Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. C-01**
	Paragraph	4	Generating Facilities (Others)	
	Clause	29	Renewable Energy, Portable Generators and Small Hydro Generations	
Title	Condition of Connection with Power System for Distributed Generator **Classification of Power System for Distributed Generator-1**			

Classification of Power System for Distributed Generator

The classification by the method of connecting of Distributed Generator becomes as in the next table.

Classification of Power System for Distributed Generator

Connecting Method Distributed Generator with Power System	Type of Distributed Generator
Alternative current generator	Wind firm generator
	Mini (micro)hydro power generator
	Biomass power generator
Direct current generator (Using inverter system)	*Photovoltaic generator*

The matter cared about in the case of connecting Distributed Generator to Power System is shown below.

The Distributed Generator(s) must not affect the established quality and established reliability of electric power of Power System.

The difference of Alternative current generator and Direct current generator in the case of connecting. The Distributed Generator to Power System is shown in next table.

The item to compare	Rotating *electric* machinery *(Synchronous machines)*	Rotating *electric* machinery *(Induction machines)*	Inverter *system* (Self-commutated)	Inverter *system* (Externally-commutated)
Capability to adjust Power Factor	Capable	Incapable	Capable	Incapable
Harmonic component occurs.	None	None	It occurs	It occurs
Starting currents	Synchronizing closing (Small-Low)	High-current	Synchronizing closing (Small-Low)	High-current
Over current from line fault(s)	High-current	High-current	About 2 times of rated current	About 2 times of rated current
Protective devices	Protective devices are needed outside.	Protective devices are needed outside.	Built-in	Built-in

Remarks	Revisions	
	2003/Nov	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. C-02**
	Paragraph	4	Generating Facilities (Others)	
	Clause	29	Renewable Energy, Portable Generators and Small Hydro Generations	
Title	Condition of Connection with Power System for Distributed Generator **Classification of Power System for Distributed Generator-2**			

There is the rule for connecting Distributed Generator(s) with power system.
This Guidebook recommends the following items.

-Guidebook wants to eliminate the harmful influence on the service reliability (Interruption of service etc) and the quality (voltage, frequency, harmonic component etc.) of the other people by Distributed Generator(s).

-Guidebook wants to eliminate the harmful influence on the safety of members of the public and the electric equipment by Distributed Generator(s).

It is different from the technical condition for connecting Distributed Generator(s) with power system by the voltage level, the kind of generator and the presence of back current.

Voltage Level - low voltage, high, extra-high voltage

Kind of Generator - Alternative current generator or Direct current generator

Presence of Back Current

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. C-03**
	Paragraph	4	Generating Facilities (Others)	
	Clause	29	Renewable Energy, Portable Generators and Small Hydro Generations	
Title	Condition of Connection with Power System for Distributed Generator **Isolated operation-1**			

Equipment measures for the interconnection with the high voltage distribution line

- Protection coordination
- Measures for limitation of reverse current
- Measures against voltage fluctuation
- Measures for suppression of short-circuit-capacity
- Establishment of communication system

(Protection coordination)

・Purpose

Prevention against

[1]Public electric shock

[2]Equipment damage

[3]Influence to fire-fighting activities

[4] *Search for accident point and an abatement worker's electric shock etc* caused by **Isolated operation**

・Measures

installation of various protective relays

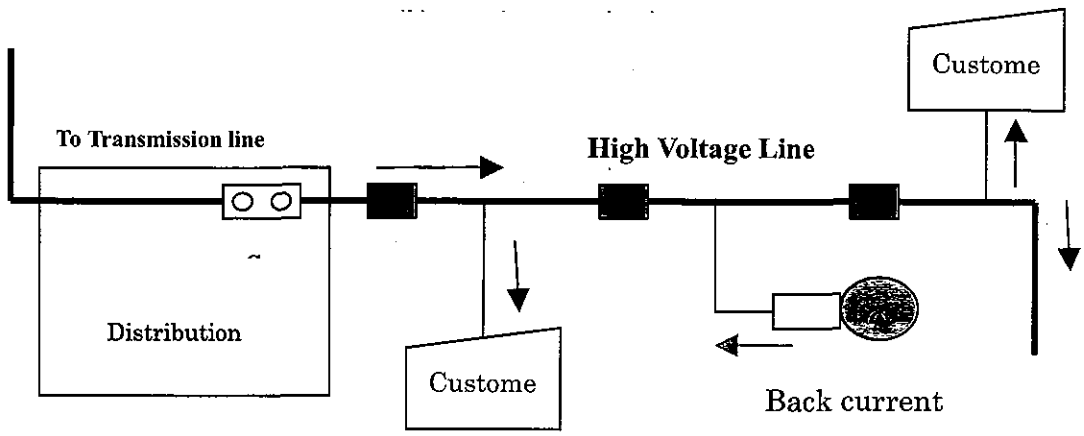
What is Isolated operation?

In the condition that the generation facility which used to be interconnected power network was separated from the network by accident, work, etc, generating continuously only operating that generation facility which interconnects power network, and supplying electric power to the load locally.

Remarks	Revisions	
	2003/Nov.	Original

Category				
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. C-04
	Paragraph	4	Generating Facilities (Others)	
	Clause	29	Renewable Energy, Portable Generators and Small Hydro Generations	
Title	Condition of Connection with Power System for Distributed Generator **Isolated operation-2**			

The image of Connection with Power System



G: Dispersed Generator

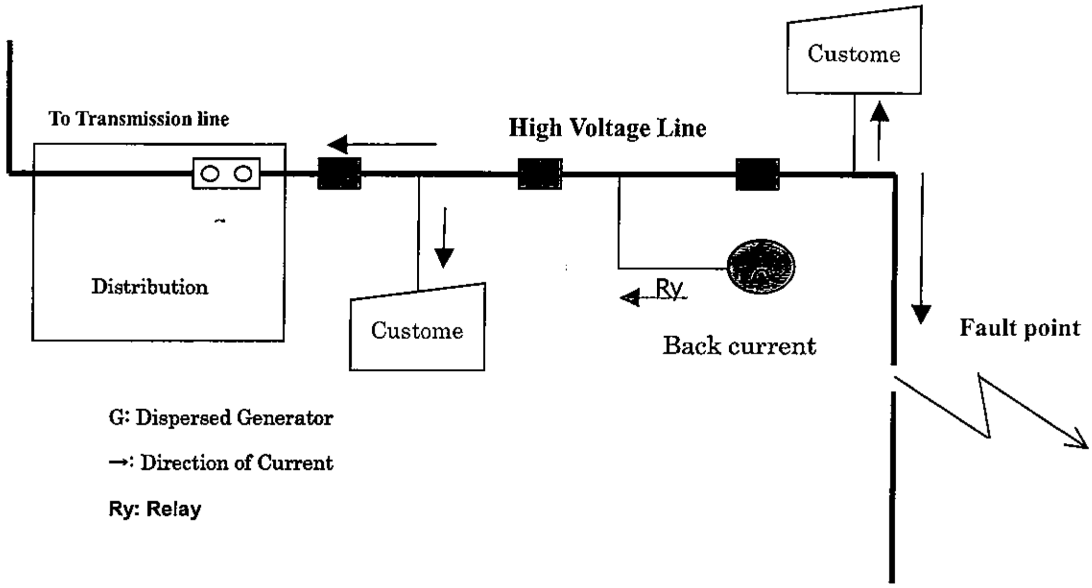
→: Direction of Current

Ry: Relay

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. C-05
	Paragraph	4	Generating Facilities (Others)	
	Clause	29	Renewable Energy, Portable Generators and Small Hydro Generations	
Title	Condition of Connection with Power System for Distributed Generator **Isolated operation-3**			

The image of Connection with Power System



G: Dispersed Generator

→: Direction of Current

Ry: Relay

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. C-06
	Paragraph	4	Generating Facilities (Others)	
	Clause	29	Renewable Energy, Portable Generators and Small Hydro Generations	
Title	Condition of Connection with Power System for Distributed Generator **Main Protection Relay**			

Main Protection Relay

Types of Protection Relay (Code)	Types of accident	Detect level	Regulation values in Japan	Regulation values in Philippines (Grid Code)
Over Voltage Relay OVR	Abnormality of power generation	110-120% Nominal voltage	106%Nominal voltage (light)	110% Nominal voltage
Under Voltage Relay UVR	Abnormality of power generation, black out of power network	80-90% Nominal voltage	94% Nominal voltage	90% Nominal voltage
Under Frequency Relay UFR	Under Frequency of network, Isolated operation	58.2-59.4Hz	59.9Hz	49.5Hz
Over Frequency Relay OFR	Over Frequency of network, Isolated operation	60.6-61.8Hz	60.1Hz	50.5Hz
Function of Isolated operation	Isolated operation	Depend on types	-	-

If restriction values, such as a voltage and a frequency are not kept ,The malfunction of a protective relay occurs →electric power failure

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. C-07
	Paragraph	4	Generating Facilities (Others)	
	Clause	29	Renewable Energy, Portable Generators and Small Hydro Generations	

Title	Condition of Connection with Power System for Distributed Generator **Measures -1**

Measures for limitation of reverse current

・Purpose

[1] Prevention of the electrical shock to worker caused by the reverse current from the distribution substation when transmission line stops electricity etc.

[2] Prevention of arising the problem concerning voltage control system caused by reverse current from network side.

・Measures

Control of power generation facilities not to rising reverse current.

Values of reverse current <Values of current in concerned substation

*Values of reverse current =generation output - load in concerned facilities.

Measures against voltage fluctuation

・*Purpose*

To prevent deviation from an appropriate value of a network voltage when a power generation facility is interconnected to network

・Measures

Install of AVR (automatic voltage regulator) etc.

Restriction value of voltage fluctuation

Items	in Cambodia
Light	Within ± 6% nominal voltage (Recommendation)
Power	

Measures for suppression of short-circuit-capacity

Purpose

If a power generation facility is interconnected to a network, the short circuit capacity of a network will increase. Moreover when short circuit capacity exceeds the breaking capacity of the circuit breaker at distributor or other consumers, damage of cables etc are prevented by installing the apparatus which suppresses a short circuit current.

・Measures

Installation of limiting current reactor

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. C-08**
	Paragraph	4	Generating Facilities (Others)	
	Clause	29	Renewable Energy, Portable Generators and Small Hydro Generations	
Title	Condition of Connection with Power System for Distributed Generator **Establishment of communication system**			

Establishment of communication system

・Purpose

When a circuit breaker for interconnections operates because of a power generation facility accident or network accident, quick contact is needed between a power company and an installation person of power generation facility, and a required action is carried out.

・Measures

Installation of private communication system

Conclusion

Types of Measures	In Cambodia
Protection coordination	・Maintenance of power qualities are needed (based on Electric Power Technical Standards) ・Various types of protection coordination equipment are needed
Measures for limitation of reverse current	A measure becomes unnecessary when the quantity of power generation is maintained in a limit.
Measures against voltage fluctuation	Calculating voltage fluctuation individually, There are cases that equipment is needed.
Measures for suppression of short-circuit-capacity	Calculating short-circuit-capacity individually, There are cases that equipment are needed
Establishment of communication system	A measure becomes unnecessary when the established telephone line is installed.

Revisions	
2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. C-09
	Paragraph	4	Generating Facilities (Others)	
	Clause	29	Renewable Energy, Portable Generators and Small Hydro Generations	
Title	Condition of Connection with Power System for Distributed Generator **Method**			

Devices (Protection Relay) with the function to detect Isolated operation

- -The equipment which detects Over and under voltage relay, over and under frequency relay, and the state where it cannot come out and detect.
- -These devices are divided roughly into method of passive detection and method of active detection by the principle for detecting.

Method of passive detection:
Detection of unified power flow jump;
Device, which detects the sudden change of unified power flow, produced more unevenly [an output power and load] when it shifts to Isolated operation.

Detection of third harmonic voltage strain, rapid increase;
Current control type is used for Inverter, Rapid increase of third harmonic voltage depending on transformer is detected when it shifts to Isolated operation.

Detection of frequency modulation;
Rapid increase of frequency by the unbalance of output power and load is detected, when it shifts to Isolated operation.

Method of active detection:
Detection of reactive power change;
Periodic reactive power change is given to output power, periodic voltage variation or periodic current changing generated at the time of shift of Isolated operation is detected.

Detection of active power change;
Periodic active power change is given to output power, periodic voltage variation or periodic current changing generated at the time of shift of Isolated operation is detected.

Sudden change of voltage variation or current changing which appears when shifting to Isolated operation etc. is detected.

Detection of load fluctuation;
Parallel impedance is inserted in power generator facility momentarily and periodically,

Detection of QC-mode frequency shift;
Frequency conversion rate of power system is detected and output voltage of power generator (station) is changed according to the positive/negative and the size of the rate -- frequency conversion at the time of Isolated operation is detected.

Detection of frequency shift;
Bias is beforehand given to frequency characteristics outputted from power generator (station), At the time of the shift to Isolated operation, Isolated operation is detected using the character shifted to frequency decided by frequency characteristics of power generator, and load characteristics of independent system.

Revisions	
2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. BT-01
	Paragraph	5	Generating Facilities (Others)	
	Clause			
Title	Electricity from Biomass			

Electricity from Bio mass

There are four primary classes of Bio Power systems: direct-fired, cofired, gasification, and modular systems. Most of today's Bio Power plants are **direct-fired** systems that are similar to most fossil - fuel fired power plants. The biomass fuel is burned in a boiler to produce high-pressure steam. This steam is introduced into a steam turbine, where it flows over a series of aerodynamic turbine blades, causing the turbine to rotate. The turbine is connected to an electric generator, so as the steam flow causes the turbine to rotate, the electric generator turns and electricity is produced.

While steam generation technology is very dependable and proven, its efficiency is limited. Biomass power boilers are typically in the 20-50 MW range, compared to coal-fired plants in the 100-1,500 MW range. The small capacity plants tend to be lower in efficiency because of economic trade - offs; efficiency-enhancing equipment cannot pay for itself in small plants. Although techniques exist to push biomass steam generation efficiency over 40%, actual plant efficiencies are in the low 20% range.

Cofiring involves substituting biomass for a portion of coal in an existing power plant furnace. It is the most economic near-term option for introducing new biomass power generation. Because much of the existing power plant equipment can be used without major modifications, cofiring is far less expensive than building a new BioPower plant. Compared to the coal it replaces, biomass reduces sulphur dioxide (SO_2), nitrogen oxides (NO_x), and other air emissions. After "tuning" the boiler for peak performance, there is little or no loss in efficiency from adding biomass. This allows the energy in biomass to be converted to electricity with the high efficiency (in the 33-37% range) of a modern coal-fired power plant.

Biomass gasifiers operate by heating biomass in an environment where the solid biomass breaks down to form a flammable gas. This offers advantages over directly burning the biomass. The biogas can be cleaned and filtered to remove problem chemical compounds. The gas can be used in more efficient power generation systems called combined-cycles, which combine gas turbines and steam turbines to produce electricity. The efficiency of these systems can reach 60%.

Gasification systems will be coupled with fuel cell systems for future applications. Fuel cells convert hydrogen gas to electricity (and heat) using an electro-chemical process. There are very little air emissions and the primary exhaust is water vapor. As the costs of fuel cells and biomass gasifiers come down, these systems will proliferate.

Modular systems employ some of the same technologies mentioned above, but on a **smaller scale** that is more applicable to villages, farms, and small industry. These systems are now under development and could be most useful in remote areas where biomass is abundant and electricity is scarce. There are many opportunities for these systems in developing countries.

Revisions	
2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. BT-02
	Paragraph	5	Generating Facilities (Others)	
	Clause			
Title	Bio Power Technologies			

Direct-fired Combustion
Biomass is the second-most utilized renewable power generation resource.
Most of today's Bio Power plants are direct-fired systems that are similar in concept to most existing fossil - fuel fired power plants.

Co-firing
Cofiring involves replacing a portion of the coal with biomass at an existing power plant boiler.
For utilities and power generating companies with coal-fired power plants, cofiring with biomass may represent one of the least-cost renewable energy options.

Gasification
Gasification is a major and unique element in the development of improved Bio Power systems. It is a thermochemical process that converts solid biomass raw materials to a clean fuel gas form. The fuel gas form allows biomass to use a wide range of energy conversion devices to produce power: gas turbines, fuel cells, and reciprocating engines.

Small Modular Bio Power
Modular Bio Power systems have the potential to help supply electric power to the more than 2.5 billion people in the world who currently live without it.

Revisions	
2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. PV-01
	Paragraph	5	Generating Facilities (Others)	
	Clause			
Title	Photovoltaic (PV) power generating systems			

Distributed generator:
It is as follows if PV system as Distributed generator is classified according to the scale and application.

Distributed generator

Scale;	Application;	Electricity;	*Size (scale);
Large-scale	Grid-connected systems	AC	1000kW more
Medium –scale	Grid-connected systems (Mini-Grid-connected systems)	AC	100kW-1000kW
Small-scale	Mini-Grid-connected systems Residential PV systems	DC/AC DC/AC	5kW-100kW
Very small-scale (A few kW in size)	Residential PV systems Solar home system (SHS)	DC/AC	10W—5kW

Thin photovoltaic (PV) systems convert sunlight into DC (direct-current) electricity, solid-state semiconductor devices called thin film PV modules.
The DC electricity Using DC-to-AC (alternating-current) inverter, it changes into AC power supply and connects with Grid.

A direct-current power supply is adapted for few equipment of power consumption, such as a power supply of an electric light and radio.

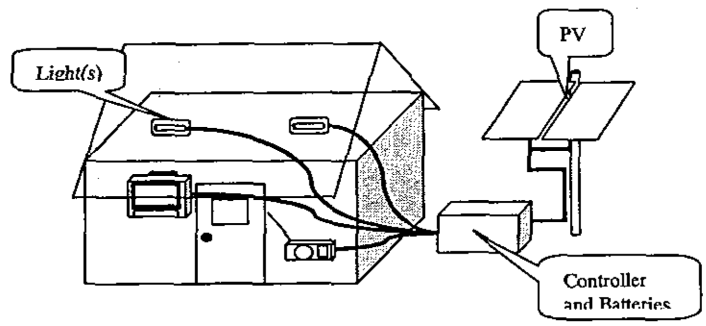
An alternating-current power is domestic and corresponds to the electric appliances with much power consumption which are, for example, use motors, such as a refrigerator, an air-conditioner, and a washing machine.

It was not established and the numerical value of *Size (scale) is a reference value.

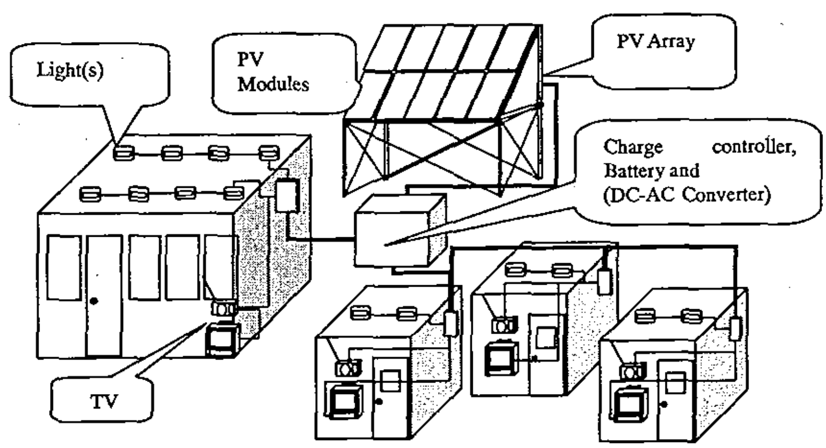
Revisions	
2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. PV-02
	Paragraph	5	Generating Facilities (Others)	
	Clause			
Title	Photovoltaic (PV) power generating systems			

Very small-scale Residential PV systems AC 100Wp
(A few kW in size) Solar home system (SHS)



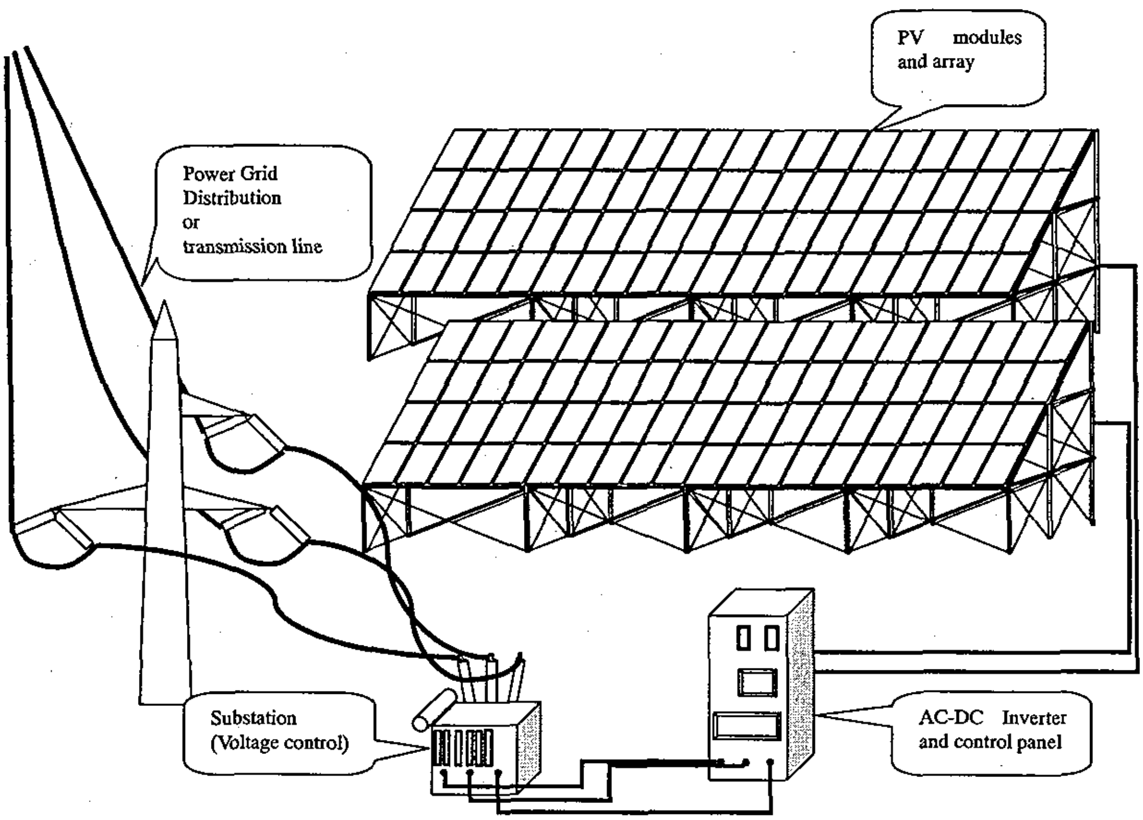
Small-scale
Mini-Grid-connected systems DC or AC 5kW-100kW
Residential PV systems



Revisions	
2003/Nov.	Original

Category				
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. PV03
	Paragraph	5	Generating Facilities (Others)	
	Clause			
Title	Photovoltaic (PV) power generating systems			

Large-scale	Grid-connected systems	AC	1000kW more
Medium –scale	Grid-connected systems (Mini-Grid-connected systems)	AC	100kW-1000kW

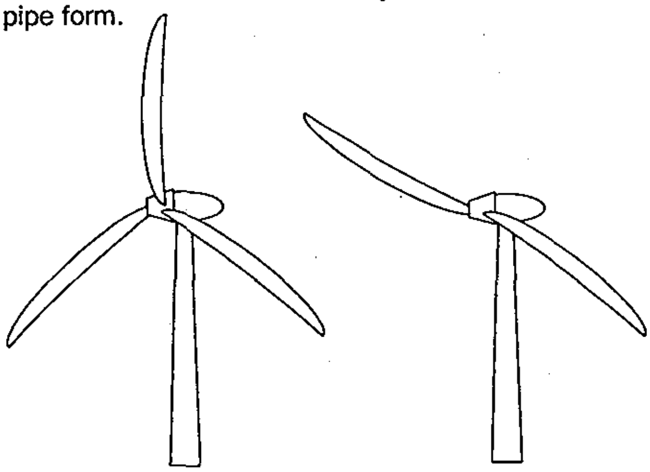


- The PV power Generating system must not affect the established quality and established reliability of electric power of Power System.
- Refer to the "Condition of Connection with Power System for Distributed Generator" for the matter cared about in the case of connecting distributed generator to power grid.

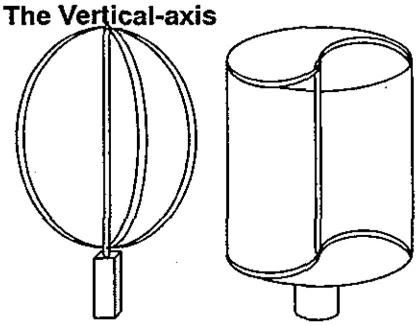
Revisions	
2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. WP-01
	Paragraph	5	Generating Facilities (Others)	
	Clause			
Title	Wind Power Generation			

Types of Wind Turbines;
The present wind power turbine can be classified into two fundamental groups.
-The horizontal-axis; The most popular wind power turbine of a type has stuck blades to a horizontal shaft like an airplane propeller.
-The Vertical-axis; The main systems are a Darrieus type like an egg whisk, and the Davoniusdesu type of a pipe form.



The Vertical-axis



Darrueus Type Savonius Type

The horizontal-axis

The typical Horizontal-axis wind turbines have two or three blades. These three-bladed wind turbines are operated "upwind" with the blades facing into the wind. The other common wind turbine type is the two-bladed *"downwind" turbine.*

Scale
-Small Scale Turbine
Below 50 (kW)kilowatts:
Single small turbines, below 50 kW, are used for homes, telecommunications, or water pumping. Small *turbines are sometimes used in connection with diesel generator(s), battery (batteries), and photovoltaic* system(s). These systems are called hybrid wind systems and are typically used in remote, off-grid locations, where a connection to the grid is not available.

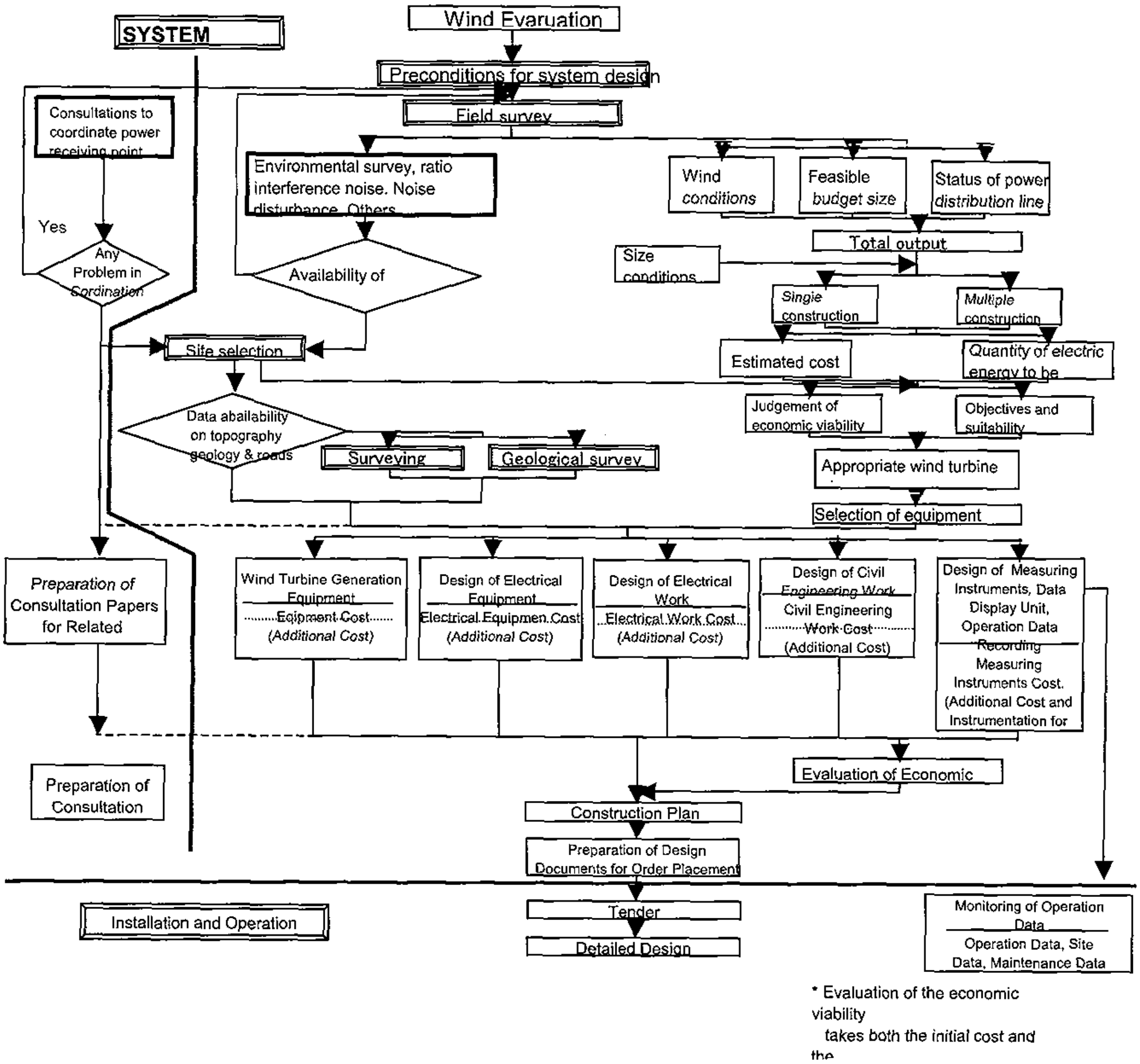
-Large Scale Turbine
50 kW to as large as several (MW) megawatts:
Utility-scale turbines range in size from 50 kW to as large as several MW.
Large-scale turbines supply electric power to electric grid(s).
If feeding the national grid, the rotation must be adjusted to synchronize the (AC) alternating current output with other operation(s) feeding the grid.
Power output is proportional to the area swept by the blades and to the cube of the wind speed. Because wind is intermittent, the average output (Declared Net Capacity) is 40% or less of the maximum.

Revisions	
2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. WP-02
	Paragraph	5	Generating Facilities (Others)	
	Clause			
Title	Wind Power Generation			

System Design, Installation and Operation
System Design, Installation and Operation flow chart is shown below.

Revisions	
2003/Nov.	Original



System Design Flow

JICA

GUIDEBOOK
FOR
POWER ENGINEERS

English Edition

VOL. No.5

HIGH VOLTAGE

TRANSMISSION SYSTEM

Dec. 2003

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

GUIDEBOOK FOR POWER ENGINEERS

High Voltage Transmission System

Document No.	Title
TS-1	Criteria for Network Operation
TS-2	Operational Planning
TS-3	Operating Reserve
TS-4	Network Maintenance Scheduling
TS-5	Record and Analysis of System Accident
TS-6	Emergency Operations
TS-7	System Restoration
TS-8	Notes for International Interconnection
TS-9	Outline of Load Dispatching Center and Control System
TS-10	Example of SCADA and Related Systems
SS-1	Composition of Power System
SS-2	System Planning
SS-3	Basis of Standard Voltage
SS-4	Standard Test Voltage
SS-5	Installation of fire-extinguishing Equipment
SS-6	Temperature-rise Limit of Transformers
SS-7	Safety of Personnel
SS-8	Safety of Third Persons
SS-9	Floods Design for Substations
SS-10	Mitigation Measures for Environmental Impact
SS-11	Protective Relay System
SS-12	Grounding for Substations
SS-13	Installation of Surge Arresters

TL-29	Clearance among Conductors and Others
TL-30	Measures for Electrostatic and Electromagnetic Inductive Interference

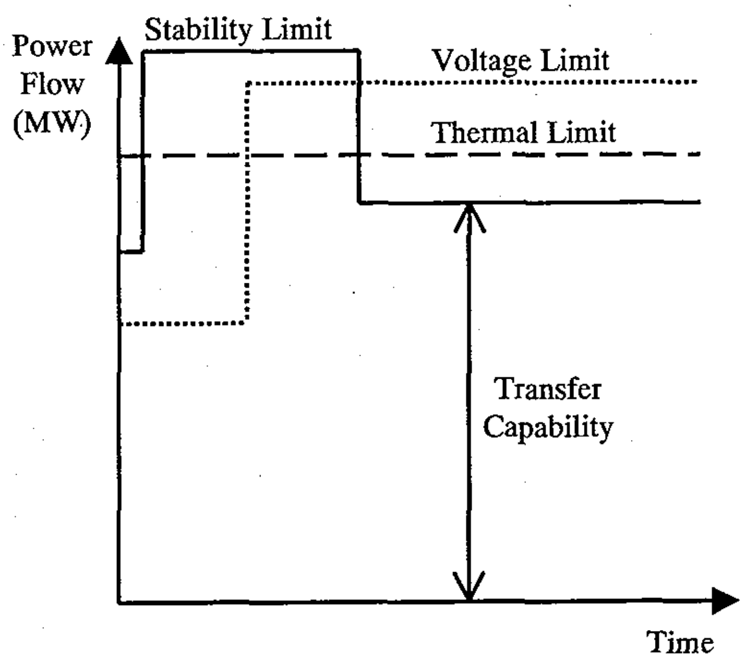
Category	Chapter	1	General Provisions	Document No. TS1
	Paragraph	3	Quality of Electric Power	
	Clause			
Title	Criteria for Network Operation			

The criteria for Network operation should be as follows:

The HV transmission networks should be planned such that they are able to operate at all load levels without causing system instability, cascading, or interruption of load in the event of an outage (whether scheduled or unscheduled).

The transfer capability of the transmission network may be limited by the physical and electrical characteristics of the systems including thermal, voltage, and stability considerations.

Transfer Capability = Minimum of {Thermal Limit, Voltage Limit, Stability Limit}



Limits to Total Transfer Capability

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No. TS2-1
	Chapter	1	General Provisions	
	Paragraph	3	Quality of Electric Power	
	Clause			
Title	Operational Planning (1/2)			

The National Transmission Licensee should co-ordinate the outages of generating units, external interconnections and the network while:

a) maintaining sufficient generating units and adequate Network capacity to meet forecast demand, operating reserve and transmission requirement
b) minimizing the generation and transmission cost.
Unit commitment by taking into account each Generator's incremental cost and penalty factor

Basic Concept of Economic Dispatch

Economic Dispatch is the process of allocating the required load demand between the available generation units such that the cost of operation is minimized.

Generation Models
The electric power system representation for Economic Dispatch consists of models for the generating units and can also include models for the transmission system. The generation model represents the cost of producing electricity as a function of power generated and the generation capability of each unit. We can specify it as:

1. Unit cost function:

$$F_i = F_i(P_i) \quad (1)$$

where F_i: production cost, P_i: production power

2. Unit capacity limits

$$P_i \le P_{imax}$$
$$P_i \ge P_{imin} \quad (2)$$

3. System Constraints (demand – supply balance)

$$\sum_{i=1}^{N} P_i = D \quad (3)$$

Remarks	Revisions	
	2003/Nov.	Original

Formulation of the Lagrangian

We are now in a position to formulate our optimization problem. We desire to minimize the total cost of generation subject to the constraints on individual units' capacity (2) and the power balance constraint (3). We have:

Minimize: $\sum_{i=1}^{N} F_i(P_i)$

The Lagrangian function, then, is:

$$L = \sum_{i=1}^{N} F_i(P_i) - \lambda\left(\sum_{i=1}^{N} P_i - D\right) \qquad (4)$$

The Lagrangian function of (4) results in:

$$\frac{\delta F_i(P_i)}{\delta P_i} = \lambda \qquad (5)$$

$$\sum_{i=1}^{N} P_i - D = 0 \qquad (6)$$

The unknowns in these equations include the generation levels P_1, $P_2 \ldots P_n$ and the Lagrange multipliers λ, a total of (n+1) unknowns. We note that (5) provides n equations, (6) provides one equation. Thus, we have a total of (n+1) equations.

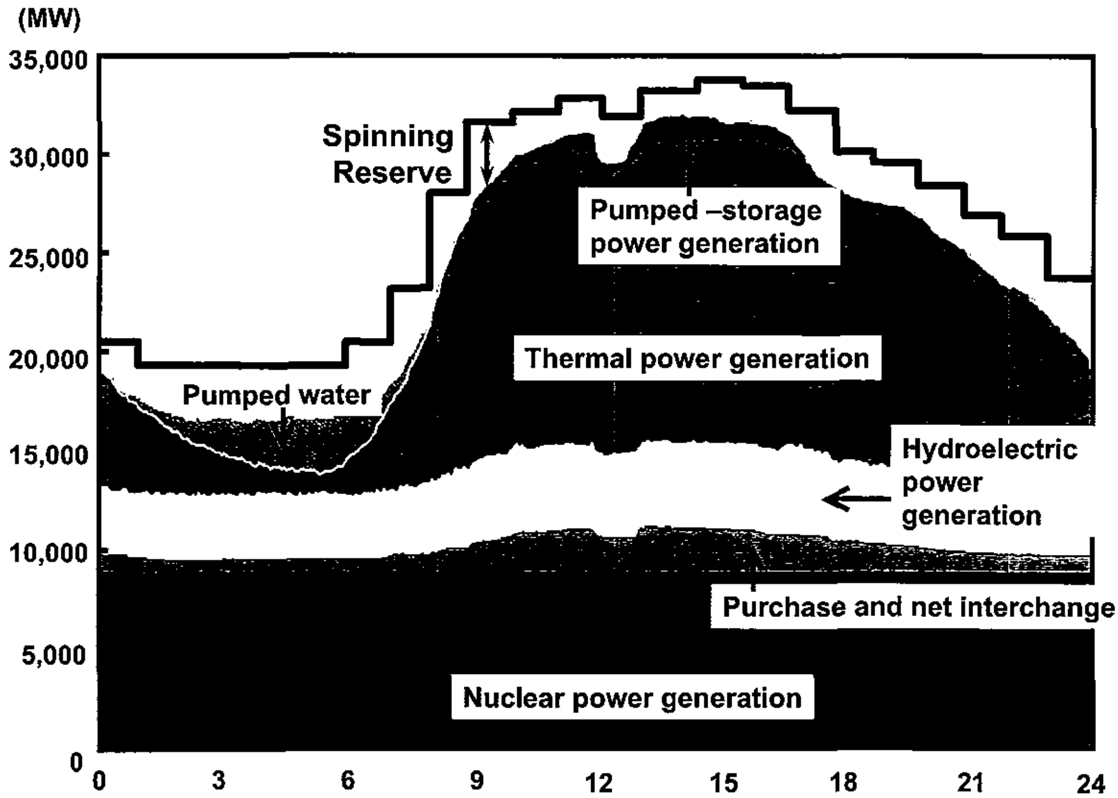
Category	**Chapter**	1	General Provisions	**Document No. TS3**
	Paragraph	3	Quality of Electric Power	
	Clause			
Title	Operating Reserve			

The National Transmission Licensee should operate the System's MW power resources to provide for a margin of Operating Reserve sufficient to account for such factors as error in forecasting, generation and transmission equipment unavailability, the number and size of generating units, the generating unit forced outage rates, and the requirement for load frequency regulation.

Operating Reserve consists of Spinning Reserve and Contingency Reserve.

SPINNING RESERVE
Spinning Reserve is the additional capacity of synchronized Generating Units sensitive to the frequency.

CONTINGENCY RESERVE
This is the output from the Generating Units, which can be fully available within a specific time from time of a frequency change.(Ex. for specific time) : 10 minutes



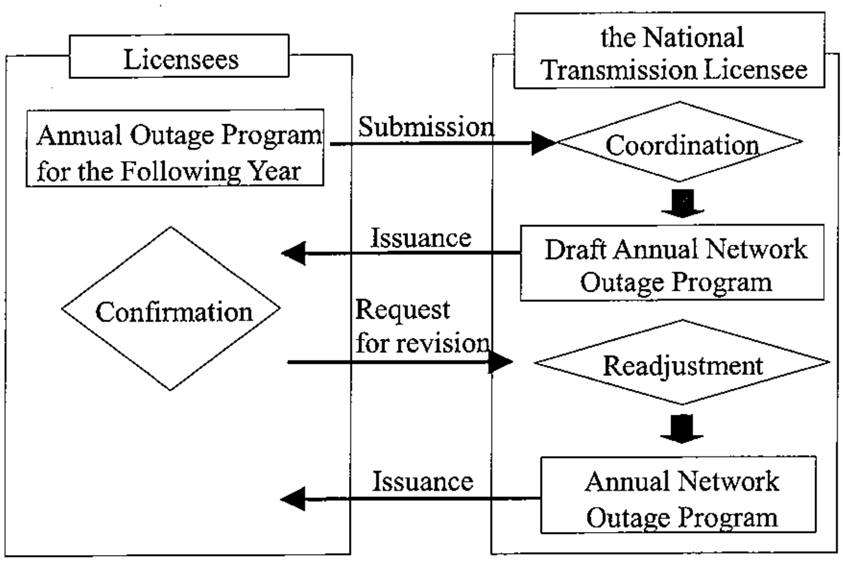
Ex. Typical Load Curve (Heavy Load Period) in Kansai, Japan

Remarks	Revisions	
Referring to the Annual Report of the KANSAI Electric Power Co., Inc.		
	2003/Nov.	Original

Category	Chapter	1	General Provisions	Document No. TS4
	Paragraph	3	Quality of Electric Power	
	Clause			
Title	Network Maintenance Scheduling			

Generation Licensees, Transmission Licensees, and Distribution Licensees who are connected to the National Transmission Network, should submit an annual planned transmission and distribution equipment outage program for the following year to the National Transmission Licensee.

The National Transmission Licensee co-ordinates all the current year submissions, taking into account the required system security, conditions of maintenance works and the Annual Overhaul Program for the following year.



Flow Diagram for Network Maintenance Scheduling

Remarks	Revisions	
Referring to the standards of the KANSAI Electric Power Co., Inc.		
	2003/Nov.	Original

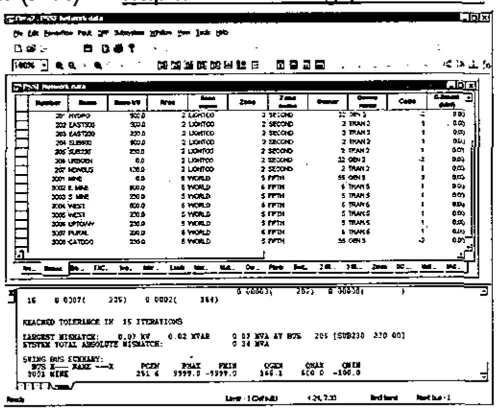
Category	**Chapter**	1	General Provisions	**Document No. TS5**
	Paragraph	3	Quality of Electric Power	
	Clause			
Title	Record and Analysis of System Accident			

The National Transmission Licensee should record information about faults or disturbance and analyze the causes to reduce the risk of the recurrence as to the National Transmission Network.

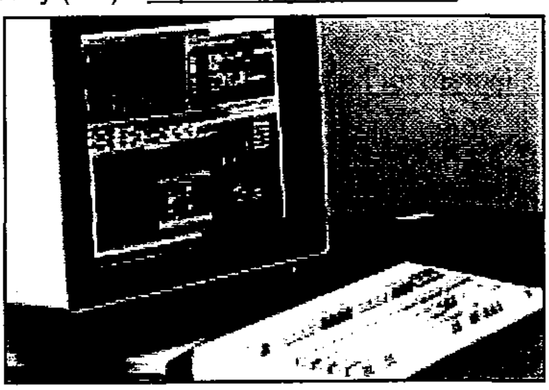
Requirements for the installation of disturbance monitoring equipment (e.g., sequence-of event, fault recording, and dynamic disturbance recording equipment) which can record and monitor data necessary to determine system performance and the causes of system disturbances should be established by the National Transmission Licensee.

The monitored data should be used to validate generator models and steady-state and dynamic system simulations.
As simulation software, PSS/E (PTI) and Power Systems Analysis Software (GE) are taken, for instance.

PSS/E:
Power Technologies, Inc. (PTI) http://www.shawgrp.com/PTI/



Power Systems Analysis Software (PSLF, PSDS, SCSC):
General Electric Company (GE) http://www.gepower.com/



Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	1	General Provisions	**Document No. TS6**
	Paragraph	5	Prevention of Electric Power Outage	
	Clause	13	Prevention of Electric Power Outage	
Title	Emergency Operations			

The National Transmission Licensee should develop, maintain, and implement a set of plans to cope with operating emergencies.

When an emergency occurs, appropriate action must be taken to relieve any abnormal conditions.

The emergency plans should consider the following items:

1. Fuel Supply and inventory
   An adequate fuel supply and inventory plan which recognizes delays or problems in the delivery or production of fuel.
2. Environmental constraints
   Plans to seek removal of environmental constraints for generating units and plants.
3. Public appeals
   Appeals to the public through all media for voluntary load reductions and energy conservation including educational messages on how to accomplish such load reduction and conservation.
4. Load management
   Implementation of load management and voltage reductions, if appropriate.
5. Optimize fuel supply
   The operation of all generating sources to optimize the availability of the fuel in short supply.
6. Appeals to large customers
   Appeals to large industrial and commercial customers to reduce non-essential energy use and start any customer-owned back-up generation
7. Interruptible and curtailable loads.
   Use of interruptible and curtailable customer load to reduce capacity requirements or to conserve the fuel in short supply
8. Maximizing generator output and availability
   Operation of all generating sources to maximize output and availability.
9. Load Curtailment
   A mandatory load curtailment plan to use as a last resort. This plan should address the needs of critical loads essential to the health, safety, and welfare of the community.
10. Notifications to government agencies
    Notifications to appropriate government agencies as the various steps of emergency plan are implemented.
11. Other Necessary Matters

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	1	General Provisions	**Document No. TS7**
	Paragraph	5	Prevention of Electric Power Outage	
	Clause	13	Prevention of Electric Power Outage	
Title	System Restoration			

The National Transmission Licensee should develop and periodically update a logical plan to reestablish the National Transmission Network in a stable and orderly manner in the event of a partial or total shutdown of the Network.

System restoration procedures should be verified by actual testing or by simulation. Operating personnel shall be trained in the implementation of the plan.

The figure shown below presents the general steps that are performed to restore a system disturbance.

1. Ascertain System Status

↓

2. Determine and Implement Restoration Process

↓

3. Disseminate Information

1. Ascertain System Status
After a system disturbance occurs that results in a significant loss of customer load in a widespread area, it is important to determine transmission and generation loss, equipment damage, and the extent of the service interruption.
Any information deemed essential to facilitate the restoration process must be conveyed to the necessary staff.

2. Determine and Implement Restoration Process
This step is performed after the status of the system is determined.
The appropriate personnel determine restoration process based on system status, and begin implementation.

3. Disseminate Information
The purpose of this step is to provide updated information of the system status to appropriate personnel. After system restoration plans are established and implemented, all participants must be apprised of system conditions.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	1	General Provisions	Document No. TS8
	Paragraph	3	Quality of Electric Power	
	Clause			
Title	Notes for International Interconnection			

The National Transmission Licensee must comply with the power purchase contract among countries.
In the technical point of view, followings should be considered;

Operation Standard
Operation Standard should be matched among countries to be interconnected, in case where there is difference in operation standard.

Ref. Operation Standard of Adjacent Countries

	Thailand	Vietnam	Laos
Voltage (%)	+5, -2	±5	±5
Frequency (Hz)	±0.1	±0.2	±0.5

Load Frequency Control
Load Frequency Control Method should be established in whole-connected countries, because the frequency depends on a balance between demand and supply in the whole area.

Normal Operation
The NERC has adopted TBC (Tie Bias frequency Control) operation under which each area intends to control its balance between demand and supply.
Emergency Operation
Operation ways in case of emergency, such as rapid frequency drop due to huge generator accident, which could induce cascading drop of generators, should be determined in advance.
Ex: Disconnection of interconnection in case of frequency drop.

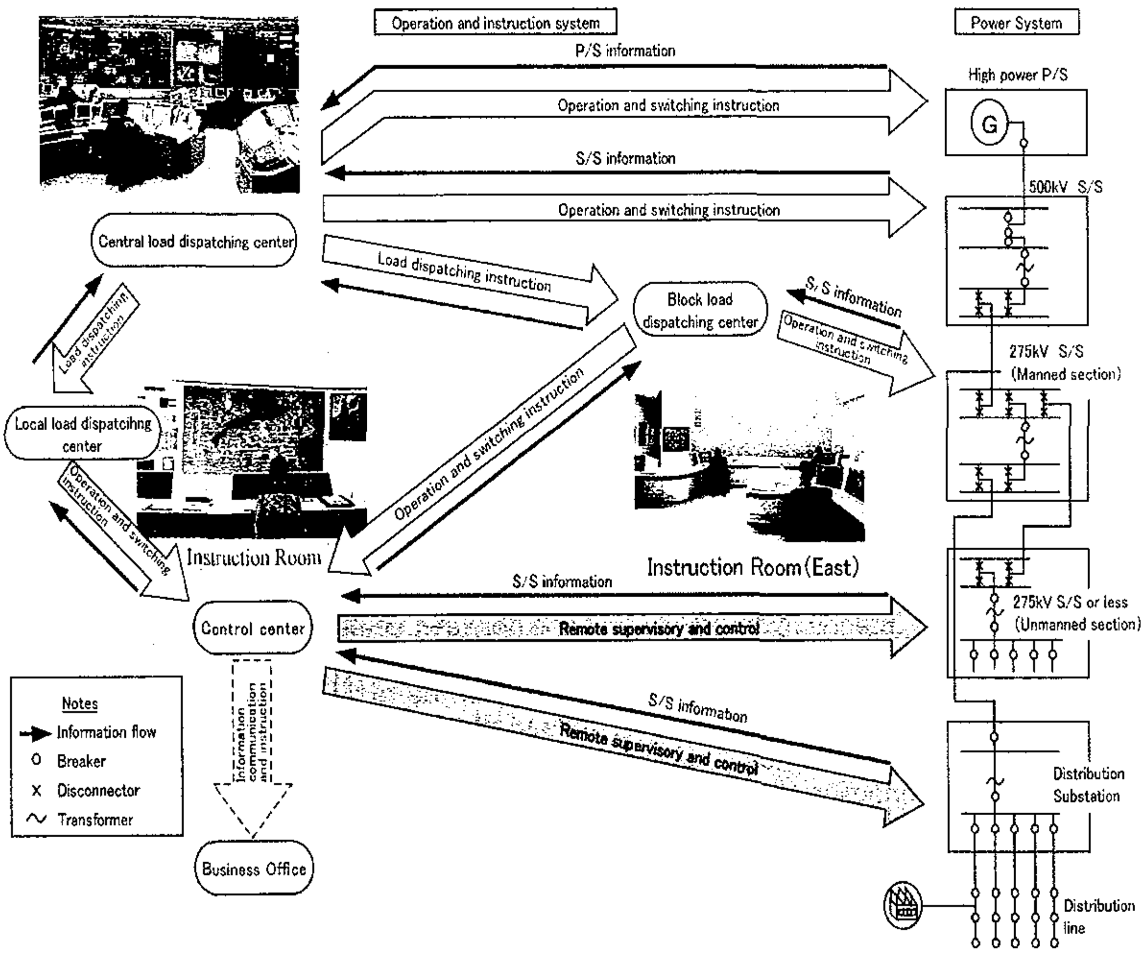
Communication lines
Communication lines are needed to exchange information among interconnected countries.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	1	General Provisions	Document No. TS9
	Paragraph	3	Quality of Electric Power	
	Clause			
Title	Outline of Load Dispatching Center and Control System			

Power system should be operated to ensure stable power supplies, with well-balanced power production and consumption all the time.

The Load Dispatching Center and Control System should be enhanced as the increase of demand. For reference, the outline of Load Dispatching Center and Control System in Kansai, Japan is shown below.



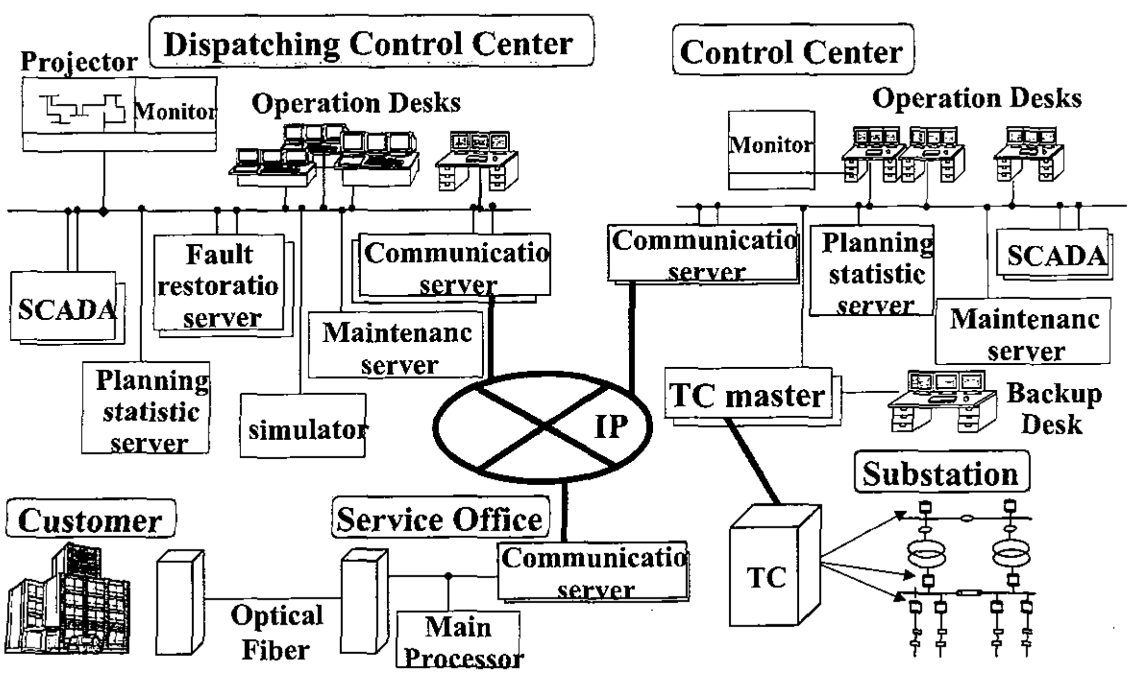
Remarks	Revisions	
Referring to the standards of the KANSAI Electric Power Co., Inc.		
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TS10**
	Paragraph	5	Transmission and Distribution Facilities	
	Clause	38	SCADA System for Load Dispatching Center	
Title	Example of SCADA and Related Systems			

The National Transmission Licensee and the participants in the National Grid should have at least two different means of communication between the dispatching center of the National Transmission Licensee and other electrical facilities e.g. substations, switching stations and power plants. Furthermore, the National Transmission Licensee and the participants in the National Grid should have an appropriate data acquisition system, which should be able to monitor conditions of the system and record information about faults or disturbance, and might be able to control the system, if necessary.

When an emergency occurs, appropriate action will be taken with the communication means and the data acquisition system.

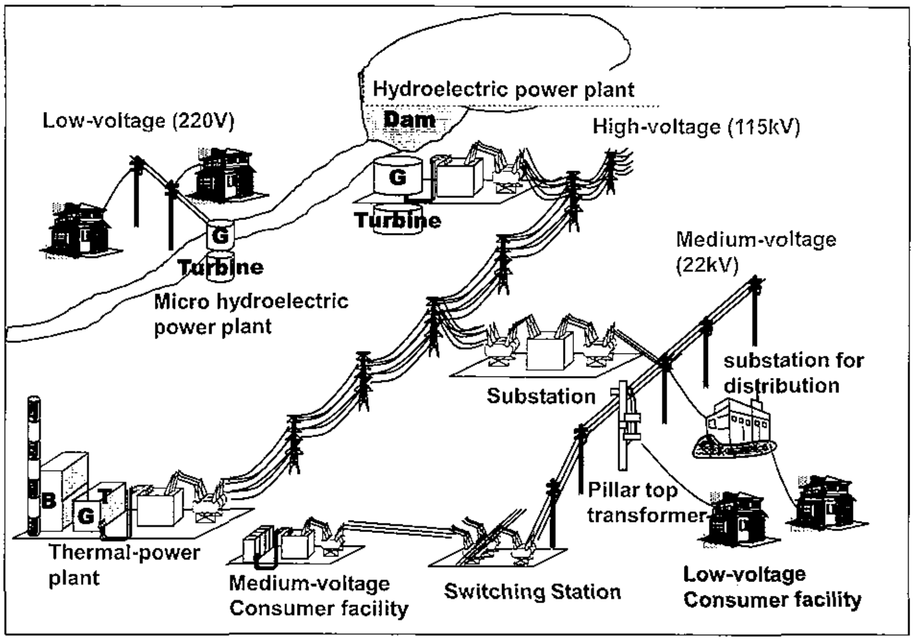
SCADA is an abbreviation of Supervisory Control and Data Acquisition. An example of SCADA and Related Systems is described below.



Remarks	Revisions	
Referring to the standards of the KANSAI Electric Power Co., Inc.		
	2003/Nov.	Original

Category	Chapter	1	General Provisions	Document No. SS1-1
	Paragraph	1	Definitions	
	Clause	1	Definitions	
Title	Composition of Power system (1/2)			

Composition of Power system



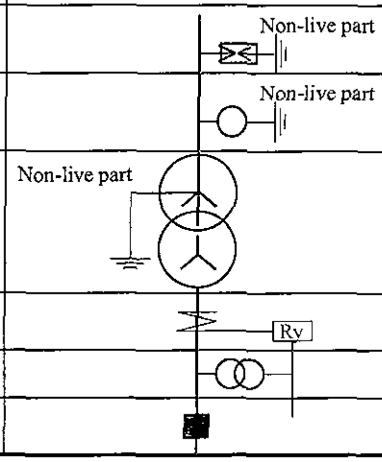
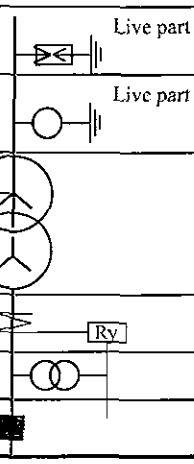
Classification of Power Facilities

Terms			Example of Facilities
Electrical Power Facilities	Generating Facilities	Electrical Equipment	Inlet valve, Turbine, Generator, Transformer, Switching device, measuring system
		Structure	Dam, water way
		Building	Power house, Control room
		Others	Fence, Fuel storage yards, Ash disposal areas
	Substations Switching Stations	Electrical Equipment	Transformer, Switching device, Surge arrester, Monitoring and control system, Conductor, Cable, Supporting structure for bus bar, Conduit
		Building	Control room
		Others	Fence
	Electrical Lines	Electrical Equipment	Conductor, Insulator, Cable, Insulated conductor, Supporting structure, Ground wire, Conduit
		Others	Fence
	Dispatching Center	Structure	Control room

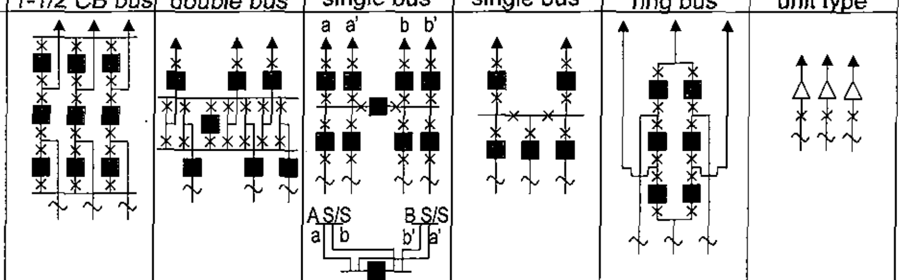
Remarks	Revisions	
	2003/Nov.	Original

Category				Document No. SS1-2
	Chapter	1	General Provisions	
	Paragraph	1	Definitions	
	Clause	1	Definitions	
Title	Composition of Power system (2/2)			

A substation is composed with surge arresters, grounding switchs, transformers, current transformers, potential transformers, circuit breakers, and so on.

Electrical equipment	SLD under normal condition	SLD under abnormal condition
Surge arrester	 Non-live part	 Enter the lightning impulse; Live part
Grounding switch	Non-live part	Close the switch; Live part
Transformer	Non-live part	Live part; Occur the ground fault
CT	Ry	Ry
PT		
Circuit breaker		

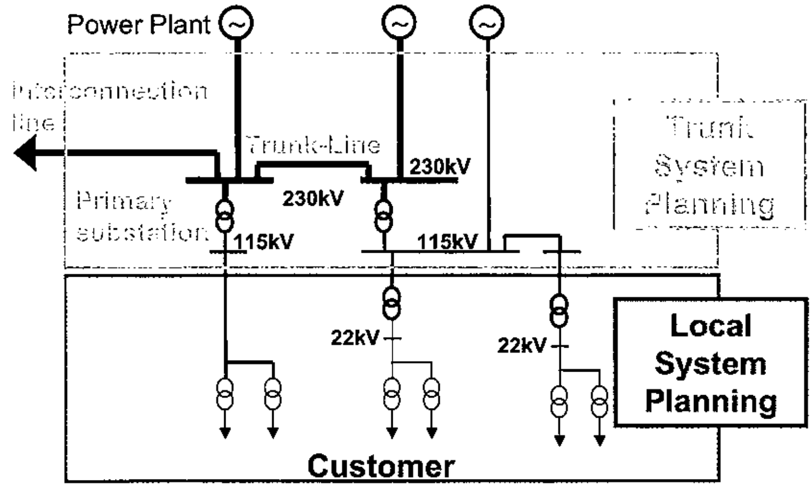
Properties of Bus Connection Schemes

item	1-1/2 CB bus	double bus	single bus	single bus	ring bus	unit type
Basic Configuration						
Reliability (N-1 Criterion)	O	O	Δ Except for Bus's outage	Δ Except for Bus's outage	O	×
Future Expansion	O	O	Δ Scheduled outage of a bus is difficult	Δ Scheduled outage of a bus is difficult	×	O
Costs	×	×	O	O	×	O
Total Evaluation						
Primary substation	O	O	Δ	Δ	Δ	×
Secondary/ distribution substation	×	×	O	O	×	O

Remarks	Revisions	
O: good, Δ: fair, X: bad		
	2003/Nov.	Original

Category				Document No. SS2
	Chapter	1	General Provisions	
	Paragraph	3	Quality of Electric Power	
	Clause			
Title	System Planning			

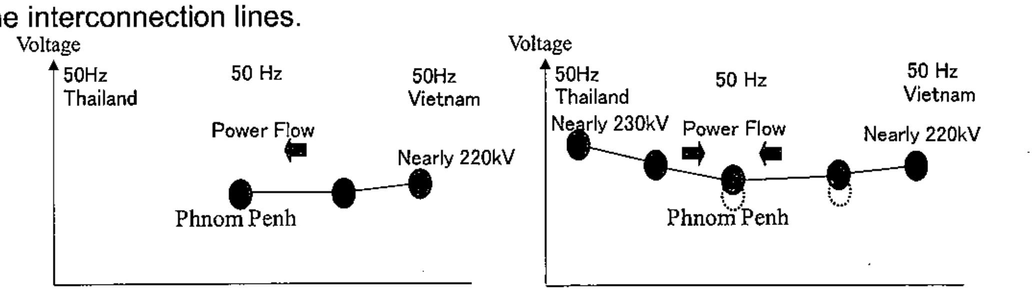
Main factors for system planning are reliability, quality, costs, and future expansion. Generally, transmission system is classified as described below, Trunk System and Local System. Priority for system planning should be desided according to the class of the system.



Reliability should be a first priority for Trunk System Planning. The system planning should be carried out taking into consideration not only thermal limit, but also stability, frequency drop, short-circuits capacity, etc.

[supplementary explanation, Interconnection with Vietnam (220kV)]
The voltages (220kV, 230kV) are just nominal voltages and not operation voltages. Therefore, it is possible to interconnect Thailand system (230kV) with Vietnam system (220kV) via Cambodian system (230kV) with proper operation planning and/or installing proper capacity of capacitance and/or reactance. Furthermore, at substations near the Vietnam border, it might be necessary that taps of the transformers have enough margins.

It is important to simulate future system conditions and estimate capacity of capacitance and/or reactance necessary for stable and flexible operation prior to the construction of the interconnection lines.



Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	1	General Provisions	Document No. SS3
	Paragraph	3	Quality of Electric Power	
	Clause	6	Voltage	
Title	Basis of Standard Voltage			

Nominal Voltage
"Nominal Voltage" is voltage by which a system is designated, provided in **IEC 60038**.

Highest Voltage
"Highest Voltage" is allowable highest voltage for equipment in normal condition, provided in **IEC 60038**.

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No. SS4
	Chapter	1	General Provisions	
	Paragraph	3	Quality of Electric Power	
	Clause	6	Voltage	

Title	Standard Test Voltage

Standard test voltages, which are decided in accordance with foreseen overvoltages, are shown as follows, provided in **IEC60071-1** (Insulation co-ordination) .

Standard Test Voltages

Nominal system voltage	Highest voltage for equipment	Standard short-duration power frequency withstand voltage	Standard switching impulse withstand voltage (*1)	Standard lightning impulse withstand voltage
Un	Um	ACSD	SIWV	LIWV
kV, L-L rms	kV, L-L rms	kV, L-L rms	kV, L-E peak	kV, L-E peak
115	123	230 Applies(*2)	---	550 Applies
230	245	360,395 Applies(*2)	---	950 Applies

(*1) Insulation strength against switching impulse may be confirmed by the lightning impulse test. (In IEC, the switching impulse test applies as to the 500kV electrical equipment.)

(*2) Either the short-duration power-frequency test or the long-duration power-frequency test (ACLD) shall be applied taking the time characteristics of insulation capability into consideration.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	1	General Provisions	Document No. SS5-1
	Paragraph	4	Prevention of Electric Power Disasters	
	Clause	9	Prevention of Electric Power Disasters	
Title	Installation of fire-extinguishing Equipment (1/2)			

Fire prevention equipment described below should be installed at substations and switching stations.

1. Clearance or a firewall between transformers
   As for high-voltage transformers, the clearance should be as follows. If a firewall is installed between transformers, the clearance is not necessary.

Clearance between a Transformer and Other Transformers or Buildings

Liquid Volume	With other transformers [m]	With fireproof buildings [m]	With non-fireproof buildings [m]
Over 1,000 L, but not exceeding 2,000 L	3	3	7.6
Over 2,000 L, but not exceeding 20,000 L	5	5	10
Over 20,000 L, but not exceeding 45,000 L	10	10	20
Over 45,000 L	15.2	15.2	30.5

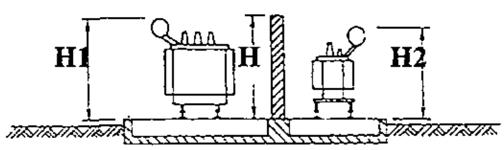
IEC61936-1: Power installations exceeding 1kV a.c. - Part1: Common rules

The firewalls should be installed as follows,

a. The firewalls should be self-supporting and withstand fire for one hour.
b. The height and length are the value shown in following figure.

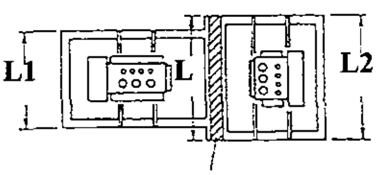
Reference to <u>IEC 619361 Ed1/CVD (IEC TC99)</u>

H: Height



H≧H1 (withH1>H2)

L: Length



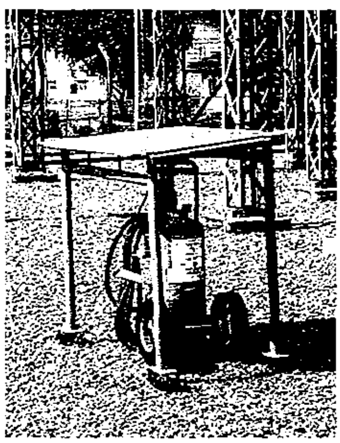
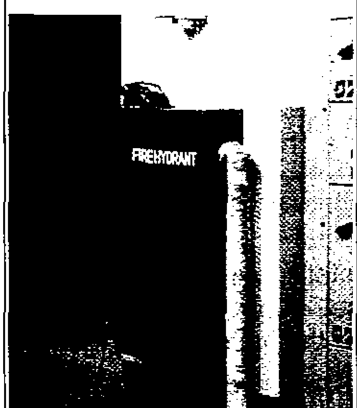
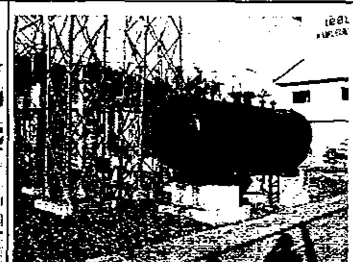
L≧L2 (withL2>L1)

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	1	General Provisions	Document No. SS5-2
	Paragraph	4	Prevention of Electric Power Disasters	
	Clause	9	Prevention of Electric Power Disasters	
Title	Installation of fire-extinguishing Equipment (2/2)			

2. Appropriate extinguishers

Appropriate fire-extinguishing equipment should be applied according to size and importance of substations.

Fire extinguisher	**Hydrant**	**Sprinkler system**
Small-scale fire	Large-scale fire	Transformer
		 

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No. SS6-1
	Chapter	1	General Provisions	
	Paragraph	4	Prevention of Electric Power Disasters	
	Clause	9	Prevention of Electric Power Disasters	
Title	Temperature-rise limit of Transformers (1/2)			

The temperature-rise limit of transformers is as follows, according to **IEC 60076-2: Power transformer-Part: Temperature rise.**

Temperature-rise Limits for Oil-immersed Type Transformers

Temperature-rise limit at the top of insulation oil	**60K**
Temperature-rise limit of a winding (Normally measured by the resistance)	**65K,** For transformers identified as ON.. or OF.. **70K,** For transformers identified as OD..

The temperature-rise limits are valid for transformers with solid insulation designed as class A according to IEC 85, and immersed in mineral oil or synthetic liquid with fire point not above 300°C (first code letter:O)

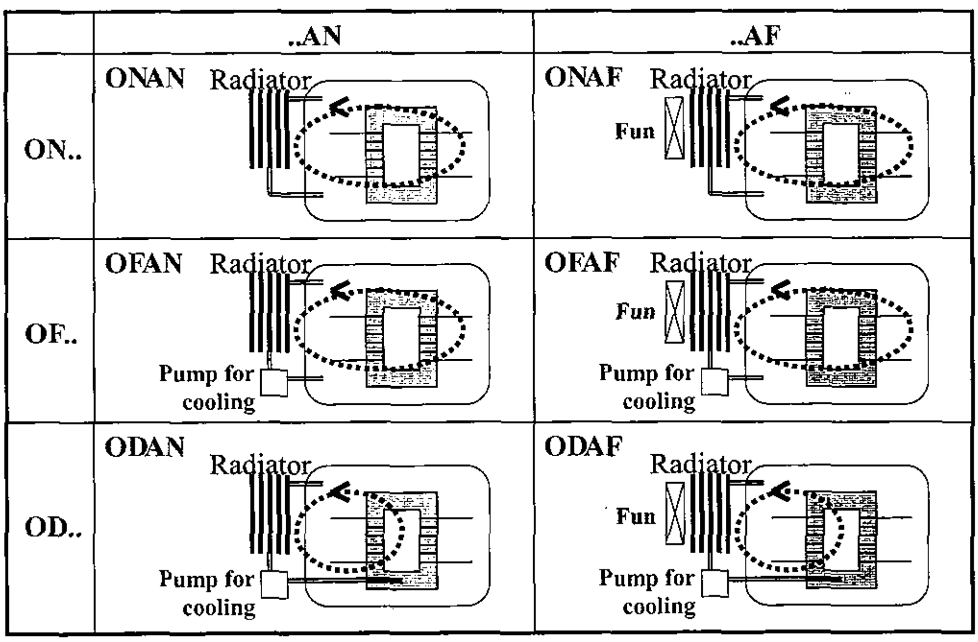
Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	1	General Provisions	**Document No. SS6-2**
	Paragraph	4	Prevention of Electric Power Disasters	
	Clause	9	Prevention of Electric Power Disasters	
Title	Temperature-rise limit of Transformers (2/2)			

[supplementary explanation]

ONAN: Oil-immersed naturally cooled type,**OFAN**: Forced-oil naturally-cooled type

Order of symbol	Explanation	Symbol	*Kind of cooling medium and its circulation* mechanism
First letter	Internal cooling medium in contact with winding and core	O	Mineral Oil or synthetic liquid with fire point of 300 ℃ or below.
		A	Air
		G	Gas (e.g. sulfur hexafluoride SF6)
Second letter	Circulation mechanism for internal cooling medium	N	Natural (Natural thermo-siphon flow through cooling equipment and in winding)
		F	Forced circulation through cooling equipment, thermo-siphon flow winding
		D	Forced circulation through cooling equipment, Directed from them into at least the main winding
Third letter	External cooling	A	Air
		W	Water
Fourth letter	Circulation mechanism for external cooling medium	N	Natural convection
		F	Forced circulation (cooling fans, blowers, pumps)



AN : No Fun

ON : Circulation is natural and not forced.

OF : There is a forced circulation system through cooling equipment, but not any forced circulation system into winding.

OD : There is not only a forced circulation system through cooling equipment, but also a forced circulation system into winding.

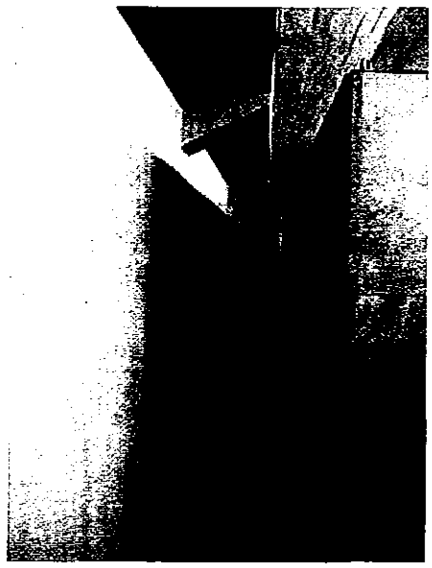
Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	1	General Provisions	**Document No. SS7-1**
	Paragraph	4	Prevention of Electric Power Disasters	
	Clause	10	Prevention of Accidents Caused by Electric Power Facilities	
Title	Safety of Personnel (1/3)			

1. Patrol Aisles

Patrol aisles and other maintenance spaces should be taken to enable operators/workers to operate and safely carry out maintenance.

Width of an aisle should be 800mm wide or more in accordance with **IEC 61936-1** (behind metal-closed equipment needs 500mm).



Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.SS7-2
	Chapter	1	General Provisions	
	Paragraph	4	Prevention of Electric Power Disasters	
	Clause	10	Prevention of Accidents Caused by Electric Power Facilities	
Title	Safety of Personnel (2/3)			

2. Prevention of contact with facilities
Appropriate measures should be taken to prevent operators/workers from easily contacting live parts of facilities.

a. Installation of protective fences or walls

b. Installation of signs at the entrances/exits

c. Installation of a locking device or another appropriate device at the entrances/exits

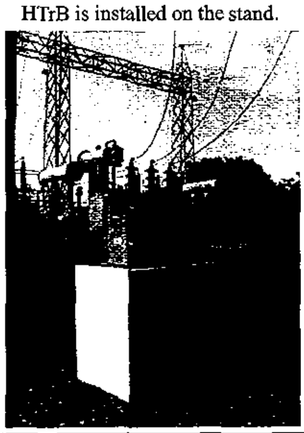
[*Supplementary Explanation of " a. Installation of protective fences or walls "*]
Appropriate measures listed below should be taken where the height of live parts of electrical equipment is N+2,250 mm or less.
These are based on **IEC 619361 Ed1/CVD (IEC TC99).**

Minimum insulating clearance

Highest voltage for equipment [kV]	Minimum line-to-ground insulating clearance N[mm]
123	1100
245	1900

Distance/clearance from fence or wall to live

Structure of protective fence or wall	Protective barrier clearance [mm]
Wall without opening	N
Fence (Highest Voltage is 52kV or less)	N+80
Fence (Highest Voltage is over 52kV)	N+100

<table>
<tr><th>Live parts is higher than N+2,250mm</th><th colspan="2">Live parts is lower than N+2,250mm</th></tr>
<tr><td rowspan="2">HTrB is installed on the stand.
</td><td>HTrB is enclosed by the metal-fence</td><td></td></tr>
<tr><td>Live parts on the HTrB is covered by the wire mesh.</td><td></td></tr>
</table>

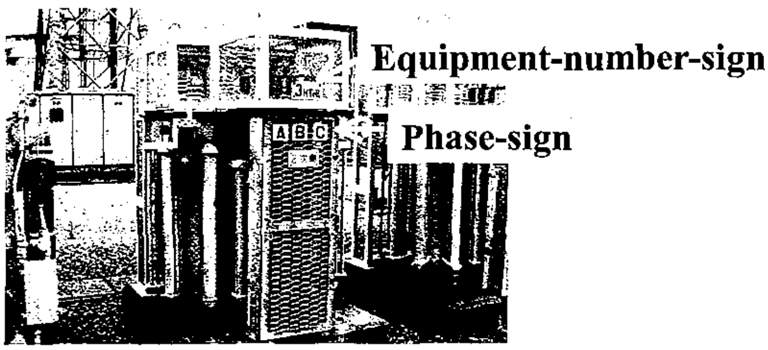
HTrB: Station service transformer

Remarks	Revisions	
	2003/Nov.	Original

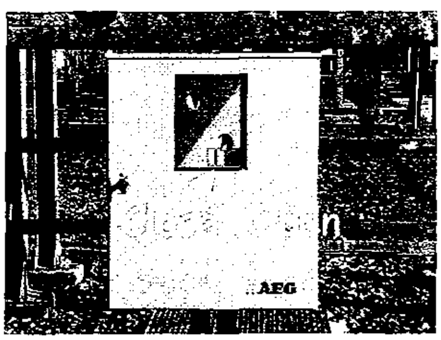
Category	**Chapter**	1	General Provisions	**Document No.SS7-3**
	Paragraph	4	Prevention of Electric Power Disasters	
	Clause	10	Prevention of Accidents Caused by Electric Power Facilities	
Title	Safety of Personnel (3/3)			

1. Countermeasures for failures of maintenance
   Appropriate measures should be taken to prevent operators/workers from doing faulty maintenance and/or operation, as follow.

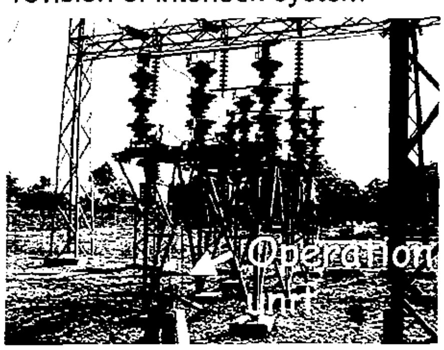
   (1) Provision of clear phase-signs and equipment-number-signs



   (2) Provision of indicators showing switching status



   (3) Provision of interlock system



Remarks	Revisions	
	2003/Nov.	Original

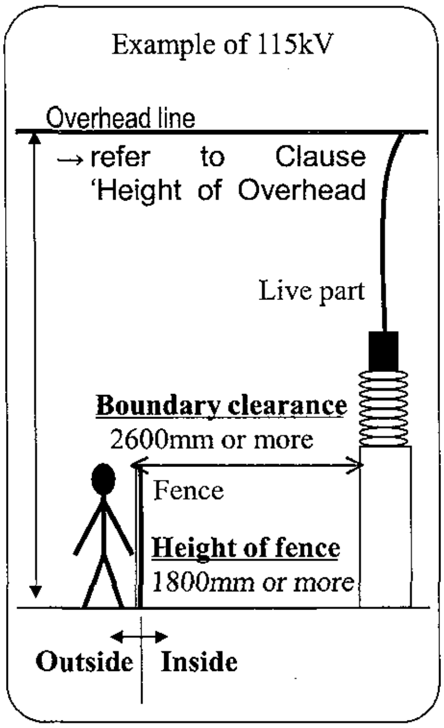
Category				Document No. SS8
Category	Chapter	1	General Provisions	Document No. SS8
	Paragraph	4	Prevention of Electric Power Disasters	
	Clause	11	Safety of Third Persons	
Title	Safety of Third Persons			

1. Following measures should be taken to prevent the danger of third persons at substations and switching stations.

   (1) External fences and walls

   Height of external fences or walls should not be lower than 1,800 mm. Boundary clearance should not be smaller than the values described in following table. These values are base on **IEC 619361 Ed1/CVD (IEC TC99)**.

Nominal voltage [kV]		Boundary clearance [mm]	Minimum line-to-ground insulating clearance N[mm]
160 kV or less	115	Wall: N+1,000	1100
Over 160kV	230	Fence: N+1,500	1900



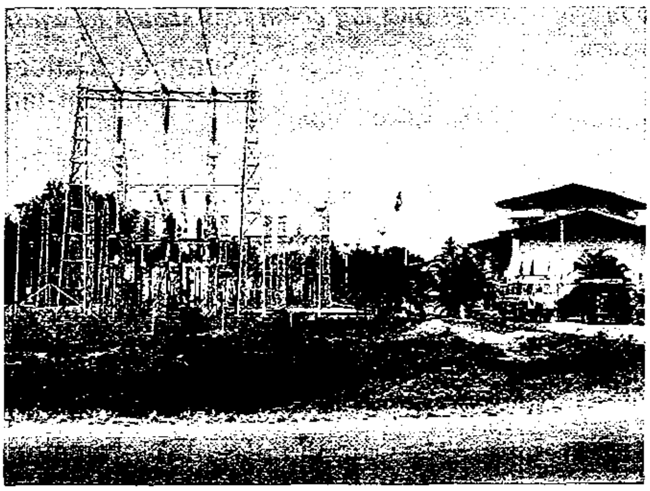
   (2) Signs to make third persons recognize danger should be installed at the entrances/exits.

   (3) Locking devices or other appropriate devices should be installed at the entrances/exits.

Remarks	Revisions	
	2003/Nov.	Original

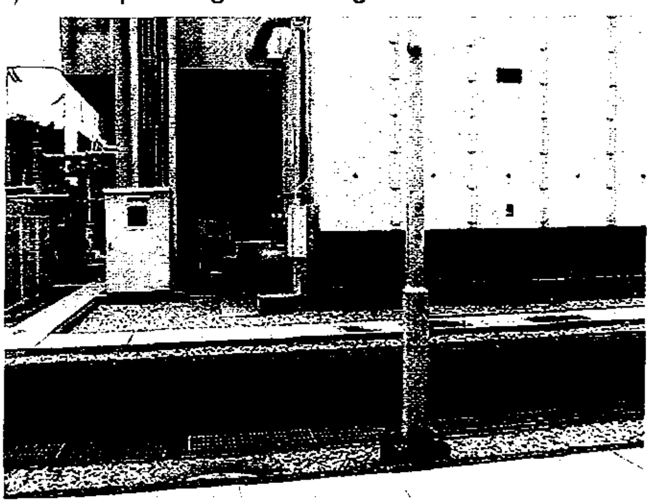
Category	Chapter	1	General Provisions	Document No. SS9
	Paragraph	4	Prevention of Electric Power Disasters	
	Clause	12	Prevention of Failures of Electric Power Facilities from Natural Disasters	
Title	Floods Design for Substations			

1. Electrical equipment should be installed not to suffer damage from submersion due to foreseeable floods.
   The ground level should be decided, based on past records of floods.



(Landfill)

2. Following measures should be taken by the following methods not to suffer damage to electrical equipment from rainwater under the normal conditions.
   (1) Installation of drainage facilities.
   (2) Waterproofing of buildings in which electrical equipment is installed.



(Drainage facilities)

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	1	General Provisions	**Document No. SS10-1**
	Paragraph	6	Preservation of Environment	
	Clause	14	Compliance with the Environmental Standards	
Title	Mitigation Measures for Environmental Impact (1/2)			

1. Appropriate measures should be taken to prevent outflow and seepage of insulation oil, referring to **IEC 619361 Ed1/CVD (IEC TC99),** as followings;

The quantity of insulating liquid in equipment, the volume of water from rain and fire protection system, the proximity to watercourses and soil conditions should be considered in the selection of a containment system.

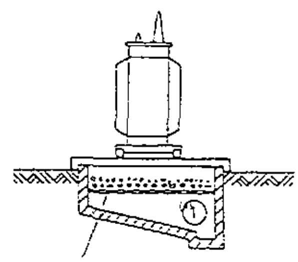
·Tanks

·Sump with integrated-catchment-tank for the whole fluid (see the following figure)

·Sump with separate catchment-tank. Where there are several sumps, the drainpipes may lead to a common catchment-tank; this common catchment tank should then be capable of holding the fluids of the largest transformer. (see the following figure)

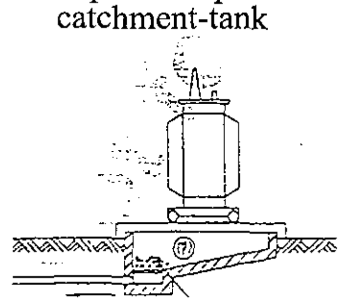
·Sump with integrated common catchment-tank for several transformers. It should be capable of holding the fluids of the largest transformer.

Sump with integrated catchment-tank

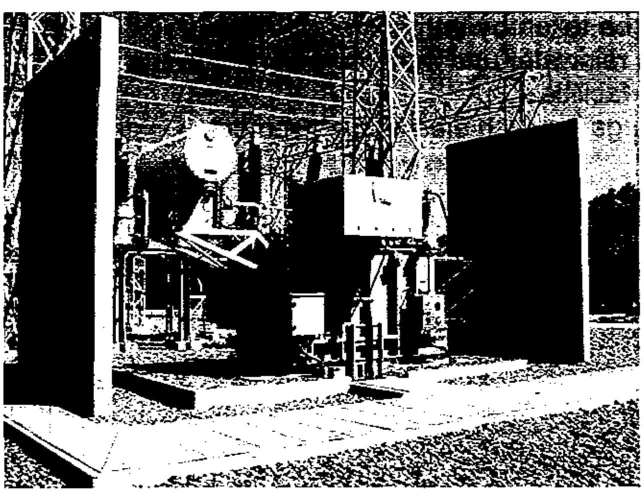


Gravel layer for fire protection

Sump with separate catchment-tank



Gravel layer for fire protection



Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	1	General Provisions	**Document No. SS10-2**
	Paragraph	6	Preservation of Environment	
	Clause	14	Compliance with the Environmental Standards	
Title	Mitigation Measures for Environmental Impact (2/2)			

2. Electrical equipment, for which insulation oil containing polychlorinated biphenyl is used, must not be installed.

Although PCB (polychlorinated biphenyl) is chemically stable, it has the toxicity which causes a skin obstacle and a liver obstacle. It is a substance with a possibility of not only polluting environment, but also accumulating to people through fishes etc because of remaining without decomposing for a long period of time when it is emitted into environment.

3. For electrical equipment that uses SF6 gas, appropriate measures shall be taken so that SF6 gas is not emitted into the atmosphere.

Since SF6 is one of Global Warming Gas (CO_2, N_2O, CH_4, HFCs, PFCs, SF_6), discharge of SF6 gas should be controlled as much as possible in consideration of global environment.

Remarks	Revisions	
	2003/Nov.	Original

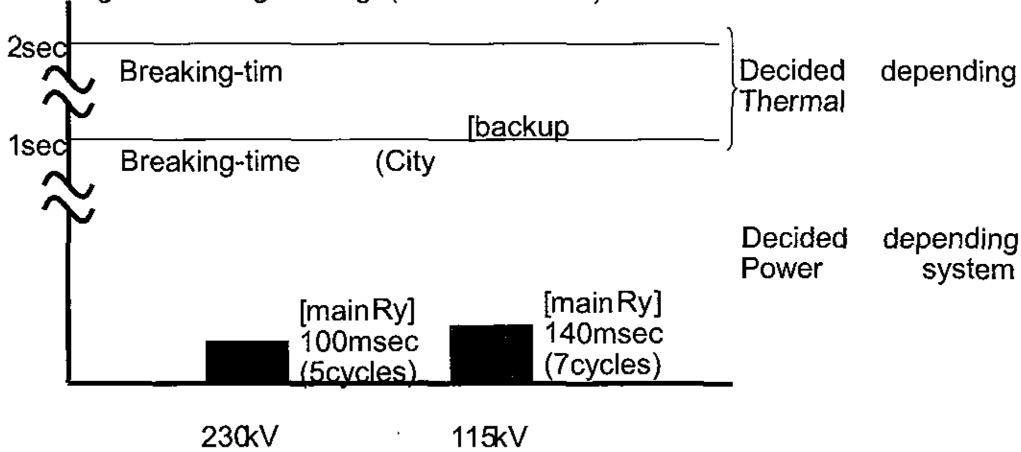
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. SS11
	Paragraph	5	Transmission and Distribution Facilities	
	Clause	36 37	Protection against Over-current Protection against Ground Faults	
Title	Protective Relay system			

1.Circuit Breaker
The circuit breaker should hold sufficient capacity for intercepting current.

2.Protective Relay System
The system should be sufficiently sensitive to distinguish internal fault from external fault.
The main relay should clear quickly the fault within a definite operation time in order to keep the power system stability including circuit breaker interruption time.
If the main relay responsible to the fault fails to clear it,the backup relay should clear,but with a longer operation time, which will give a bigger disturbance to the power system.

(1) Regular use state
Circumference temperature should be 40 ℃ or less and −10 ℃ or more, referring to IEC61936-1.

(2) Breaking-time for high voltage(100kV or more)

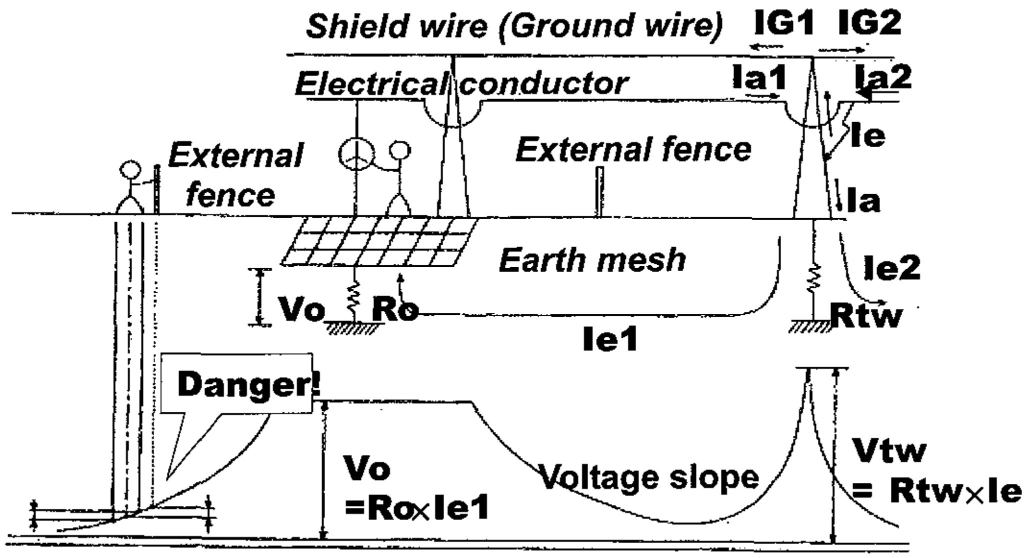


Remarks	Revisions	
	2003/Nov.	Original

Category				Document No. SS12-1
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. SS12-1
	Paragraph	5	Transmission and Distribution Facilities	
	Clause	39	Classification of Grounding for Electrical Lines	
Title	Grounding for Substations (1/4)			

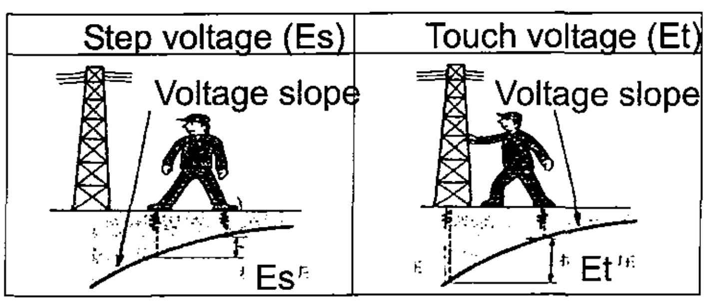
1. Purpose of Grounding

Purpose of Grounding is to prevent workers' electric shock from lightning surge or any other abnormal voltages occurring in the system, as well as to protect electrical devices and low voltage circuits. Grounding should be designed to have so low grounding resistance as to satisfy allowable step-voltage and touch-voltage.



- Legend -

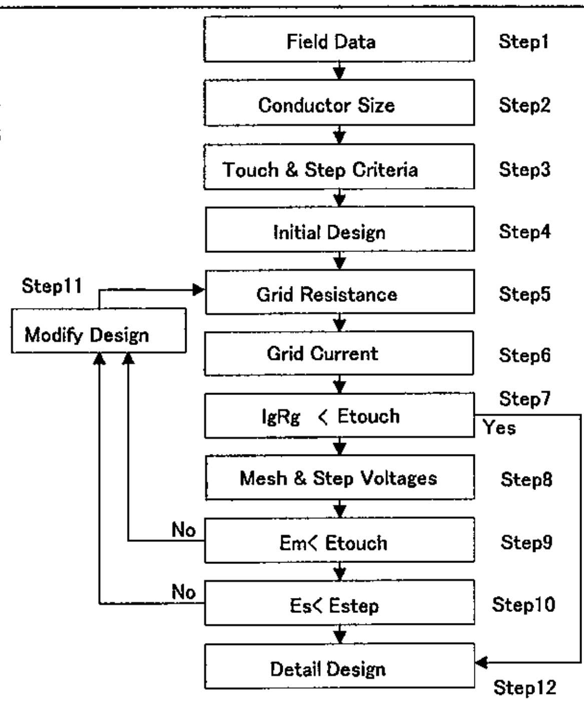
Ia: Ground Fault Current, **IG**: Ground Wire Current, **Ie**: Earth Current
Ia = IG + Ie
R0: Earth Resistance



Remarks	Revisions	
	2003/Nov.	Original

Category				Document No. SS12-2
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	5	Transmission and Distribution Facilities	
	Clause	39	Classification of Grounding for Electrical Lines	
Title	Grounding for substations (2/4)			

2. Design Procedure
Design procedure is provided in IEEE Std 80 or IEC61936-1, as shown on the right.



IEEE's Design Procedure

3. Example of Grounding Design
An example of grounding design based the IEEE procedure is described below.

Step1. Field data
(1) Surface Resistivity

Surface Resistivity is shown in following table.

Sample: $\rho s = 1000\ \Omega$-m

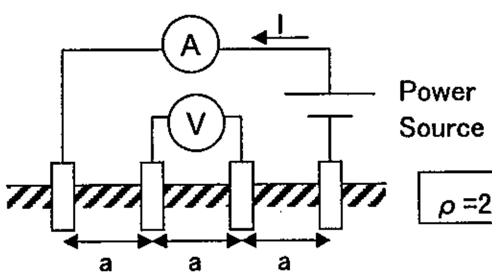
Range of earth resistivity

Type of earth	Average resistivity (Ω-m)
Wet organic soil	10
Moist soil	10^2
Dry soil	10^3
Bed rock	10^4

(2) Ground Resistivity
Ground Resistivity is measured like following figure.

Sample: $\rho s = 50\ \Omega$-m

four-pin-method



$\rho = 2\pi aV/I$

(3) Grounding Current
Grounding current should be Estimated on the basis of system's Short circuit capacity taking shunting (ground wire) to substation of about 40% into consideration.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. SS12-3
	Paragraph	5	Transmission and Distribution Facilities	
	Clause	39	Classification of Grounding for Electrical Lines	
Title	Grounding for substations (3/4)			

Sample: Short circuit capacity=25kA, Grounding Current=25kA*40%=10kA,
t (Duration)=1sec

Step2. Conductor Size

Conductor size is decided in accordance with the grounding current.

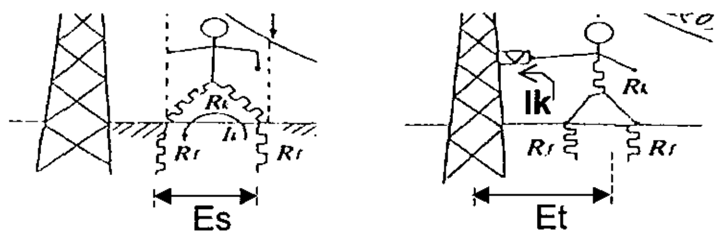
Step3. Touch and Step Criteria

Ik (allowable body current IEEE) $=0.116/\sqrt{t}$

Es = (Rk + 2Rf) Ik=(1000+6ρs)*0.116/√t =812 V

Et = (Rk + Rf/2) Ik=(1000+1.5ρs)*0.116/√t =**290 V**

Sample: Rk (human body resistance)=1000Ω, Rf =3ρs



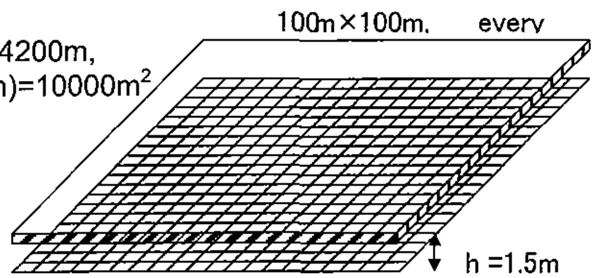
Step4- 7. Rough Calculation

Rough calculation of grounding design should be carried out for the step 4-7 as follows.

$$\text{Rg (substation ground resistance)} = \rho * \left[\frac{1}{L} + \frac{1}{\sqrt{(20A)}}\left(1 + \frac{1}{1+h\sqrt{(20/A)}}\right)\right]$$

$$=0.23\ \Omega$$

Sample :
L (total buried length of conductors)=4200m,
A (area occupied by the ground mesh)=10000m²
h (depth of the mesh) =1.5m



Remarks	Revisions	
	2003/Nov.	Original

Category				Document
	Chapter	2	Technical Standards of Electric Power Facilities	No. SS12-4
	Paragraph	5	Transmission and Distribution Facilities	
	Clause	39	Classification of Grounding for Electrical Lines	
Title	Grounding for substations (4/4)			

Step8- 10. Calculation of Mesh Voltage and Estimation

Calculation of Mesh Voltage and Estimation of the voltage should be carried out for the step 8-10 as follows.

Em (Mesh Voltage)= ρ *Km*Ki*I/L=50*0.40*3.75*16000/4200= 286V < Etouch 290V [OK]

$$Km = \frac{1}{2\pi}[\ln(\frac{D^2}{16hd} + \frac{(D+2+h)^2}{8Dh} - \frac{h}{4d}) + \frac{Kii}{Kh} * \ln(\frac{8}{\pi(2n-1)})] = 0.40$$

n (number of parallel lines)=21

Kii=1/(2*n)$^{2/n}$ =0.7

Kh=$\sqrt{(1+h/h0)}$=1.6 (h0: grid reference depth=1)

D (separation)=5

d (diameter)=0.016

Ki = 0.644+0.148n = 3.75

4. Countermeasures to Improve Grounding

In the case that the result of estimation is unsatisfied, countermeasures described below should be taken.

(1) Grounding rods should be used when grounding mesh cannot be extended although grounding resistance is high.
(2) The interval of a mesh should be contracted.
(3) Surface layer with high resistance should be installed.
(4) A part of grounding current should be made to shunt toward other circuits.
(5) Material to decrease grounding resistance should be used.
(6) Grounding current should be restricted.
(7) Entry should be forbidden.

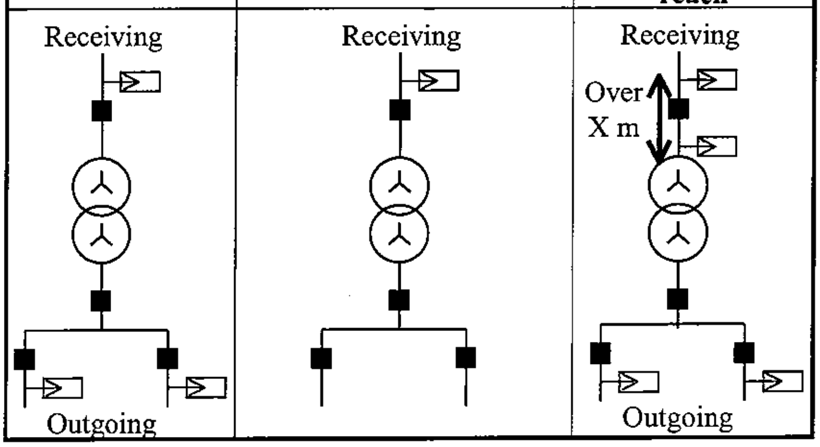
Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. SS13-1**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	48	Surge Arresters	
Title	Installation of surge arresters (1/2)			

1. Installation points for surge arresters
   Surge arresters should be installed at points listed below in high-voltage electrical circuits at substations and switching stations except for cases where there is no risk of damage to such electrical equipment.
   a. Receiving and outgoing points on overhead electrical lines at substations
   b. Receiving points on the HV and MV user's sites to which power is supplied from high-voltage and medium voltage overhead electrical lines.
   c. Other points where installation of surge arresters are effective. For instance, installation of a surge arrester near a transformer might be necessary after detailed calculation of a valied reach of the suege arresters mentioned above in the article a and b.

Installation points for surge arresters

a. Receiving and outgoing points on overhead electrical lines in the Stations	b. Receiving points on the HV or MV user' s sites to which power is supplied from high-voltage or medium voltage overhead electrical lines	c. Other points Over protective reach



X: Protective reach of surge arrester

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. SS13-2
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	48	Surge Arresters	
Title	Installation of surge arresters (2/2)			

2.Performances of surge arresters

The performances of surge arresters to be installed at substations and HV user's sites should conform to the following provisions, IEC60099 and other relevant IEC.

a. Rated voltage

The rated voltage of surge arresters should be chosen so that the surge arrester can perform the prescribed operating duties under the condition of over voltages that temporarily occur at stations and HV and MV user's sites due to a single-line earth fault and load rejection.

b. Nominal discharge current

Nominal discharge current of surge arresters at high-voltage substations should be no less than 10 kA.

Nominal discharge current of surge arresters

Installation point of the surge arrester		Nominal discharge current
Surge arresters to be installed in high-voltage electrical circuits		10 kA
Surge arresters to be installed in medium- voltage electrical circuits	It is unnecessary to treat switching surge.	5 kA
	It is necessary to treat switching surge	10 kA
Surge arresters to be installed in medium voltage electrical circuits to be connected with an overhead distribution line to be installed on the top of an overhead transmission electrical line		10 kA

Referring to IEC 60099

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	1	General Provisions	Document No. TL1
	Paragraph	1	Definitions	
	Clause	1	Definitions	
Title	Main Components of Transmission Line			

Main components of high-voltage lines are as follows.

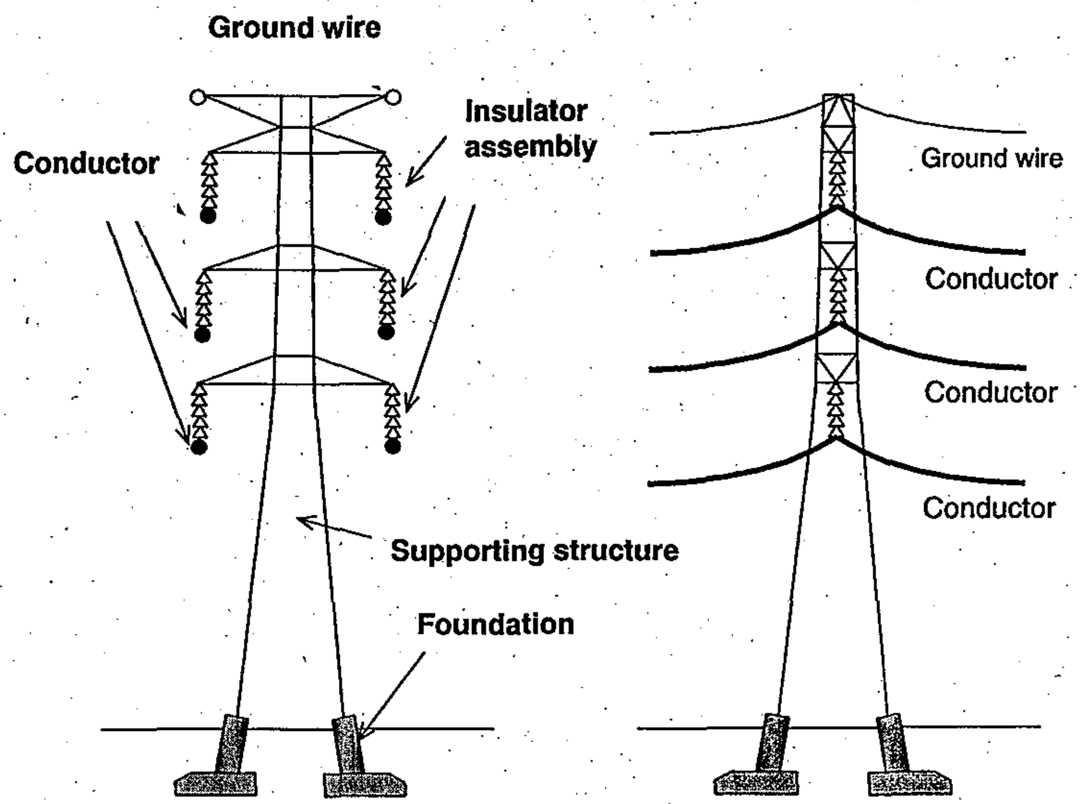
1.Supporting structure
"Supporting structure" means a structure to support ground wires, conductors and so on.

2.Foundation
"Foundation" means an underground structure designed to support the supporting structure.

3.Conductor
"Conductor" means an electrical conductor to transmit electricity.

4.Ground wire
"Ground wire" means metal wires, generally installed on the top of a supporting structure to protect electrical lines from damage by lightning.

5.Insulator assembly
"Insulator assembly" means a set which consists of insulator discs and the fittings.

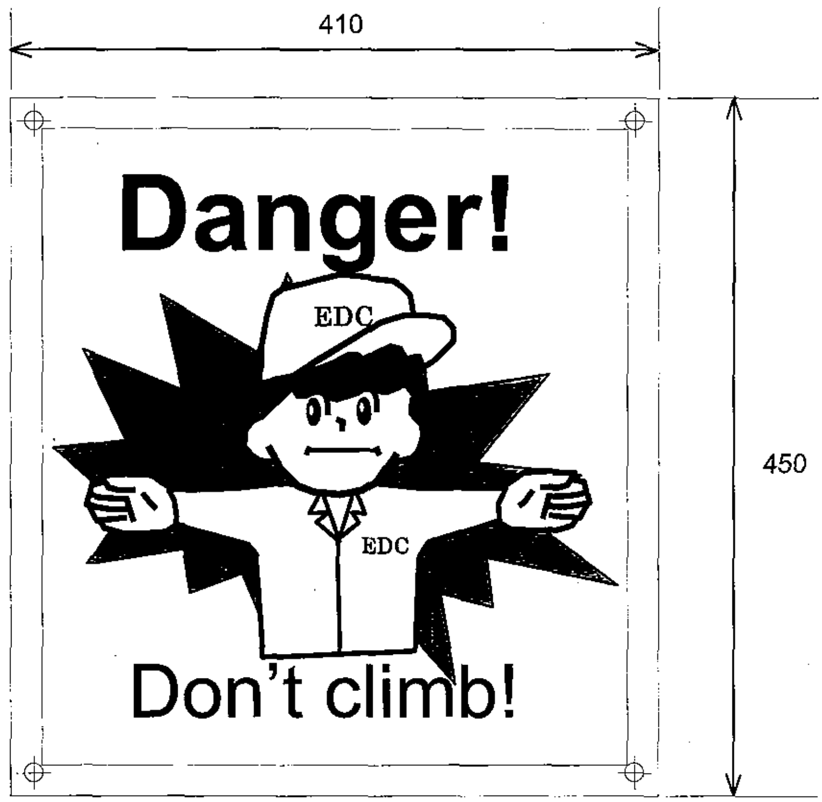


Remarks	Revisions	
	2003/Nov.	Original

Category				Document No. TL2
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	5	Transmission and Distribution Facilities	
	Clause	32	Prevention of Climbing on Supporting Structures	
Title	An Example of a Warning Sign			

1.Installation of sign(Danger plate)

An example of a danger plate is as follows.

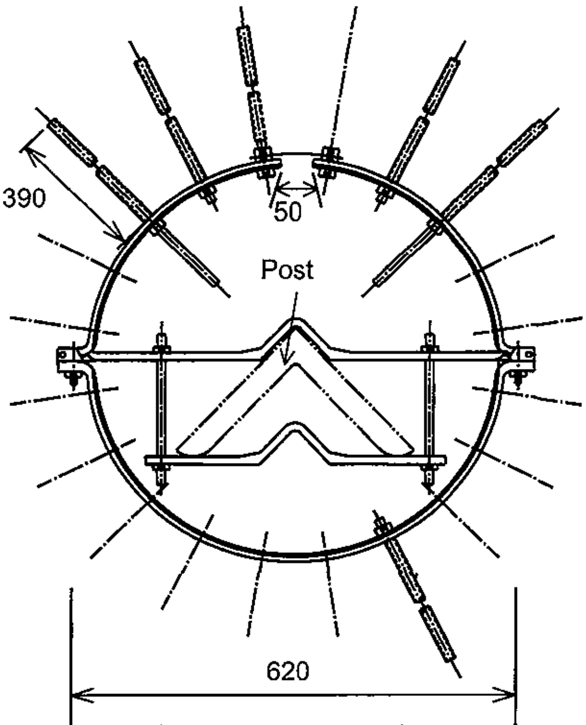


Remarks	Revisions	
Referring to the standards of the KANSAI Electric Power Co., Inc.		
	2003/Nov.	Original

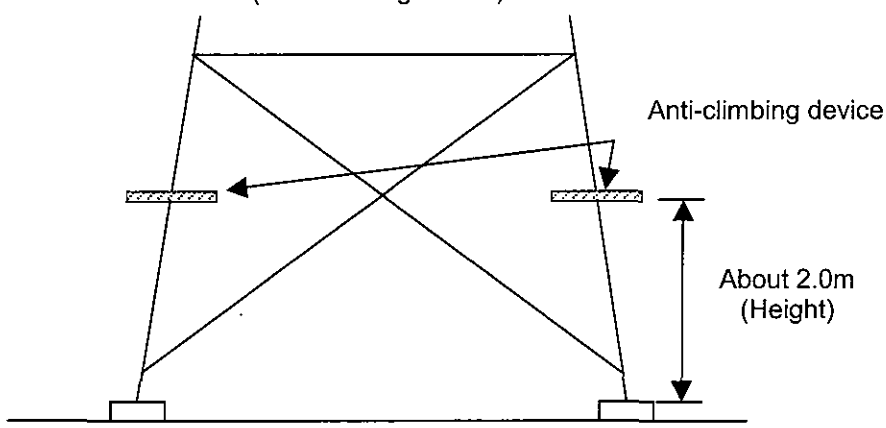
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. TL3
	Paragraph	5	Transmission and Distribution Facilities	
	Clause	32	Prevention of Climbing on Supporting Structures	
Title	An Example of a Device to Prevent Third Persons from Climbing			

1.Installation of anti-climbing device

An example of anti-climbing device is as follows.



(Anti-climbing device)



(Installation position)

Remarks	Revisions	
	2003/Nov.	Original

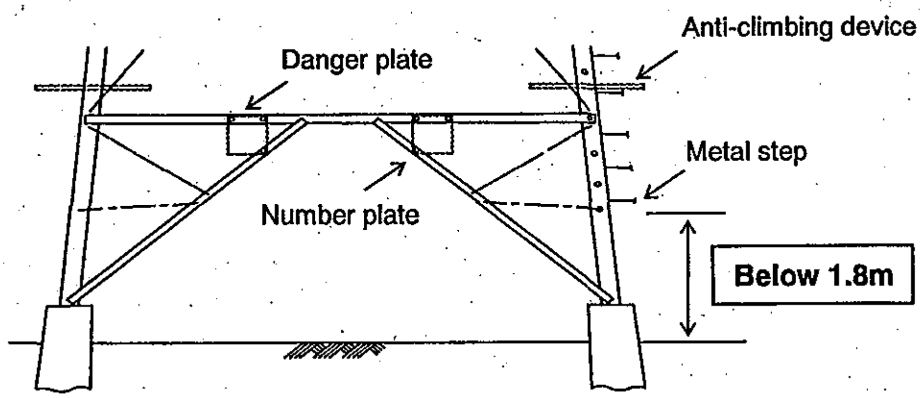
Category				Document No. TL4
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	5	Transmission and Distribution Facilities	
	Clause	32	Prevention of Climbing on Supporting Structures	
Title	An Example of Arrangement of a "Danger sign", "Anti-climbing Devices" and "Steps"			

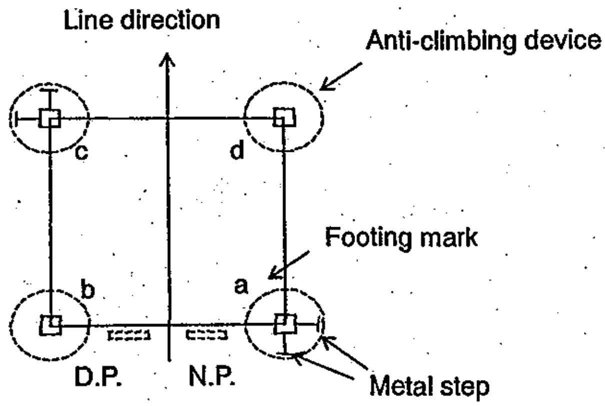
1. Steps
   No steps shall be installed with height of 1.8m or below at each leg of supporting structures.

2. An example of arrangement of "a danger plate", "anti-climbing devices" and "steps" is as follows.

   Points to be considered are as follows;

   a. For adults, signs which simply and obviously describe danger of electricity are necessary.
   b. For children, who could not read the signs, devices that physically prevent from climbing are necessary.





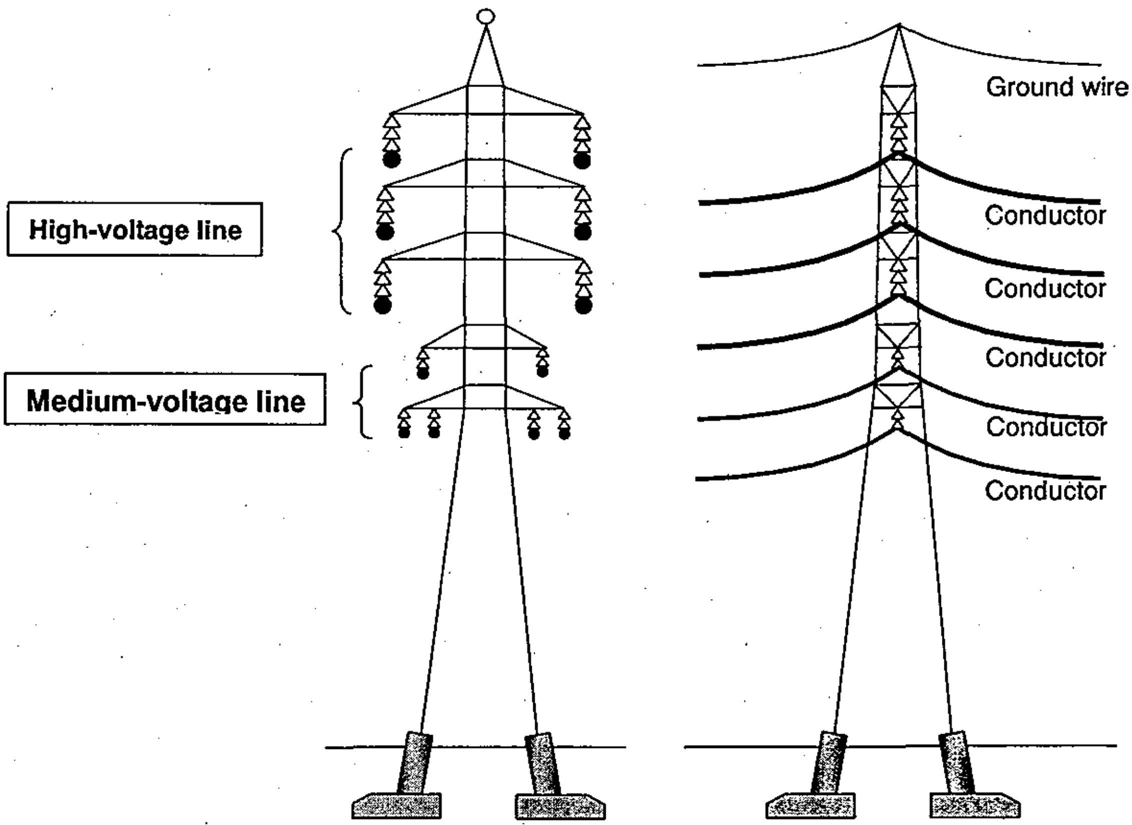
Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL5**
	Paragraph	5	Transmission and Distribution Facilities	
	Clause	34	Side by Side Use and Joint Use of Electrical Lines or Communication Lines	
Title	Side by Side Use and Joint Use of High-voltage Lines and Other Lines			

Medium-voltage lines shall be Installed under high-voltage lines and on separate cross arms. An example of arrangement of high-voltage lines and medium-voltage lines is as follows.

High-voltage lines and low-voltage lines shall not be installed at the same supporting structure, taking into account danger and/or interruption due to electrostatic and electromagnetic induction.

High-voltage lines and communication lines shall not be installed at the same supporting structure.

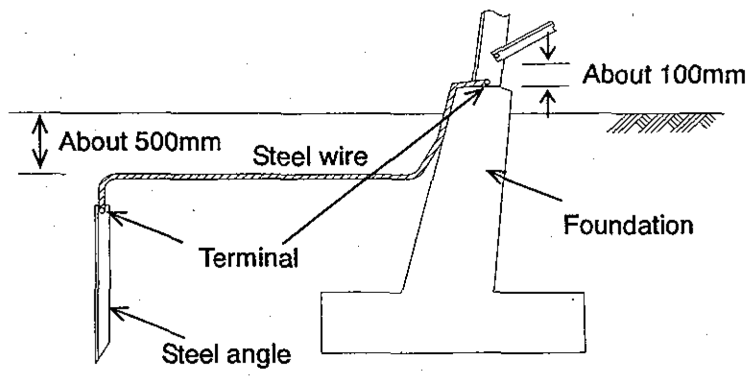


Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. TL6
	Paragraph	5	Transmission and Distribution Facilities	
	Clause	39	*Classification of Grounding for Electrical Lines*	
Title	Installation of Grounding			

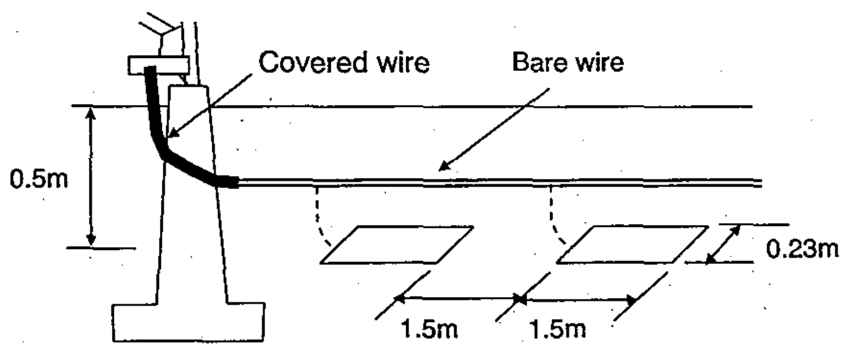
1.Earthing steel angle

Tower-footing resistance can be reduced by installation of an earthing steel angle to each tower leg. The tower-footing resistance shall be less than 10 Ω. A galvanized steel wire of 38 mm^2 (7/2.6) is used for connection of the earthing steel angle and the leg.
Normally the galvanized steel wire is radically buried while being extended from the leg at the depth of about 0.5m from the ground surface.



2.Grounding sheets

There might be some sites with high tower-footing resistance, where the installation of the earthing angle is not enough to reduce the resistance
In this case, such a countermeasure as application of grounding sheets is applied. The grounding sheets are fixed on counterpoise wires. Furthermore, in case that the grounding sheets are not enough, the grounding by boring to a deep layer should be applied.

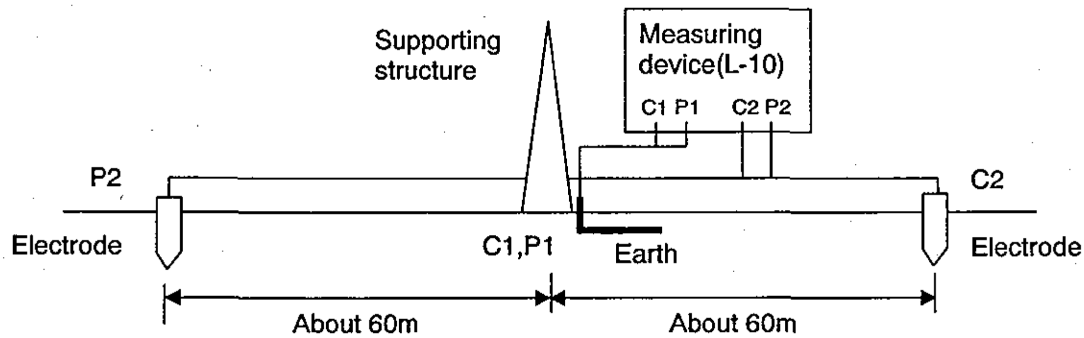


Remarks	Revisions	
	2003/Nov.	Original

Category				Document No. TL7
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	5	Transmission and Distribution Facilities	
	Clause	39	Classification of Grounding for Electrical Lines	
Title	Measuring of Tower-footing Resistance			

1. Measuring Method

The following figure shows a typical measuring method of tower-footing resistance. In the figure, L-10 type (YOKOGAWA ELECTRIC CORPORATION) Measuring Device is used.



2. Notes of the Measuring

Notes on the measuring are as follows.

a. Distance between a tower and electrodes should be more than 60m long.
b. Electrodes should be installed deeply.
c. Measuring should not be done in case that ground surface is moist.
d. Electrodes should be extended at right angles to the transmission line.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. TL8
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	40	Design of Supporting Structures of Overhead High-voltage Line	
Title	Assumed Maximum Wind Velocity			

Supporting structure and foundation of overhead high-voltage lines shall be designed in consideration of wind pressure based on the assumed maximum wind velocity.

30m/s is appropriate for the maximum wind velocity for tower design, based on records in Cambodia.

Records of wind velocity for 5 years are as follows.

Observation point	Direction	Wind velocity [m/s]	Date
Pochentong (1998-2002)	W	24	29.AUG.1999
	W	20	27.JUN.2000
	W	20	25.JUN.2001
Siem Reap (1998-2002)	NW	26	25.MAY.1998
	W	24	21.JUN.1997
	W	24	24.JUN.1997
Sihanoukville (1994-1998)	SW	25	1.SEP.1995
	SW	18	2.JUN.1994
	N	18	20.NOV.1994

(Reference; Ministry of Water Resources and Meteorology)

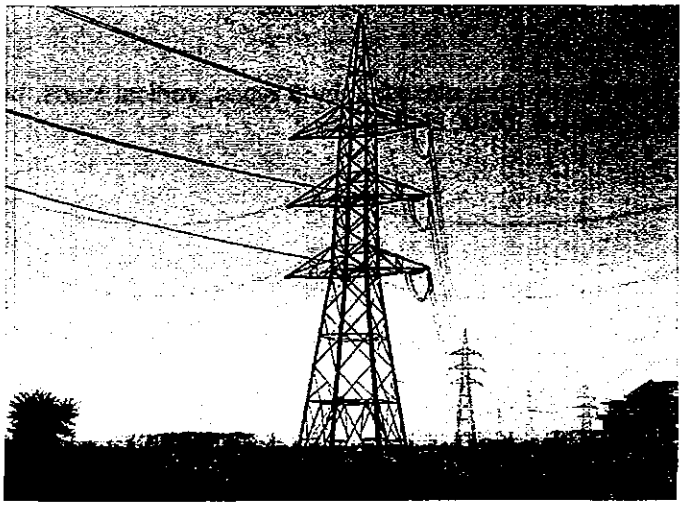
However, the quantity of the records that we can get is not enough because the assumed maximum wind velocity for high-voltage lines should be decided with about 50 years return period, taking into account reliability required. Therefore, the figure 30m/s suggested should be changed according to rolling up of the records.

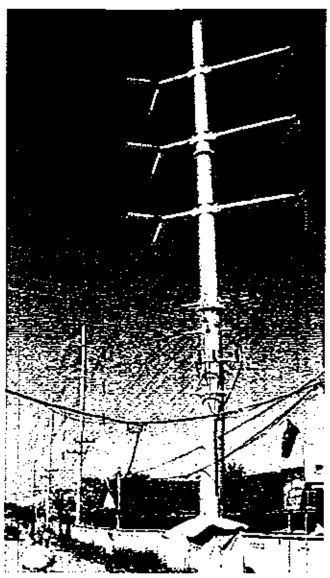
Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. TL9
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	40	Design of Supporting Structures of Overhead High-voltage Lines	
Title	Kinds of Supporting Structures			

Kinds of supporting structures are as follows.

Steel tower



Steel pole	Concrete pole
	

Remarks	Revisions	
	2003/Nov.	Original

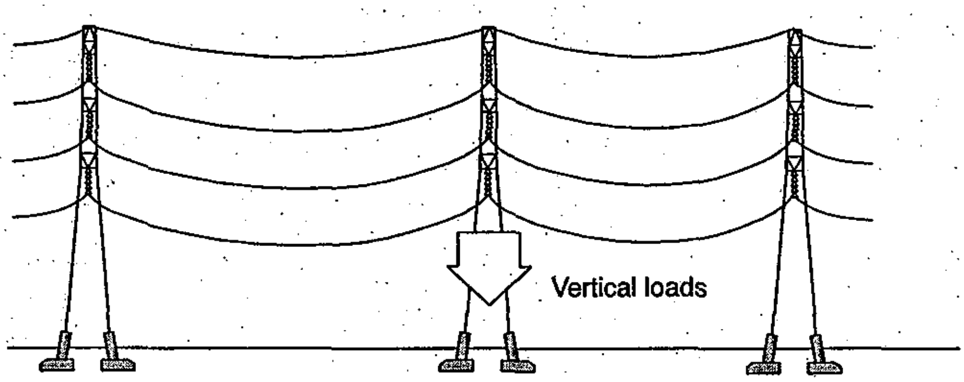
Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL10-1**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	40	Design of Supporting Structures of Overhead High-voltage Lines	
Title	Design of Supporting Structures (1/11)			

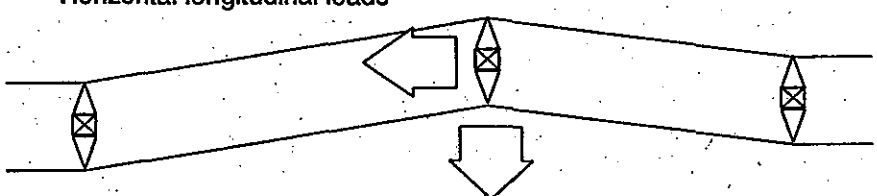
1. Application

The Documents No.TL10-2 to No.TL10-11 describe a design method for high-voltage lines, while design for medium and low voltage lines are described in the other proper articles in Electrical Power Technical Standards and the Guidebook.

2. Kind of loads

Loads for supporting structures are classified by 3 types, vertical loads, horizontal transverse loads and horizontal longitudinal loads, as follows.





Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL10-2**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	40	Design of Supporting Structures of Overhead High-voltage Lines	
Title	Design of Supporting Structures (2/11)			

3. Subdivision of loads
The loads are subdivided as follows

Type of Load	*Contents*	*Symbol*
Vertical loads	Weight of the supporting structure	Wt
	Weight of the conductors and the ground wires and the accessories supported by the supporting structure	Wc
	Weight of the insulator strings and the fittings supported by the supporting structure	Wi
	A vertical component of the maximum tension of the guy wires supporting the supporting structure, if any	Ws
Horizontal transverse loads	Wind pressure of the supporting structure under the maximum wind velocity	Ht
	Wind pressure of the conductors and the ground wires supported by the supporting structure under the maximum wind velocity	Hc
	Wind pressure of the insulator strings and the fittings supported by the supporting structure	Hi
	A horizontal transverse component of the maximum tension of the conductors and the ground wires supported by the supporting structure and the guy wires supporting the supporting structure, if any	Ha Hs
Horizontal longitudinal loads	Wind pressure of the supporting structure under the maximum wind velocity	Ht'
	A horizontal longitudinal component of the unbalanced maximum tension of the conductors and the ground wires supported by the supporting structure and the maximum tension of the guy wires supporting the supporting structure, if any	P Ws'

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. TL10-3
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	40	Design of Supporting Structures of Overhead High-voltage Lines	
Title	Design of Supporting Structures (3/11)			

4. Vertical loads

(1)"Wt"

"Wt" is weight of the supporting structure.

(2)"Wc"

"Wc" is calculated by the following formula.

$$Wc = (Wc' \times S \times g) \times n + T1 \tan\delta 1 + T2 \tan\delta 2 \text{ [N]}$$

where, Wc':Unit weight of a conductor [kg/m]

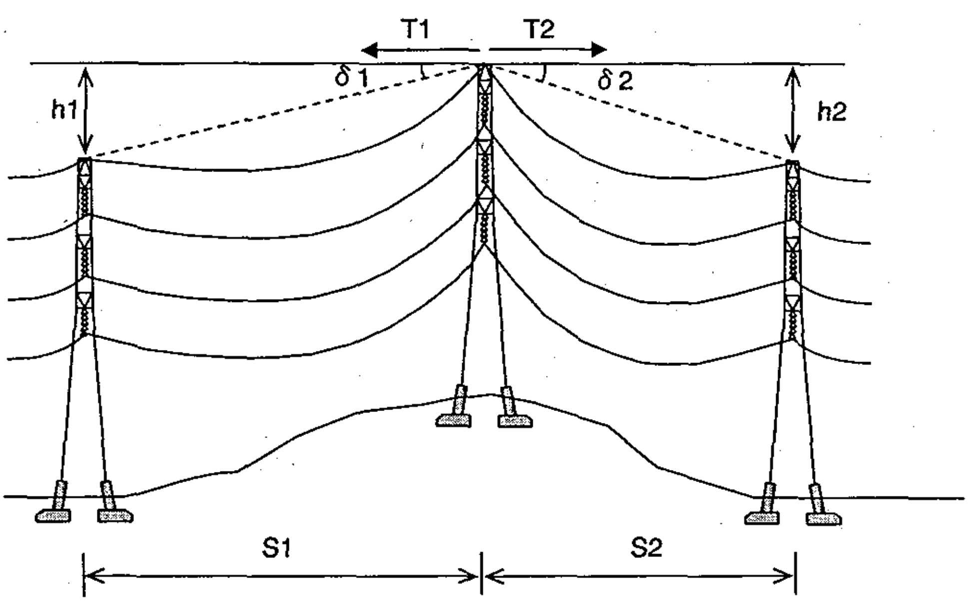
S :Weight span, (S1+S2)×0.5[m]

g :apparent gravity, 9.8[m/s^2]

n :*Number of conductors*

T1, T2 :Horizontal component of the maximum working tension of conductors or ground wires [N]

δ1, δ2 :A vertical angle of a line which is drawn between supporting points of adjacent supporting structures



Remarks	Revisions	
	2003/Nov.	Original

Category				
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. TL10-4
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	40	Design of Supporting Structures of Overhead High-voltage Lines	
Title	Design of Supporting Structures (4/11)			

(3)"Wi"

"Wi" Is calculated as follows.

$$Wi = (a \times N + I) \times g \quad [N]$$

where, a :Weight of an insulator disc [kg]

N :Number of insulator discs

I :Weight of fittings for the insulator discs [kg]

g : apparent gravity, 9.8[m/s^2]

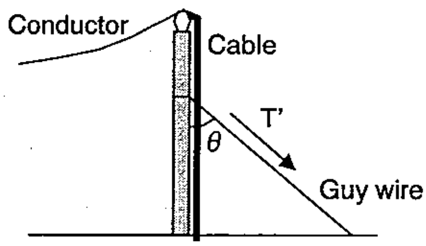
(4)"Ws"

"Ws" is calculated as follows, if any.

$$Ws = T' \times \cos\theta \quad [N]$$

where, T' :Maximum tension of a guy wire[N]

θ :angle between a supporting structure and a guy wire



(5)Others

Furthermore, 200kg could be considered for each cross arm as dead loads, which consist of weights of linemen and their tools.

Remarks	Revisions	
	2003/Nov.	Original

5. Horizontal transverse loads

(1)"Ht"

"Ht" is calculated multiplying a wind pressure by the sum of the projected areas of all members of transverse face. Wind pressure "P" is obtained from the following equation.

$$P = (1/2 \times \rho \times V^2) \times C \times g \ [N/m^2]$$

where, P: Wind pressure

ρ :Air density[kg・sec^2/m^2]

V: Design wind velocity [m/s]

C: Coefficient of air resistance

g: Apparent gravity, 9.8[m/s^2]

Height[m]	Ht [N/m²]	
	Concrete pole (Circle type) Steel pole (Circle type)	Steel tower Single steel pole
~40	450	1600
~50	480	1700
~60	500	1800

(2)"Hc"

"Hc" Is calculated as follow.

$$Hc = Ww \times D \times S \times n \times 10^{-3} \times g \ [N]$$

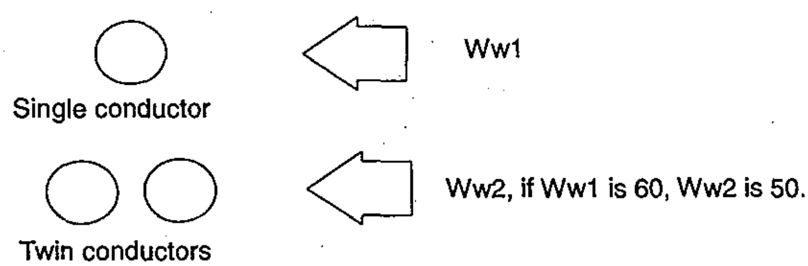
where, Ww : Wind pressure, where Ww for twin or quad bundle conductors are 90 % of Ww for a single conductor

D: Diameter of conductor [mm]

S: Weight span [m]

n: Number of conductor

g: apparent gravity, 9.8[m/s^2]



Category				Document No. TL10-6
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	40	Design of Supporting Structures of Overhead High-voltage Lines	
Title	Design of Supporting Structures (6/11)			

Type of conductor	Diameter [mm]	Weight span [m]	Number of conductor	Hc [N]
ACSR 410	28.5	300	1	5027
ACSR 810	38.4	300	1	6774

(3)"Hi"

"Hi" is calculated multiplying a wind pressure by the sum of the projected areas of insulator assembly of transverse face.

The wind pressure of the standard insulator strings is as follows.

Number of insulator discs	Hi [N]	
	115kV	230kV
8	250	−
15	−	400

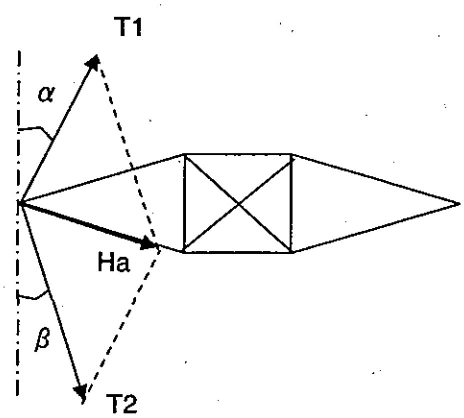
(4)"Ha"

"Ha" is calculated as follow.

$$Ha = T1\sin\alpha + T2\sin\beta \text{ [N]}$$

where, T1,T2 :Horizontal component of maximum working tension of conductors[N]

α, β :Horizontal angle of conductors



Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. TL10-7
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	40	Design of Supporting Structures of Overhead High-voltage Lines	
Title	Design of Supporting Structures (7/11)			

(5)"Hs"

"Hs" is calculated as follow, if any.

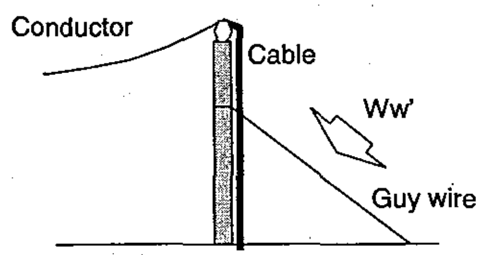
$$Hs = Ww' \times D' \times S' \times 10^{-3} \times g \ [N]$$

where, Ww': Wind pressure (Single conductor 100[kg/m^2])

D': Diameter of guy wire [mm]

S': Length of guy wire [m]

g :apparent gravity, 9.8 [m/s^2]



6.Horizontal longitudinal loads

(1)"Ht'"

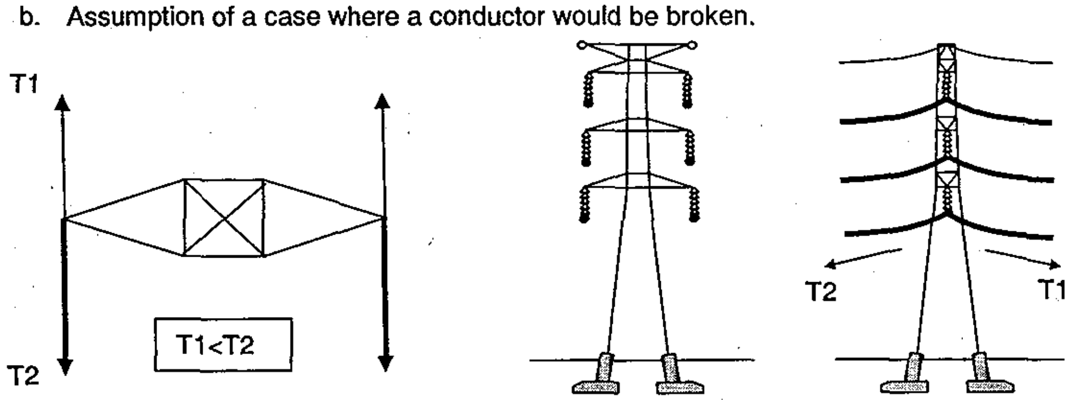
"Ht'" is calculated multiplying a wind pressure by the sum of the projected areas of all members of longitudinal face.

(2)"P"

A horizontal longitudinal component of the unbalanced maximum working tension of conductors and ground wires is considered.

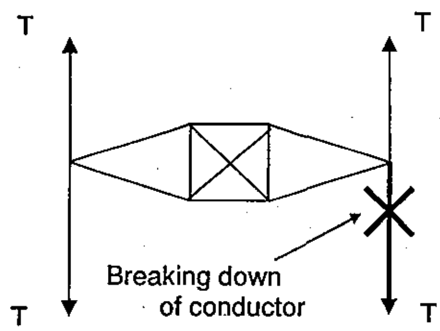
Points to be considered are as follows

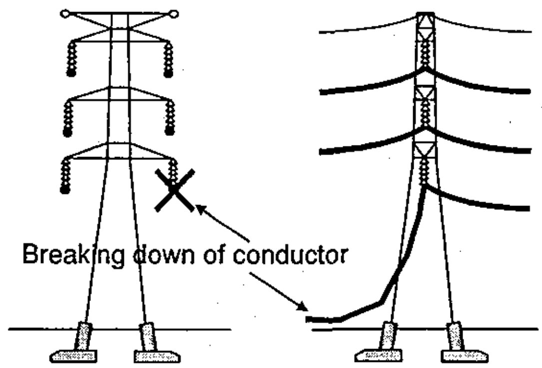
a. Unbalanced loads
b. Assumption of a case where a conductor would be broken.



Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. TL10-8
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	40	Design of Supporting Structures of Overhead High-voltage Lines	
Title	Design of Supporting Structures (8/11)			





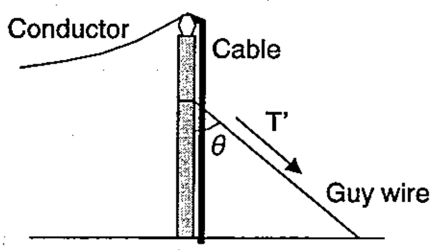
(3)"Ws'"

"Ws'" is calculated as follow, if any.

$$Ws' = T' \times \sin\theta \quad [N]$$

where, T' :Maximum tension of guy wire[N]

θ :angle between supporting structure and guy wire



Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL10-9**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	40	Design of Supporting Structures of Overhead High-voltage Lines	
Title	Design of Supporting Structures (9/11)			

7. Oblique wind for bigger towers

Regarding relation between direction of wind and the intensity of the wind pressure, wind with direction of 60 degree to lines might be the most severe (pessimum) condition for tall towers with large cross arms, though normally perpendicular direction (90 degrees to lines) of wind is the most severe.

Therefore, towers with voltage of 230kV or more should be designed taking into account the oblique direction wind.

Generally, an oblique wind pressure is derived, multiplying coefficients by the 90-degree-wind pressure.

Items		Coefficients (in case of square tower)
Wind pressure load to steel tower	Wind pressure load to body	1.6
	Wind pressure load to cross arm	0.5 (for the wind pressure in the direction of electrical line)
Wind pressure load to strung wire		0.75

Remarks	Revisions	
	2003/Nov.	Original

Category				
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. TL10-10
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	40	Design of Supporting Structures of Overhead High-voltage Lines	
Title	Design of Supporting Structures (10/11)			

8.Combination of loads

Combination of loads is as follows.

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

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

Abnormal Condition:

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

Notes: Circles "O" indicate the assumed loads to be considered at the same time.

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

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL10-11**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	40	Design of Supporting Structures of Overhead High-voltage Lines	
Title	Design of Supporting Structures (11/11)			

9.Safety factors

Safety factors of supporting structures are as follows.

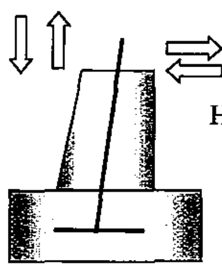
Classification of supporting structure	load condition	Safety factor
Concrete pole Steel pole	*Normal*	2.0
Steel tower	Normal	1.5
	abnormal	1.0

Remarks	Revisions	
	2003/Nov.	Original

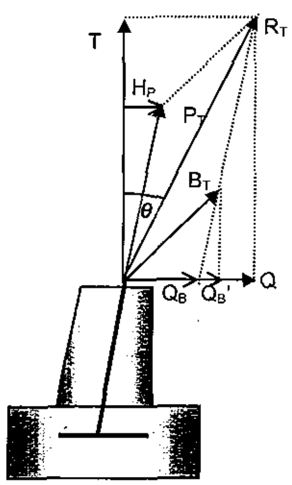
Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL11-1**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	40	Design of Supporting Structures of Overhead High-voltage Lines	
Title	Design of Foundations (1/5)			

1.Kinds of loads of foundation

Kinds of loads of foundation are as follows.



Formation of the detailed loads is as follows.



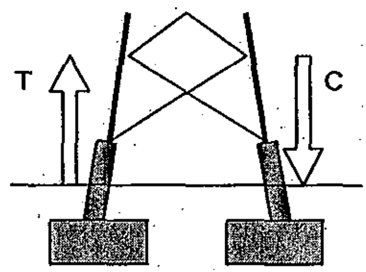
P_T : A load of a post (kN)
B_T : A load of a breath (kN)
H_P : A horizontal component of P_T (kN)
Q_B': A horizontal component of B_T (kN)
R_T : A resultant of P_T and B_T (kN)
T : Tension load (kN)
Q : Horizontal load (kN)
θ : An angle of a post to the vertical line

Remarks	Revisions	
	2003/Nov.	Original

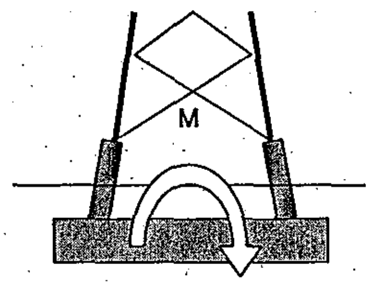
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. TL11-2
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	40	Design of Supporting Structures of Overhead High-voltage Lines	
Title	Design of Foundations (2/5)			

2.Kinds of loads

There are 2 types of foundation from viewpoint of design.
One is foundation to be designed with a compression load and a tension load (vertical-load foundation).
And the other is foundation to be designed with a moment load



(Vertical-load foundation)



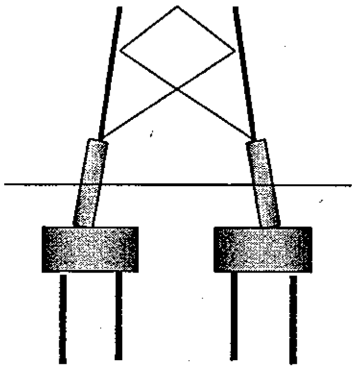
(Moment-load foundation)

A foundation type should be decided on the basis of results of such geological study as the Standard Penetration Test. The foundation types are as follows.

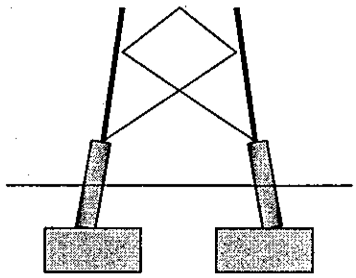
Foundation type	Value of N	Condition
Anchor foundation	–	Rock
Pad and chimney foundation	20~	Normal ground
Caisson type pile foundation	12~	
Mat foundation	~19	Soft ground
Pile foundation		

Remarks	Revisions	
	2003/Nov.	Original

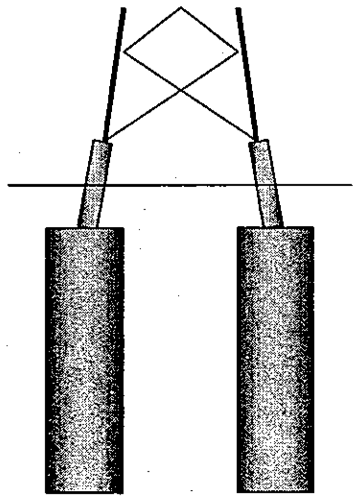
Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL11-3**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	40	Design of Supporting Structures of Overhead High-voltage Lines	
Title	Design of Foundations (3/5)			



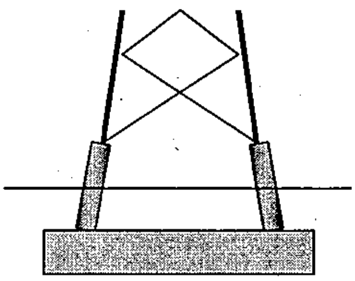
(Anchor foundation)



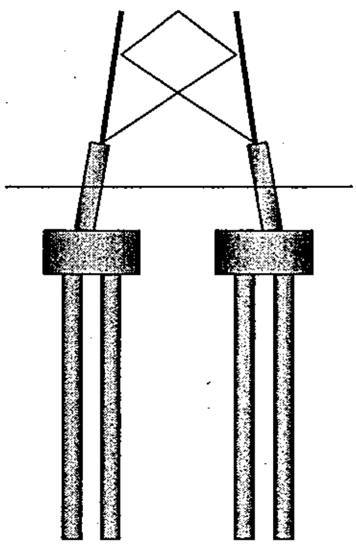
(Pad and chimney foundation)



(Caisson type pile foundation)



(Mat foundation)



(Pile foundation)

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No. TL11-4
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	40	Design of Supporting Structures of Overhead High-voltage Lines	
Title	Design of Foundations (4/5)			

3. An example of calculation of foundation stability

[Design condition]

T=1,500[kN] , C=1,650[kN] , Q= 82.5[kN]

Angle of soil against tension loads: $\theta = 30°$

Equivalent unit weight of soil: $\gamma' = 16.0$[kN/m^2]

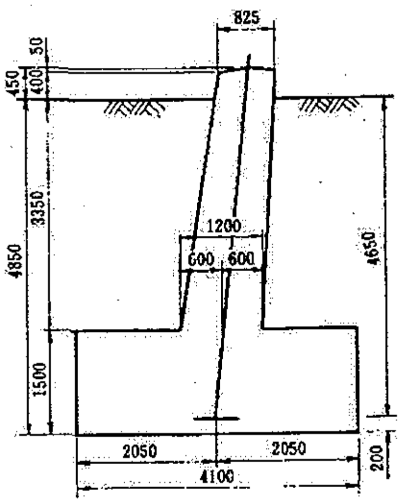
Compression strength of foundation base:

$q' = 588$[kN/m^2]

Compression strength of foundation side:

$q_s' = 392$[kN/m^2]

Unit weight of reinforced concrete: $\gamma_c = 24.0$[kN/m^3]



[Calculation of foundation weight]

Volume of chimney of foundation: $V_{c1} = 3.054$[m^3]

Volume of chimney of foundation above the ground:

$V_{c1}' = 0.224$[m^3]

Volume of pad of foundation: $V_{c2} = 19.803$[m^3]

Weight of foundation:

$G = (V_{c1} + V_{c2}) \times \gamma_c = (3.054 + 19.803) \times 24.0 = 548.6$[kN]

[Examination against compression strength]

$$\frac{q'}{F_1 \cdot F_2} \geqq \frac{C + G + W_s}{A}$$

$$\frac{C + G + W_s}{A} = \frac{1650 + 548.6 + 662.4}{13.2} = 216.74[\text{kN}] < \frac{q'}{F_1 \cdot F_2} = \frac{588}{2.0} = 294[\text{kN}] \quad \text{ok}$$

$$\text{Ws} = \{\frac{\pi \times 4.1^2 \times 3.35}{4} - (3.054 - 0.224)\} \times 16.0 = 662.4[\text{kN}]$$

[Examination against tension strength]

$$\frac{G}{F_1} + \frac{\gamma'\left(V_e - V_c'\right)}{F_1 \cdot F_2} \geqq T$$

$$\frac{G}{F_1} + \frac{\gamma'\left(V_e - V_c'\right)}{F_1 \cdot F_2} = \frac{548.6}{1.5} + \frac{16.0 \times (191.32 - 22.64)}{2.0} = 1{,}715.16[\text{kN}] < 1{,}500[\text{kN}] \quad \text{ok}$$

$$\text{V}_e = \frac{\pi}{4} \cdot \text{D}'\left(\text{B}^2 + 2 \cdot \text{B} \cdot \text{D}' \cdot \tan\theta + \frac{4}{3} \cdot \text{D}'^2 \cdot \tan^2\theta\right)$$

$$= \frac{\pi}{4} \times 4.85 \times \left(4.1^2 + 2 \times 4.1 \times 4.85 \times \tan 30° + \frac{4}{3} \times 4.85^2 \times \tan^2 30°\right) = 191.32[\text{kN}]$$

Remarks	Revisions	
	2003/Nov.	Original

Category				Document
	Chapter	2	Technical Standards of Electric Power Facilities	Document No. TL11-5
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	40	Design of Supporting Structures of Overhead High-voltage Lines	
Title	Design of Foundations (5/5)			

[Examination of horizontal strength]

$$\frac{q_f' \cdot A_f'}{F_1 \cdot F_2} \geqq Q$$

$$\frac{q_f' \cdot A_f'}{F_1 \cdot F_2} = \frac{392 \times 4.1 \times 1.5}{2.0} = 1{,}205.4[\text{kN}] > 82.5[\text{kN}]$$

4. Safety factors of a foundation

Allowing strength " P_a" is calculated as follows.

$$P_a = \frac{1}{F_1 \cdot F_2} P_y \left(= \frac{1}{1.5F_1 \cdot F_2} P_u \right)$$

P_a : Allowing strength (kN)
P_y : Capitulating strength (kN)
P_u : Maximum strength (kN)
F_1 : Safety factor against the loads
F_2 : Safety factor against the ground

Assumed loads	Safety factors	
	F_1	F_2
Long-term load	1.5	1.33
Short-term load calculated by instantaneous wind velocity against the maximum wind velocity	1.0	1.33
Short-term load calculated by average wind velocity against the maximum wind velocity	1.5	1.33

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. TL12-1
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	41	Safety Factor of Fittings for Conductors and/or Ground Wires of Overhead High-voltage Lines	
Title	Kinds of Insulators (1/2)			

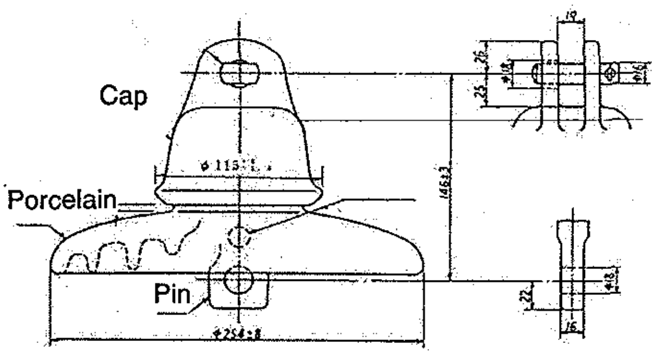
Kinds of Insulators are as follows.

- Insulators
  - Suspension insulator
    - Crevice type insulator
    - Ball-socket type insulator
  - Long-rod insulator

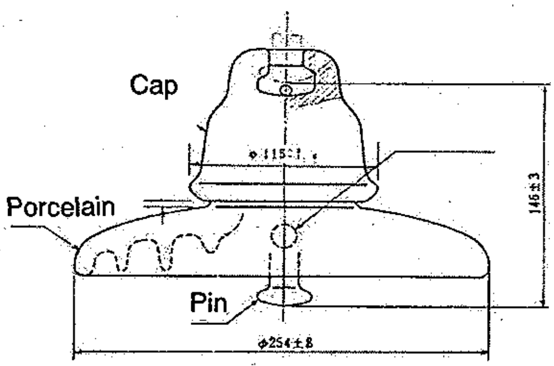
1.Suspension Insulator

There are two types of suspension insulators, one is a crevice type and the other is a ball-socket type.

Properties of the suspension insulators should comply with IEC standards (e.g., IEC60305, IEC60120 and IEC60471) or equivalent.



Crevice type insulator



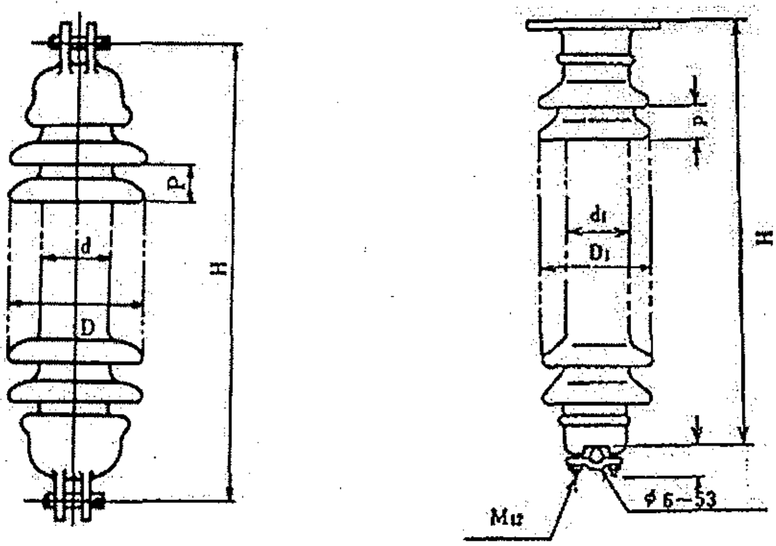
Ball-socket type insulator

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. TL12-2
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	41	Safety Factor of Fittings for Conductors and/or Ground Wires of Overhead High-voltage Lines	
Title	Kinds of Insulators (2/2)			

2.Long-rod insulator

Properties of long-rod insulators should comply with IEC standards (e.g., IEC60443, IEC60120 and IEC60471) or equivalent.



Long-rod insulator

Remarks	Revisions	
	2003/Nov.	Original

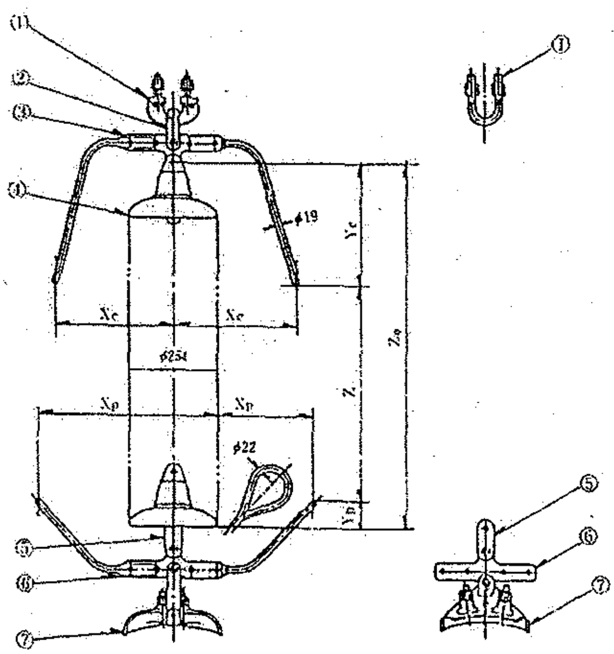
Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL13-1**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	41	Safety Factor of Fittings for Conductors and/or Ground Wires of Overhead High-voltage Lines	
Title	Kinds of Insulator Assemblies (1/2)			

Kinds of Insulator assemblies are as follows.

- Assembly for conductors
  - Suspension assembly
  - Tension assembly
- Assembly for ground wires
  - Suspension assembly
  - Tension assembly

1.Suspension assembly for conductor

An example of a suspension assembly is as follows.

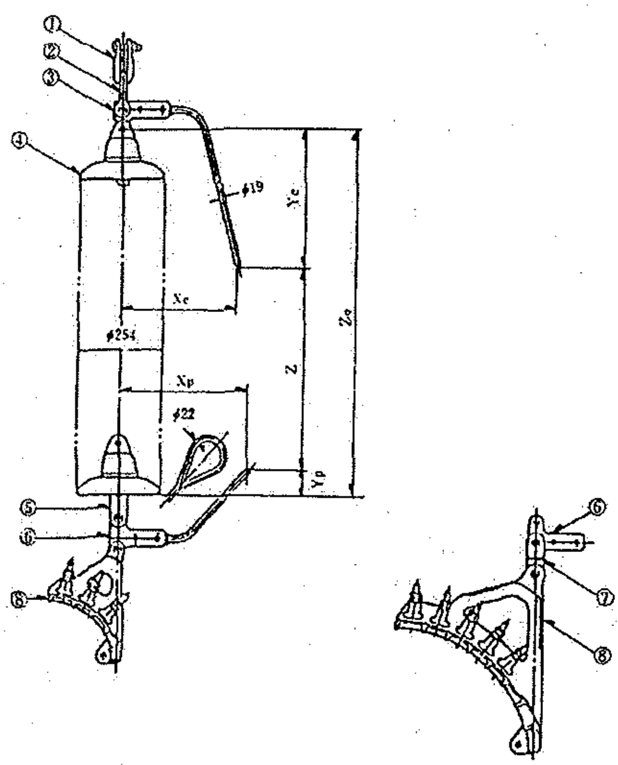


Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	Document No. TL13-2
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	41	Safety Factor of Fittings for Conductors and/or Ground Wires of Overhead High-voltage Lines	
Title	Kinds of Insulator Assemblies (2/2)			

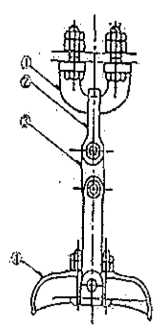
2.Tension assembly for conductor

An example of a tension assembly is as follows.

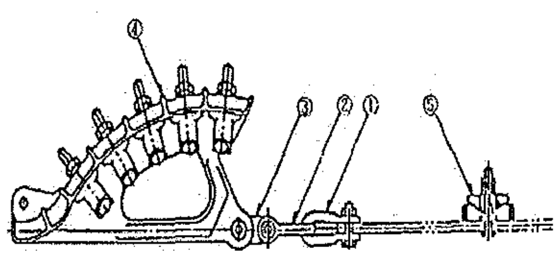


3.Assemblies for ground wires

Examples of assemblies for ground wires are as follows.



(Suspension assembly)



(Tension assembly)

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. TL14
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	41	Safety Factor of Fittings for Conductors and/or Ground Wires of Overhead High-voltage Lines	
Title	Insulator Strength			

A safety factor of insulator assemblies for overhead transmission lines shall be no less than 2.5.

The safety factor is derived as follows:

a. For tension insulator assemblies

[Safety factor] = [Tensile breaking strength] / [Assumed maximum tension at a supporting point]

b. For suspension insulator assemblies

[Safety factor] = [Tensile breaking strength] / [Assumed maximum resultant of vertical loads and horizontal transverse loads]

c. For supporting insulator assemblies, such as Long-rod insulator assemblies

[Safety factor] = [Bending breaking strength] / [Assumed maximum load perpendicular to the axis of the insulator assembly]

The following table shows foreign countries' standards for reference.

	Safety factor based on U.T.S.
Technical Standard: Japan	No less than 2.5
National Electrical Safety Code(NESC): U.S.A.	No less than 2.0 against tensile No less than 2.5 against bend
The Electricity (Overhead Lines) Regulations: U.K.	No regulation
VDE0210: Germany	No less than 3.3

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL15**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	41	Safety Factor of Fittings for Conductors and/or Ground Wires of Overhead High-voltage Lines	
Title	Safety Factor of Fittings for Conductors and Ground Wires			

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

Foreign countries' standards are described below for reference.

	Safety factor based on yield strength
Technical Standard: Japan	No less than 2.5
National Electrical Safety Code(NESC): U.S.A.	No less than 2.0 against tensile No less than 2.5 against bend
The Electricity (Overhead Lines) Regulations: U.K.	No regulation
VDE0210: Germany	No less than 3.3

Remarks	Revisions	
	2003/Nov.	Original

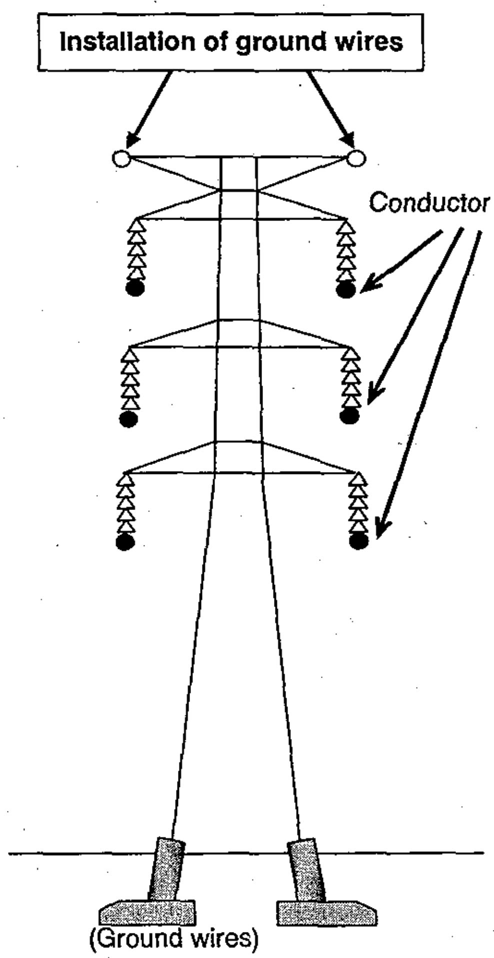
Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL16**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	42	Protection against Lightning for Overhead High-voltage Lines	
Title	Protection against Lightning			

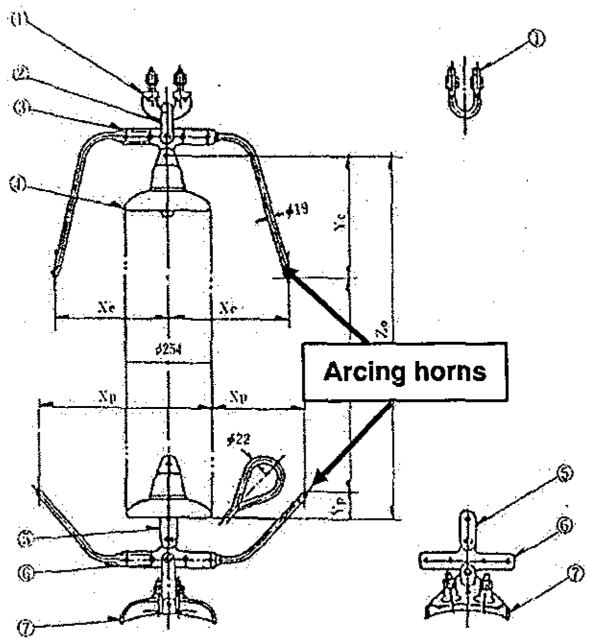
The following measures shall be taken for overhead high-voltage lines to decrease the number of electrical faults, and to protect equipment from damage by the faults

1.Installation of ground wires

2.Installation of arcing horns

3.Decreace of tower-footing resistance
No less than 10 Ω





(An example of a set of arching horns
for a single conductor)

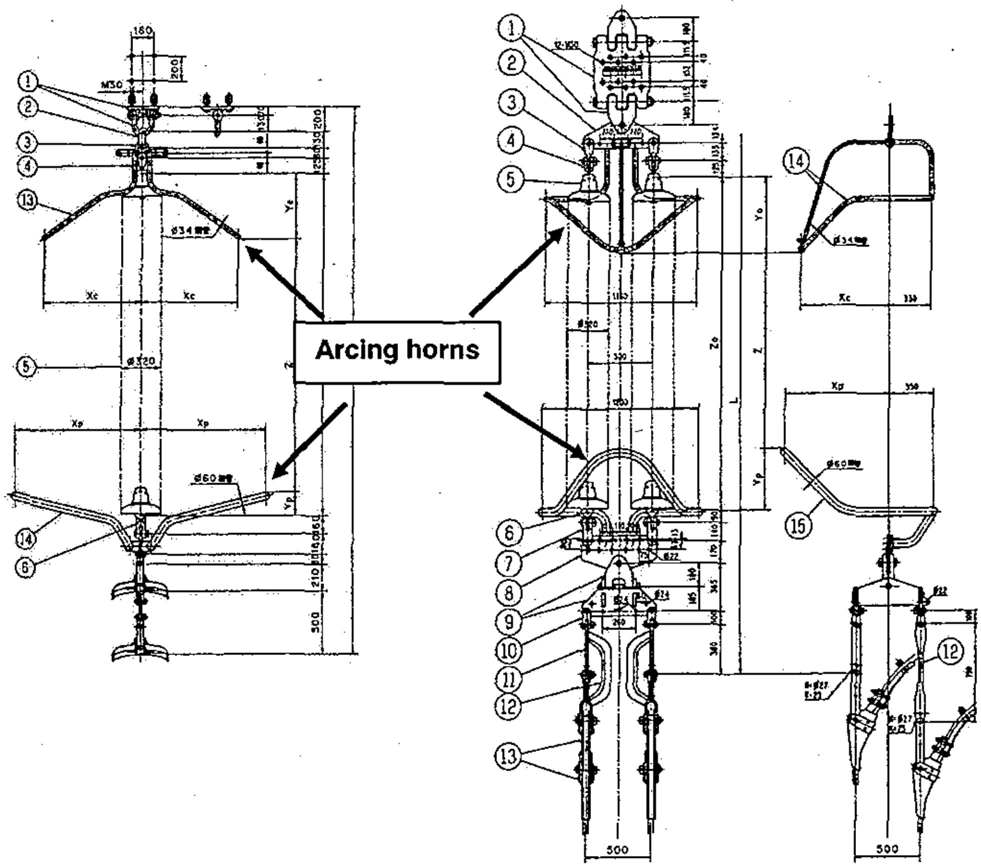
Remarks	Revisions	
	2003/Nov.	Original

Category				Document No. TL17
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	42	Protection against Lightning for Overhead High-voltage Lines	
Title	Arcing Horns			

Arcing horns shall be installed to protect overhead high-voltage lines against lightning

When lightning strikes an electrical line, insulators are occasionally destroyed. Normally, damage of insulators is caused by follow-current (50Hz), after the lightning stroke and not the lightning surge itself. Application of arcing horns, which move the arcs of the lightning surge on a surface of an insulator assembly to the end of the arcing horns, is the effective and economical countermeasure.

The gap of the arcing horns must be decided to withstand at least switching-surge, and so that the critical cascading flashover voltage of the horn gap can be predominant over one of the insulator string.



(Suspension type) (Tension type)

(An example of a set of arching horns for a quadruple conductor)

Remarks	Revisions	
Referring to the standards of KANSAI Electric Power Co., Inc.		
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL18**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	43	Bare Conductors of Overhead High-voltage Lines	
Title	Kinds of Conductors			

Properties of solid wires (hard-drawn aluminum wire, zinc-coated steel wire, aluminum-clad steel wire, etc.) that compose an electrical conductor should comply with following IEC standards.

IEC60889 Hard-drawn aluminum wire for overhead line conductors
IEC60888 Zinc-coated steel wires for stranded conductors
IEC61232 Aluminum-clad steel wires for electrical purposes

Cross section of a typical stranded wire (ACSR) is as follows.

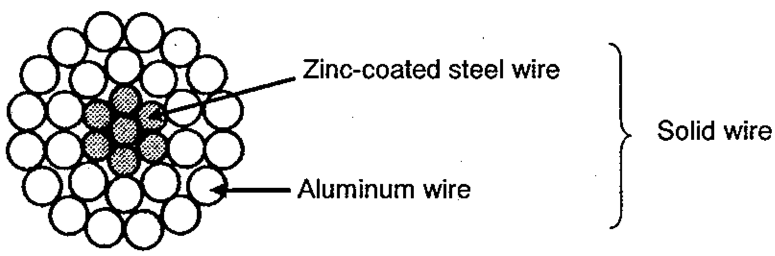


Fig.1 Cross section of stranded wire (ACSR410mm^2)

Where corrosion of conductors and ground wires is expected due to such pollution as salt, Aluminum Conductor Aluminum Clad Steel Wire Reinforced (ACSR/AS) should be adopted.

A size of a conductor should be decided in consideration of the following points.

a. Loading current
b. Short-circuit current
c. Mechanical strength

Remarks	Revisions	
	2003/Nov.	Original

Category				
Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL19**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	43	Bare Conductors of Overhead High-voltage Lines	
Title	Current-carrying Capacity			

Current-carrying capacity of overhead high-voltage lines can be computed by the following equations.

$$I = \sqrt{\frac{\left\{Hw + \left(Hr - \frac{Ws}{\pi\theta}\right)\eta\right\}\pi D\theta}{\beta \cdot R}}$$

where, $$Hw = \frac{0.00572}{\left(273 + T + \frac{\theta}{2}\right)^{0.123}} \cdot \sqrt{\frac{V}{D}}$$

$$Hr = 0.000567 \frac{\left(\frac{273+T+\theta}{100}\right)^4 - \left(\frac{273+T}{100}\right)^4}{\theta}$$

$$R = R_{20}\{1 + \alpha(t - 20)\}$$

$$\theta = t - T$$

I	:Current-carrying capacity (A)
Hw	:Coefficient of conventional heat dissipation (W/°C. cm^2)
Hr	:Coefficient of radiative heat dissipation (W/°C. cm^2)
R	:Conductor resistance at the conductor temperature t (ohm/cm)
R_{20}	:Conductor resistance at 20°C (ohm/cm)
θ	:Temperature rise of conductor (°C)
t	:Conductor temperature (°C)
T	:Ambient temperature (°C)
Ws	:Solar radiation energy (W/cm^2), assumed to be 0.13
η	:Surface coefficient, assumed to be 0.9
D	:Overall diameter of conductor (cm)
V	:Wind velocity (m/sec)
α	:Temperature coefficient of resistance (per °C), assumed to be 0.004
β	:AC/DC resistance ratio, assumed to be 1.0

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. TL20-1
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	43	Bare Conductors of Overhead High-voltage Lines	
Title	Sag of Conductors (1/4)			

(1) Calculation of Tension of Conductors

A tension of a conductor is calculated based on the quadratic approximation, as follows:

In the following equation, subscript 1 and 2 mean the Conditions, respectively.

Condition 1

$L_1 = S[1 + (w_1/T_1)^2 (S^2/24)]$ ...1)

Condition 2

$L_2 = S[1 + (w_2/T_2)^2 (S^2/24)]$ ...2)

where,

L = Length of conductor[m]

T = Tension of the conductor[kg]

S = Span[m]

w = Load of conductor [kg/m]

where,

$$w = \sqrt{W_c^2 + Pw'^2}$$

Wc : Mass of Conductor[kg/m]

Pw' : Wind Pressure of Conductor

$Pw' = d \times Pw \times 10^{-3}$[kg/m]

Pw = Wind Pressure of Conductor[kg/m²]

d = Diameter of Conductor[mm]

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL20-2**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	43	Bare Conductors of Overhead High-voltage Lines	
Title	Sag of Conductors (2/4)			

On the other hand, expansion of conductor is described as follows:

$$L_2 - L_1 = \left\{ (t_2 - t_1)\varepsilon + \frac{T_2 - T_1}{A \cdot E} \right\} L_1 \quad ...3)$$

where,

$(t_2 - t_1)\varepsilon$	=	Length difference by temperature change
$\frac{T_2 - T_1}{A \cdot E}$	=	Length difference by tension change
t	=	Temperature[°C]
ε	=	Coefficient of linear expansion[/°C]
A	=	Sectional area of conductor (total)[mm²]
E	=	Modulus of elasticity[kg/mm²]

In the above equations from 1) through 3), assuming as follows:

$$\left\{ (t_2 - t_1)\varepsilon - \frac{T_2 - T_1}{A - E} \right\} \frac{S^3 \cdot w_1^2}{24 T_1^2} = 0$$

The following equation 4) is derived.

$$\frac{S^2 w_2^2}{24 T_2^2} - \frac{S^2 w_1^2}{24 T_1^2} - (t_2 - t_1)\varepsilon + \frac{T_1 - T_2}{A \cdot E} = 0 \quad ...4)$$

In the above equation, assuming as follows;

$$K = \frac{T_1}{A} - \frac{S^2 \cdot w_1^2 \cdot E}{24 T_1^2}$$

$$M = \frac{S^2 \cdot w_2^2 \cdot E}{24 A^2}$$

$$f_2 = \frac{T_2}{A}$$

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No. TL20-3
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	43	Bare Conductors of Overhead High-voltage Lines	
Title	Sag of Conductors (3/4)			

The following equation is derived.

$$\frac{M}{f_2^2} - f_2 = -K + \varepsilon (t_2 - t_1) E$$

$$f_2^2 \left[f_2 - \left\{ K - \varepsilon (t_2 - t_1) E \right\} \right] = M \quad \dots 5)$$

(2) Example of the Calculation

Physical constants of each conductor are assumed as follows.

		ACSR 429
Calculated Sectional Area A	[mm^2]	484.5
Overall Diameter d	[mm]	28.62
Mass per meter Wc	[kg/m]	1.621
Coefficient of Linear Expansion ε	[/°C]	1.954×10^{-5}
Modulus of elasticity E	[kg/mm^2]	7987

As the "Condition 1" mentioned in (1), when following values are selected,

Span	S [m]	350
MWT	T_1[kg]	3,400
Temperature	t_1 [°C]	10
Wind Pressure	P_{w1} [kg/m^2]	40
W1[kg/m] ACSR429	1.984	

"Condition 2" (tension of conductor) mentioned in (1) is derived as follows;

Conductor	Input			---			Answer	
	t_2 [°C]	P_{w2} [kg/m^2]	w_2 [kg/m]	K	M	$K - \varepsilon (t_2 - t_1) E$	f_2 [kg/m·mm^2]	T_2 [kg]
ACSR 429	30	0	1.621	-6.871	456.338	-9.992	5.439	2.635
	75	0	1.621	-6.871	456.338	-17.015	4.596	2.227
	90	0	1.621	-6.871	456.338	-19.356	4.384	2.124

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL20-4**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	43	Bare Conductors of Overhead High-voltage Lines	
Title	Sag of Conductors (4/4)			

(3)Sag Calculation

Sags are described with the result of the tension calculation mentioned in (1) and (2), and the following equation.

$$Sag = \frac{S^2 \cdot w}{8 \cdot T}$$

(4)Sag Template Calculation

Sag Template is made on the basis of the assumption in which all spans between two tension towers have the same tension.

$$T = \frac{S_1^2 \cdot w}{8 \cdot Sag_1} = \frac{S_2^2 \cdot w}{8 \cdot Sag_2}$$

Basic Span 350 m

Conductor ACSR 429 mm² Zebra (90 °C)

$$\frac{S_1^2 \cdot w}{8 \cdot Sag_1} = \frac{S_2^2 \cdot w}{8 \cdot Sag_2} \rightarrow \frac{350^2}{11.37} = \frac{S_2^2}{Sag_2}$$

$$\boxed{Sag_2 = \frac{11.69}{350^2} = S_2^2 = 9.543 \times 10^{-5} S_2^2}$$

According to this relation, Sag Template for Basic Span 350 m is prepared.

Sag Template for ACSR 429 mm² for Basic Span 350 m and 90 °C

Span (m)	Sag (m)
200	3.82
250	5.96
300	8.59
350	11.69
400	15.27
450	19.32
500	23.86

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL 21**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	43	Bare Conductors of Overhead High-voltage Lines	
Title	Safety Factor of Conductors			

A safety factor of conductors and ground wires for overhead high-voltage lines shall be no less than 2.5 to the tensile strength (ultimate tensile strength; breaking strength).

Foreign countries' standards are described below for reference.

	Safety factor based on U.T.S.
Technical Standard: Japan	No less than 2.5
National Electrical Safety Code(NESC): U.S.A	No less than 1.67
The Electricity (Overhead Lines) Regulations: U.K.	No less than 2.0-2.5
VDE0210: Germany	No less than 2.3-2.5

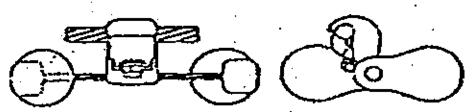
Remarks	Revisions	
	2003/Nov.	Original

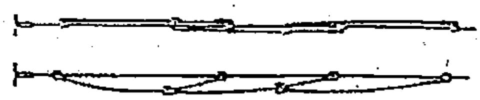
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. TL22
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	42	Protection against Lightning for Overhead High-voltage Lines	
		43	Bare Conductors of Overhead High-voltage Lines	
Title	Measures for Aeolian Vibration			

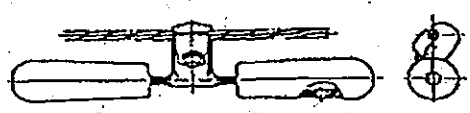
The following measures shall be taken to prevent aeolian vibration for overhead high-voltage lines.

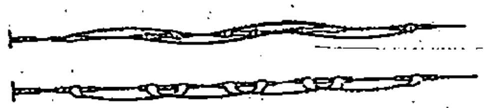
1.Installation of vibration dampers
Examples of dampers are shown as follows.

2.Installation of armor rods
An example of armor rods is shown as follows.

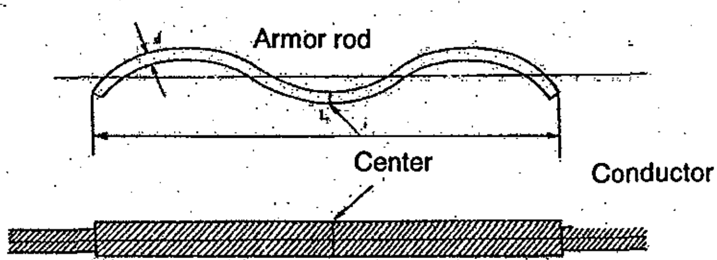

Double Torsional Damper


Bate Damper


Stock Bridge Damper


Christmas Tree Damper


Vibration Less Damper



Armor rods

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL23**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	43	Bare Conductors of Overhead High-voltage Lines	
Title	Connection of Conductors			

For connections of conductors and ground wires of high-voltage lines, compression type sleeves shall be used. And checking of the condition before and after the compression is one of major jobs of the construction supervision, shown as follows.

(Before joint)

(After joint)

An example of jointing of conductors

Remarks	Revisions	
Referring to the standards of KANSAI Electric Power Co., Inc.		
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL24**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	43	Bare Conductors of Overhead High-voltage Lines	
Title	Kinds of Ground wires			

Properties of solid wires (hard-drawn aluminum wire, zinc-coated steel wire, aluminum-clad steel wire, etc.) that compose an ground wire should comply with following IEC standards.

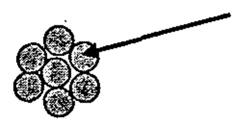
IEC60889 Hard-drawn aluminum wire for overhead line conductors
IEC60888 Zonic-coated steel wires for stranded conductors
IEC61232 Aluminum-clad steel wires for electrical purposes

Cross section of a typical stranded wire (GSW and AS) is as follows.

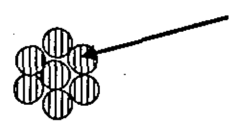
Where corrosion of conductors and ground wires is expected due to such pollution as salt, Aluminum Clad Wire (AS) should be adopted. For an example in Kansai Area in Japan, Galvanized Steel Wire (GSW) applies in areas of more than 30km away from seacoast.

A size of a ground wire should be decided in consideration of the following points.

a. Mechanical strength
b. Current-carrying capacity against inductive current
c. Countermeasures of electromagnetic induction against communication lines



(GSW55mm^2)



(AS55mm^2)

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No. TL25
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	43	Bare Conductors of Overhead High-voltage Lines	
Title	Safety Factor of Ground Wires			

A safety factor of conductors and ground wires for overhead high-voltage lines shall be no less than 2.5 to the tensile strength (ultimate tensile strength; breaking strength).

Foreign countries' standards are described below for reference.

	Safety factor based on U.T.S.
Technical Standard: Japan	No less than 2.5
National Electrical Safety Code(NESC): U.S.A	No less than 1.67
The Electricity (Overhead Lines) Regulations: U.K.	No less than 2.0-2.5
VDE0210: Germany	No less than 2.3-2.5

Remarks	Revisions	
	2003/Nov.	Original

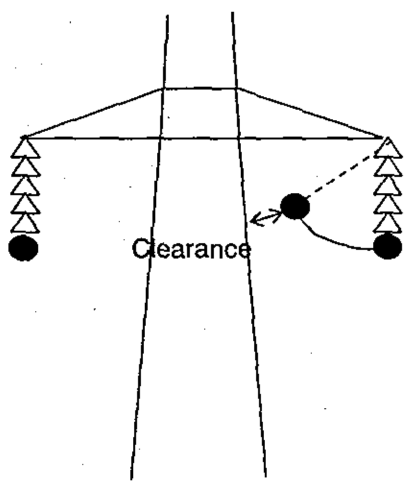
Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL26**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	44	Clearance among Bare Conductors and Supporting Structures of Overhead High-voltage Lines	
Title	Clearance among Bare Conductors and Supporting Structures, Arms, Guy Wires or Pole Braces			

Clearance between a conductor and a supporting structure should be decided in accordance with the switching surge voltage, taking into account the swing of the conductors. Normally, the switching surge voltages are decided as follows.

Nominal voltage :V[kV]	115	230
Highest equipment voltage :Vm=V×1.2/1.1[kV]	125.5	250.9
Peak value of line to ground voltage :Vm×√(2/3)[kV]	102.5	204.9
Switching surge multiple	2.8	2.8
Switching surge voltage[kV]	287.0	573.7
Insulating drop coefficient	1.1	1.1
Required withstand voltage[kV]	316	631
Clearance[m]	0.68	1.44

where, switching surge multiple is following;

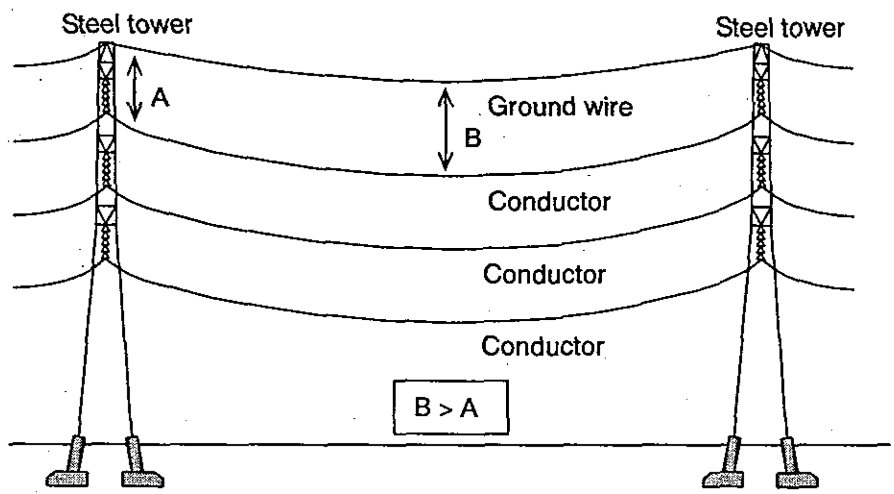
Type of neutral grounding	Multiple
Neutral reactor grounding	3.3
Neutral direct grounding	2.8
Neutral resistance grounding	2.0



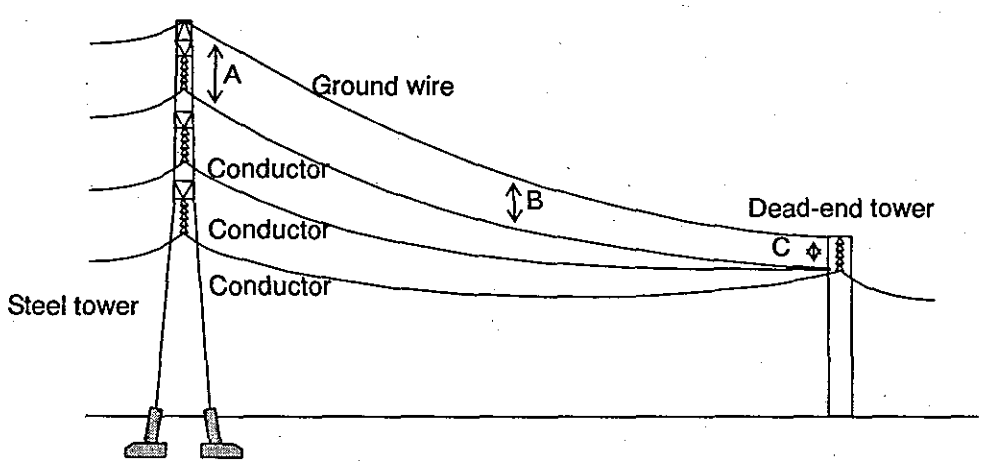
Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. TL27**
	Paragraph	6	Transmission and Distribution Facilities (High Voltage)	
	Clause	44	Clearance among Bare Conductors and Supporting Structures of Overhead High-voltage Lines	
Title	Clearance among Ground Wires and the Nearest Conductor			

Clearance between a ground wire and a conductor shall be designed as B>A, in any cases to be designed.



In the case of the end span to substations, as shown in the following figure, clearance should be designed as A > B > BC.



Remarks	Revisions	
	2003/Nov.	Original