Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HW1
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Common Rules for Waterways**			

Waterways shall meet the following:

1. Waterways shall not be damaged by disasters such as floods and landslides;
2. Installation of waterways shall not cause serious water leakage, landslides, or any other detrimental consequences;
3. Waterways shall not be significantly damaged by driftwood, floating debris, or sediment that flows into the waterways and so on;
4. Waterways shall be able to safely eliminate the water flow in case the water flow in excess of the design plant discharge flows into the waterways;
5. Waterways shall be such structures that necessary parts are easily inspected and repaired;
6. Concrete materials for waterways shall meet Document No.HD17;
7. Steel materials for waterways shall be confirmed whether they have required strength through the tests that are specified in a standard such as ISO, or be such materials that are specified in a standard for example ISO, which meets required strength; and
8. Other materials for waterways shall have required strength and durability.

References

(Steel)

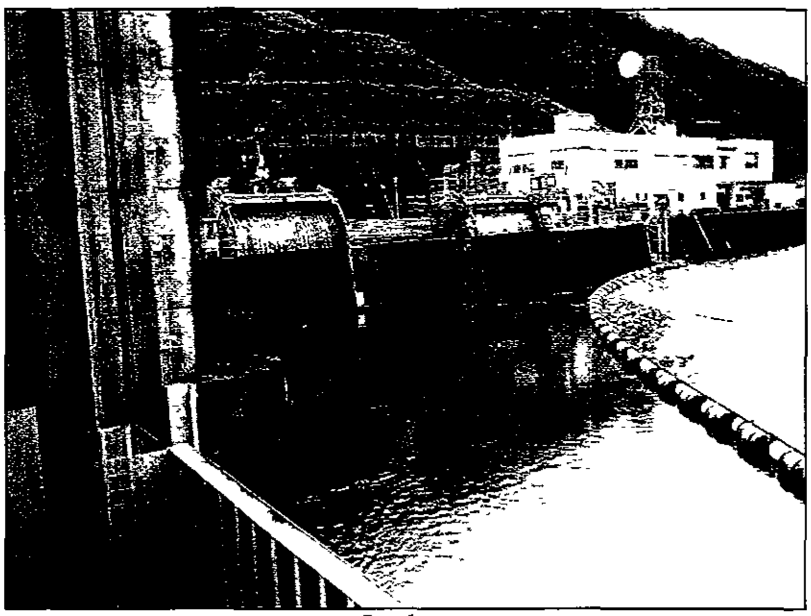
- ISO630/ Structural steels, E275, E355
- ISO4950-2/ High yield strength flat steel products, Part 2: Products supplied in the normalized or controlled condition, E355
- ISO4950-3/ High yield strength flat steel products, Part 3: products supplied in the heat-treated (quenched + tempered) condition, E460

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HW2-1
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Intakes (1)			

Intakes shall meet the following:

1. Intakes shall be stable for anticipated loads such as self-weight, hydrostatic pressure, hydrodynamic pressure, mud pressure, seismic force, external water pressure, uplift, and earth pressure. Every material for the intakes shall have required strength and durability for the said loads;
2. Hydraulic gates, hydraulic valves, or stop-logs shall be installed in order to inspect and repair the waterways and to limit an inflow of excessive water in excess of the design plant discharge,
3. Locations and structures of intakes shall be designed to protect the intakes from inflowing sediment, debris, driftwood, and rubbish; and
4. In case intakes are directly connected to pressure headraces or penstocks, the locations and structures of the intakes shall be designed to maintain proper inflow conditions and to protect the waterways and hydraulic turbines from harmful impacts such as air entrainment.

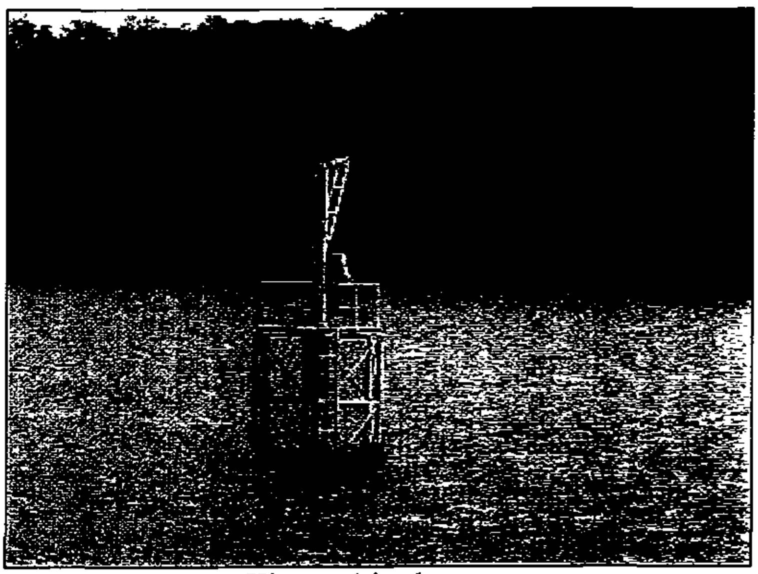


Intakes

Remarks	Revisions	
	2003/Nov.	Original

Category				Document
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HW2-2
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Intakes (2)			

O Chum 1 intake tower



Kirirom 1 intake tower

Remarks	Revisions	
	2003/Nov.	Original

Category				
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HW3
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Purpose of Equipping a Hydraulic Gate or a Hydraulic Valve to an Intake Facility**			

The purposes of equipping a hydraulic gate or a hydraulic valve to an intake facility are as follows:

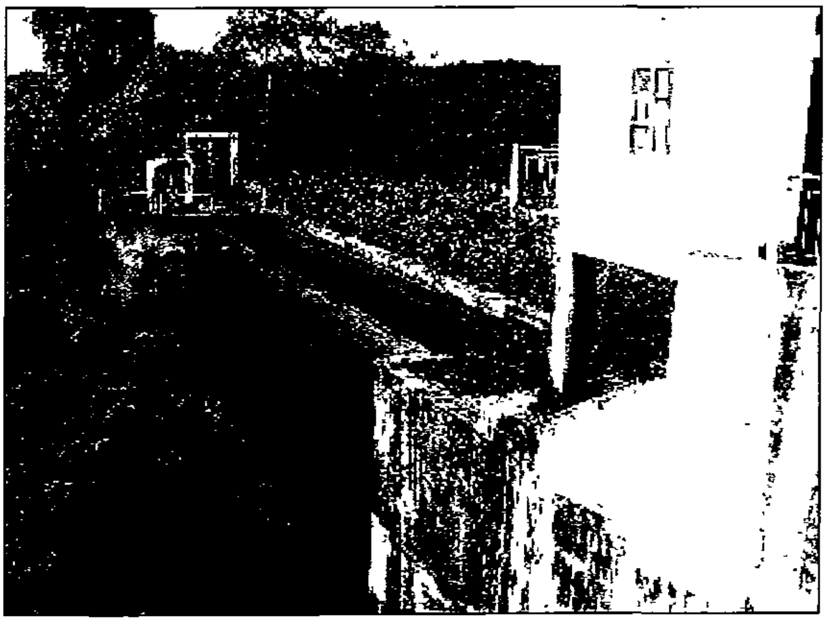
1. To prevent an intake from abnormal water flow under a flood condition in case the intake is connected to a free-flow type headrace;
2. To make, in principal, a hydraulic gate interlocked according to the change in water level in order to maintain the discharge under any load condition, in case the discharge is controlled according to the load and the change in water level, when the intake is connected to a free-flow type headrace at a power plant with a reservoir.
3. To enable the headrace inspected and repaired.
4. But it is not necessary for an intake facility with small a discharge capacity to be equipped with hydraulic gates in case the intake can meet the purpose of 1 and 3 mentioned above by using stop-logs.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HW4
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Forebays (Settling Basins)			

Forebays (Settling Basins) shall meet the following:

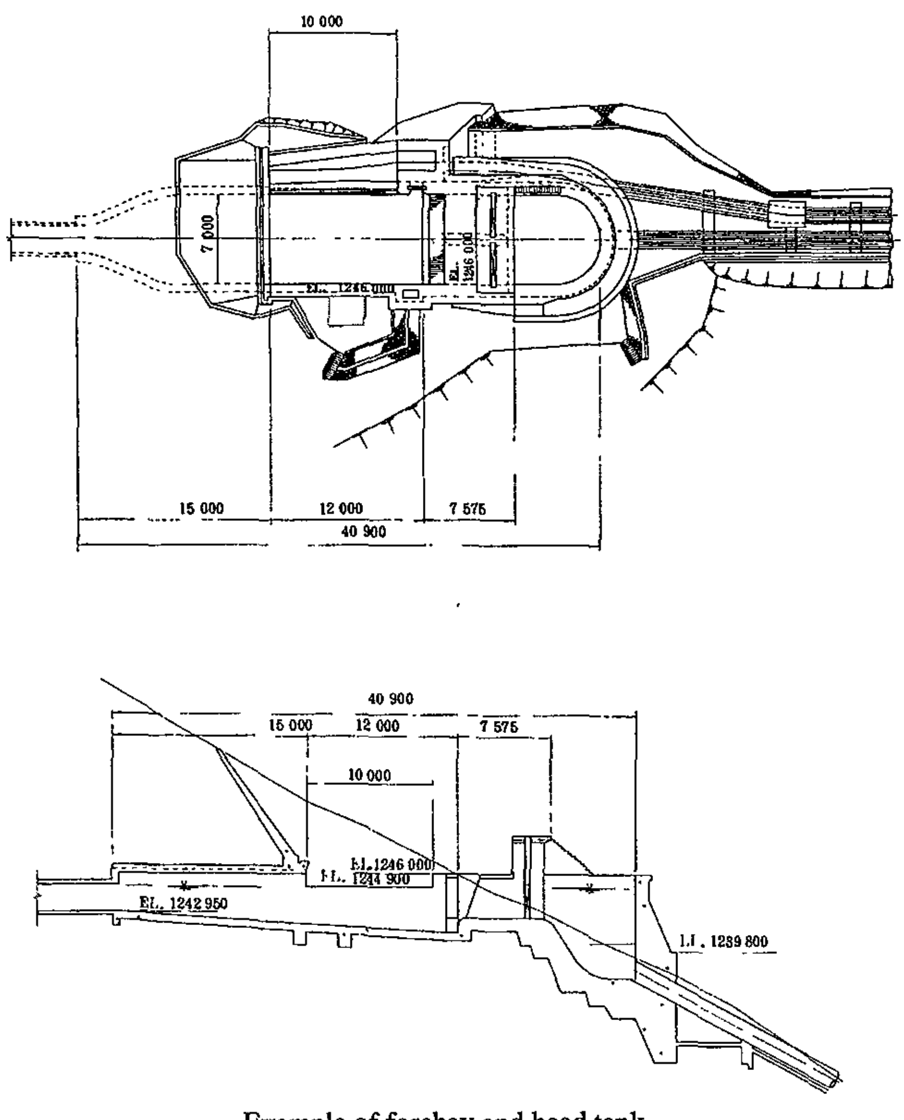
1. Forebays (Settling Basins) shall be stable for anticipated loads such as self-weight, hydrostatic pressure, hydrodynamic pressure, seismic force, external water pressure, and earth pressure. Every material for the Forebays (Settling Basins) shall have required strength and durability for the said loads;
2. Forebays (Settling Basins) shall be able to settle sediment that may damage downstream waterways or hydraulic turbines; and
3. Forebays (Settling Basins) shall be designed so that accumulated sediment can be easily flushed out.



O Chum 2 forebay

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HW5
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Example of Forebay**			



Example of forebay and head tank

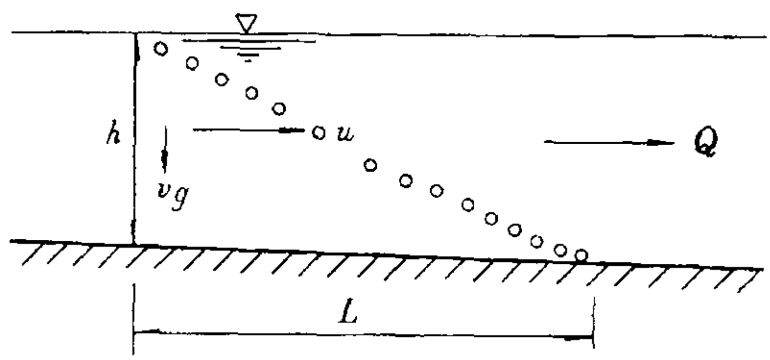
Remarks	Revisions	
	2003/Nov.	Original

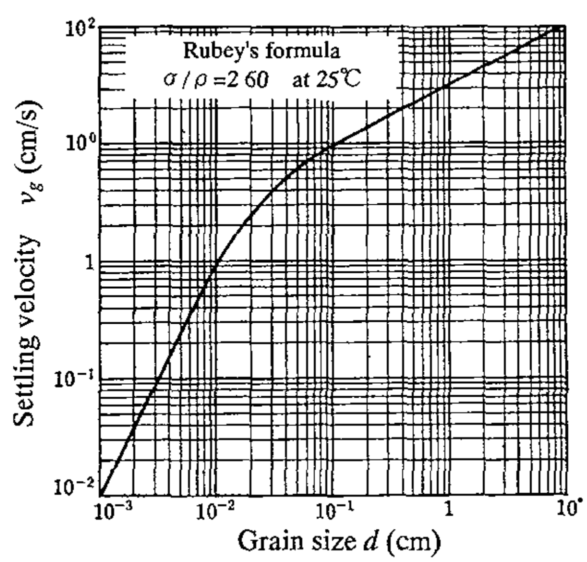
Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HW6**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Capability to Settle Sediment**			

The length of a forebay or settling basin is obtained as follows:

$L \geqq hu/v_g = Q/Bv_g$

Where,
L: necessary length(m)
h: depth(m)
B: width of forebay (settling basin) (m)
u: mean flow velocity (m/s)
v_g: settling velocity (m/s)
Q: discharge (m^3/s)





Source Formulas for Hydraulics 1985, Japan Society of Civil Engineers

Remarks	Revisions	
Formulas for Hydraulics 1985, Japan Society of Civil Engineers		
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HW7**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Headraces**			

Headraces shall meet the following:

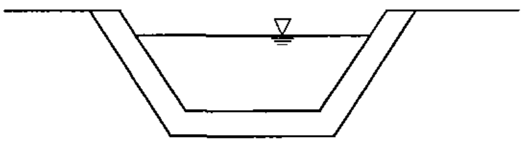
1. Headraces shall be stable for anticipated loads such as self-weight, water weight, hydrostatic pressure, internal water pressure, external water pressure, seismic force, earth pressure, surcharge, and temperature load. Every material for the headraces shall have required strength and durability for the said loads;
2. Water leakage from inside of headraces shall not cause any harmful impacts on the surrounding ground or other structures;
3. In case tunnels or open channels are not lined, headraces shall not cause significant damage to the downstream waterways or the hydraulic turbines due to slitting of the waterways;
4. Pressure headraces shall meet the following:
   (1) Countermeasures such as lining shall be taken to prevent a cave-in of the surrounding ground;
   (2) Pressure headraces shall be placed below the hydraulic gradient line when the water levels in the intakes or surge tanks are at their lowest ones; and
   (3) Pressure headraces shall be designed to easily and securely intake and discharge air for filling and draining water.
5. Headraces shall be designed so that waterways or hydraulic turbines are not significantly damaged by air entrainment.

Remarks	Revisions	
	2003/Nov.	Original

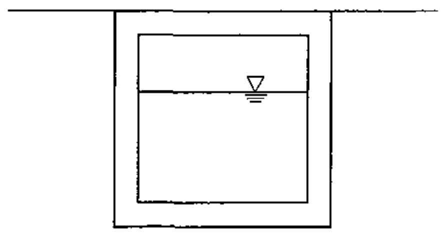
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HW8
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Types of Headraces			

Headraces ┬ pressure waterways
└ non- pressure waterways

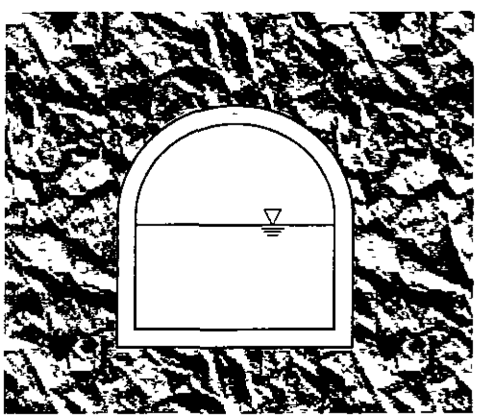
Headraces structures: open canal, covered canal, culvert, aqueduct, inverted siphon, tunnel, etc.



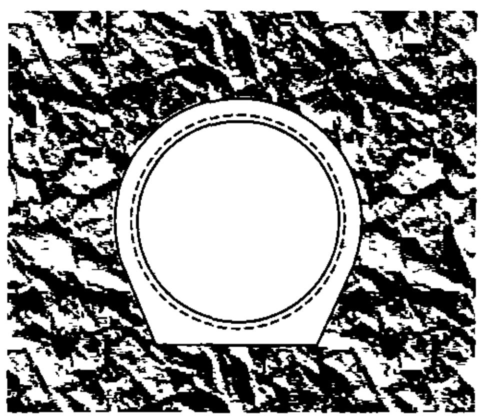
Non-pressure waterway (open canal)



Non-pressure waterway (culvert)



Non-pressure waterway (tunnel)



Pressure waterway (tunnel)

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HW9**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Surge Tanks and Head Tanks**			

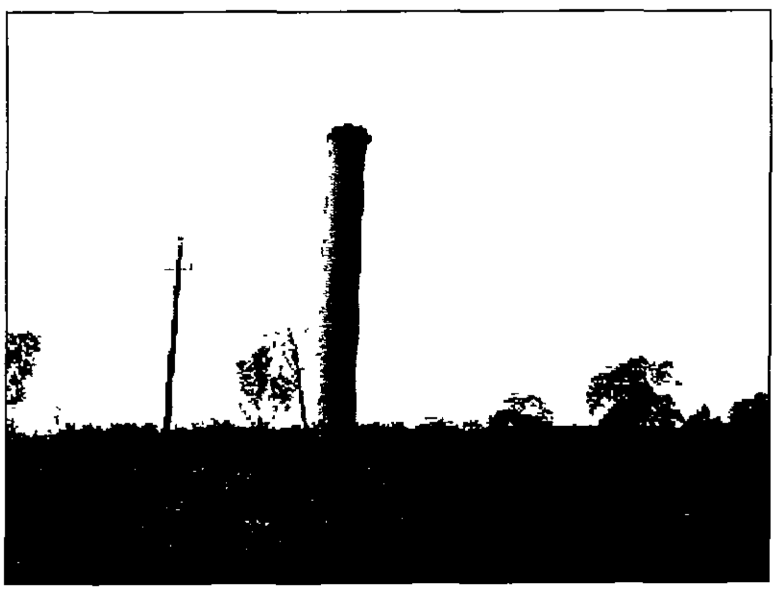
1. Surge tanks shall meet the following:
   (1) Surge tanks shall be stable for anticipated loads such as self-weight, water weight, internal water pressure, seismic force, external water pressure, earth pressure, force caused by wind, and temperature load. Every material for the surge tanks shall have required strength and durability for the said loads;
   (2) The fluctuations in water levels at the surge tanks shall not accelerate and shall return to equilibrium in a short period;
   (3) The anticipated water level fluctuation shall not result in an overflow and not cause any harmful impacts on the waterways and the penstocks. The previous provision concerning an overflow may not apply in case spillways or spillway channels are installed in accordance with the next Section 2. (5); and
   (4) Surge tanks at hydroelectric power plants with a function of automatic frequency control shall not cause any damages to other objects and facilities caused by water level fluctuations due to frequency fluctuations in power system connected with the plants.

2. Head tanks shall meet the following:
   (1) Head tanks shall be stable for anticipated loads such as self-weight, internal water pressure, seismic force, external water pressure, and earth pressure. Every material for the head tanks shall have required strength and durability for the said loads;
   (2) Head tanks shall have sufficient water capacities for the safe operation of the power plants so that penstocks do not draw in air under the conditions of a normal operation and a rapid load rise;
   (3) Structures of pipe-shells at penstock entrance shall be able to maintain proper flow conditions and not cause any damages to the penstocks or hydraulic turbines;
   (4) Head tanks shall have spillway channels so that they can safely discharge the maximum plant discharge when the full load is shut off. But the above provision may not apply in case facilities except for spillway channels have functions to safely control spillage;
   (5) In the previous provision, in case spillways or spillway channels are installed, the following provisions shall be complied with:
      a. For penstock type spillway channels, they shall not cause excessive negative internal water pressure;
      b. Spillways or spillway channels shall not cause any harmful impacts on the spillways and spillway channels themselves, surrounding facilities, and downstream properties, and so on by discharging the spillage; and
      c. An upsurge in water level due to spillage overflow shall not cause damage to headraces.
   (6) The structures of head tanks shall be designed so that rubbish or sediment does not flow into the penstocks or the hydraulic turbines, and that the accumulated sediment can be easily flushed out.

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HW10
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HW10
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Surge Tanks			

O Chum 2 surge tank

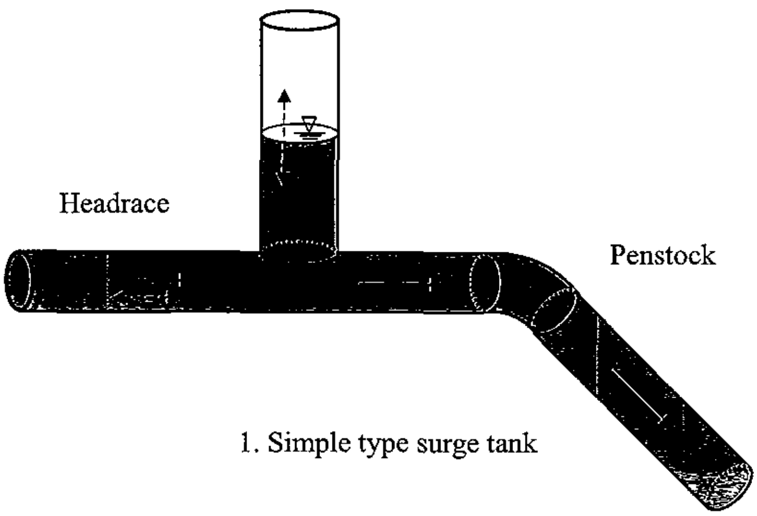


Kirirom 1 surge tank

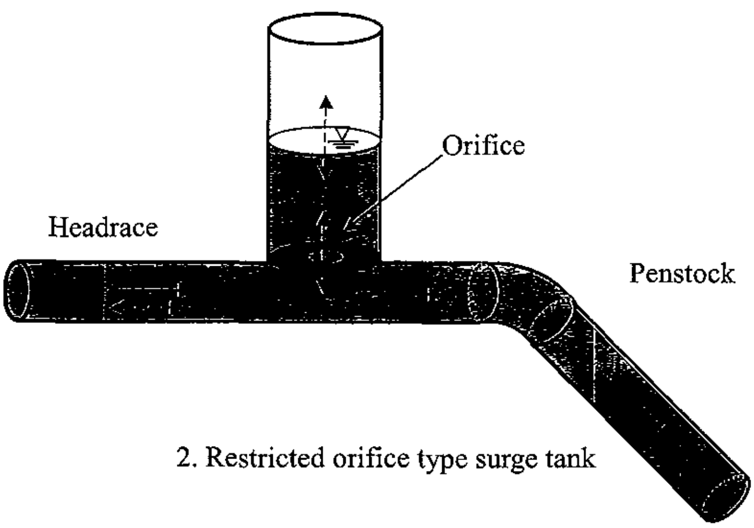
Remarks	Revisions	
	2003/Nov.	Original

Category				
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HW11-1
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	

Title	Type of Surge Tanks (1)



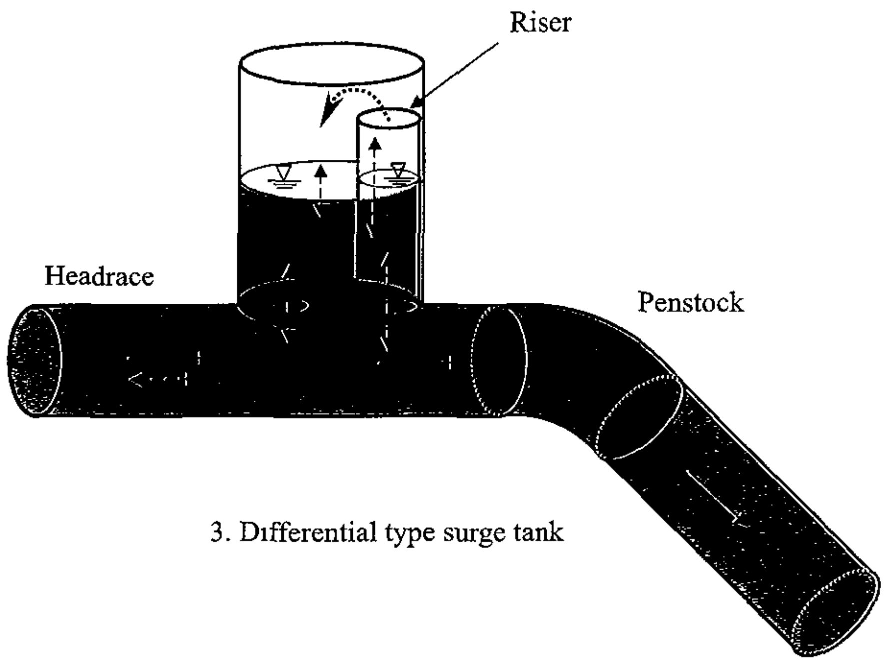
1. Simple type surge tank



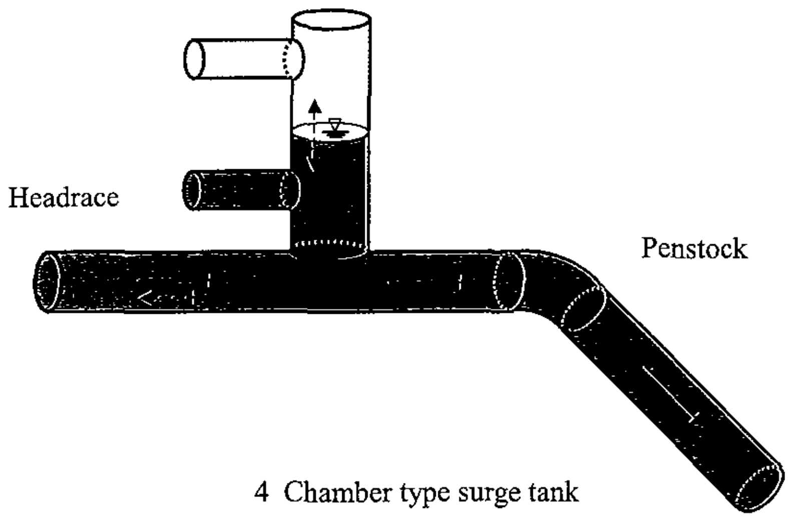
2. Restricted orifice type surge tank

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HW11-2**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Type of Surge Tanks (2)**			



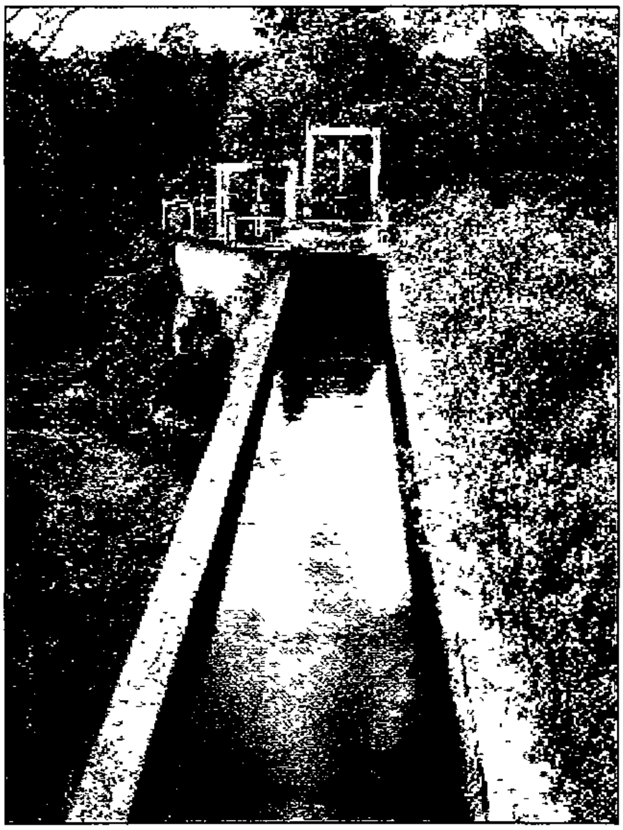
3. Differential type surge tank



4 Chamber type surge tank

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HW12**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Head Tanks**			



O Chum 2 head tank

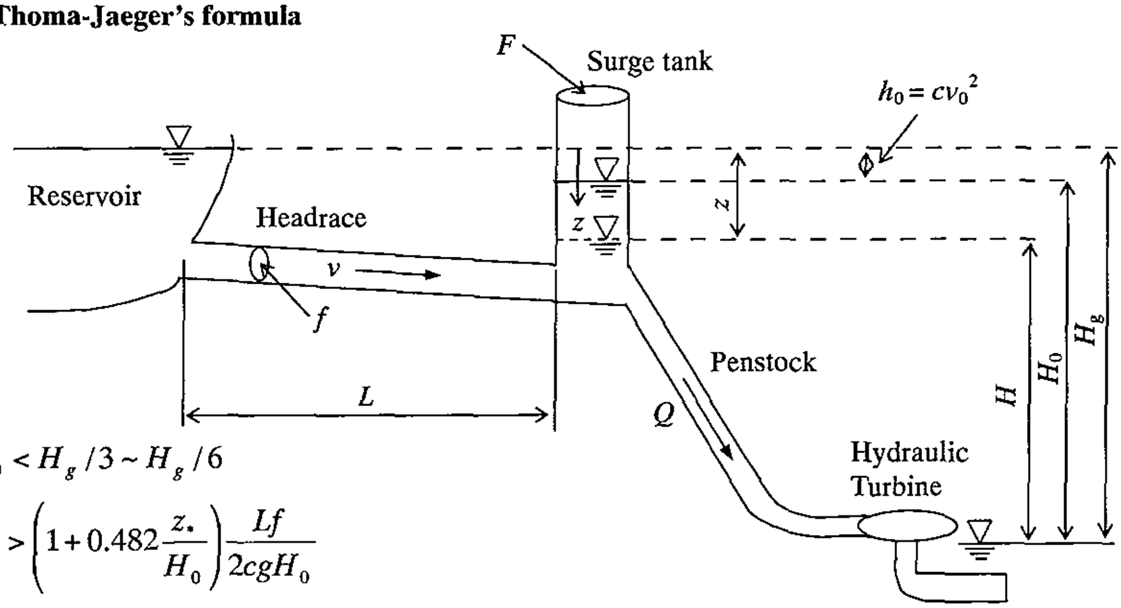
Remarks	Revisions	
	2003/Nov.	Original

Category				Document
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HW13-1
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Conditions that the Fluctuations of Water Level Are not Accelerated and Return to Equilibrium in a Short Period (1)**			

Conditions that the fluctuations of water level in a surge tank are not accelerated and return to equilibrium in a short period are generally to meet the following formulas:

- Thoma-Jaeger's formula, in case a simple type or a chamber type surge tank; and
- Thoma-Schuller's formula in case a differential type or a restricted orifice type surge tank.

- Thoma-Jaeger's formula



$$h_0 < H_g/3 \sim H_g/6$$

$$F > \left(1 + 0.482\frac{z_*}{H_0}\right)\frac{Lf}{2cgH_0}$$

Where,

h_0: Total head loss under the maximum plant discharge

$$h_0 = cv_0^2$$

v_0: Flow velocity in headrace under the maximum plant discharge

H_g: Total head

z_*: Free surge

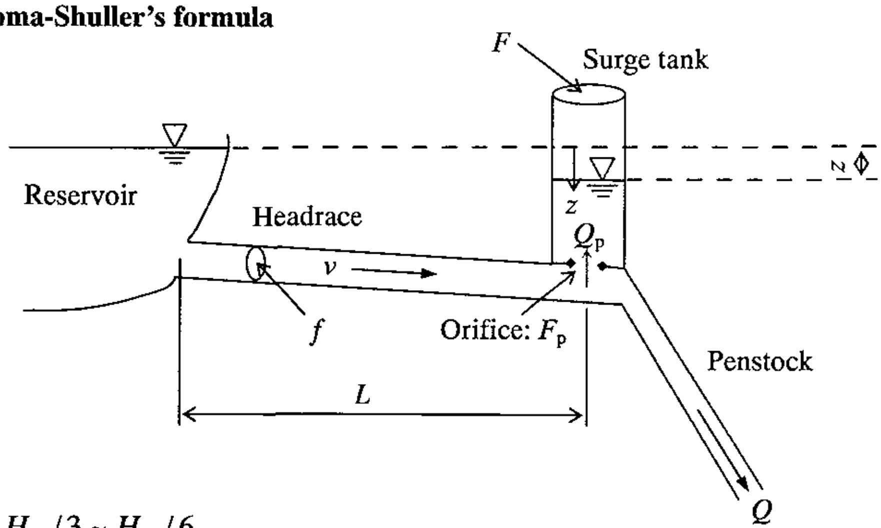
$$z_* = v_0\sqrt{Lf/gF}$$

$$H_0 = H_g - h_0$$

Remarks	Revisions	
Formulas for Hydraulics 1999, Japan Society of Civil Engineers		
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HW13-2**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Conditions That the Fluctuations of Water Level Are not Accelerated and Return to Equilibrium in a Short Period (2)**			

- Thoma-Shuller's formula



$$h_0 < H_g/3 \sim H_g/6$$

$$F > \frac{LF}{c(1+\eta)gH_g} \cong \frac{LF}{2cg(H_g - z_m)}$$

Where,

h_0: Total head loss under the maximum plant discharge

$\eta = k_0 / h_0$

$k_o = v_0^2 / 2g$

z_*: The highest upsurge water level after full load shut down

Remarks	Revisions	
Formulas for Hydraulics 1999, Japan Society of Civil Engineers		
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HW14**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Conditions That the Fluctuations of Water Level do not Lead to Overflows or Damages to Waterways or Turbines**			

The fluctuations of water level do not lead to overflows or damages to waterways or turbines under the following conditions:

- In case full loads are shut off; and
- In case loads increase from partial load to full load.

Conditions that the fluctuations of water level do not cause any harmful impacts on the waterways and the penstocks is that the lowest water level is always above the crest of headraces and that of penstocks.

Remarks	Revisions	
	2003/Nov.	Original

Category				
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HW15
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Expected Water Level Fluctuations under Hydroelectric Power Plant Operation**			

Categories		Values to be added to and subtracted from the roughness coefficient of the headrace
In case full loads are shut off.	Penstock	Subtract 0.001
	Concrete lining waterway	Subtract 0.0015
	No lining waterway	Subtract 0.003
In case loads increase from half to full load.	Penstock	Add 0.001
	Concrete lining waterway	Add 0.0015
	No lining waterway	Add 0.003

Calculations of fluctuations of water level (example in Japan)

Remarks	Revisions	
Interpretation of Technical Standards for Hydropower Stations, 1998, Japan		
	2003/Nov.	Original

Category				Document
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HW16-1
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Penstocks (1)**			

Penstocks shall meet the following:

1. Penstocks shall be stable for anticipated loads corresponding to such respective types of penstocks as the following Table. Every material for the penstocks shall have required strength and durability for the said loads;

Loads Acting on Penstocks

	Exposed type	Rock-embedded type	Earth-embedded type
Loads	- Composite maximum water pressure of hydrostatic pressure, water hammer pressure and pressure rise by surging - Self-weight of the penstock pipeshells - Temperature loads - External pressure - Water weight in the penstock - Seismic force - Forces caused by wind - Forces of flowing water inside the penstock	- Composite maximum water pressure of hydrostatic pressure, water hammer pressure and pressure rise by surging - Temperature loads - External pressure	- Composite maximum water pressure of hydrostatic pressure, water hammer pressure and pressure rise by surging - Earth pressure, Surcharge loads - Temperature loads - External loads - Water weight in the penstock

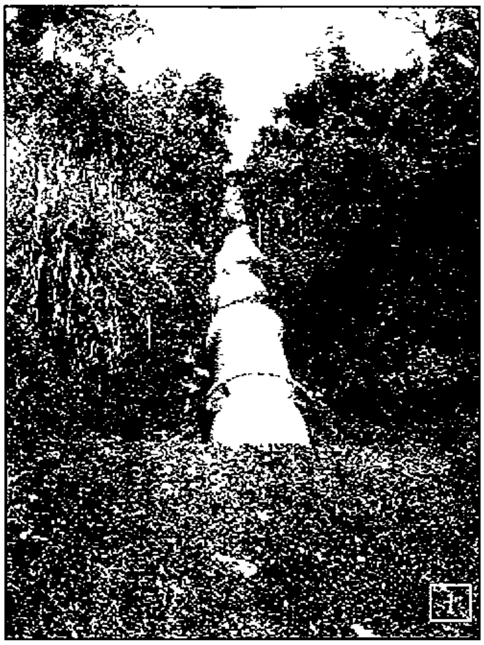
2. The crests of penstocks shall be placed below the Lowest Hydraulic Gradient Lines when the water levels at the head tanks or the surge tanks are at their lowest ones;
3. Pipeshells shall be stable for vibration, buckling, and erosion;
4. Penstocks shall not cause harmful water leakage;
5. In case of exposed type penstocks, anchor blocks or saddles shall be installed in order to securely fix the penstock pipeshells;
6. Anchor blocks or saddles shall be stable for anticipated loads such as their self-weights, self-weights of the pipeshells and their supplemental equipment, self-weights of water in the pipeshells, forces of flowing water inside the pipeshells, water pressure forces acting on the reducers, seismic force, surcharge load, forces caused by wind, and temperature loads. Every material for the anchor blocks or saddles shall have required strength and durability for the said loads; and
7. The supporting parts of saddles shall be such pipeshells that can move safely and smoothly as their expansion and contraction.

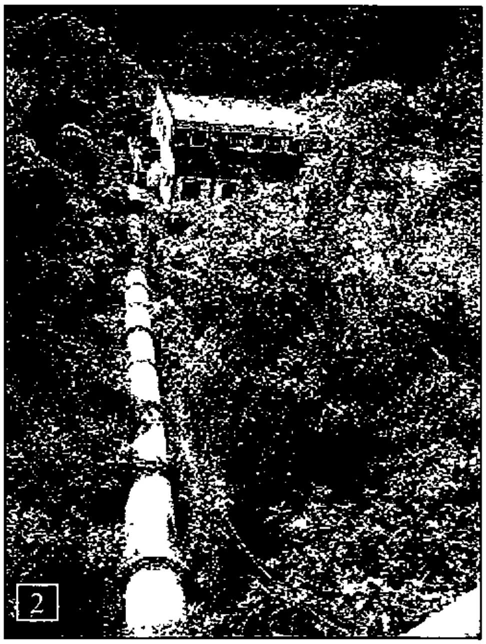
Remarks	Revisions	
	2003/Nov.	Original

GUIDEBOOK FOR POWER ENGINEERS

MIME (JICA)

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HW16-2
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Penstocks (2)			

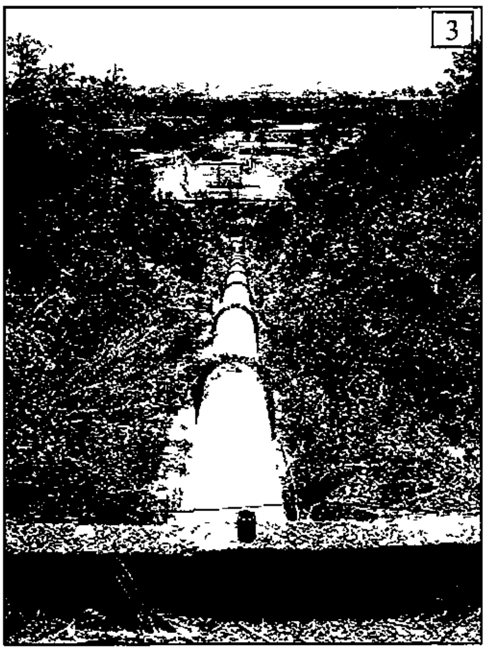




O Chum 2 Penstock

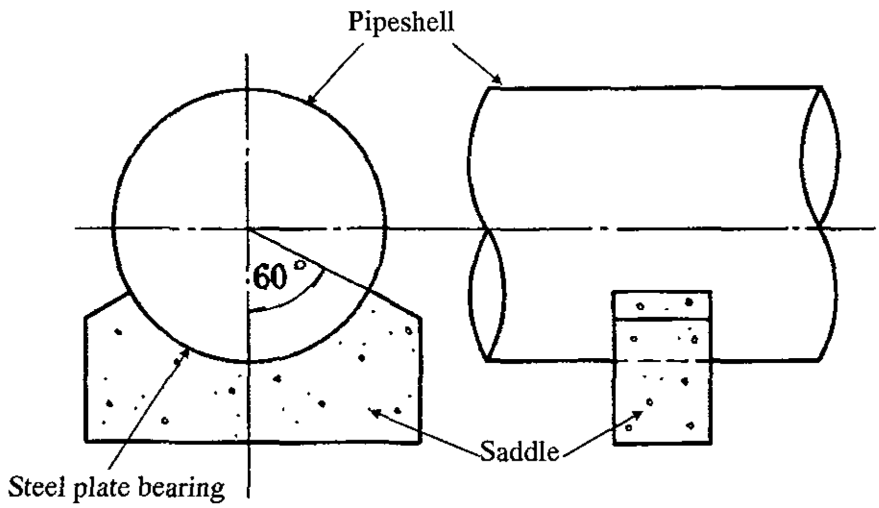
1	2
3	4

Kirirom 1 Penstock

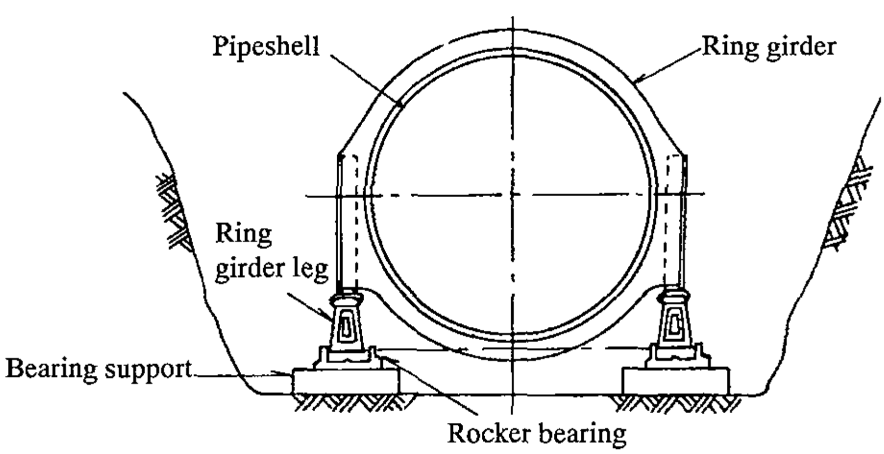


Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HW16-3**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	*26*	*Dams, Waterways, Powerhouses and Other* Facilities	
Title	**Penstocks (3)**			



Saddle supported penstock



Ring supported penstock

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HW17**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Structures of Pipe-Shells**			

The pipeshell must be safe for vibration, buckling, and corrosion.

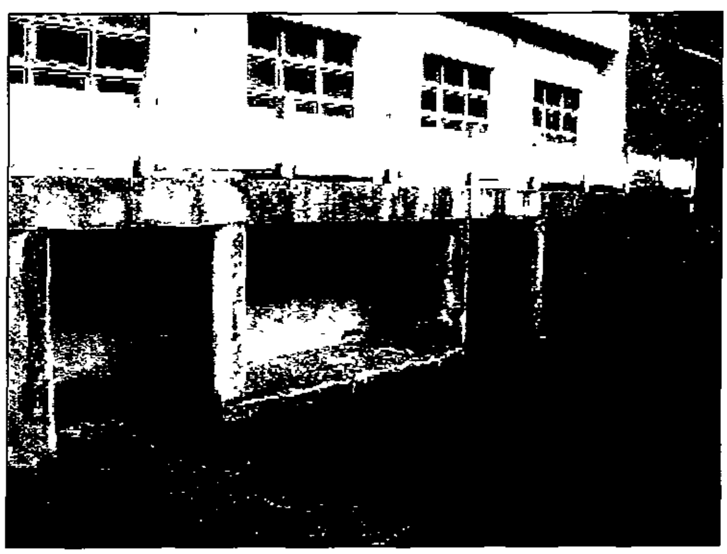
Stipulated safety is as follows:

1) There shall be no significant vibration during operation.
2) Pipeshells shall not buckle for the pressure 1.5 times as much as the external pressure.
3) In case the hydrogen ion density of flowing water inside is below a hydrogen index of 4, the internal surface of a pipe shall be coat-painted or treated in some measure to minimize corrosion.

Remarks	Revisions	
	2003/Nov.	Original

Category				
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HW18
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Tailraces, Outlets, and Surge Chambers**			

1. Document No.HW7, Sections 1., 2., and 4. (exclusive of (2)) are applied to the tailraces, where the term "headrace" and "pressure headrace" is interchangeable with "tailrace" and "pressure tailrace" respectively.
2. In case tunnels or open channels are not lined, tailraces shall not cause significant damage to the downstream waterways due to collapse of the waterways.
3. Outlets shall be stable for anticipated loads such as their self-weights, hydrostatic pressure, external water pressure, seismic water pressure, uplift, seismic force, earth pressure, and surcharge load. Every material for the outlets shall have required strength and durability for the said loads.
4 In case surge chambers are installed at the pressure tailraces, the surge chambers shall meet the following:
   (1) The surge chambers shall be installed in accordance with Document No.HW9, Section 1. (exclusive of (3)).
   (2) The anticipated water level fluctuation shall not result in an overflow and not cause any harmful impacts on the waterways and the penstocks.



O Chum 2 outlets

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HW19
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**A Surge Chamber at a Tailrace and its Lowest Water Level**			

1. A conventional hydroelectric power plant whose draft tube is connected to a pressured tailrace is installed a surge chamber with free water surface at direct downstream of the draft tube in order to ease excessive water hammer pressure due to load fluctuations.
2. A surge chamber at a tailrace includes a tailbay which has a function as a temporally pressured tailrace under a flood condition.
3. The lowest water level in a surge chamber is allowed to be beneath the crest of a tailrace depending on the operational conditions and the water level at an outlet.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HW20
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Hydraulic Gates, Hydraulic Valves, and their Auxiliaries**			

Hydraulic gates, hydraulic valves, and their auxiliaries shall meet the following:

1. Hydraulic gates, hydraulic valves, and their auxiliaries shall be stable for anticipated loads such as their self-weights, hydrostatic pressure, hydrodynamic pressure, seismic force, and buoyancy. Every material for the hydraulic gates, the hydraulic valves, and their auxiliaries shall have required strength and durability for the said loads;
2. Hydraulic gates, hydraulic valves, and their auxiliaries shall be watertight;
3. Hydraulic gates, hydraulic valves, and their auxiliaries shall be opened and closed easily and securely;
4. Hydraulic gates, hydraulic valves, and their auxiliaries shall not cause harmful vibration on opening or closing the gates or the valves, or discharging water;
5. Hydraulic gates and hydraulic valves shall not result in a buckling;
6. Operation of hydraulic gates or hydraulic valves shall be done while confirming actual conditions of the gates and the valves in principle; and
7. Control panels for hydraulic gates, hydraulic valves, and their auxiliaries installed outdoors shall be durable and weatherproof.

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HP1-1**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Powerhouse Buildings and Structures around Hydraulic Turbines and Generators (1)**			

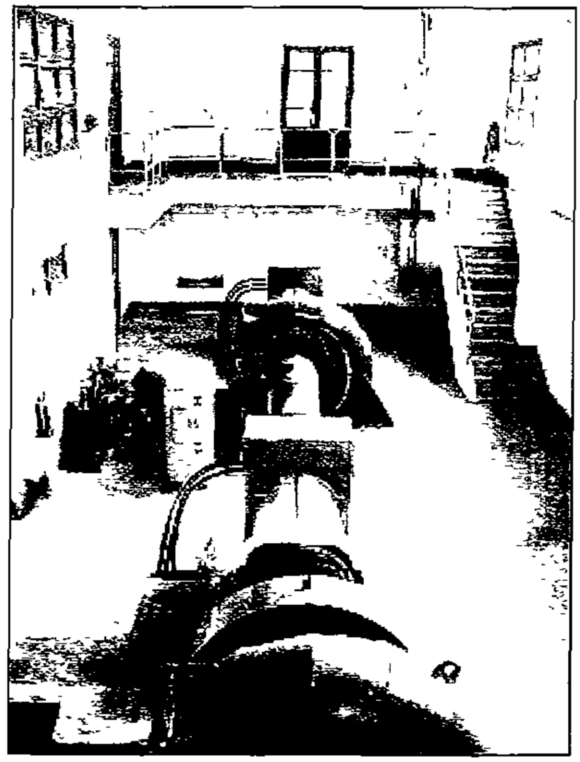
Powerhouse buildings and structures around hydraulic turbines and generators shall meet the following:

1. Powerhouse buildings shall be stable for anticipated loads such as their self-weights, water pressure, seismic force, earth pressure, force caused by wind, crane-weight, and lifting loads of crane. Every material for the powerhouse buildings shall have required strength and durability for the said loads;
2. Structures around hydraulic turbines and generators shall be stable for vibration. Every material for the structures around the hydraulic turbines and generators shall have required strength and durability for the said loads;
3. Powerhouse buildings shall not be flooded, and not suffer failure and damage due to landslides; and
4. If noise or vibration from powerhouses may cause harmful impacts on the surrounding environment, proper remedial measures shall be taken.

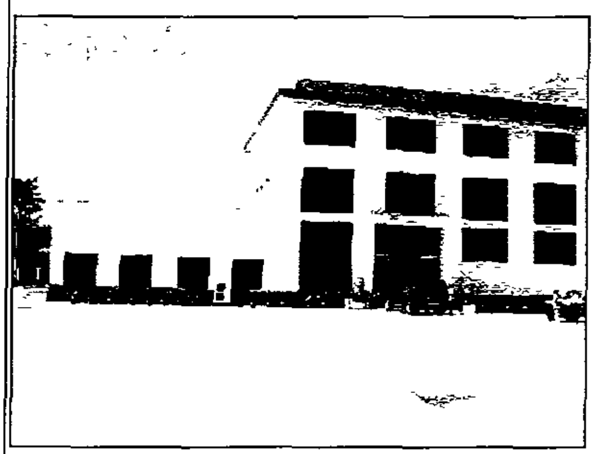
Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HP1-2
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Powerhouse Buildings and Structures around Hydraulic Turbines and Generators (2)**			

O Chum 2 powerhouse building



O Chum 2 turbines and generators



Kirirom 1 powerhouse building

Kirirom 1 turbines and generators

Remarks	Revisions	
	2003/Nov.	Original

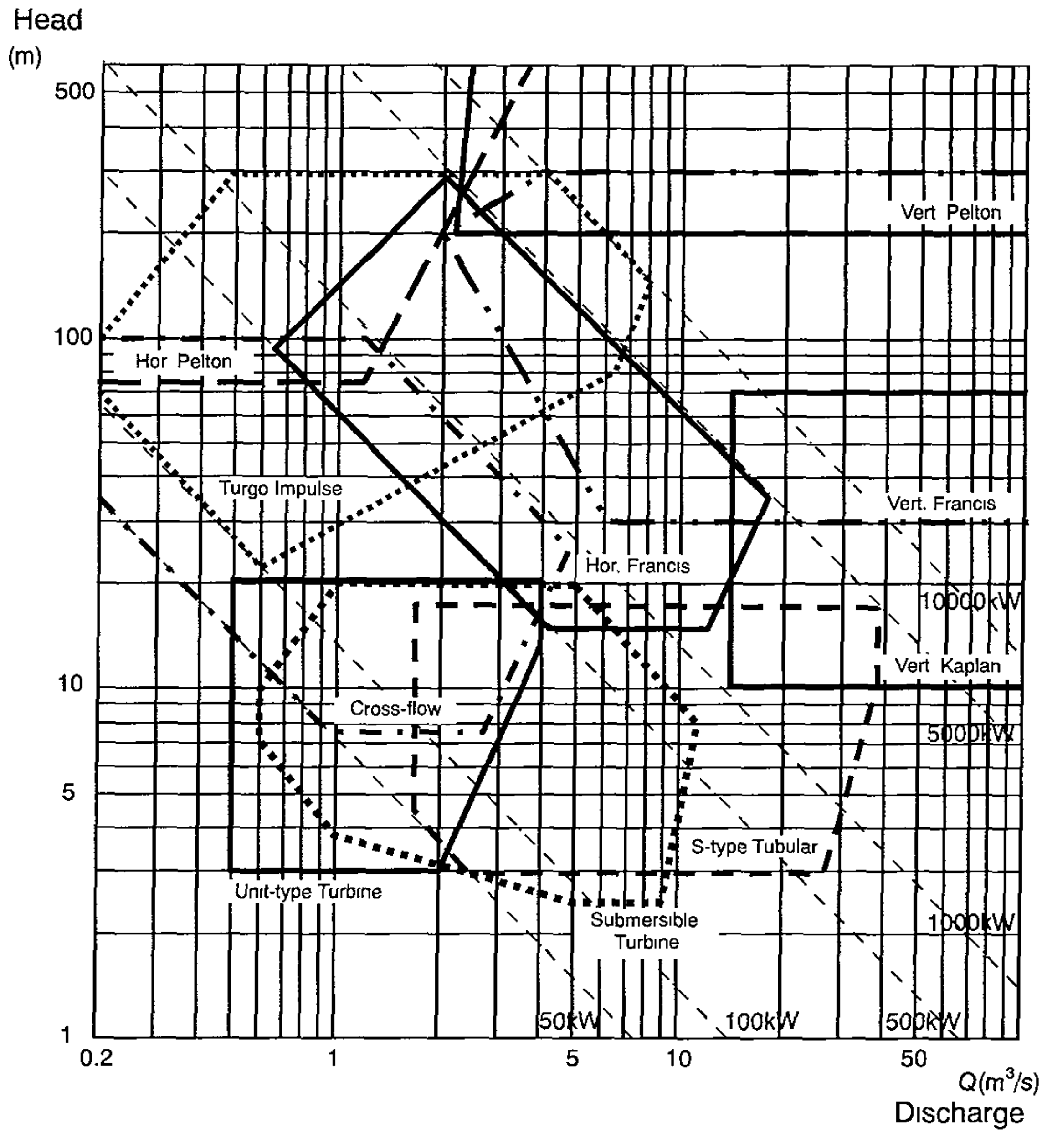
Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HP2**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**The Other Hydroelectric Power Civil Engineering Facilities**			

The other hydroelectric power civil engineering facilities such as maintenance roads and temporary facilities for construction works (those facilities except for dams, reservoirs, waterways, and powerhouses) shall meet the following:

1. Permanent facilities such as maintenance roads shall be structurally stable, and be installed and managed so as not to cause serious turbid water as much as possible; and
2. Temporary facilities for construction works shall be structurally stable in consideration of their available periods during construction, and be managed so as not to cause serious turbid water flows out of the construction areas. After their available periods, they shall be removed or managed so as not to cause harmful impacts on the surrounding environments.

Remarks	Revisions	
	2003/Nov.	Original

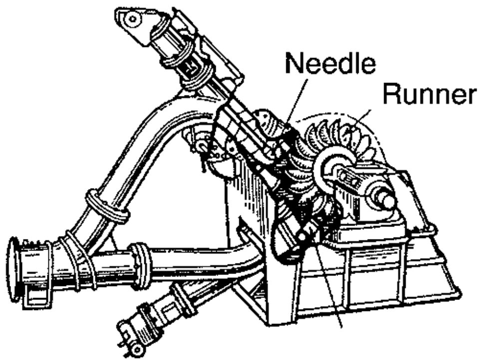
Category				Document No.HE1
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	28	Hydraulic Turbines and Generators	
Title	Hydraulic Turbine Selection Diagram			



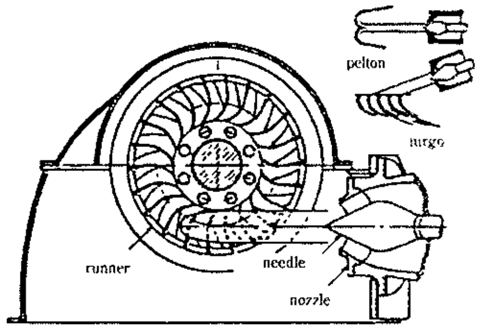
Source: Middle-Small Hydro-power Generation Guidebook (Japanese), New Energy Foundation

Remarks	Revisions	
Middle-Small Hydro-power Generation Guidebook (Japanese), New Energy Foundation		
	2003/Nov.	Original

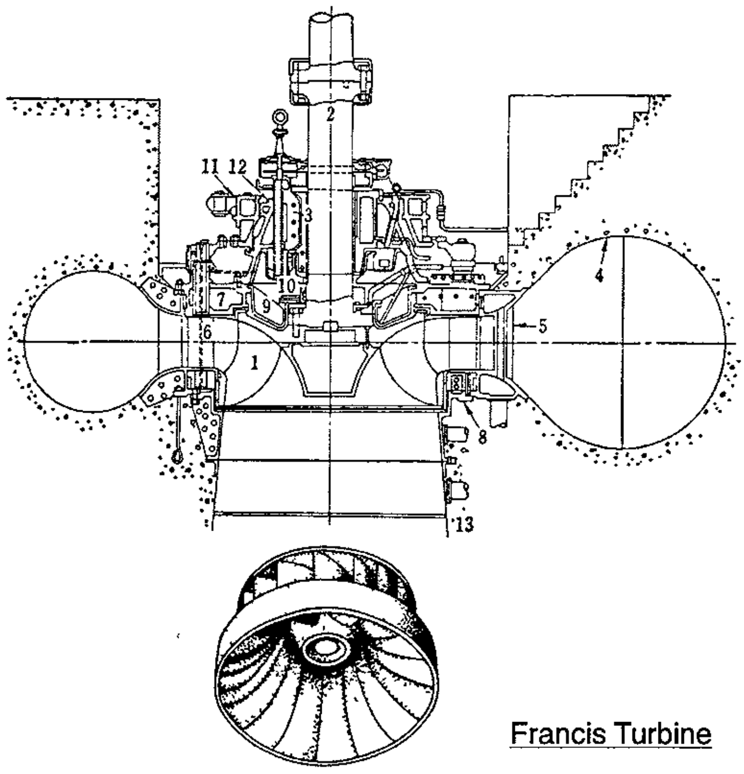
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HE2-1
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	28	Hydraulic Turbines and Generators	
Title	**Hydraulic Turbine Types (1)**			



Pelton Turbine



Turgo Impulse Turbine

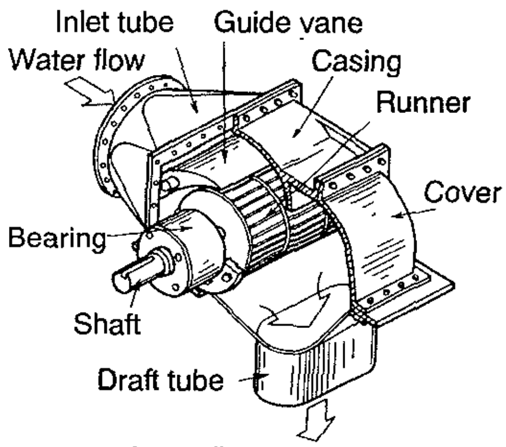


Francis Turbine

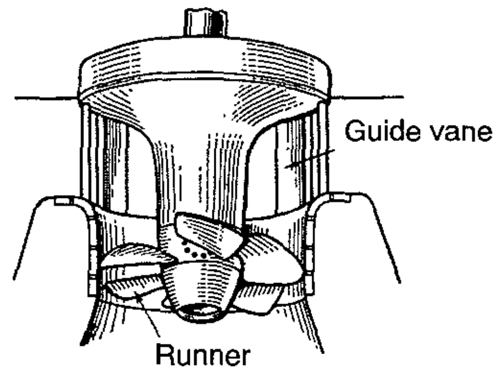
Source: Middle-Small Hydro-power Generation Guidebook (Japanese), New Energy Foundation

Remarks	Revisions	
Middle-Small Hydro-power Generation Guidebook (Japanese), New Energy Foundation		
	2003/Nov.	Original

Category				Document No.HE2-2
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	28	Hydraulic Turbines and Generators	
Title	Hydraulic Turbine Types (2)			



Cross-flow Turbine

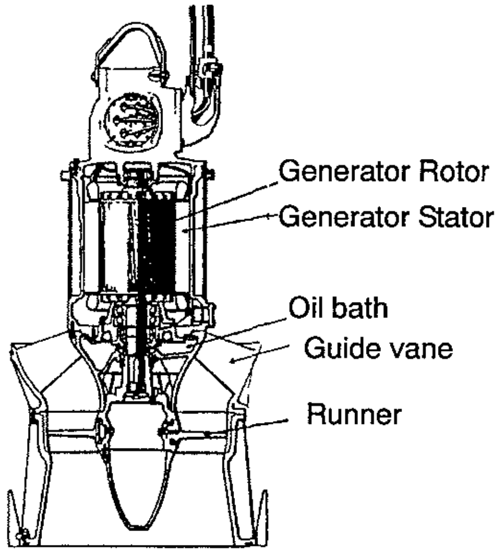


Propeller (Kaplan) Turbine

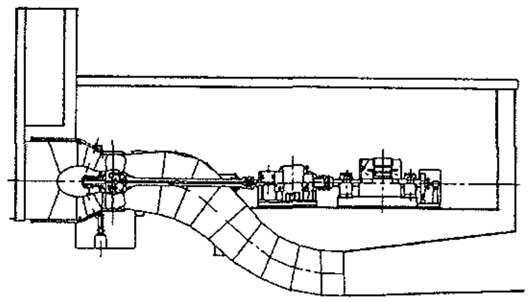
Source: Middle-Small Hydro-power Generation Guidebook (Japanese), New Energy Foundation

Remarks	Revisions	
Middle-Small Hydro-power Generation Guidebook (Japanese), New Energy Foundation		
	2003/Nov.	Original

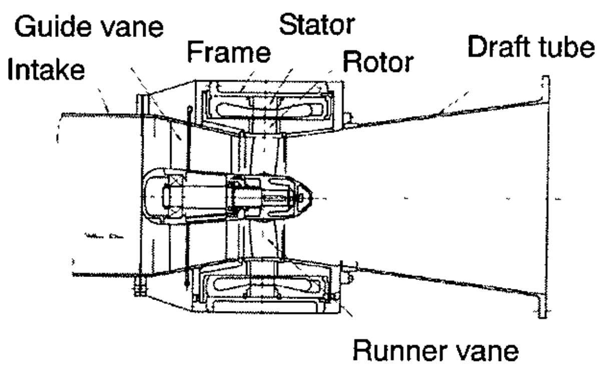
Category				Document
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HE2-3
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	28	Hydraulic Turbines and Generators	
Title	**Hydraulic Turbine Types (3)**			



Submersible Turbine



S-type Tubular Turbine



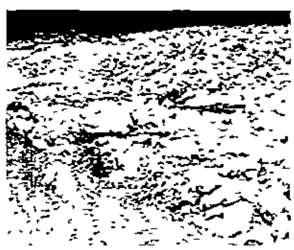
Unit-type Turbine

Source: Middle-Small Hydro-power Generation Guidebook (Japanese), New Energy Foundation

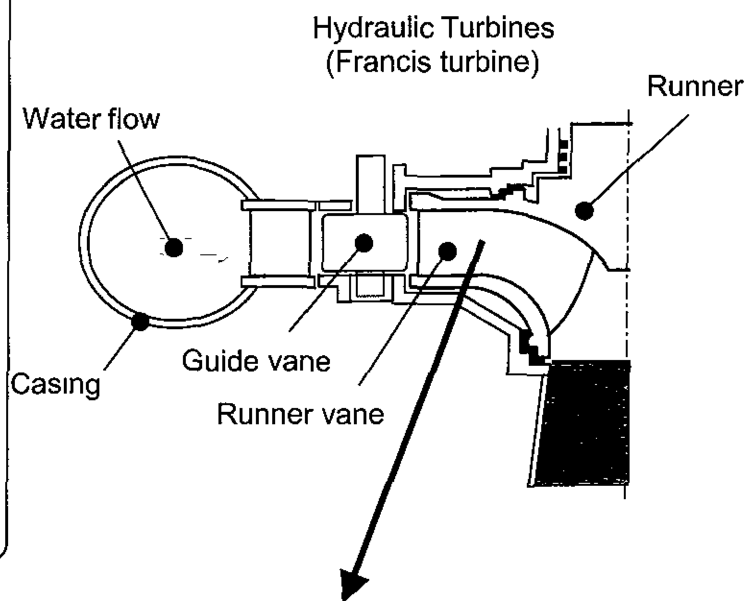
Remarks	Revisions	
Middle-Small Hydro-power Generation Guidebook (Japanese), New Energy Foundation		
	2003/Nov.	Original

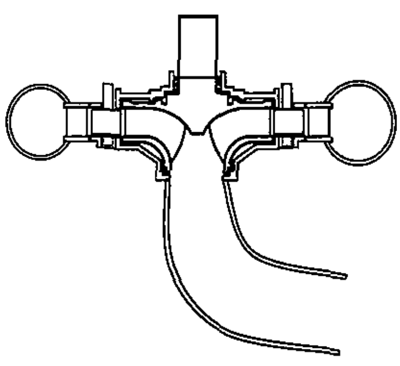
Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HE3**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	28	Hydraulic Turbines and Generators	
Title	**Damage to Hydraulic Turbines - Driftwood, Floating Debris, or Sediment**			

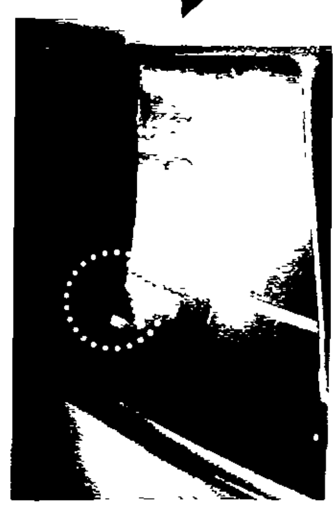
Driftwood



Sediment



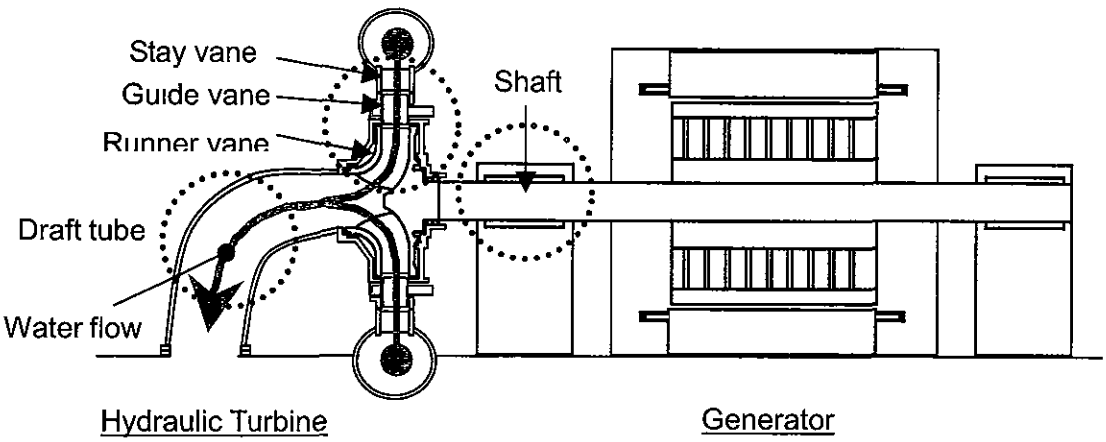




Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HE4
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	28	Hydraulic Turbines and Generators	
Title	**Damage to Hydraulic Turbines - Vibrations**			

【 Vibration 】

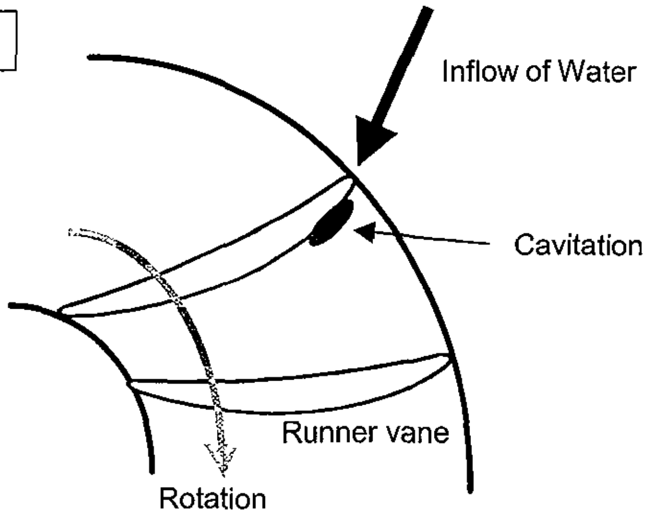


Remarks	Revisions	
	2003/Nov	Original

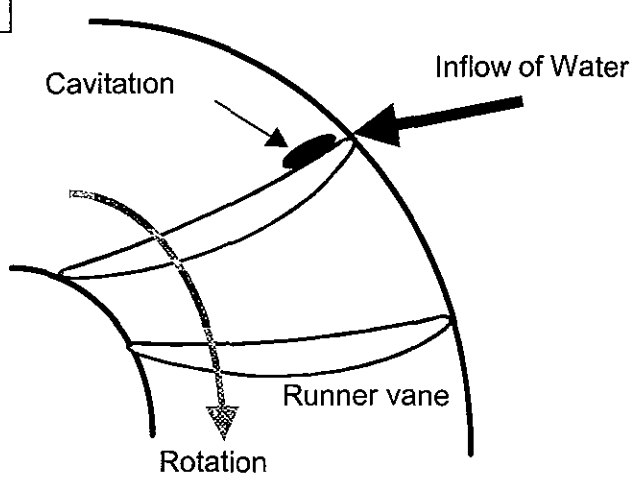
Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HE5-1**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	28	Hydraulic Turbines and Generators	
Title	**Damage to Hydraulic Turbines - Cavitation Erosion (1)**			

High Head

Cavitation



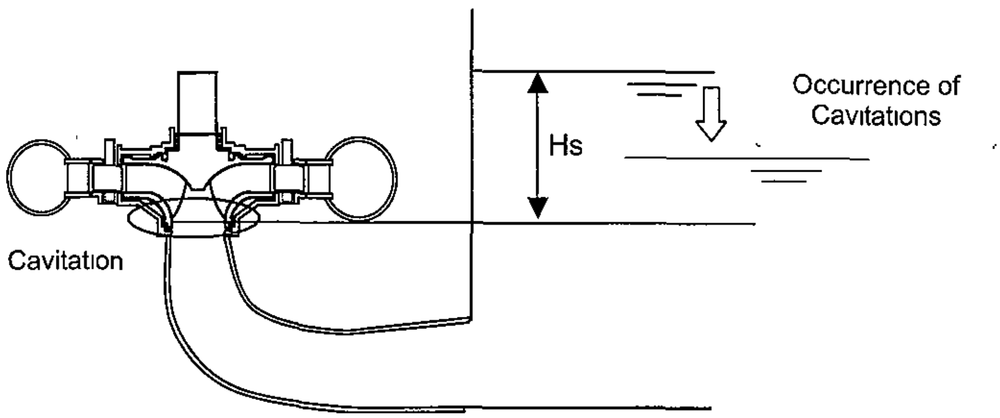
Low Head



For Francis Turbine, Propeller Turbine

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HE5-2
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	28	Hydraulic Turbines and Generators	
Title	**Damage to Hydraulic Turbines - Cavitation Erosion (2)**			



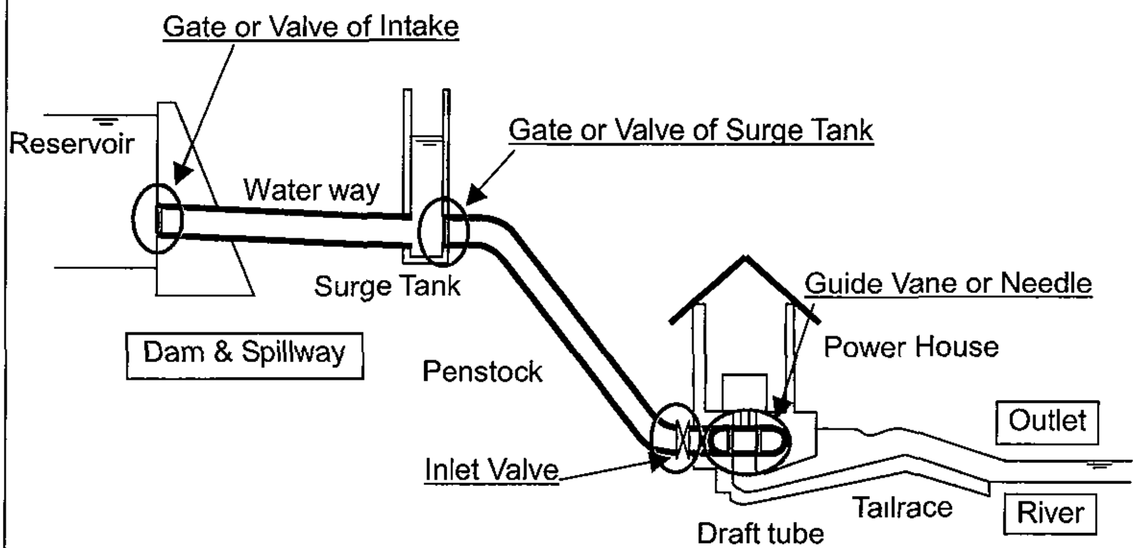
Hs: Draft head

For Francis Turbine, Propeller Turbine

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HE6
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	28	Hydraulic Turbines and Generators	
Title	**Equipment to Quickly Shut off the Inflow of Water**			

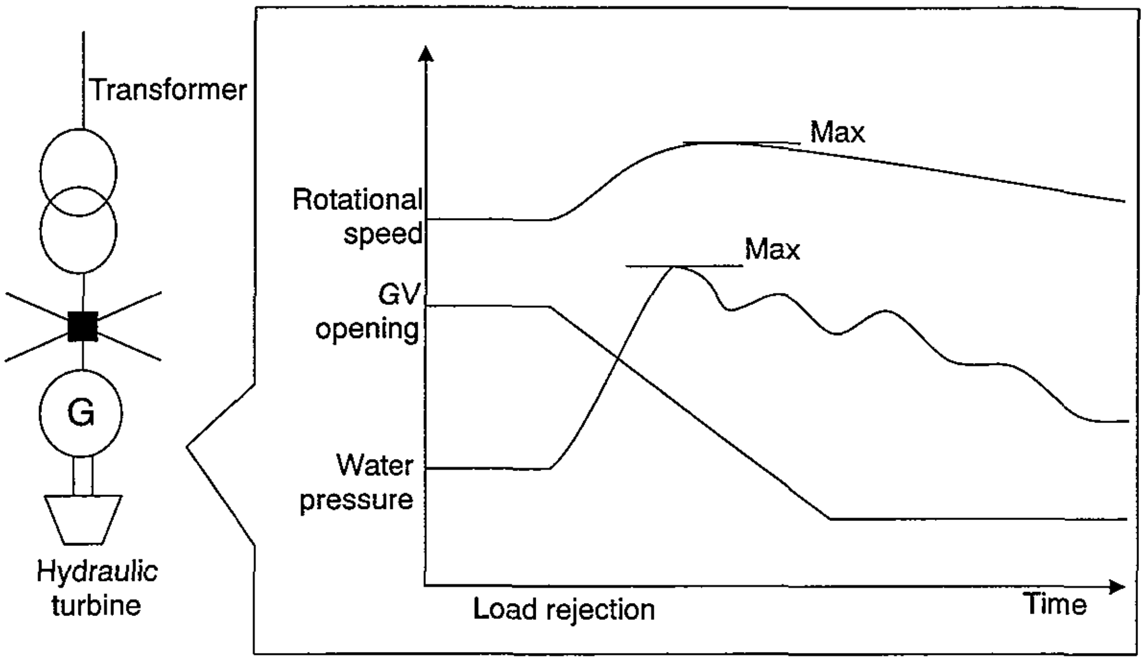
1. Facilities that can quickly shut off the inflow of water shall be one of the following.
   (1) If they are installed at hydraulic turbines, they shall be such guide vanes or needles with a function to shut off in an emergency or such inlet valves capable of shutting off the water flow, and
   (2) If they are installed at waterways, they shall be such hydraulic gates or hydraulic valves that equipped with emergency shut off devices and installed at intake facilities, head tanks, or surge tanks.



2. If rotating parts are structurally safe and the discharge to downstream does not harm to humans or properties until the runaway rotation of the hydraulic turbine stops, equipment to quickly shut off the inflow of water may not apply. But facilities to stop the discharge shall be installed at waterways or hydraulic turbines.

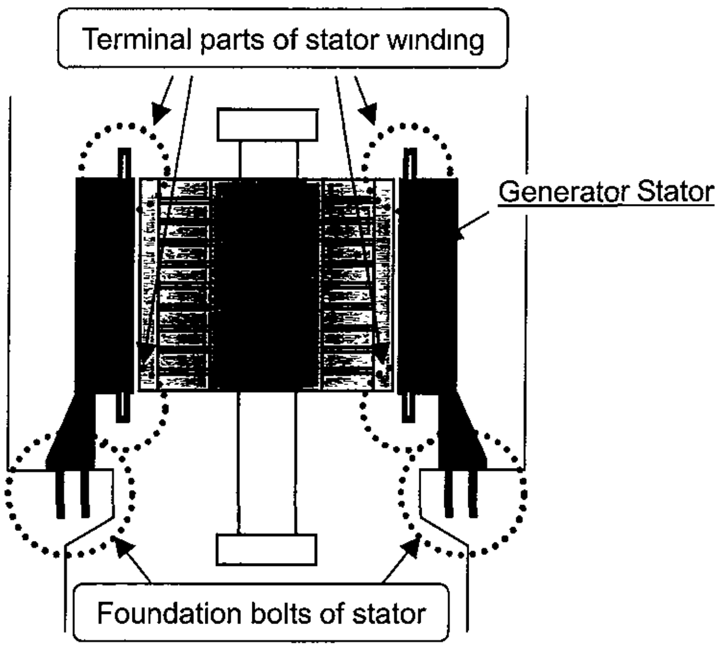
Remarks	Revisions	
Interpretation of Technical Standards for Hydropower Stations, 1998, Japan		
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HE7**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	28	Hydraulic Turbines and Generators	
Title	**Maximum Water Pressure and Maximum Speed in Load Rejection**			



Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HE8
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	28	Hydraulic Turbines and Generators	
Title	**Mechanical Shock Caused by Short-Circuit Current**			



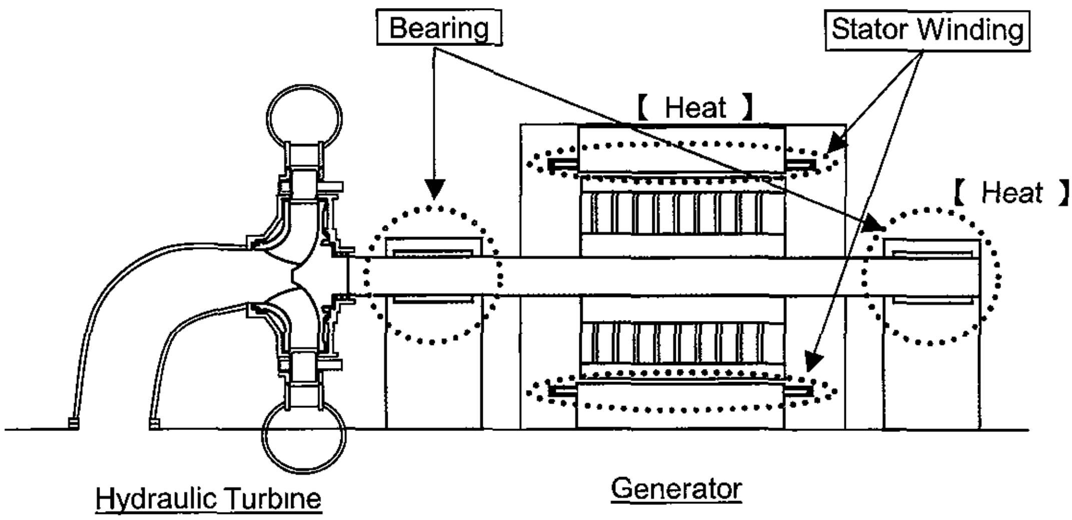
Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HE9
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	28	Hydraulic Turbines and Generators	

Title	Heat Generated by Hydraulic Turbines and Generators under Normal Operations

1. Generators
The temperature rise of generators operated at the rated load shall not exceed the allowable maximum temperature corresponding to their thermal strength class, and the thermal strength of generators shall be such that damage to the generators may not occur within the range of the allowable maximum temperature.

2. Bearings of hydraulic turbines and generators
Bearings of hydraulic turbines and generators shall be such that the maximum temperature to be generated in the bearings with the rated load may not cause damage to the bearings.

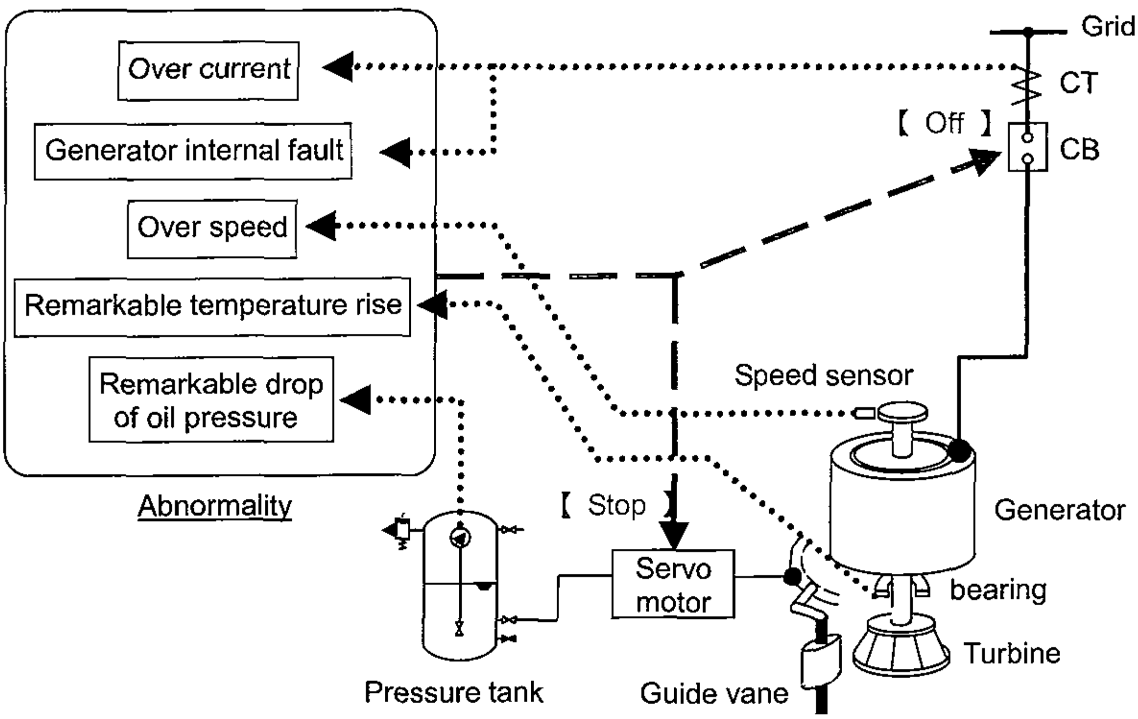


Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HE10
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	28	Hydraulic Turbines and Generators	
Title	**Protective Devices for Hydraulic Turbines and Generators**			

Protective devices that automatically stop the turbines and break the generators from an electrical line when the following abnormality occurs shall be installed:

1. The rotating speed increases remarkably;
2. The oil pressure of oil-pressure supply system drops remarkably;
3. The temperature of bearings rises remarkably;
4. Over current is generated at generators; and
5. Internal fault occurs at generators.



CT: Current Transformer
CB: Circuit Breaker

Remarks	Revisions	
	2003/Nov	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HO1**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	27	Prevention of Damage caused by Hydroelectric Power Plant	
Title	**Sedimentation and Water Quality**			

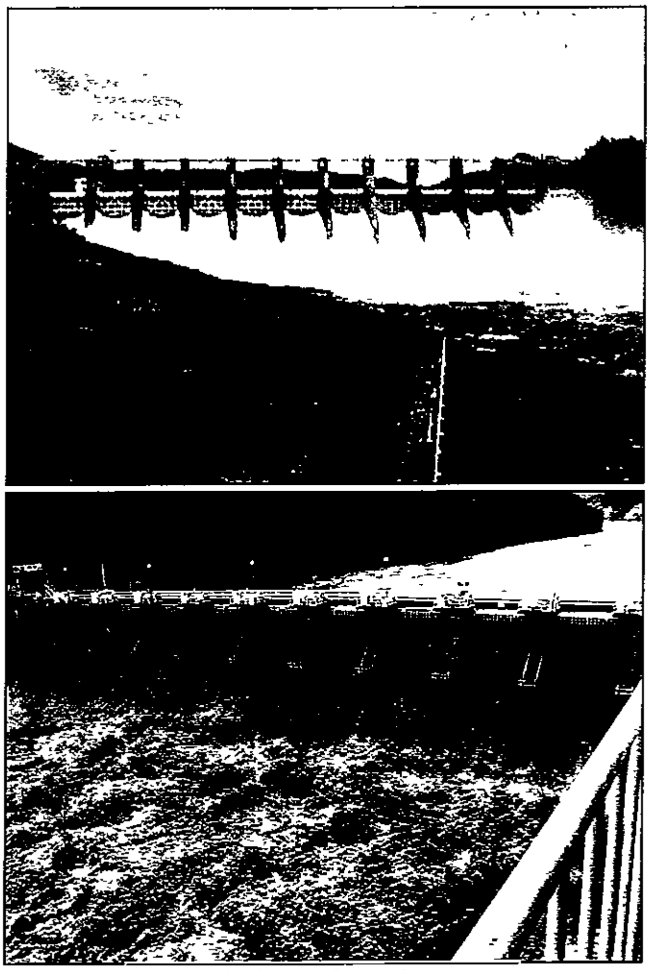
1. Proper remedial measures such as sedimentation dredging, sedimentation flushing, and check dam installation shall be taken as necessary so that the excessive sedimentation due to the existence of reservoirs does not cause losses of reservoir functions such as serious rises in water level at upstream areas and serious decline in reservoir capacity. When sedimentation flushing is done, minimizing impacts on downstream areas shall be considered; and
2. If deterioration in water quality of reservoirs or the downstream rivers such as cool water damage and turbid water residence may occur due to existence or operation of the reservoirs, proper remedial measures shall be taken as much as possible.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HO2
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	27	Prevention of Damage caused by Hydroelectric Power Plant	
Title	**Control of Discharge from Dams to Downstream Areas**			

Discharge from dams to downstream areas shall be done in accordance with the following:

1 Discharge from dams to the downstream areas shall be properly controlled;
2. In case of flood, discharge from dams shall not cause any increases in damage to the downstream areas in comparison with anticipated flood damage before installation of the dams, such that discharge to the downstream areas does not increase in comparison with an inflow from the basin to the reservoir. Proper remedial measures such as installation of alarm devices and warning to the downstream people shall be taken so that damage at the downstream areas due to a flood is minimized; and
3. Facilities that discharge necessary water for water utilization and environmental preservation in the areas affected by river diversion shall be installed as necessary.



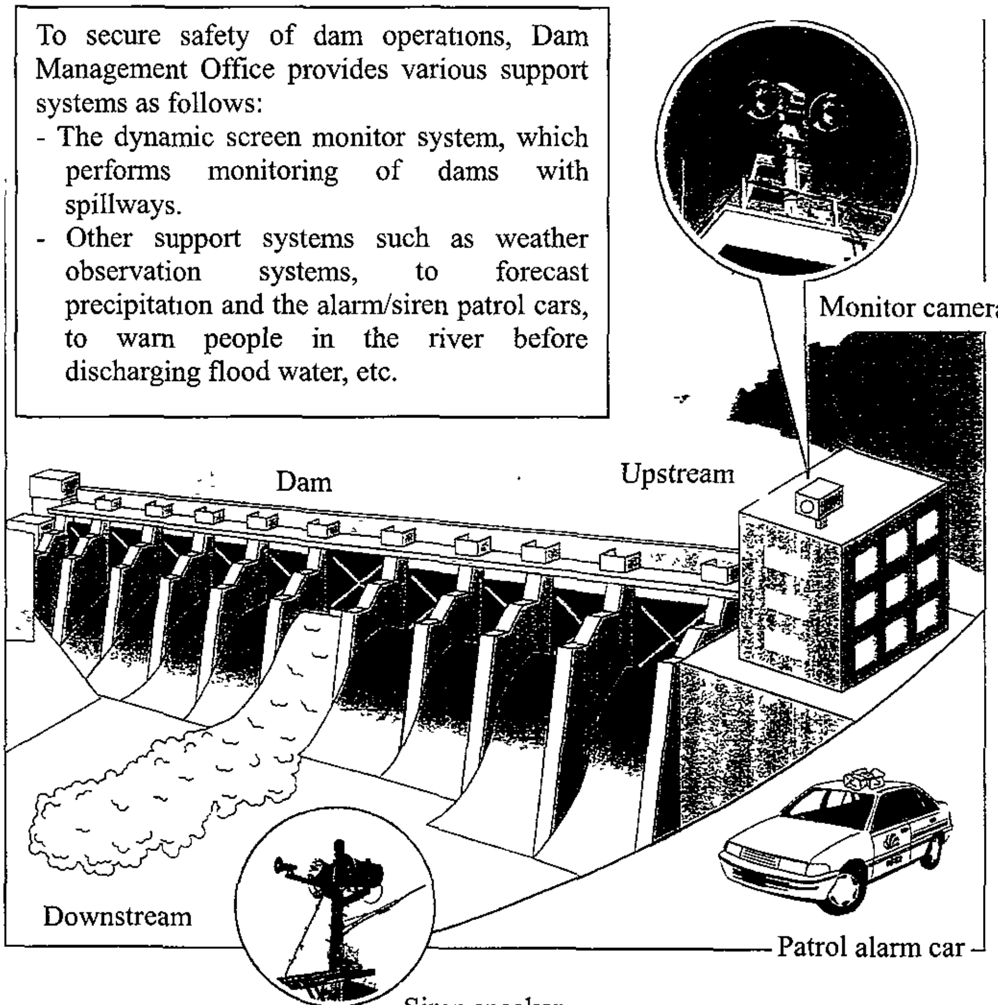
Discharge from dam

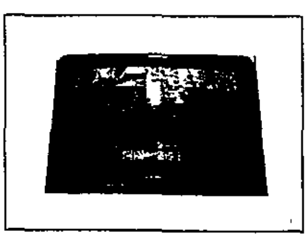
Remarks	Revisions	
	2003/Nov.	Original

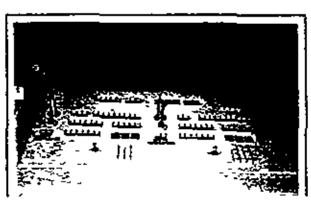
Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HO3**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	27	Prevention of Damage caused by Hydroelectric Power Plant	
Title	**Countermeasures against Damage due to Discharge from Dams to the Downstream Areas**			

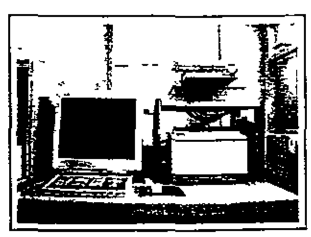
- Alarm devices

To secure safety of dam operations, Dam Management Office provides various support systems as follows:
- The dynamic screen monitor system, which performs monitoring of dams with spillways.
- Other support systems such as weather observation systems, to forecast precipitation and the alarm/siren patrol cars, to warn people in the river before discharging flood water, etc.




Dynamic screen monitor


Dynamic screen monitor operation table

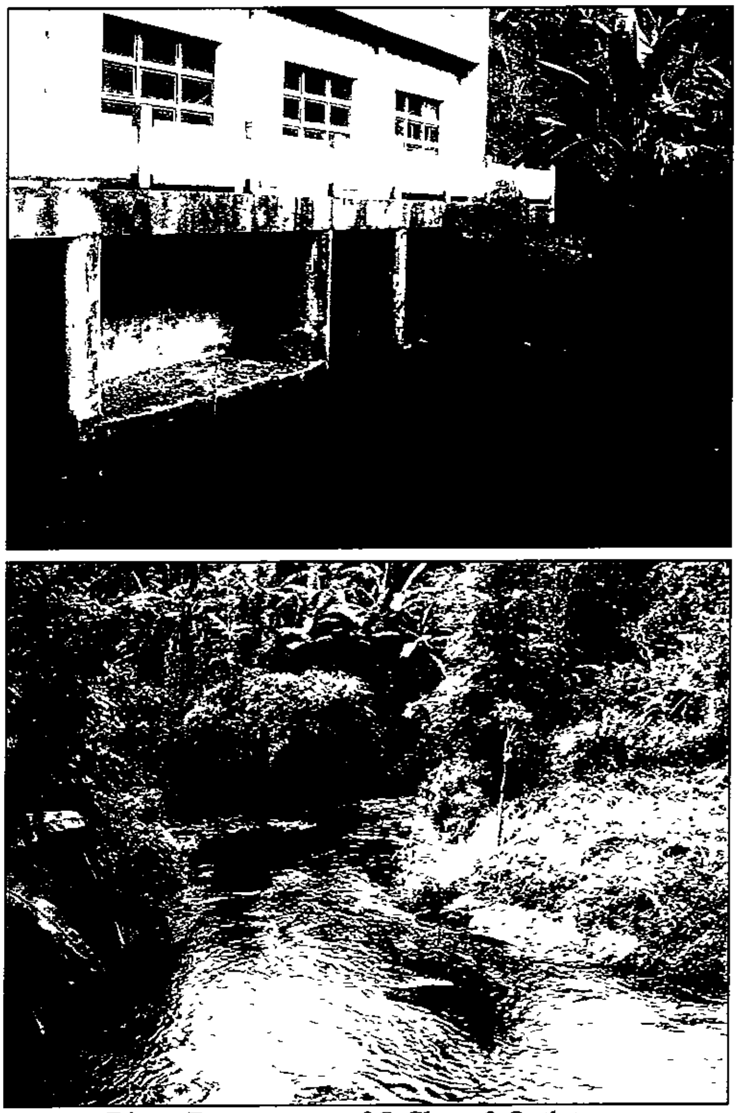

Weather observation system

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HO4**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	27	Prevention of Damage caused by Hydroelectric Power Plant	
Title	**Control of Discharge from Outlets to Downstream Areas**			

Discharge from outlets to downstream areas shall be done in accordance with the following:

1. Discharge from outlets to downstream areas shall be properly controlled; and
2. If serious environmental impacts or damage to humans or properties, and so on caused by rapid changes in water level due to discharge from hydroelectric power plants are predicted, proper remedial measures to mitigate possible impacts or damage shall be taken. These measures include installation of re-regulating reservoirs to mitigate water level changes and warning with installed alarm devices at downstream areas.



Direct Downstream of O Chum 2 Outlets

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HO5
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	27	Prevention of Damage caused by Hydroelectric Power Plant	
Title	**Countermeasures against Damage due to Discharge from Outlets to the Downstream Areas**			

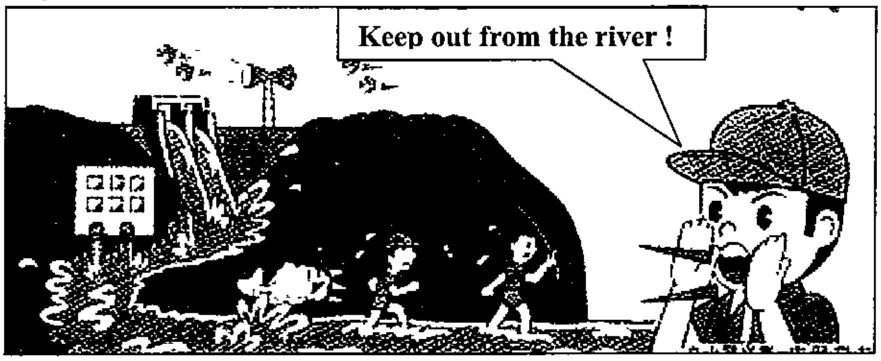
Re-regulating pond

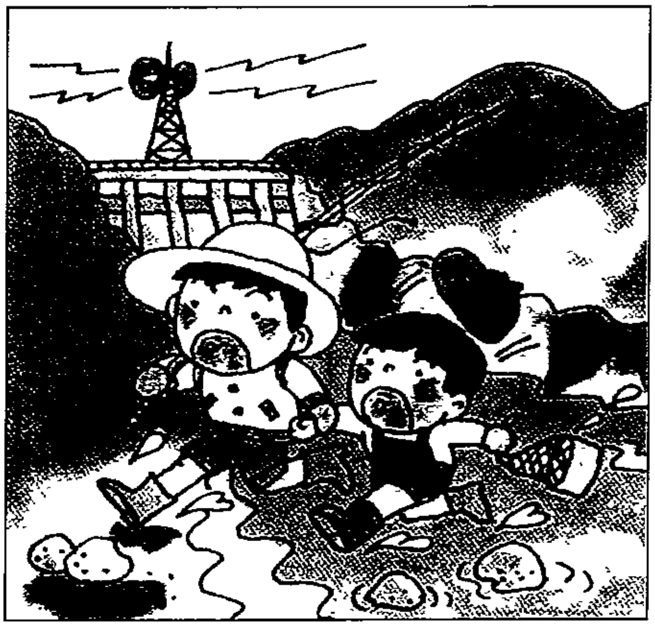
As a power plant of reservoir type or regulating pond type hydroelectric power plant is operated during peak load time in accordance with a peak load, a plant discharge is released into the river for a short period. Consequently, the difference in river flow between peak load time and off-peak load time is large and may affect the living circumstances of the people and other water uses located at downstream. A reservoir in order to re-regulate the peak discharge to prevent the undesirable situation mentioned above is called a re-regulating pond.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HO6-1
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	27	Prevention of Damage caused by Hydroelectric Power Plant	
Title	**Countermeasures against Damage due to Discharge from Dams and Outlets to the Downstream Areas (1)**			

Siren warning to downstream areas

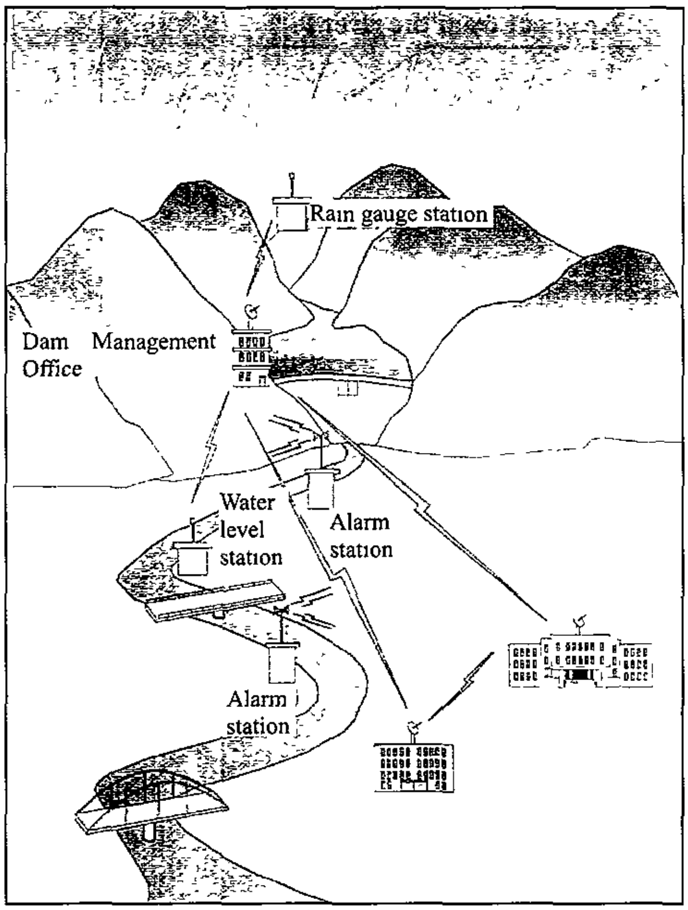




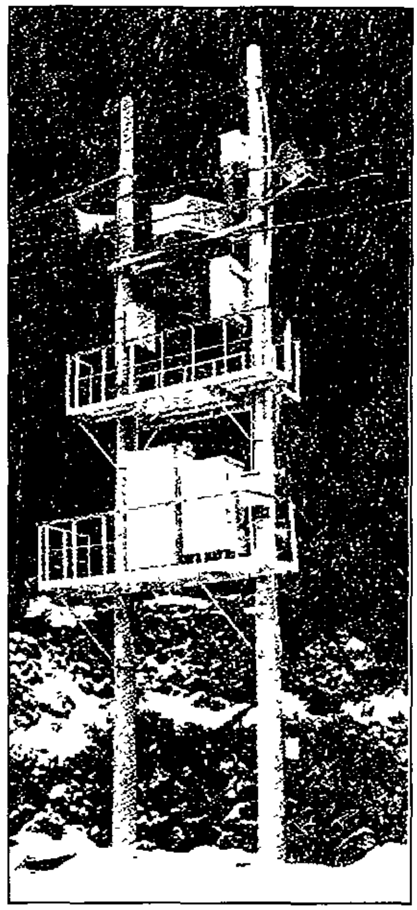
Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HO6-2**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	27	Prevention of Damage caused by Hydroelectric Power Plant	
Title	**Countermeasures against Damage due to Discharge from Dams and Outlets to the Downstream Areas (2)**			

Alarm warning system to downstream areas



http //www.pref toyama.jp/branches/1550/renraku.JPG



Alarm device

Remarks	Revisions	
http://www pref.toyama.jp/branches/1550/renraku.JPG		
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HO7**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	27	Prevention of Damage caused by Hydroelectric Power Plant	
Title	**Compliance with Laws and Regulations such as River Management and Environmental Preservation**			

1. In case the purposes of the dam installations are not only power generation but also flood control, irrigation, water supplies, and so on, the dams shall be built and operated in accordance with the relevant laws and regulations.
2. In case a certain organization or authority regulates utilization of the rivers and/or the land, the hydroelectric power plants shall be installed and operated in accordance with the relevant laws and regulations.
3. Hydroelectric power plants shall comply with laws and regulations related to environmental preservation.

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HO8**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	27	Prevention of Damage caused by Hydroelectric Power Plant	
Title	**Laws and Regulations Related to Environmental Preservation**			

Laws and regulations related to environmental preservation in Cambodia as of November 2003 are as follows:

- Royal decree on the creation and designation of protected areas, November 1, 1993;
- Prakas (Declaration) No.1033 on protected areas, June 3, 1994;
- Law on environmental protection and natural resource management, December 24, 1996;
- Sub-decree on water pollution control, April 6, 1999;
- Sub-decree on environmental impact assessment process, August 11, 1999;
- Sub-decree on solid waste management, August 27, 1999;
- Prakas (Declaration) on guideline for conducting environmental impact assessment report; March 9, 2000; and
- Sub-decree on air and noise pollution control, June 10, 2000

According to the Sub-decree on environmental impact assessment process, hydroelectric power plant projects with capacity 1 MW and more are required the Initial Environmental Impact Assessment (IEIA) procedures. Furthermore, the Environmental Impact Assessment (EIA) procedures are required if they are crucial for environment.

Royal decree on the creation and designation of protected areas and Prakas (Declaration) No.1033 on protected areas regulate the protected areas in Cambodia, hydroelectric power plant projects should follow these laws and regulations related to the protected areas in Cambodia.

The Ministry of Environment is responsible for environmental preservation in Cambodia. Thus, the projects related to hydroelectric power plant should cooperate with the Ministry.

An important report of the World Commission on Dams for dam development

As for development of dams particularly large dams, the World Commission on Dams finalized and released a report "Dams and Development A New Framework for Decision-Making" in November 2000. (http://www dams.org/) The report is a milestone in the evolution of dams as a development option. The Commission's framework for decision-making is based on five core values -equity, sustainability, efficiency, participatory decision-making and accountability.

The Commission's rationale and recommendations will ensure that decision-making on water and energy development:

- reflects a comprehensive approach to integrating social, environmental and economic dimensions of development;
- creates greater levels of transparency and certainty for all involved, and
- increases levels of confidence in the ability of nations and communities to meet their future water and energy needs.

Remarks	Revisions	
- Sub-decree on Environmental Impact Assessment Process		
- Royal Decree on the Creation and Designation of Protected Areas		
- Prakas (Declaration) No.1033 on Protected Areas	2003/Nov.	Original
- http //www.dams.org/		

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HO9
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	27	Prevention of Damage caused by Hydroelectric Power Plant	
Title	**Law on Water Resources Management**			

The draft law on water resources management is going to be submitted to the National Assembly after approval of the Council of Ministers in the Kingdom of Cambodia.
The draft law prescribes licenses issued by the Ministry of Water Resources and Meteorology (MOWRM). The diversion, abstraction and use of water resources for purposes including a power generation purpose, and construction of the waterworks relating thereto are subject to a license.

Remarks	Revisions	
Draft Law on Water Resources Management, Ministry of Water Resources and Meteorology (MOWRM)		
	2003/Nov.	Original

JICA

GUIDEBOOK
FOR
POWER ENGINEERS

English Edition

VOL. No.4
RENEWABLE ENERGY

Dec. 2003

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

GUIDEBOOK FOR POWER ENGINEERS

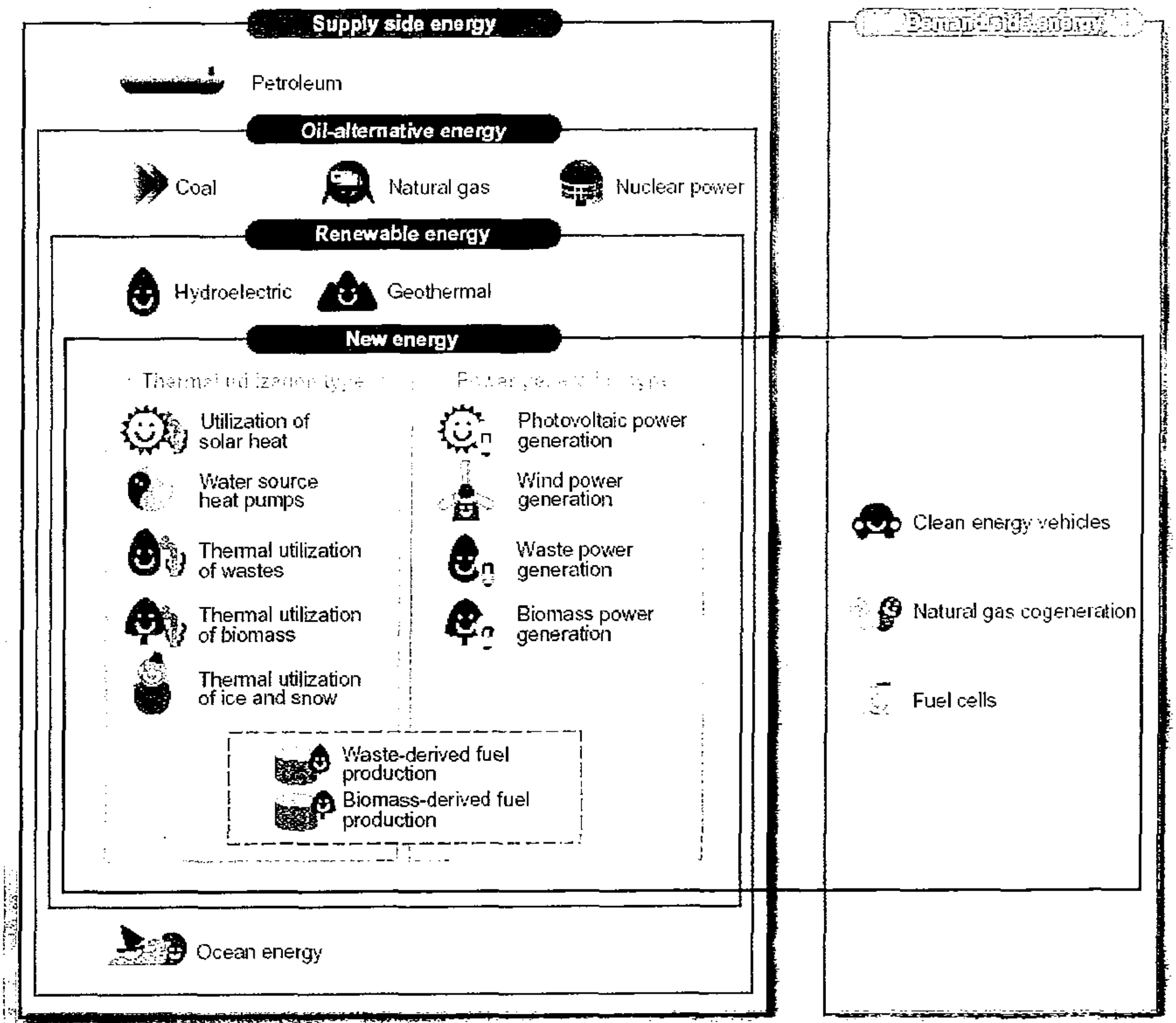
Contents of Renewable Energy

Wind Power Generation	
WP1	Wind Power Generation
WP2	System Design, Installation and Operation

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. RE-01**
	Paragraph	5	Generating Facilities (Others)	
	Clause			
Title	Renewable Energy			

Renewable energy: energy sources derived directly or indirectly from the energy of the sun, the earth's core or from lunar and solar gravitational forces and which are therefore renewable over time. These include solar, wind, biomass,

If the power generation technology using renewable energy is positioned into the whole energy, it will become as it is shown in the following figure(s).



Remarks:	Revisions	
NEDO Activities to Promote the Introduction of New Energy [http://www.nedo.go.jp/english/publications/index.html]		
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. RE-02
	Paragraph	5	Generating Facilities (Others)	
	Clause			
Title	Renewable Energy (Photovoltaic Power Generation)			

The power generation facility using renewable energy is Photovoltaic Power Generation, Wind power Generation, Waste power generation and Biomass power Generation. Hereafter, the systems are briefly explained about each power generation facilities. It combines and these web-sites are indicated.

Photovoltaic power system: A system including photovoltaic modules, inverters, batteries (if applicable), and all associated installation and control components, for the purpose of producing solar photovoltaic electricity.

Photovoltaics: The method for capturing the sun's energy is through the use of photovoltaics. Photovoltaics (PV) utilize the sun's photons or light to create electricity. PV technologies rely on the photoelectric effect first described by French physicist Edmund Becquerel in 1839.

The photoelectric effect occurs when a beam of UV light, composed of photons (quantized packets of energy), strike one part of a pair of negatively charged metal plates. This causes electrons to be "liberated" from the negatively charged plate. These free electrons are then attracted to the other plate by electrostatic forces. This flowing of electrons is an electrical current. This electron flow can be gathered in the form of direct current (DC). This DC can then be inverted into alternating current (AC), which is the electrical power that is most commonly used in buildings.

Basics of PV:
http://www.oja-services.nl/iea-pvps/pv/index.htm

- -How it works
- -The solar resource
- -Photovoltaic cells
- -Photovoltaic modules and systems
- -Inverters to convert direct current into alternating current
- -Environmental considerations, including energy payback time
- -Stand-alone applications: systems operating independently of the grid network
- -Grid-connected applications: systems are tied into the grid network

http://www.eco-assist.co.jp/esco.htm

Remarks: http://www.oja-services.nl/iea-pvps/pv/index.htm	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. RE-03**
	Paragraph	5	Generating Facilities (Others)	
	Clause			
Title	Renewable Energy (Wind Power Generation)			

Wind Power:
Wind power station; a power station in which wind energy is converted into electricity.
Wind Power systems generally comprise a rotor, a generator or alternator mounted on a frame, a tail (usually), a tower, wiring, and the "balance of system" components: controllers, inverters, and/or batteries.
Through the spinning blades, the rotor captures the kinetic enerav of the wind and converts it into rotary motion to drive the generator.

http://www.eco-assist.co.jp/esco.htm

Wind Energy Reference Manual :
http://www.windpower.org/en/stat/units.htm
1.Wind Energy Concepts
2.Energy and Power Definitions
3.Proof of Betz' Law
4.Wind Energy Acoustics
5.Wind Energy and Electricity
6.Wind Energy, Environment, and Fuels
7.Bibliography
8.Wind Energy Glossary

Certification and Standards Guidelines for Certification:
http://www.nrel.gov/wind/working_cert_guidelines2.html
-Commissioning Guideline
-Loads Analysis Guideline
-Strength Analysis Guideline
-Yaw and Pitch Rolling Bearing Life Guideline (PDF 5.2 MB)
-Gearbox Specification Guideline
-Control & Protection Systems

Certification & Design Checks:
http://www.nrel.gov/wind/working_cert_checklists.html
*Description of Services Template
*Documentation Checklist
*Document Readiness Statement
*Certificate to Conduct Design Evaluation
*Control & Protection Evaluation
*Strength Analysis Evaluation
*Pitch Bearing Evaluation
*Mechanical Components Evaluation
*Manufacturing, Installation & Maintenance Plan Evaluation
*Pre-Review
*Commissioning
*Turbine Characteristics
*Contract Monitoring
*Evaluation Report Template
*Evaluator Acceptance
*Load Analysis Evaluation
*Yaw Bearing Evaluation
*Gearbox Evaluation
*Foundation Design Evaluation
*Small Wind Turbine Evaluation
*Electrical Components Evaluation

Remarks: http://www.windpower.org/en/stat/units.htm http://www.nrel.gov/wind/working_cert_guidelines2.html http://www.nrel.gov/wind/working_cert_checklists.html	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. RE-04
	Paragraph	5	Generating Facilities (Others)	
	Clause			
Title	Renewable Energy (Biomass Power Generation)			

Biomass Power:

Biomass (biogenic) energy is renewable energy from organisms where the solar energy has been converted by plants and stored.

Therefore, even if we burn the biomass to obtain energy, emitted CO_2 has been inherent to the atmosphere, and as long as we keep growing the biomass simultaneously, we are not generating any additional CO2.

We can define the origin of biomass in 2 kinds by its raw material, wastes and plants (cultivated).

http://www.enecho.meti.go.jp/english/energy/new_energy/biomass.html

Classification of Biomass Source

Waste	Waste	Landfill gas	-
		Living waste	Sewage sludge, pulp sludge, food processing residue, chips, etc.
		Industry waste	Sewage sludge, pulp sludge, food processing residue, chips, etc.
	Agriculture and fishery	Forest waste	Forest residue branch, thinning waste, small lumber, etc.
		Livestock waste	Cow, pig, manure, chicken manure
		Agricultural waste	Rice hull, rice straw, wheat straw, etc.
Cultivated plants	Water organism	Micro-organisms	Chlorella, photosynthesis bacteria, etc.
		Marin	Kelp, giant kelp
		Fresh water	Scallop alga, etc.
	Land organism	Oil	Coconut, rage seed, sunflower, etc.
		Hydrochloride	Eucalyptus, blue coral, etc.
		Cellulose	Bamboo, poplar, sycamore, etc.
		Starch	Corn, cassava, sweet potato, etc.
		Sugar	sugar cane, sugar beet, sweet sorurugum

http://www.jpower.co.jp/new_business/index.html

Remarks:	Revisions	
http://www.enecho.meti.go.jp/english/energy/new_energy/biomass.html		
http://solstice.crest.org/articles/static/1/1004994679_6.html		
	2003/Nov.	Original

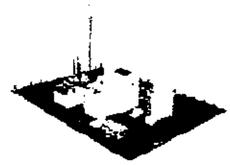
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. RE-05
	Paragraph	5	Generating Facilities (Others)	
	Clause			
Title	Renewable Energy (Biomass Power Generation)			

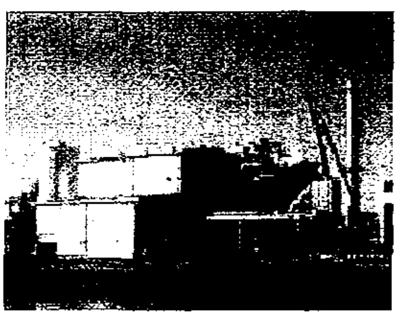
Biomass:
-What is bioenergy?
-Why is bioenergy considered renewable?
-How is biomass used to create energy?
-What are the main forms of biomass?
-What percentage of the world energy mix does bioenergy represents?
-How much does bioenergy cost?
-What are the environmental impacts of bioenergy?
-What are some barriers to bioenergy?
-Where can I get more information on bioenergy?

http://solstice.crest.org/articles/static/1/1004994679_6.html

Biomass: Overview of Biomass Technologies
-Gasification-Based Biomass
-Direct-Fired Biomass
-Biomass Co-Firing

http://www.eere.energy.gov/power/techchar.html





Roi-Et Biomass Generation Project in Thailand
http://www.jpower.co.jp/english/index.html

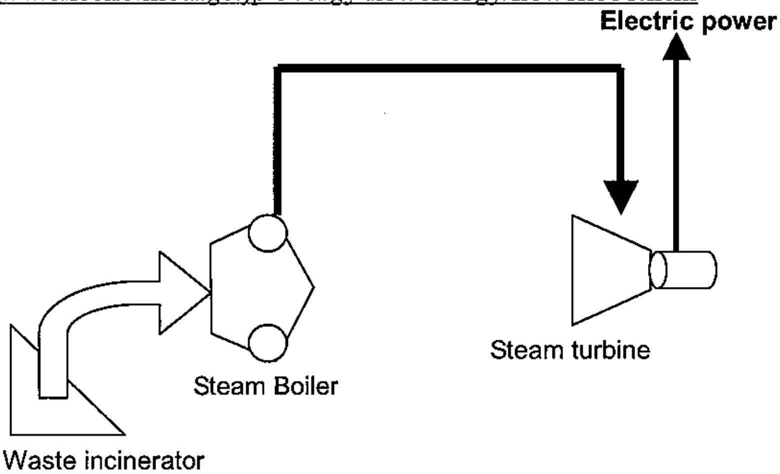
	Revisions	
http://solstice.crest.org/articles/static/1/1004994679_6.html http://www.eere.energy.gov/power/techchar.html http://www.jpower.co.jp/english/index.html		
	2003/Nov.	Original

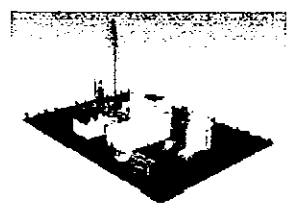
Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No. RE-06**
	Paragraph	5	Generating Facilities (Others)	
	Clause			
Title	Renewable Energy (Waste Power Generation)			

Waste Power Generation:

Typical waste power generation is to use high-temperature combustion gas produced by waste incineration for the boiler to generate steam, and to use the steam to turn the dynamo. It has the characteristics such as; it does not have an impact on the environment by emitting additional CO2, ; it is the stable and continuous power source among the new Energy; and even though the generating capacity is small, it is the local power source that can be situated near the demand area.

http://www.enecho.meti.go.jp/energy/newenergy/newene06.htm





http://www.eco-assist.co.jp/esco.htm

Method of Waste Power Generation
(Separated ash melting furnace)

Incinerating method –
- Stoker furnace --- Stoker furnace
  - -- Rotating stoker furnace
- Fluidized-bed furnace --Hub ring type
  - --Circulation fluidized bed-- Outer circulation
    - -- Inner circulation
- Gus turbine re-powering combined type (Super waste power generation)

Remarks:http://www.eco-assist.co.jp/esco.htm

Revisions	
2003/Nov.	Original

Category				
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

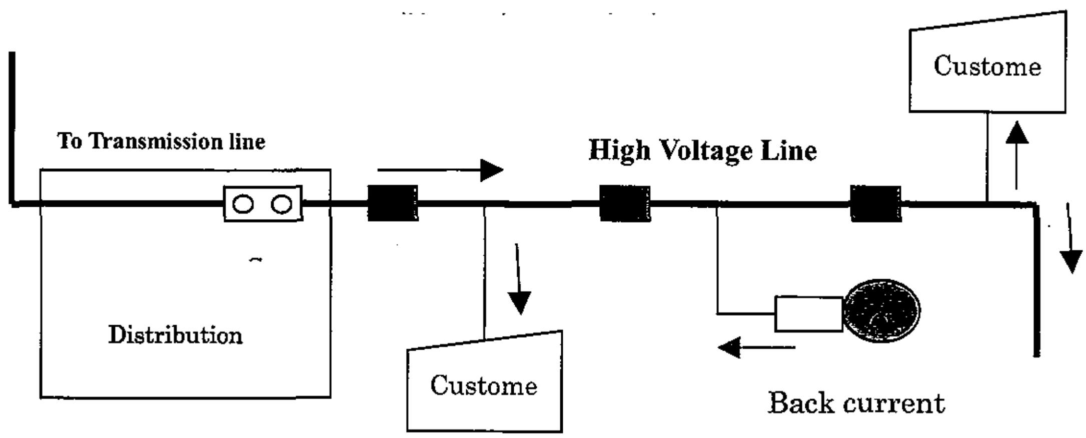
What is Isolated operation?

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	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

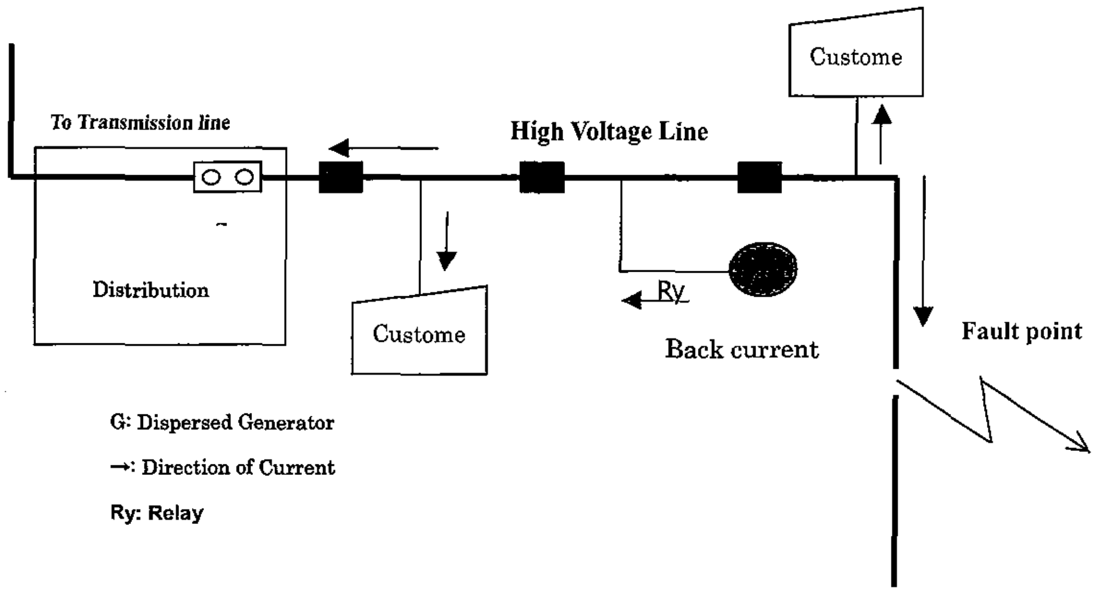
→: Direction of Current

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 (SO2), nitrogen oxides (NOx), 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				Document No. BT-02
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	5	Generating Facilities (Others)	
	Clause			
Title	Bio Power Technologies			

Direct-fired Combustion

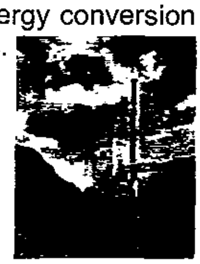
Biomass is the second-most utilized renewable power generation resource.
Most of today's Bio Power plants are direct-fired systems that are similar in concept to most existing fossil - fuel fired power plants.

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.

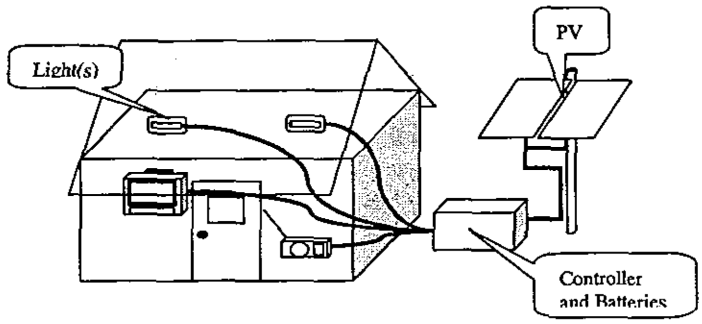
An alternating-current power is domestic and corresponds to the electric appliances with much power consumption which are, for example, use motors, such as a refrigerator, an air-conditioner, and a washing machine.

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

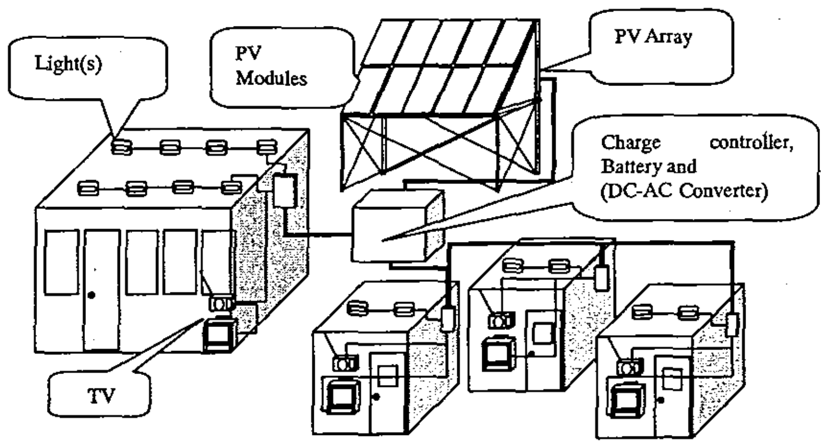
Revisions	
2003/Nov.	Original

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)



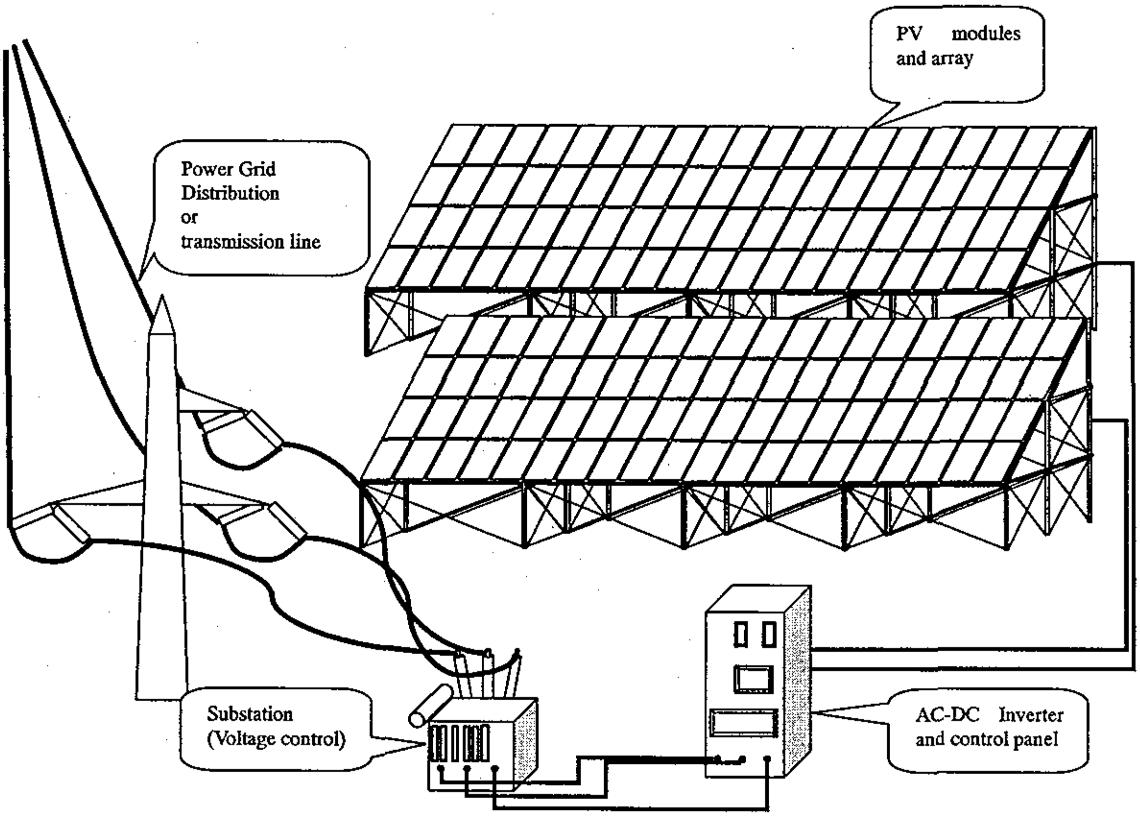
Small-scale
Mini-Grid-connected systems DC or AC 5kW-100kW
Residential PV systems



	Revisions	
	2003/Nov.	Original

Category	**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

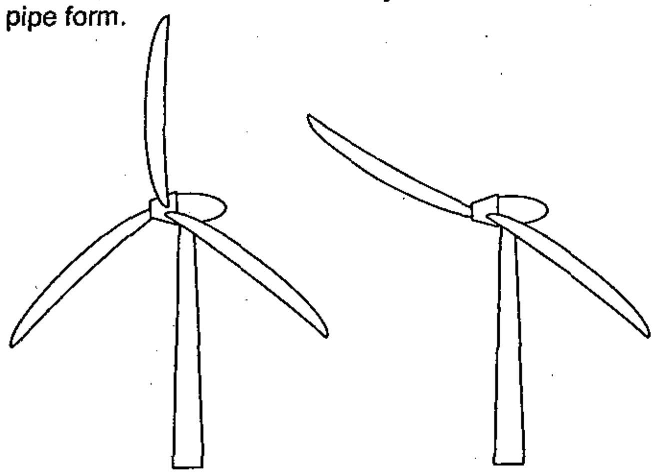


- The PV power Generating system must not affect the established quality and established reliability of electric power of Power System.
- Refer to the “Condition of Connection with Power System for Distributed Generator” for the matter cared about in the case of connecting distributed generator to power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

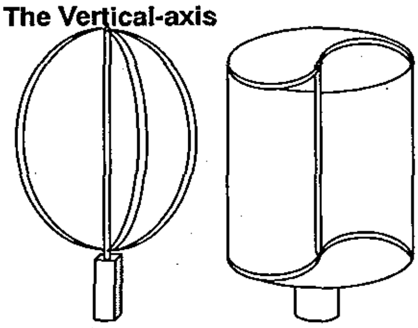
Revisions	
2003/Nov.	Original

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.

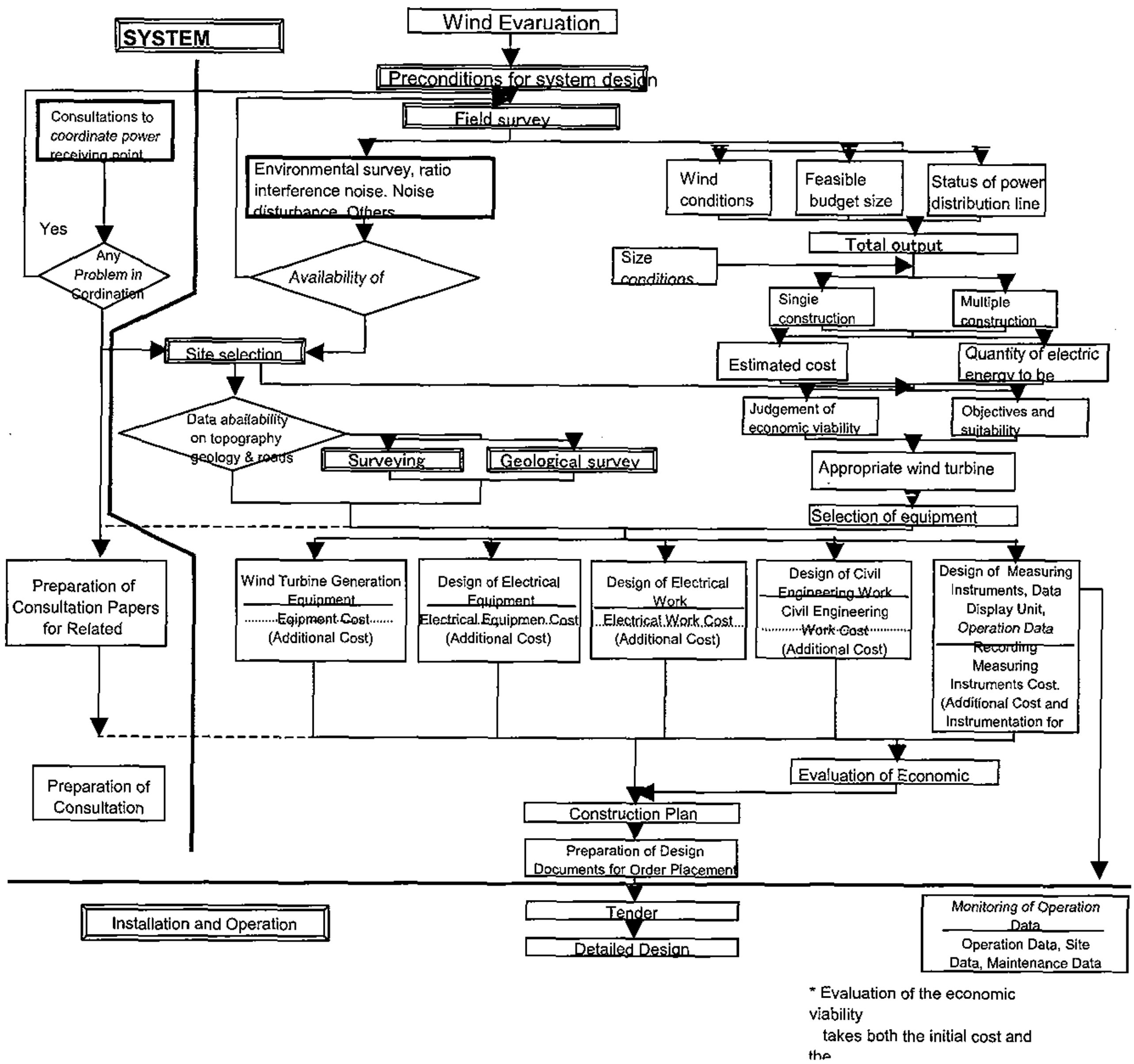
Revisions	
2003/Nov.	Original

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
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SS-11	Protective Relay System
SS-12	Grounding for Substations
SS-13	Installation of Surge Arresters

TL-1	Main Components of Transmission Line
TL-2	An Example of a Warning Sign
TL-3	An Example of a Device to Prevent Third Persons from Climbing
TL-4	An Example of Arrangement of a "Danger sign", "Anti-climbing Devices" and "Steps"
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TL-16	Protection against Lightning
TL-17	Arcing Horns
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TL-19	Current-carrying Capacity
TL-20	Sag of Conductors
TL-21	Safety Factor of Conductors
TL-22	Measures for Aeolian Vibration
TL-23	Connection of Conductors
TL-24	Kinds of Ground Wires
TL-25	Safety Factor of Ground Wires
TL-26	Clearance among Bare Conductors and Supporting structures, Arms, Guy wires or Pole Braces
TL-27	Clearance among Ground Wires and the Nearest Conductor
TL-28	Height of Conductors

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

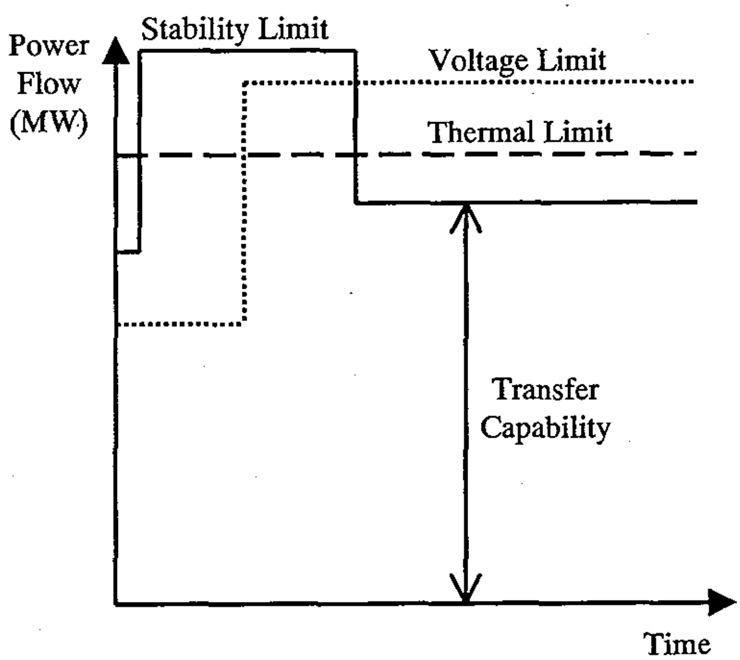
Category	Chapter	1	General Provisions	Document No. TS1
	Paragraph	3	Quality of Electric Power	
	Clause			
Title	Criteria for Network Operation			

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	Chapter	1	General Provisions	Document No. TS2-1
	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:

$F_i = F_i (P_i)$ (1)

where F_i: production cost, P_i: production power

2. Unit capacity limits

$P_i \leq P_{imax}$
$P_i \geq P_{imin}$ (2)

3. System Constraints (demand – supply balance)

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

Remarks	Revisions	
	2003/Nov.	Original

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

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:

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

The Lagrangian function of (4) results in:

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

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

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.

Remarks	Revisions	
	2003/Nov.	Original

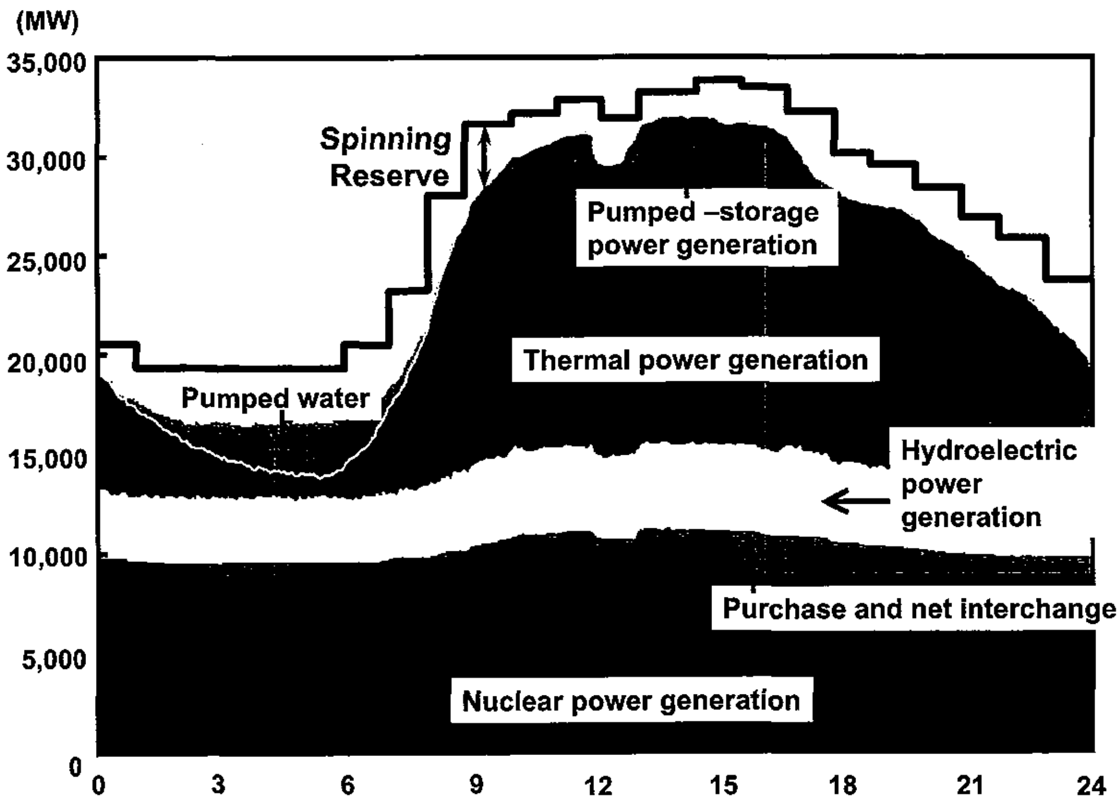
Category	Chapter	1	General Provisions	Document No. TS3
	Paragraph	3	Quality of Electric Power	
	Clause			
Title	Operating Reserve			

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



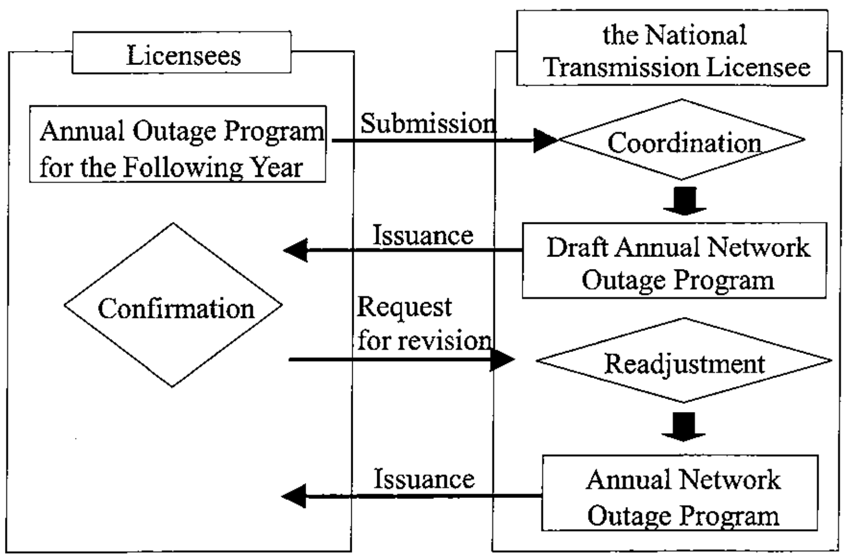
Ex. Typical Load Curve (Heavy Load Period) in Kansai, Japan

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

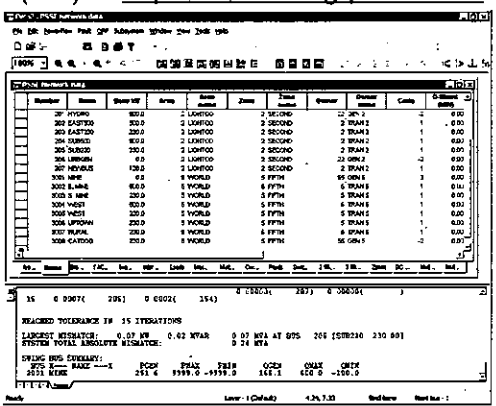
Category	**Chapter**	1	General Provisions	**Document No. TS5**
	Paragraph	3	Quality of Electric Power	
	Clause			
Title	Record and Analysis of System Accident			

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.

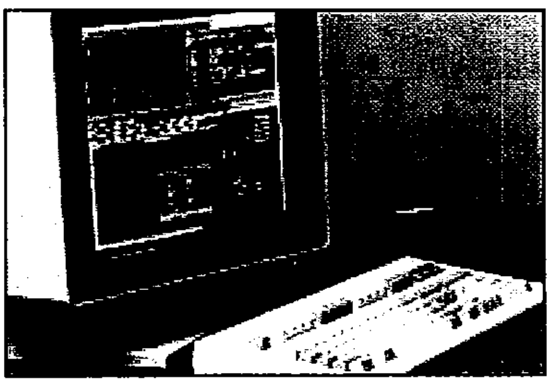
Requirements for the installation of disturbance monitoring equipment (e.g., sequence-of event, fault recording, and dynamic disturbance recording equipment) which can record and monitor data necessary to determine system performance and the causes of system disturbances should be established by the 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				Document No. TS6
	Chapter	1	General Provisions	
	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				Document No. TS8
	Chapter	1	General Provisions	
	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.

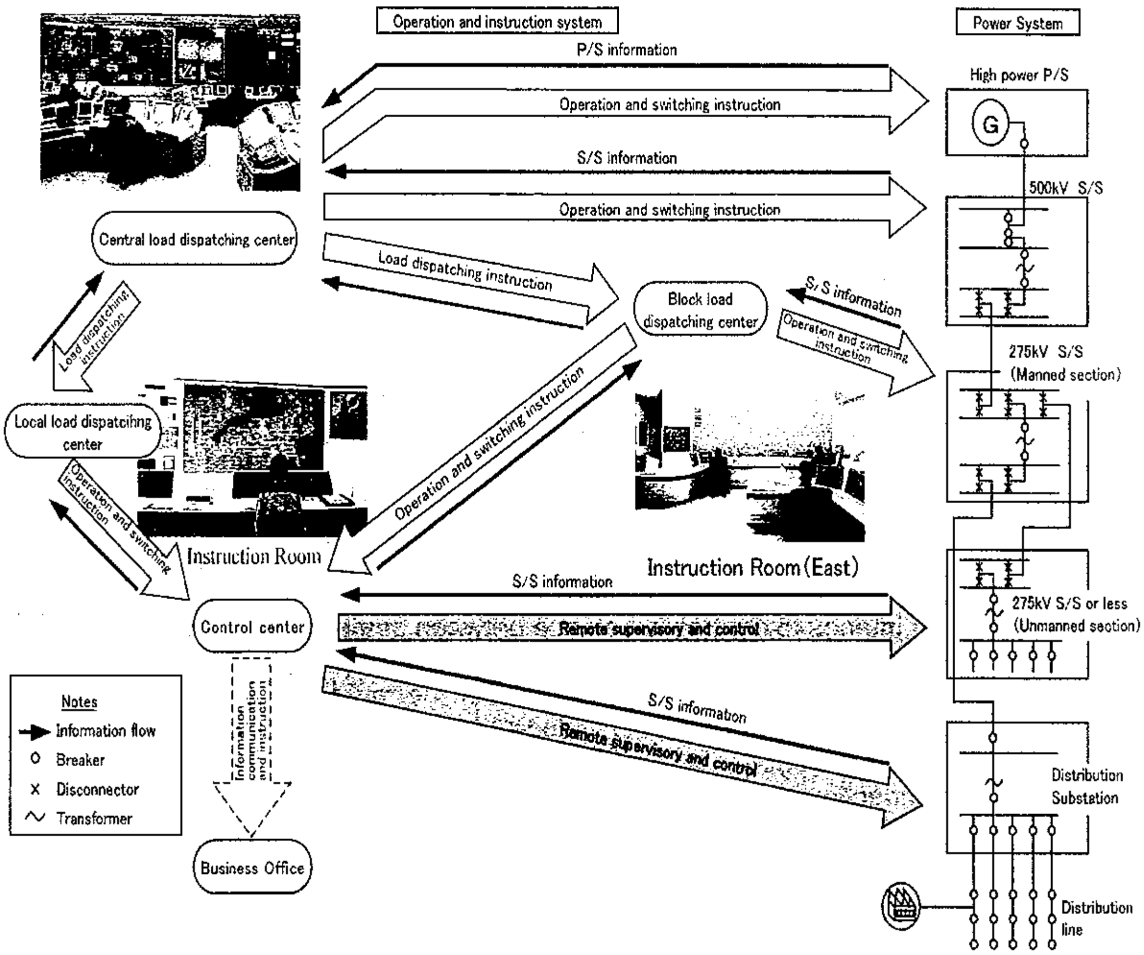
Communication lines
Communication lines are needed to exchange information among interconnected countries.

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.



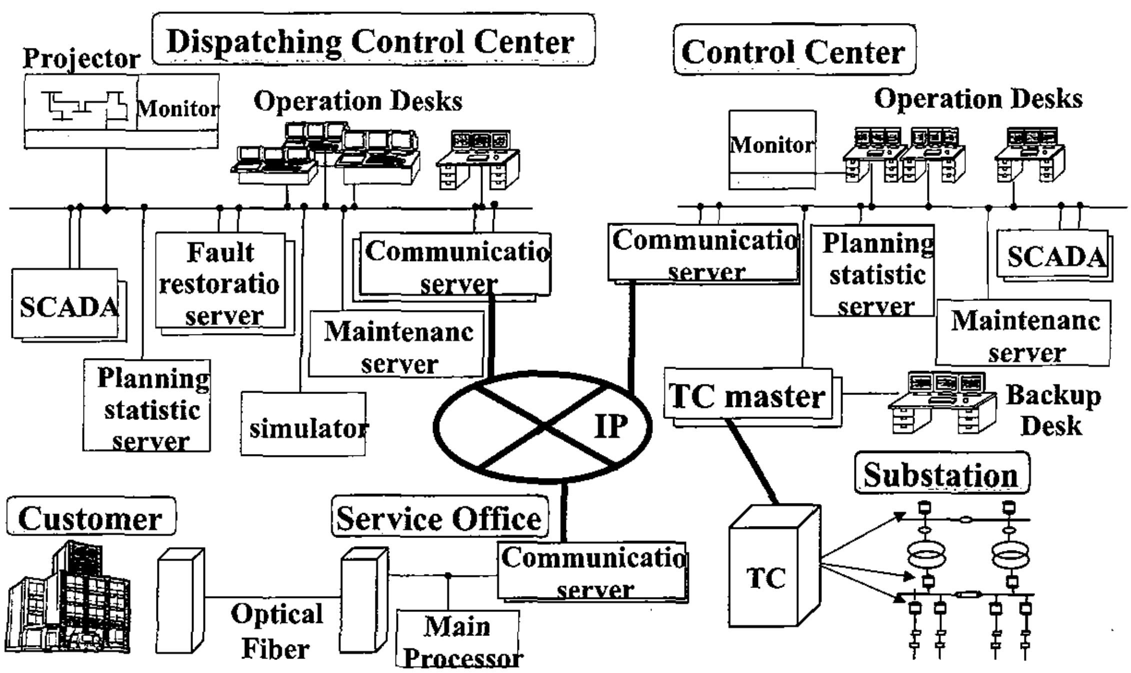
Remarks	Revisions	
Referring to the standards of the KANSAI Electric Power Co., Inc.		
	2003/Nov.	Original

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.

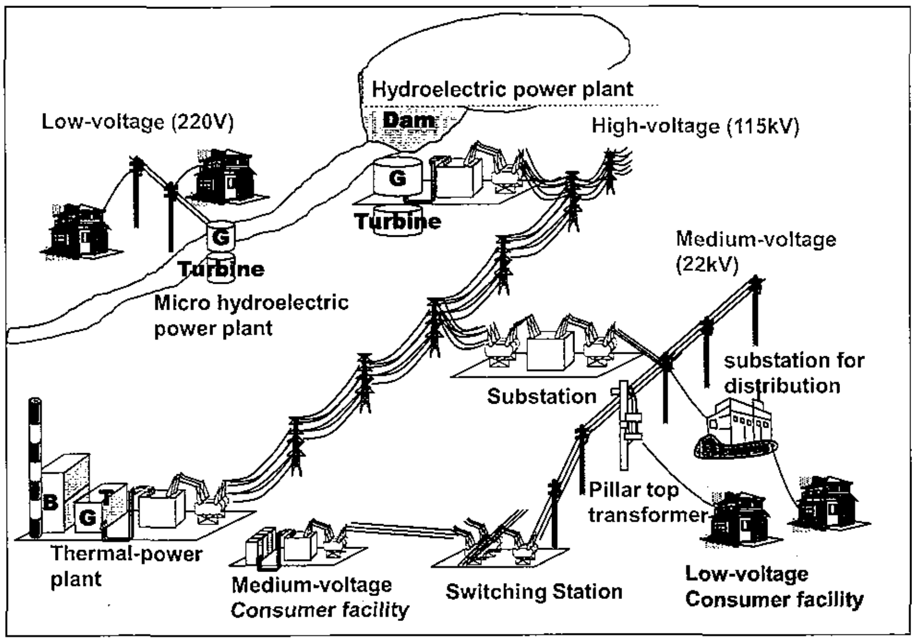
SCADA is an abbreviation of Supervisory Control and Data Acquisition. An example of SCADA and Related Systems is described below.



Remarks Referring to the standards of the KANSAI Electric Power Co., Inc.	Revisions	
	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



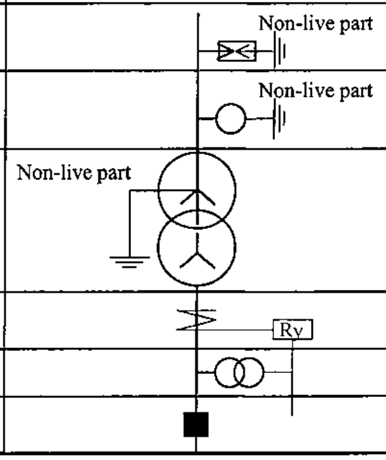
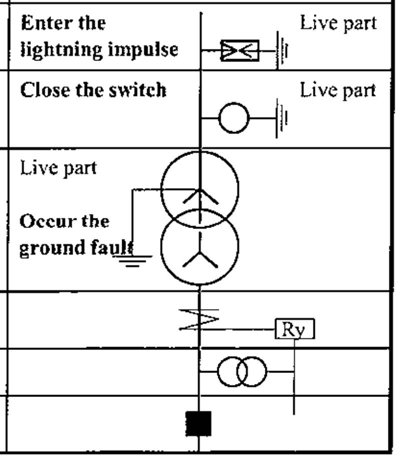
Classification of Power Facilities

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

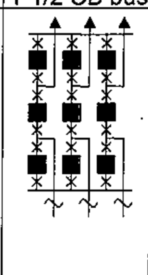
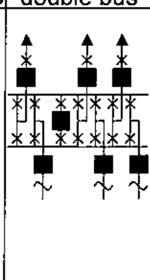
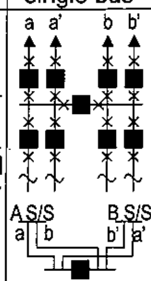
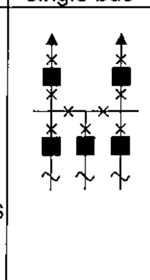
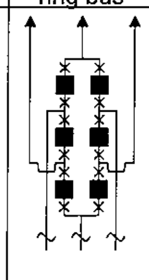
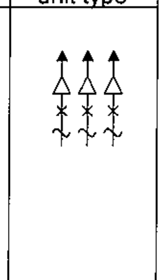
Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	1	General Provisions	**Document No. SS1-2**
	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 <u>normal condition</u>	SLD under <u>abnormal condition</u>
Surge arrester		
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		

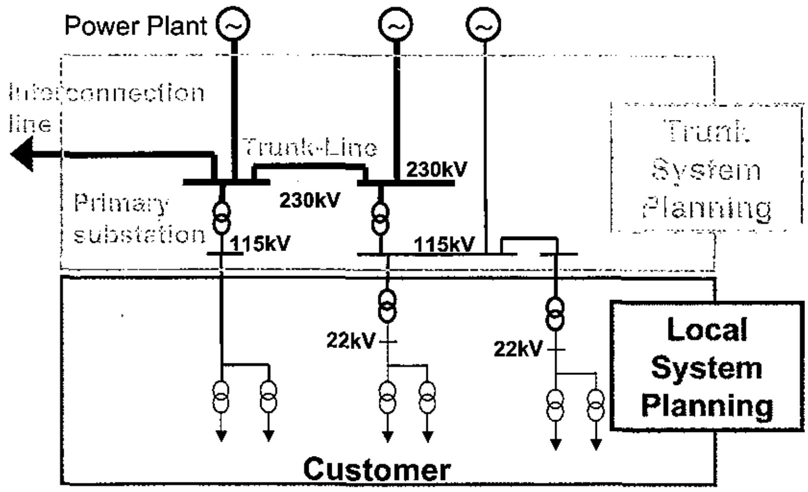
Properties of Bus Connection Schemes

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			

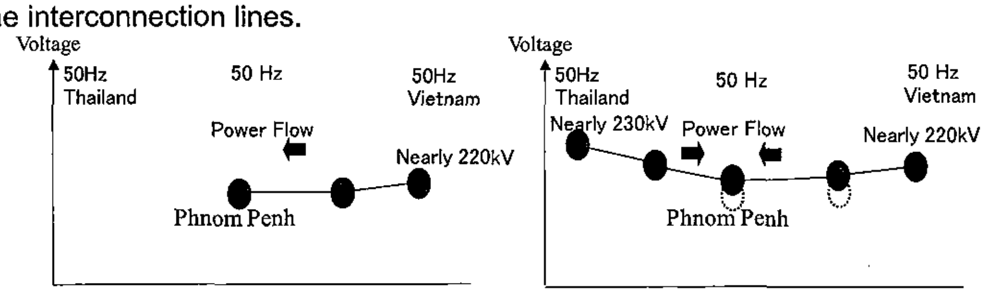
Main factors for system planning are reliability, quality, costs, and future expansion. Generally, transmission system is classified as described below, Trunk System and Local System. Priority for system planning should be desided according to the class of the system.



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				Document No. SS3
	Chapter	1	General Provisions	
	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	Chapter	1	General Provisions	Document No. SS4
	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