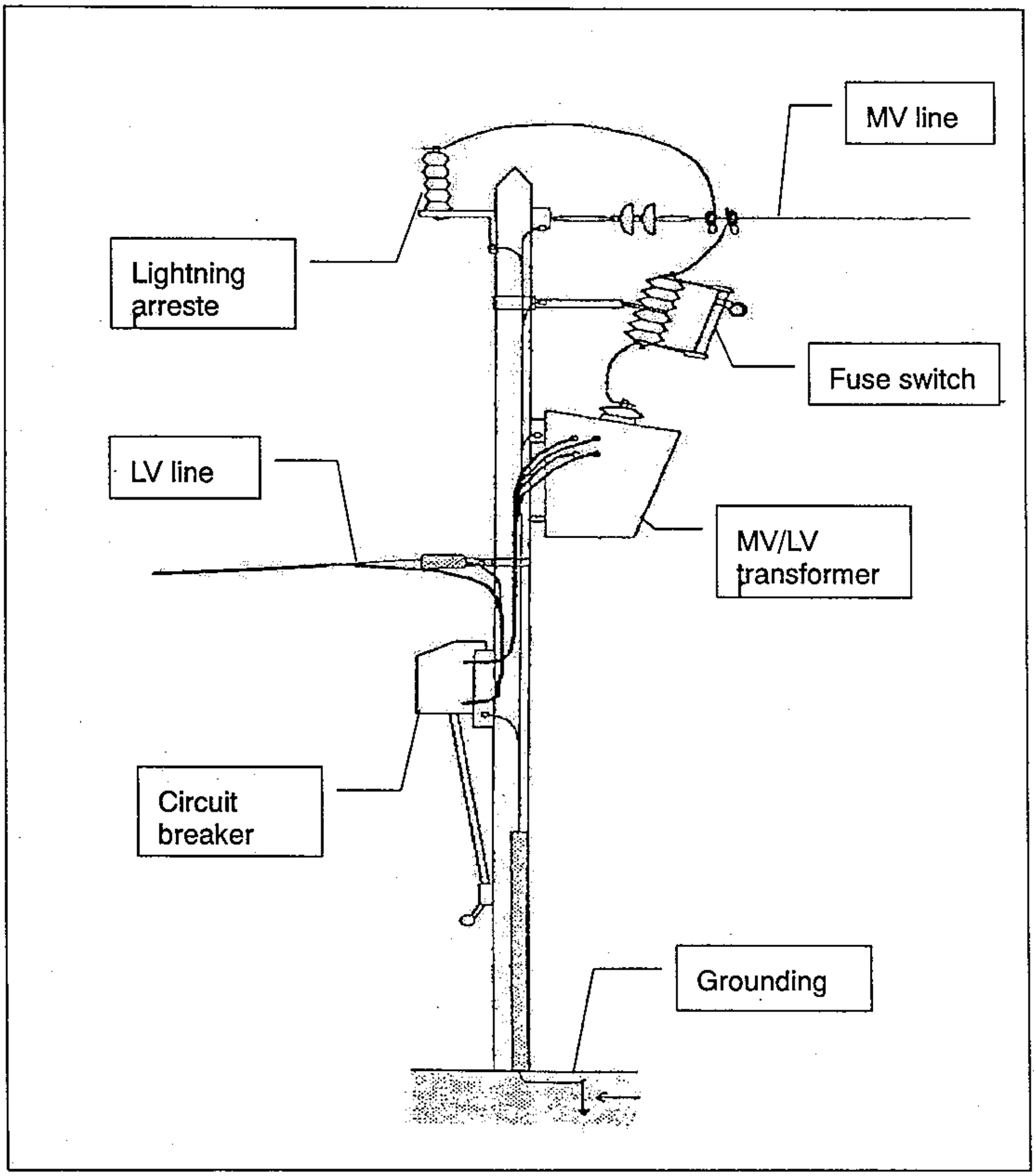
1. The possibility of the entanglement of lines will increase.
2. The height of lines above the ground will become lower.

The sag will be decided taking into consideration these characteristics.
It is desired that the tensile strength on both spans will be equal.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS48-1
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	-	Others	
Title	Composition of Overhead Distribution System (1/3)			

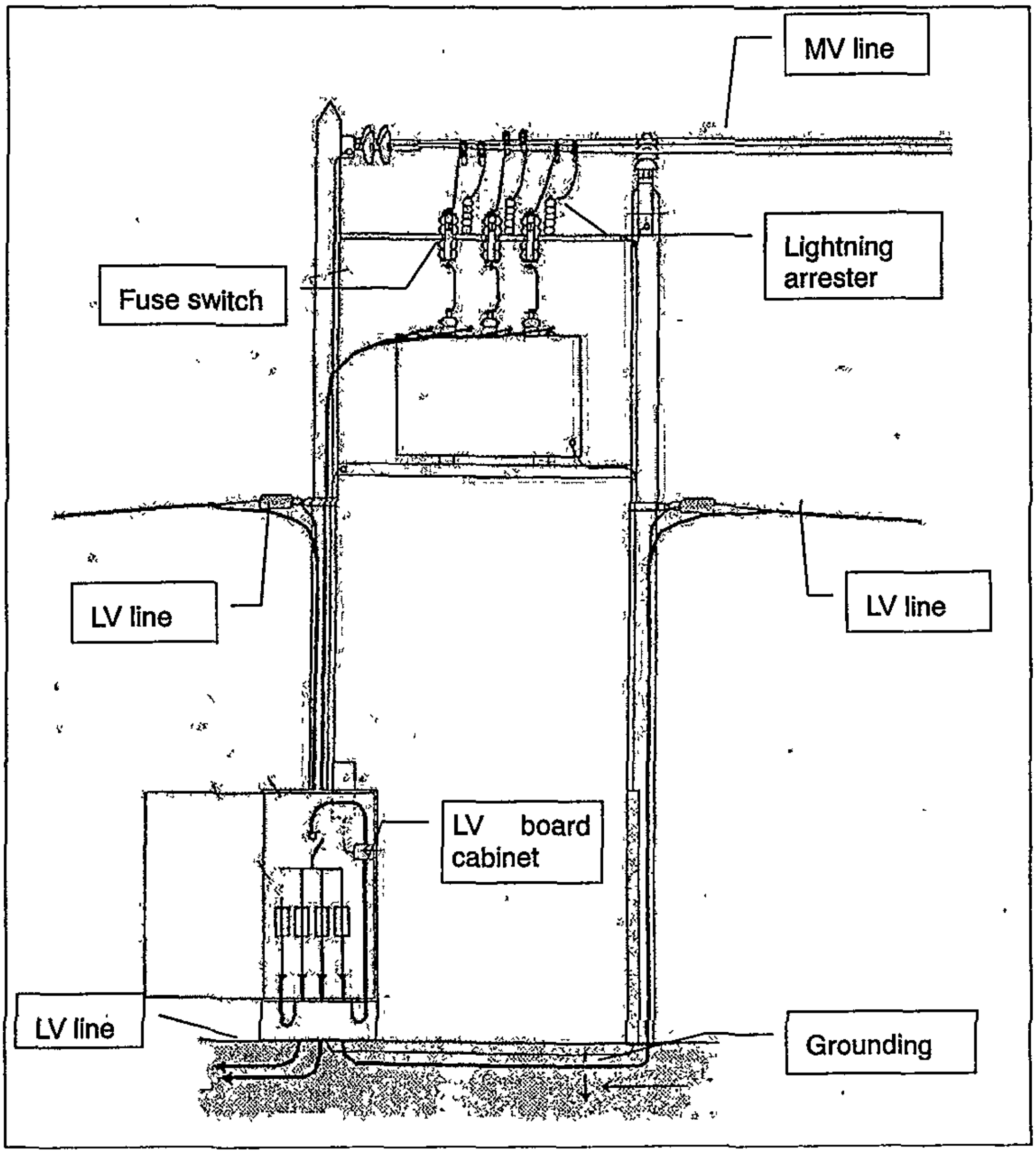
Example of Overhead Distribution System (1)



Remarks	Revisions	
Source: EDC Design Standard (July 1996)		
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS48-2
	Paragraph	7	*Transmission and Distribution Facilities* (Medium and Low Voltage)	
	Clause	-	Others	
Title	Composition of Overhead Distribution System (2/3)			

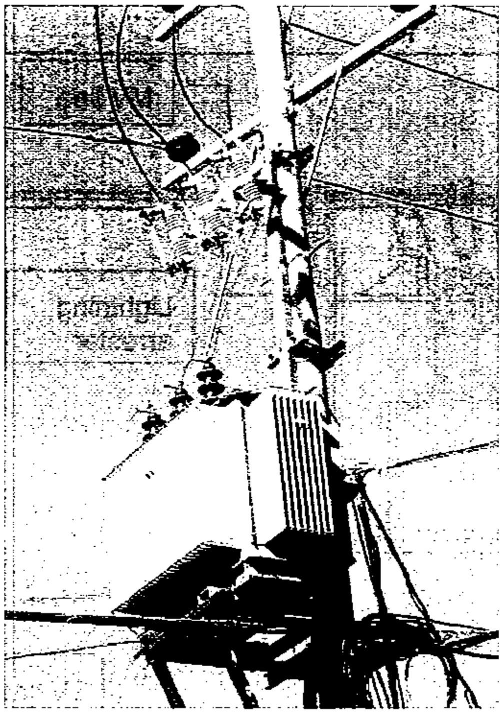
Example of Overhead Distribution System (2)

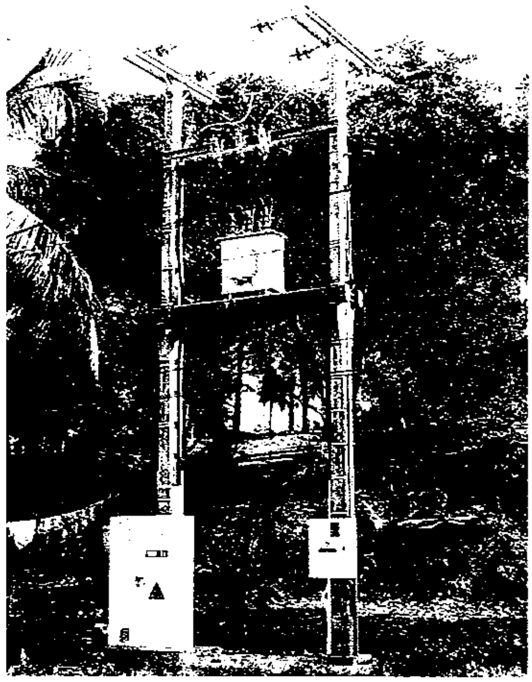


Remarks
Source: EDC Design Standard (July 1996)

Revisions	
2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS48-3
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	-	Others	
Title	Composition of Overhead Distribution System (3/3)			

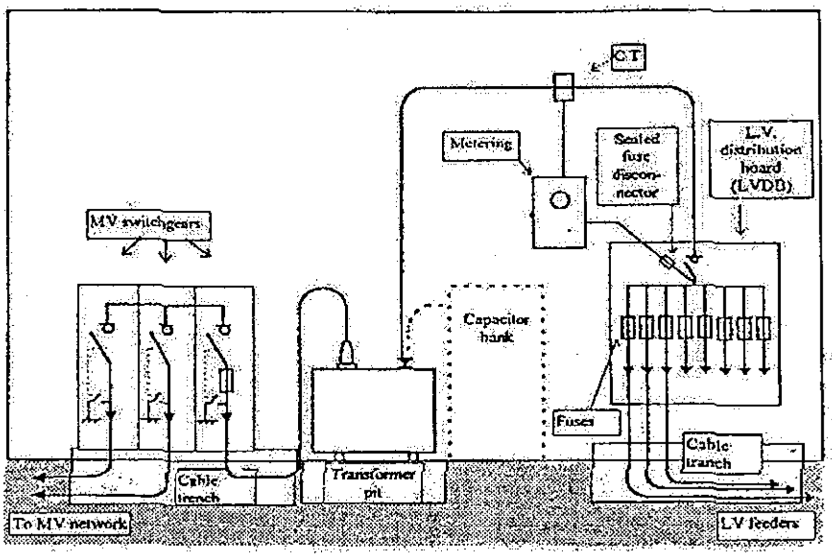




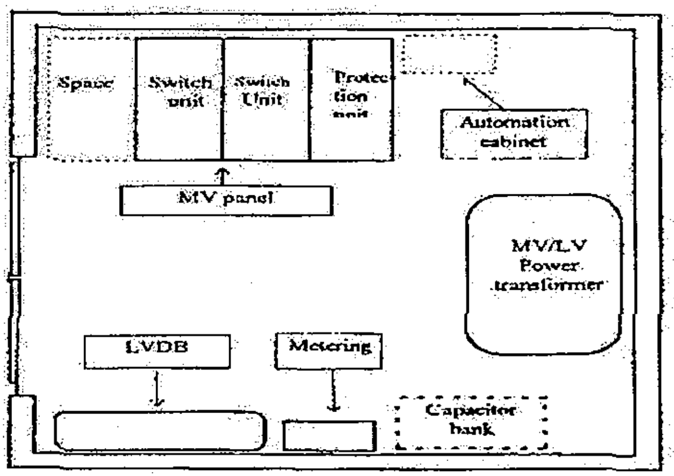
Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DS49-1**
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	-	Others	
Title	Distribution Substation (1/3)			

Diagram of Distribution Substation with one transformer (Example)



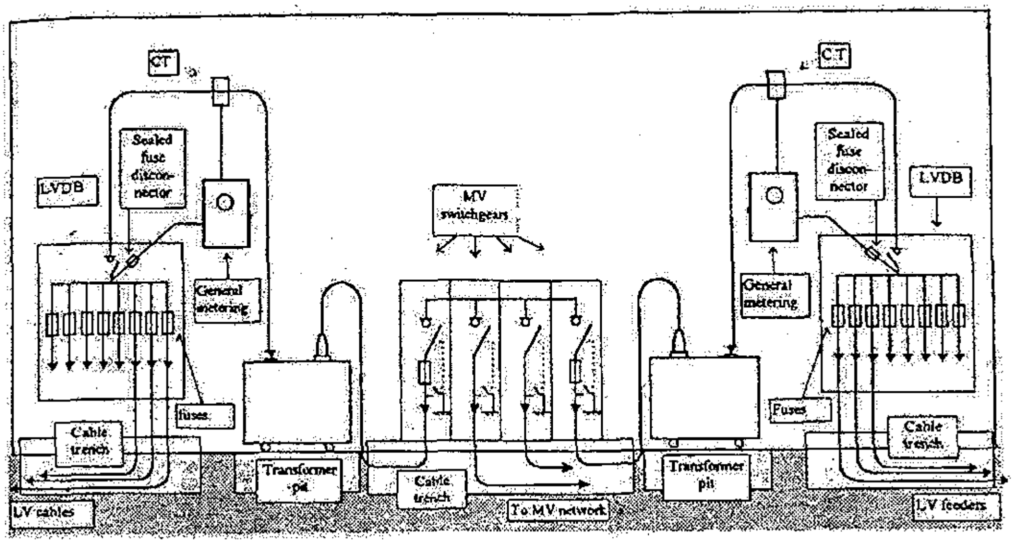
Layout of Distribution Substation with one transformer (Example)



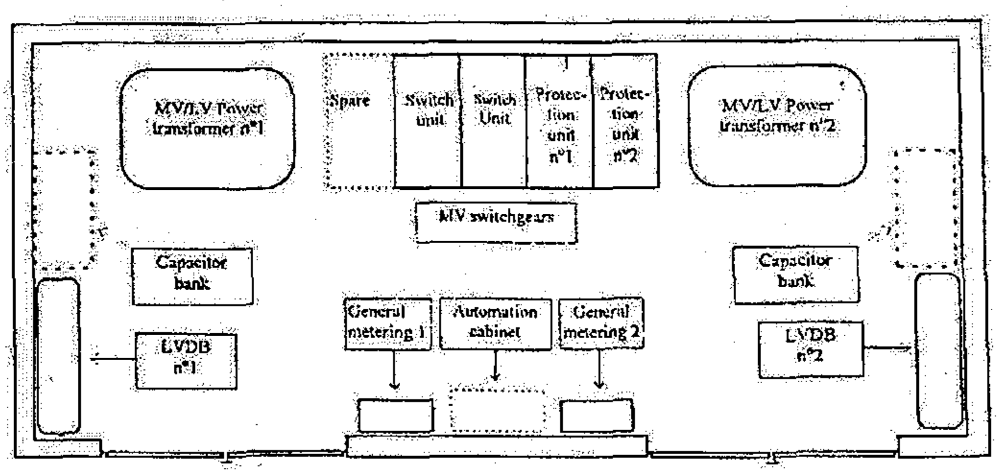
Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS49-2
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	-	Others	
Title	Distribution Substation (2/3)			

Diagram of Distribution Substation with two transformers (Example)



Layout of Distribution Substation with two transformers (Example)



Remarks	Revisions	
Source: EDC Design Standard (July 1996)		
	2003/Nov.	Original

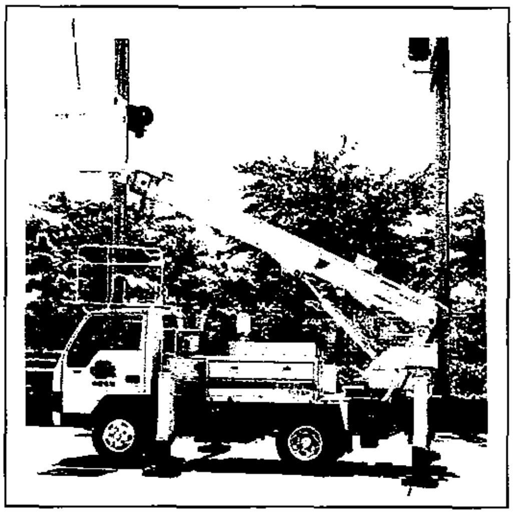
Category				
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS49-3
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	-	Others	
Title	Distribution Substation (3/3)			

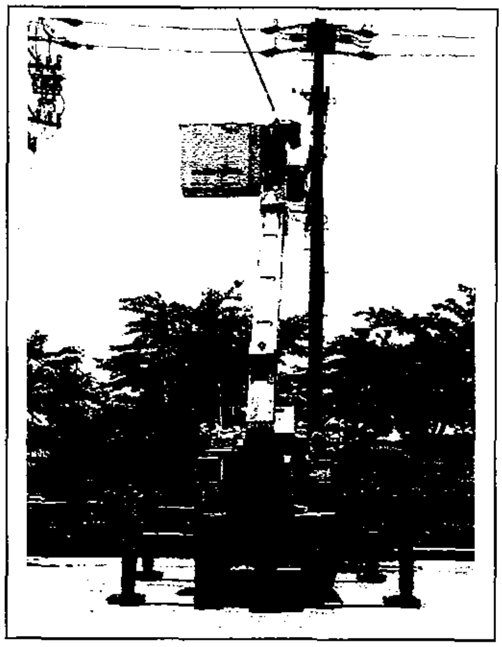
Cabin for Distribution Substation

Remarks	Revisions	
	2003/Nov.	Original

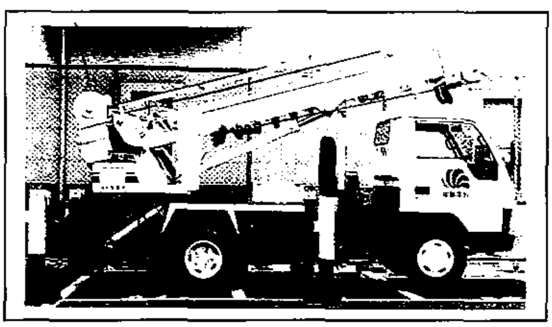
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS50
	Paragraph	7	Transmission and Distribution Facilities (Medium and Low Voltage)	
	Clause	-	Others	
Title	Vehicles for Distribution Work			

Bucket Vehicle





Pole installation Vehicle



Remarks
Source: Manual of Chubu Electric Power Co., Inc.

Revisions	
2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DS51
	Paragraph	4	Prevention of Electric Power Disasters	
	Clause	9-	Prevention of Electric Power Disasters	
Title	Interconnection of Privately Owned Power Generators			

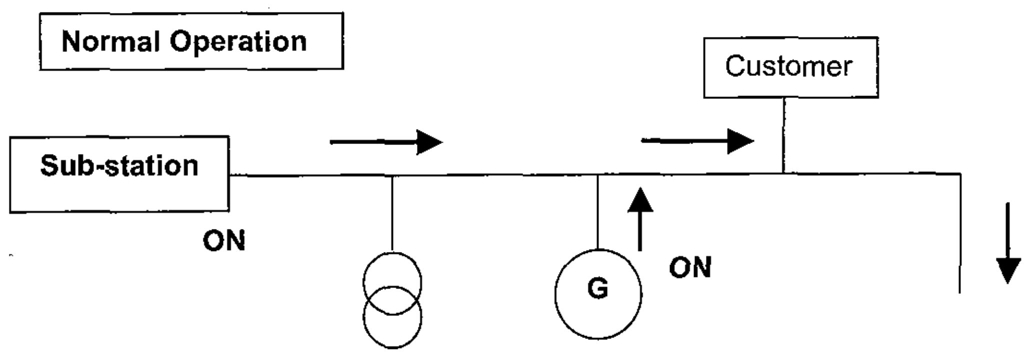
When an privately owned power generator is connected to a distribution network, a licensee has to consider following items to prevent accidents of the third persons or line workers etc..

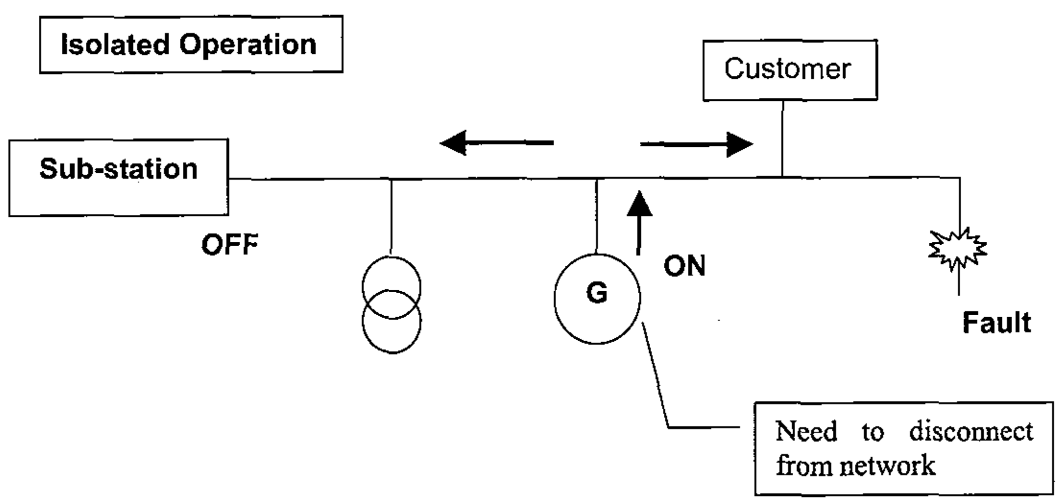
1. Disconnection of auto-producer from distribution network

When a privately owned power generator breaks down, the generator shall be disconnected from the distribution network quickly.

2. *Prevention of isolated operation of auto-producer*

When a fault occurs on the distribution line, the privately owned power generator shall be disconnected quickly. In order to prevent the isolated operation, over voltage relay, under voltage relay shall be installed at the generator.





Remarks	Revisions	
	2003/Nov.	Original

JICA

GUIDEBOOK
FOR
POWER ENGINEERS

English Edition

VOL. No.7
LOW VOLTAGE
HOUSE WIRING

Dec. 2003

MINISTRY OF INDUSTRY, MINES AND ENERGY
ELECTRICITY AUTHORITY OF CAMBODIA
ELECTRICITE DU CAMBODGE

Contents of House Wiring

Document No.	Title
IW25	Low-voltage Indoor Wiring Work (Flexible Conduit Work)
IW26	Low-voltage Indoor Wiring Work (Metallic Tube Work)
IW27	Low-voltage Indoor Wiring Work (Synthetic Resin Raceway Work)
IW28	Low-voltage Indoor Wiring Work (Metallic Raceway Work)
IW29	Low-voltage Indoor Wiring Work (Insulator Work)
IW30	Low-voltage Indoor Wiring Work (Floor duct work)
IW31	Applications of Work Methods
IW32	Allowable Voltage Drop at Indoor Wiring
IW33	Connection Methods of Indoor Wiring
IW34	Equipment of Indoor Wiring

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. IW1-1
	Paragraph	8	House Wiring	
	Clause	57	Insulation	
Title	Completion Inspection of the Customer's Facilities (1/5)			

For house wiring, which is the customer's facilities, the customers are responsible for its maintenance, but the suppliers have an completion inspection duty according to chapter 3.3.15(in case of small consumer), 3.4.24 (in case of medium consumer) in EAC's regulations to supplement safety of customers' electric equipment.
Completion inspection procedures for house wiring are as follows.

1. Inspection of equipment
Inspectors shall confirm whether they are applied to the technology standard.
At first Inspectors shall confirm the condition of house wiring or electric appliance by means of *one's eyes and hands.*
Second Inspectors shall measure insulation resistance etc by measurement machine etc.

2. Measurement
After confirming the condition of house wiring or electric appliance by means of one's eyes and hands, Inspectors shall judge good or bad on the basis of results in following measurements.
(1) The insulation resistance
The insulation resistance between conductors of low-voltage wiring and between the electrical circuit and ground shall be no less than the value given in below Table with respect to the nominal circuit voltage for each section into which the electrical circuit can be divided by switching devices or overcurrent circuit breakers.
If insulation resistance measurement is difficult, it is sufficient to keep the leak current 1 mA or less.

Minimum of insulation resistance [IEC 60364-6-61]

Nominal circuit voltage [V]	Test voltage d.c. [V]	Insulation resistance[MO]
500 V or less	500	More than 0.5
Over 500 V	1,000	More than 1.0

*Insulation resistance measurement shall be conducted for each circuit with no equipment attached.
*If electronic equipment is present in the circuit, measurement shall be conducted only between a phase and the ground with the phase connected to the neutral conductor in order to avoid destruction of electronic equipment.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. IW1-2
	Paragraph	8	House Wiring	
	Clause	57	Insulation	
Title	Completion Inspection of the Customer's Facilities (2/5)			

(2) Ground resistance measurement
Inspectors shall measure the ground resistance at the grounding work installed point by means of ground resistance meter, and confirm that those values satisfy regulation.

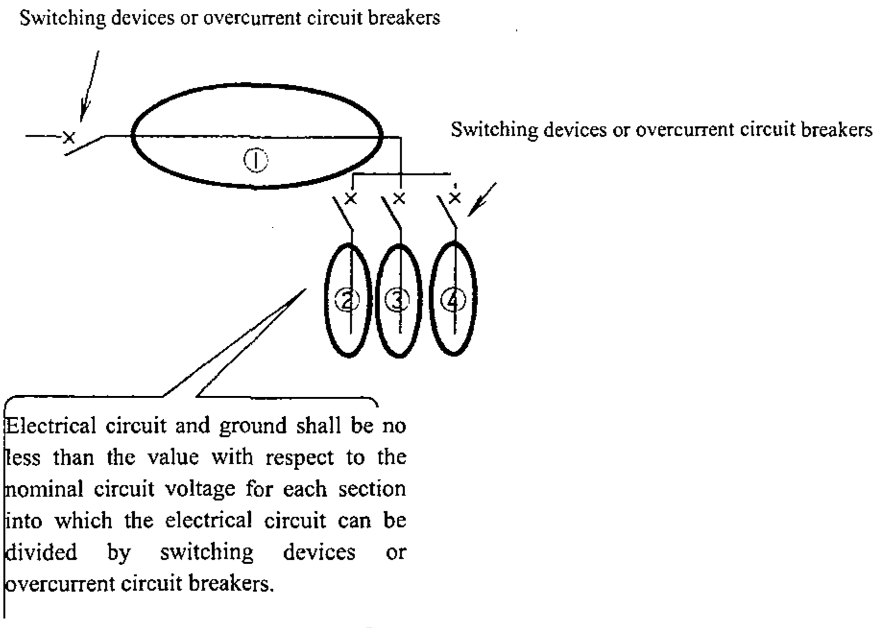
(3) Conductor test
If necessary, inspectors shall perform the conductor test by means of circuit tester etc in order to confirm the [no breaking of house wiring], [correct connection in joint box], [correct connections toward electronic equipment].

3. Switch-on test
Inspectors shall confirm the fault of electric equipment etc by means of switch-on tests after finishing measurements.
Inspectors shall confirm from source side to load side in order.
If any problems are found by the inspection, make a note, and perform re-inspection later.

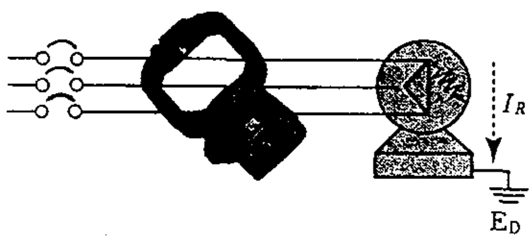
Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. IW 1-3
	Paragraph	8	House Wiring	
	Clause	57	Insulation	
Title	Completion Inspection of the Customer's Facilities (3/5)			

Insulation resistance of low-voltage wiring at users' sites



If insulation resistance measurement is difficult, it is sufficient to keep the leak current 1 mA or less

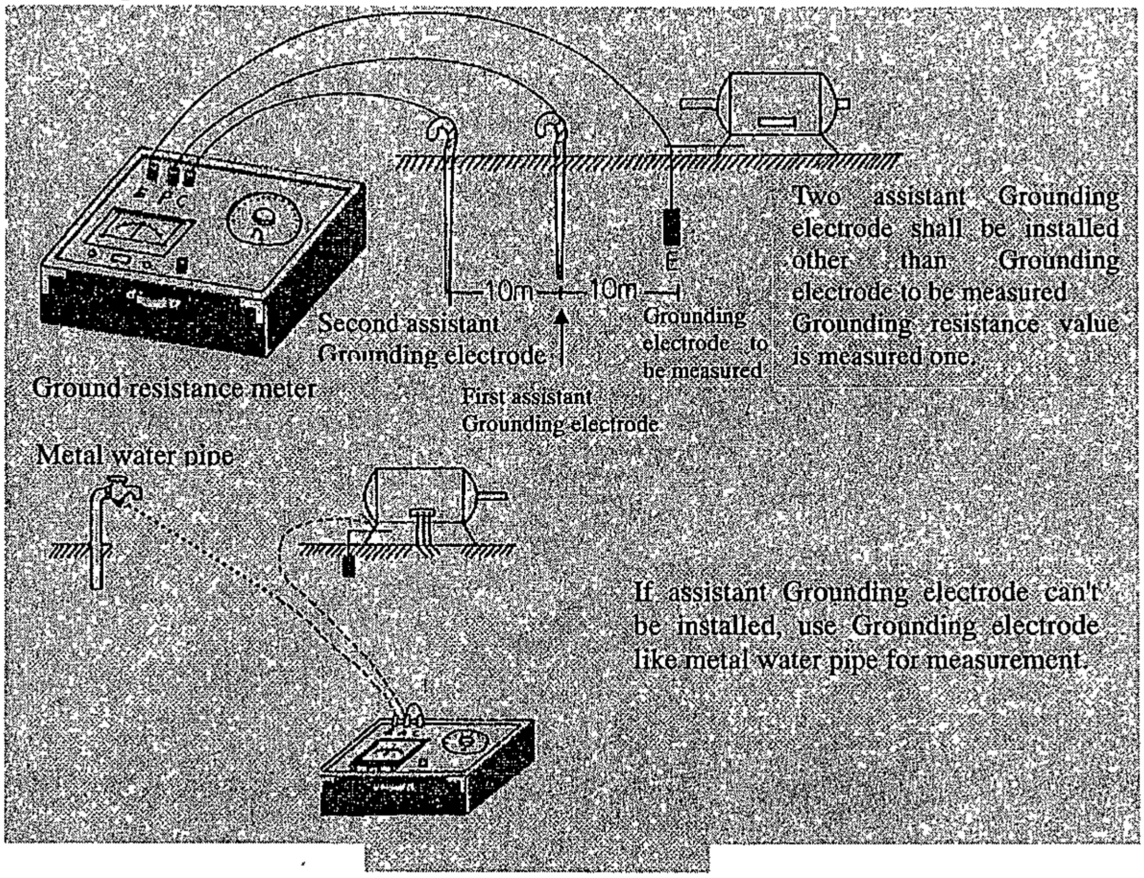


Clamp meter (Leak current meter)

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No. IW 1-4
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	8	House Wiring	
	Clause	57	Insulation	
Title	Completion Inspection of the Customer's Facilities (4/5)			

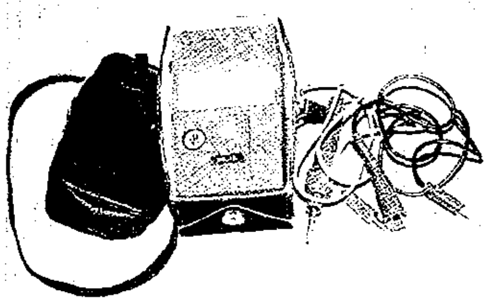
Grounding resistance measurement



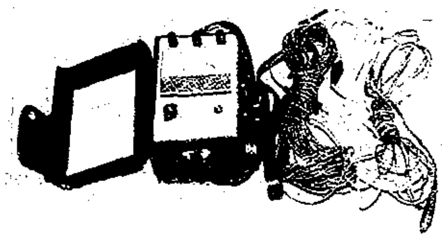
Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	*Technical Standards of Electric Power Facilities*	**Document No. IW 1-5**
	Paragraph	8	House Wiring	
	Clause	57	Insulation	
Title	Completion Inspection of the Customer's Facilities (5/5)			

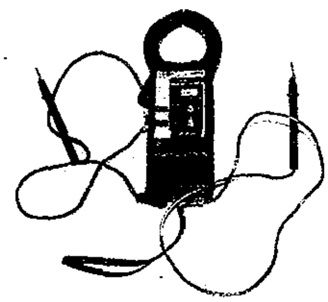
Insulation resistance meter



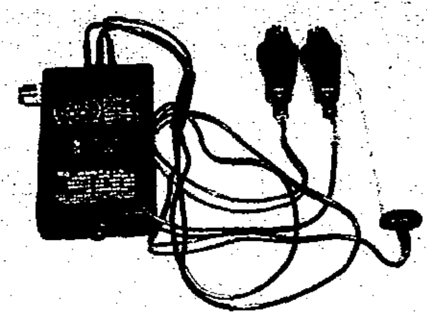
Ground resistance meter



Clamp meter (Leak current meter)



Phase rotation check machine



Remarks	Revisions	
	2003/Nov.	Original