Category				Document No.HD20-1
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Stability of Concrete Gravity Dams (1)			

Example of stability criteria for concrete gravity dams (based on the draft Electric Power Technical Standards in Lao)

Concrete gravity dams shall meet the following:

1. Dam bodies shall be stable for overturning due to cracking.
   (1) Under conditions of a normal dam operation, a resultant force consolidated both anticipated external forces and a self-weight shall be within the center one-third (1/3) (so called, the middle third) of the horizontal section of the dam body.
   (2) Under earthquake or flood conditions, the resultant force shall be within the center one-second (1/2) (so called, the middle half) of the horizontal section of the body.

2. Dam bodies, the contact areas between the dam bodies and their foundations, and any weak strata in the foundations shall be stable for sliding.
   (1) The safety factor for sliding calculated by the following formula shall be three (3) or more under normal conditions (the water level of the reservoir is between the Normal Water Level and the Low Water Level, and the downstream water level of the dam is equal to or lower than the water level when the maximum design discharge flows). It shall be two (2) or more under earthquake or flood conditions.

$$n = (f \times V + \tau \times L) / H$$

Where,
n: Shear friction safety factor
f: Internal friction coefficient
τ: Shear strength
V: Total vertical force acting on the shear plane per unit width
H: Total horizontal force acting on the shear plane per unit width
L: Area resisting against the shear force per unit width

   (2) In case the dam is not crucial for human safety, properties, economy, and environment, and the shear strength of the foundations is not taken into account, the shear friction safety factor defined by the above formula shall be at 1.5 or more under normal conditions and 1.2 or more under earthquake or flood conditions.

Remarks	Revisions	
Laotian Electric Power Technical Standards (Draft), April 2002, Ministry of Industry and Handicrafts, Lao P.D.R. and JICA		
	2003/Nov.	Original

Category				Document No.HD20-2
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Stability of Concrete Gravity Dams (2)**			

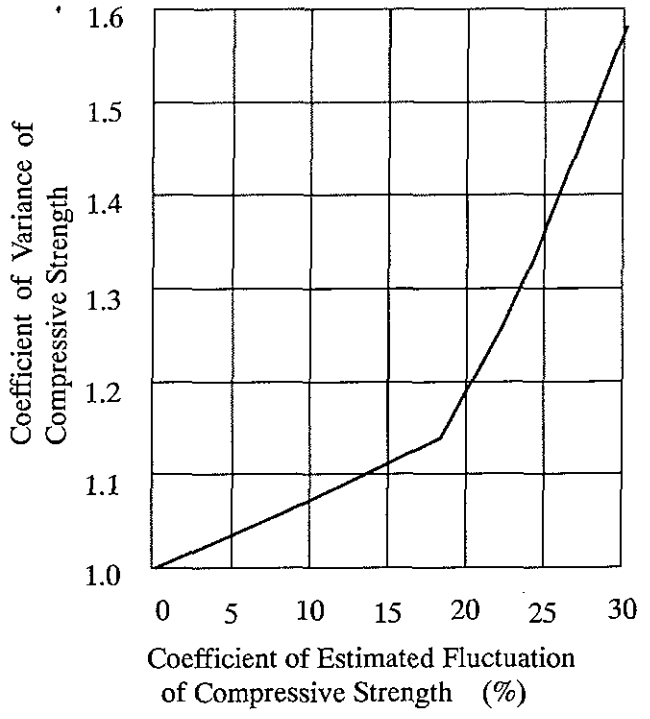
3. The inside stresses of dam bodies shall not exceed the allowable stress as described below:
   (1) The allowable compressive stress of concrete shall be one-third (1/3) of its compressive strength. It shall be one-half (1/2) of its compressive strength under earthquake or flood conditions;
   (2) The allowable tensile stress of concrete shall be one-fortieth (1/40) of its compressive strength;
   (3) The specific age of the concrete for the strength test shall be in principle 91 days. It shall be determined in consideration of the period between the time of concrete placing and that of being loaded; and
   (4) The proportioning strength of concrete shall be determined with the additional rate in consideration of variance of compressive strength to the required compressive strength as follows:

   (The proportioning strength) = (The required compressive strength) x (The coefficient of the variance of compressive strength)

4. The static analyses with a proper design seismic coefficient (so called, the Seismic Coefficient Analysis) shall be applied in principle for stability analyses under earthquake conditions.

Remarks	Revisions	
Laotian Electric Power Technical Standards (Draft), April 2002, Ministry of Industry and Handicrafts, Lao P.D.R. and JICA		
	2003/Nov.	Original

Category				Document No.HD21
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Coefficient of Estimated Fluctuation of Compressive Strength			



Coefficient of Variance of Compressive Strength

Remarks	Revisions	
Standard Specifications for Concrete Structures-2002, Dam Concrete, Japan Society of Civil Engineers		
	2003/Nov.	Original

Category				Document No.HD22
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Strength of a Concrete Dam Body**			

1. Compressive stresses caused by the loads acting on the gravity dam or a hollow gravity dam and compressive stresses caused by loads except for hydrodynamic pressure and seismic forces shall not exceed the maximum allowable compressive stress level for each type of concrete to be used.
2. Tensile stresses caused by the loads acting on the gravity dam or the hollow gravity dam shall not exceed the allowable tensile stress level for each type of concrete to be used, except for cases stipulated in below sentences.
3. The gravity dam or the hollow gravity dam shall not generate a vertical tensile stress at its upstream end.
4. At the portion near an overflow section of the dam which is reinforced with reinforcing bars for the tensile stress, the previous two sentences shall not be applied.

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HD23
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Stability of Arch Dams**			

Example of stability criteria for arch dams (based on the draft Electric Power Technical Standards in Lao)

Arch dams shall meet the following:

1. The contact areas between the dam bodies and the foundations, and any part of the foundations shall be stable for sliding.

   The safety factor for sliding calculated by the following formula shall be four (4) or more under normal conditions (the water level of the reservoir is between the Normal Water Level and the Low Water Level, and the water level of the dam downstream is equal to or lower than the water level when the maximum design discharge flows). It shall be 2.7 or more under earthquake or flood conditions.

   $$n = (f \times V + \tau \times L) / H$$

   Where,

   n : Shear friction safety factor;
   f : Internal friction coefficient;
   τ : Shear strength;
   V : Total vertical force acting on the shear plane per unit width;
   H : Total horizontal force acting on the shear plane per unit width; and
   L : Area resisting against the shear force per unit width

2. The inside stresses of dam bodies shall not exceed the allowable stress as described below:
   (1) The allowable compressive stress of concrete shall be one-third (1/3) of its compressive strength. It shall be one-half (1/2) of its compressive strength under earthquake or flood conditions;
   (2) The allowable tensile stress of concrete shall be one-fortieth (1/40) of its compressive strength;
   (3) The specific age of the concrete for the strength test shall be in principle 91 days. It shall be determined in consideration of the period between the time of concrete placing and that of being loaded; and
   (4) The proportioning strength of concrete shall be determined with the additional rate in consideration of the variance of compressive strength to the required compressive strength as follows:

   (The proportioning strength) = (The required compressive strength) x (The coefficient of variance of compressive strength)

3. The static analyses with a proper design seismic coefficient (so called, the Seismic Coefficient Analysis) shall be applied in principle for stability analyses under earthquake conditions. The dynamic analysis based on a proper evaluation of earthquake motions, the dynamic physical and mechanical properties of the foundations and the materials of the dam body, and reliable methods for analysis, is desirable to be applied.

Remarks	Revisions	
Laotian Electric Power Technical Standards (Draft), April 2002, Ministry of Industry and Handicrafts, Lao P.D.R. and JICA		
	2003/Nov.	Original

Category				Document No.HD24
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Details of Concrete Dam Bodies**			

Concrete dam bodies shall meet the following:

1. Proper expansion joints shall be installed in order to prevent detrimental cracks;
2. Drain holes shall be installed as necessary from the inspection galleries to the foundations to prevent excessive uplift that acts on the dam body itself, the contact areas between the dam body and its foundations, and the inside of the foundations;
3. The portions around openings of the dam such as inspection galleries, water discharge equipment, and penstocks installed inside of the dam body, shall be structurally safe for the concentrated stresses and the stresses due to temperature change;
4. Waterstops shall be watertight and durable, and be flexible for expanding and contracting of the joints. They shall be installed in transverse joints near the upstream surface of the dam; and
5. The maximum temperature rise of the placed concrete in the dam body shall be controlled or taken countermeasures as necessary in order to protect the dam body from detrimental cracks caused by temperature rise.

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HD25
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Embankment Materials for Fill Dam Bodies**			

Example of criteria for embankment materials for fill dam bodies (based on the draft Electric Power Technical Standards in Lao)

Embankment materials for fill dam bodies shall meet the following:

1. Materials with properties conforming to the respective purposes shall be used as dam body materials.
   (1) Soil materials of the impervious ones shall meet the following:
      a. Soil materials shall have required strength and water-tightness for dam stability;
      b. Soil materials shall be easily compacted and subject to little deformation;
      c. Soil materials shall be free of such expandability and contractibility that may cause difficulties in dam stability;
      d. Soil materials shall not be subject to softening;
      e. Soil materials shall not contain organic substances and not be water-soluble; and
      f. The Coefficient of Permeability, strength, and compaction properties shall be determined with materials to be used.
   (2) Impervious materials except for soil ones shall be identified to have required water-tightness, properties of strength and compaction, and durability with materials to be used.
   (3) Semi-pervious materials shall meet the following:
      a. Semi-pervious materials shall have required strength and drainage properties for dam stability;
      b. Semi-pervious materials shall have required grain size distribution;
      c. Semi-pervious materials shall be easily compacted and subject to little deformation; and
      d. The Coefficient of Permeability, strength, and unit weight shall be determined with materials to be used.
   (4) Pervious materials shall meet the following:
      a. Pervious materials shall have required strength and drainage properties for dam stability;
      b. Pervious materials shall be hard and durable;
      c. Pervious materials shall be easily compacted and subject to little deformation; and
      d. The Coefficient of Permeability, strength, unit weight, and durability shall be determined with materials to be used.
   (5) Materials for the surfaces of the dam bodies shall not be seriously eroded by waves and rainfall.

2. When materials are selected, they shall be tested properly to identify their properties with materials to be used. When the strength of any selected material is identified at a process of the stability analysis, its consolidation and drainage conditions shall be considered in setting the strength property.

Remarks	Revisions	
Laotian Electric Power Technical Standards (Draft), April 2002, Ministry of Industry and Handicrafts, Lao P.D.R. and JICA		
	2003/Nov.	Original

Category				Document No.HD26
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Foundations for Fill Dams**			

Dam foundations of fill dams shall meet the following:

1. Foundations at impervious zones are desirable to be hard rock foundations and shall have required water-tightness and shear strength;
2. In case the dam foundations are not rock ones, the water-tightness, strength and deformation properties shall be tested through in situ and/or laboratory tests in order to identify the foundation properties. Safety for liquefaction under earthquake conditions shall also be secured;
3. Sand-gravel foundations shall require countermeasures against seepage as necessary in order to secure adequate stability; and
4. Soil foundations shall require countermeasures against sliding and deformation as necessary in order to secure adequate stability.

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HD27
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Stability of Fill Dams**			

Example of stability criteria for fill dams (based on the draft Electric Power Technical Standards in Lao)

Fill dams shall meet the following:

1. Dam bodies and their foundations shall be stable for sliding. Reliable circular arc methods shall be applied as an analysis for sliding. In case sliding lines are anticipated to include the foundations, the calculations shall be done along not only arc lines but also anticipated sliding lines.
   Required safety factors shall be:
   (1) 1.5 or more under normal conditions (the water level of the reservoir is between the Normal Water Level and the Low Water Level, and the seepage flow in the dam body is in steady state);
   (2) 1.4 or more under flood conditions;
   (3) 1.4 or more under the conditions of at the time being just after completion of dam building and before filling the reservoir;
   (4) 1.1 or more under earthquake conditions; and
   (5) 1.3 or more under the conditions of at the time of rapid drawdown in the reservoir water level in case the drawdown is frequent.

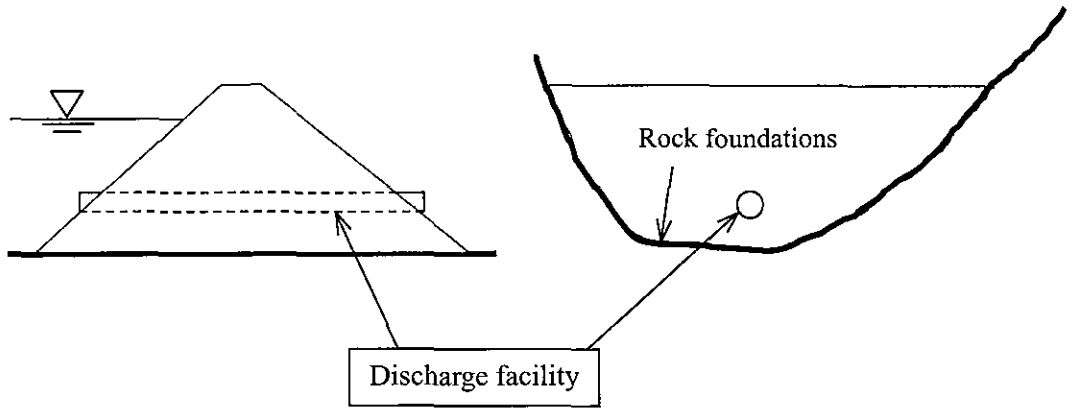
2. Static analyses (so called, the Seismic Coefficient Analysis) with a proper design seismic coefficient shall be applied in principle for stability analyses under earthquake conditions.

Remarks	Revisions	
Laotian Electric Power Technical Standards (Draft), April 2002, Ministry of Industry and Handicrafts, Lao P.D.R. and JICA		
	2003/Nov.	Original

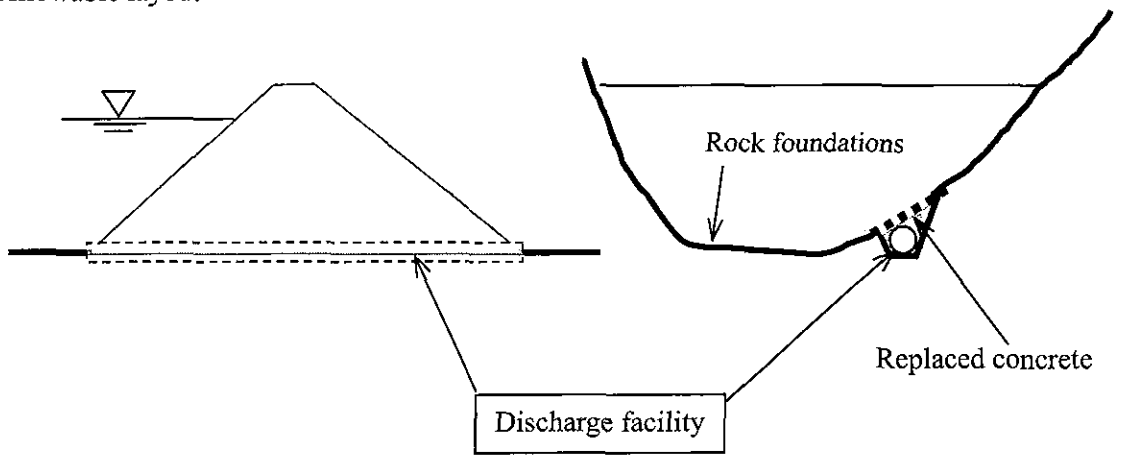
Category				Document No.HD28
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Restrictions on Facilities such as Discharge Facilities of Fill Dams**			

Discharge facilities and waterways that may cause detrimental cracks inside of fill dam bodies shall not be installed inside of the bodies.

Prohibited layout



Allowable layout



Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HD29
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Designs of Fill Dam Bodies**			

1. For homogenous type fill dams composed of impervious materials, the seepage lines shall not appear on the downstream surfaces of the dams. Proper drains shall be installed as necessary to promote reduction of pore pressure.
2. For zoned fill type dams, the zones shall be properly arranged. Every material of these zones in contact with each other shall not make too much difference so that the material particle in each zone does not move.
3. Surface diaphragm type fill dams shall meet the following:
   (1) Surface diaphragm type fill dams shall be designed and installed so that cracks which damage sealing function of the diaphragms may not appear; and
   (2) According to the permeability of the foundations, proper measures for water sealing shall be taken to protect the foundations of the diaphragm from seepage failure.

Remarks	Revisions	
	2003/Nov.	Original

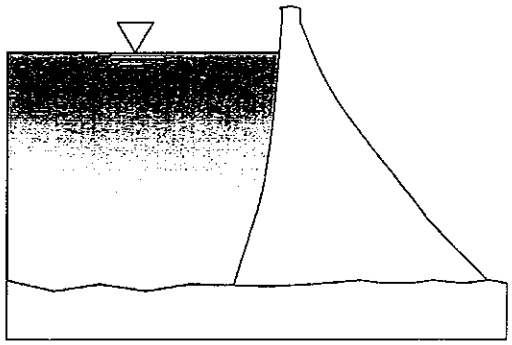
Category				Document No.HD30
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	The Other Types of Dam			

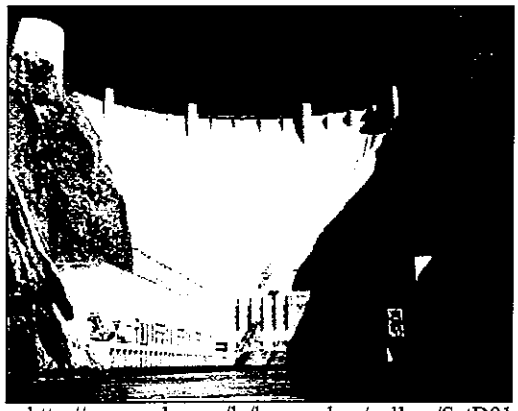
The other type dams such as rubber dams and gabion dams (those dams except for fill dams, concrete dams, and concrete arch dams) shall be installed in accordance with the following:

1. Safety for anticipated conditions such as overturning, sliding, occurrence of excessive stress on materials to be used, cracking, and seepage failure shall be sufficiently considered in designing the dams;
2. Concrete materials shall meet Document No.HD17;
3. Soil and rock materials shall meet Document No.HD25; and
4. In the case that materials except for soil, rock, and concrete are applied, they shall be sufficiently identified by tests on their durability, water-tightness, and strength.

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HD31-1
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Examples of Other Types of Dam (1)**			

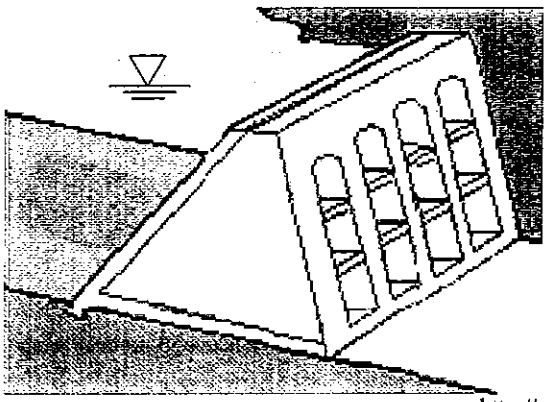


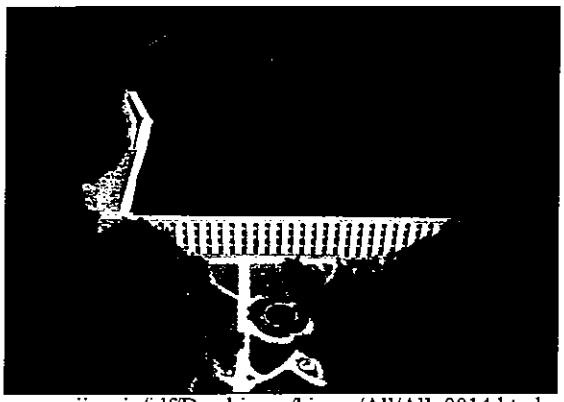


http://www.usbr.gov/lc/hooverdam/gallery/SetD01.htm

Hoover Dam (U.S.A)

1. Concrete Gravity Arch Dam





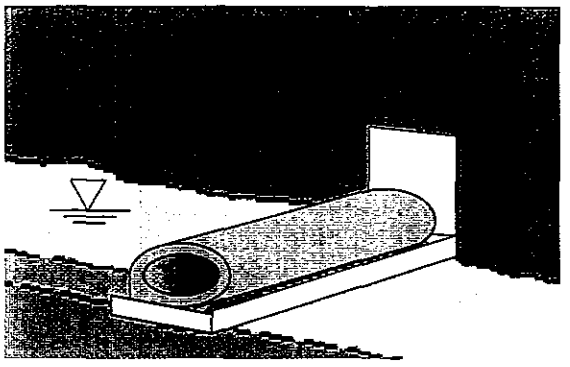
http://wwwsoc.nii.ac.jp/jdf/Dambinran/binran/All/All_0014.html

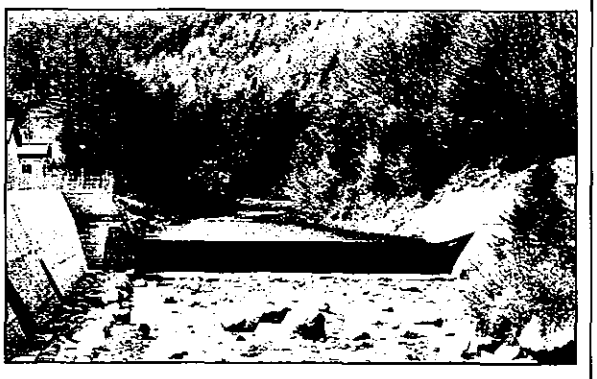
Sasanagare Dam (Hakodate, Japan)

2. Buttress Type Dam

Remarks	Revisions	
http://www.usbr.gov/lc/hooverdam/gallery/SetD01.htm http://wwwsoc.nii.ac.jp/jdf/Dambinran/binran/All/All_0014.html		
	2003/Nov.	Original

Category				Document No.HD31-2
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Examples for Other Types of Dam (2)**			





3. Rubber Inflated Dam

http://www.matsuikk.co.jp/product/jakago.html

4. Gabion Dam

Remarks	Revisions	
http://www.matsuikk.co.jp/product/jakago.html		
	2003/Nov.	Original

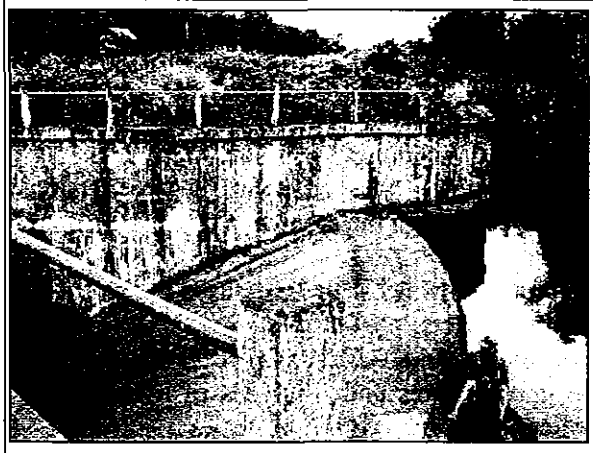
Category				Document No.HD32-1
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Spillways (1)			

Spillways shall meet the following:

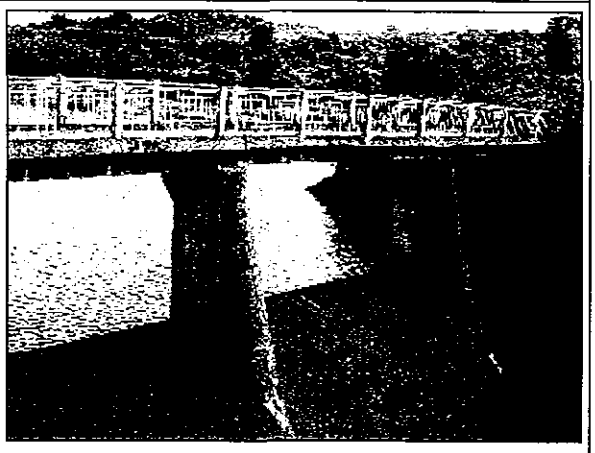
1. All dams shall be equipped with spillways on/in/beside the dams in order to safely discharge the water flow equal to or less than the inflow design flood to the downstream;
2. For fill dams, no spillways shall be equipped on/in the dam bodies themselves;
3. The bottom ends of structures such as bridges and hoisted gate leafs shall be apart enough from the surfaces of the overflowing water discharged through the spillways at the flood water level so that the overflowing water is safely discharged;
4. The forces of a water current discharged through the spillways shall be defused to protect the dam bodies and the downstream areas from harmful impacts;
5. Spillways shall have stability stipulated in Documents No.HD20 or No.HD23 for the loads based on the Documents applied for concrete gravity dams and the loads of a water flow discharged through the spillways at the flood water level;
6. Reliable calculation methods shall be applied in designing spillways and discharge facilities. If it may be difficult to obtain reliable design results for safety through calculations alone, the hydraulic model tests shall be conducted to identify the safety; and
7. No substances that may cause a malfunction to the spillways shall flow into them.

Remarks	Revisions	
	2003/Nov.	Original

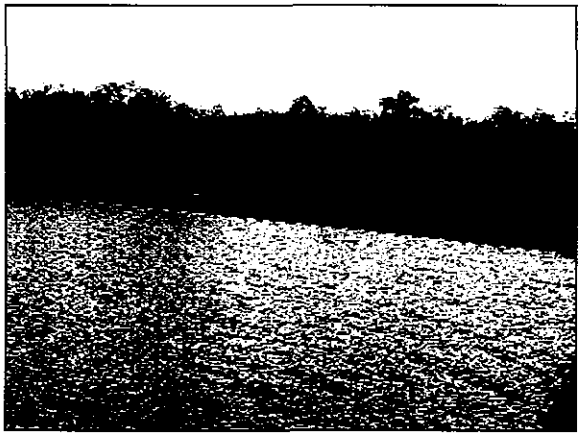
Category				Document No.HD32-2
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Spillways (2)			



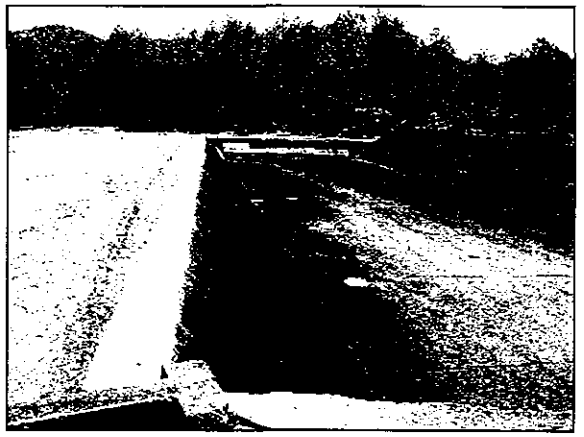
O Chum 1 spillway (no gate)



O Chum 2 spillway (no gate)



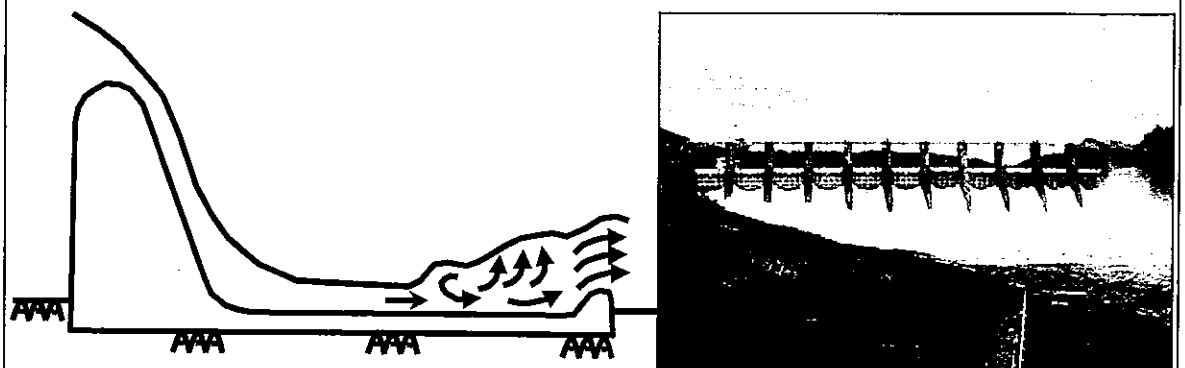
Kirirom 1 spillway (no gate)



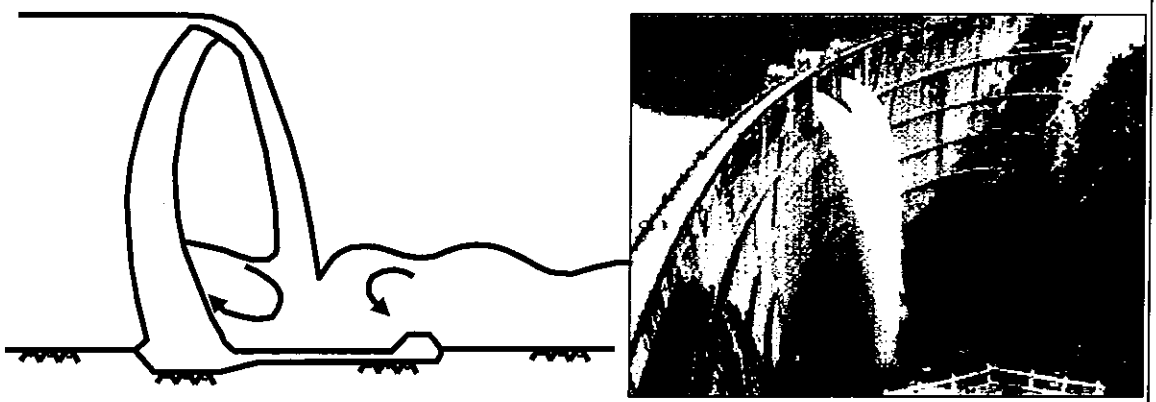
Kirirom 1 spillway (no gate)
- dry season -

Remarks	Revisions	
	2003/Nov.	Original

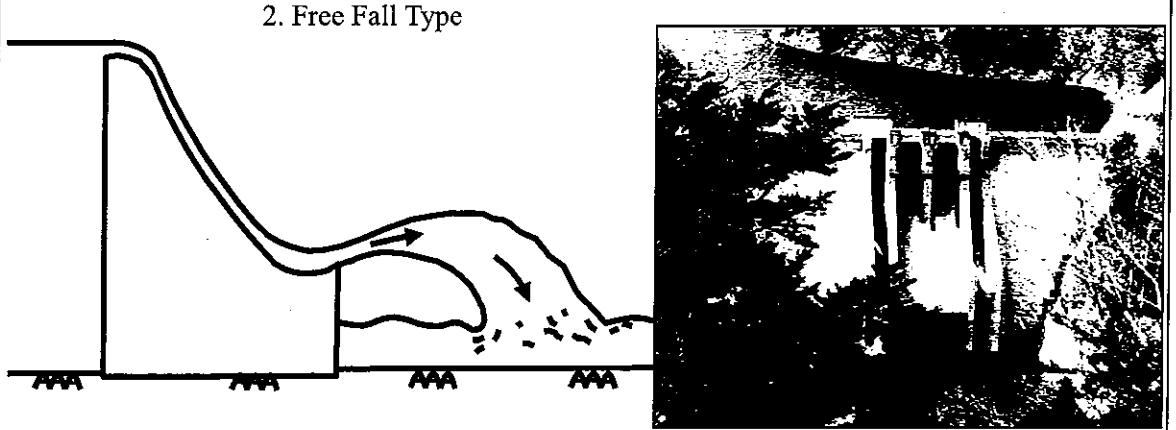
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD33
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Energy Dissipater			



1. Hydraulic jump type



2. Free Fall Type



3. Ski Jump Type

Remarks	Revisions	
	2003/Nov.	Original

J-POWER & CEPCO

Category				Document No.HD34
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Structure to Safely Release the Flow of Water**			

A spillway shall be established so that the water discharged at the design flood water level shall be able to safely flow through it and shall not cause damage to the dam or the dam's surroundings.

Example in Japan,

1. In case the spillway is an overflow type, the lower end of the structure, such as a bridge and a hoisted gate door, shall be at least 1.5 m away from the surface of overflowing water discharged from the spillway at the design flood water level.
2. In case the depth of overflowing water is less than 2.5 m for the case in the previous paragraph, the lower end of the structure shall be at least 1 m away from the surface of overflowing water.

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

Category				Document No.HD35
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Spillway Gates and their Auxiliaries**			

Spillway gates and their auxiliaries shall meet the following:

1. Spillway gates, as defined herein including valves, shall be sufficiently watertight and durable;
2. Spillway gates shall be easily opened and closed, and their operation shall not cause any harmful vibration;
3. Spillway gates shall be stable for anticipated loads such as self-weight, hydrostatic pressure, hydrodynamic pressure, mud pressure, seismic force, buoyancy, and forces caused by opening and closing of the gates and their auxiliaries. Every material for the spillway gates shall have required strength and durability for the said loads. They shall not result in a buckling against the said loads and shall be such structures that safely convey the said loads to the dam bodies and so on;
4. Materials for spillway gates shall be confirmed whether they have required strength with 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
5. In case power-drive devices are applied to operate spillway gates, the devices shall be equipped with back-up devices such as power source facilities and buck-up power sources to ensure the gates operation.

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				Document No.HD36
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Opening and Closing of the Gates**			

The gate shall be able to open and close easily and securely.

That the gate opens and closes easily and securely means that a power-driven device and a backup device (in case such a device is electrically operated, the device means a backup power supply device) shall be installed for a gate where a power-driven device is used to open the gate.

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HD37
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Power Device and Back-up Power Source**			

In case diesel generators are installed as power devices or back-up power sources, they shall meet technical standards related to thermal power plant.

Remarks	Revisions	
- Draft Electric Power Technical Standards in Cambodia, Chapter 2, Section 2, Thermal Power		
- Guidebook for Power Engineers, Vol. No.2, Thermal Power	2003/Nov.	Original

Category				Document No.HD38
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Other Discharge Facilities**			

Other discharge facilities shall meet the following:

1. Dams shall be equipped with discharge facilities in order to lower the water levels of reservoirs in case of emergency and to discharge water to the areas affected by river diversion. In case water outlet facilities or spillways meet these requirements, the said discharge facilities are not required; and
2. In case discharge facilities are not usually operated, operational checks for the facilities shall be periodically done to ensure proper gates operation.

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HW1
	Chapter	2	Technical Standards of Electric Power Facilities	
	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)

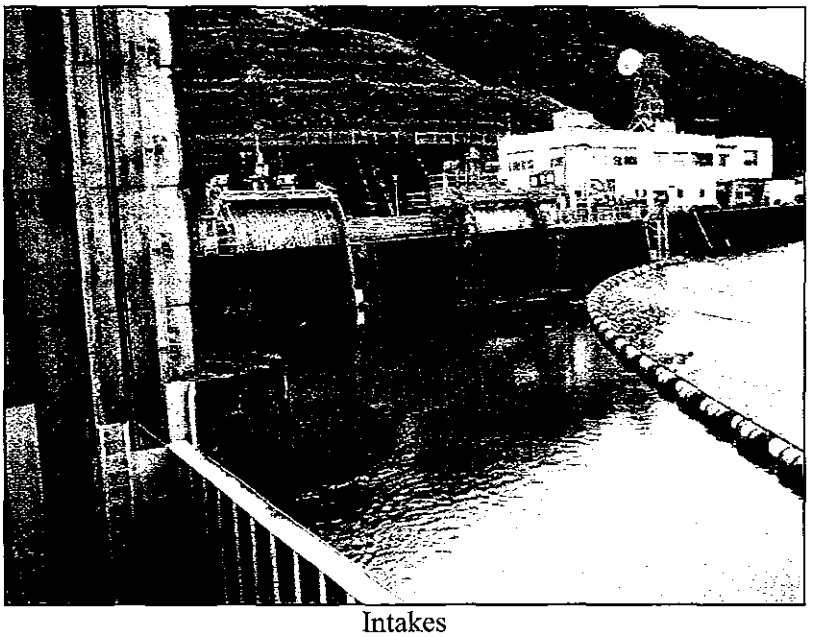
- ISO630/ Structural steels, E275, E355
- ISO4950-2/ High yield strength flat steel products, Part 2: Products supplied in the normalized or controlled condition, E355
- ISO4950-3/ High yield strength flat steel products, Part 3: products supplied in the heat-treated (quenched + tempered) condition,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

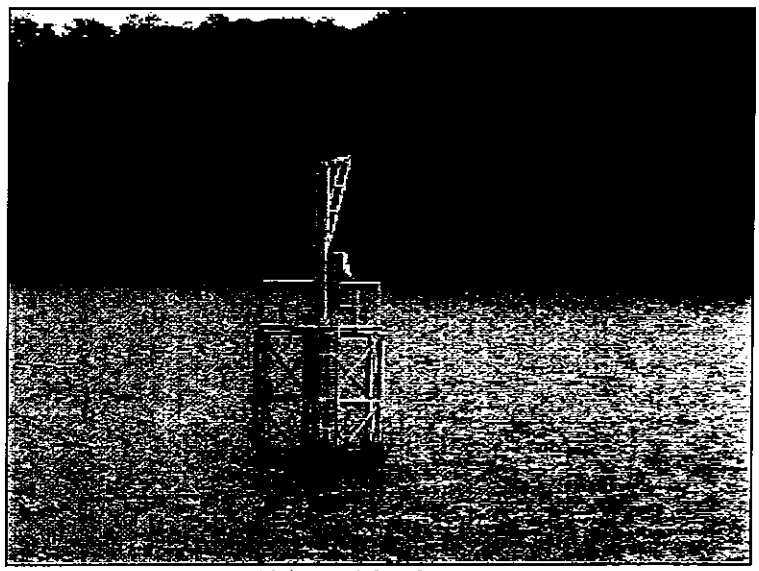


Intakes

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HW2-2
	Chapter	2	Technical Standards of Electric Power Facilities	
	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				Document No.HW3
	Chapter	2	Technical Standards of Electric Power Facilities	
	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:

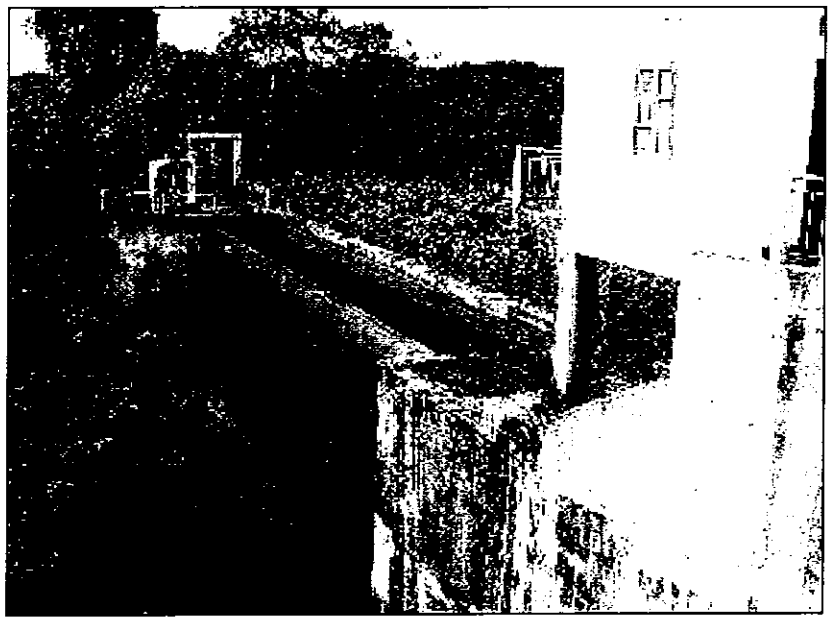
1. To prevent an intake from abnormal water flow under a flood condition in case the intake is connected to a free-flow type headrace;
2. To make, in principal, a hydraulic gate interlocked according to the change in water level in order to maintain the discharge under any load condition, in case the 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				Document No.HW4
	Chapter	2	Technical Standards of Electric Power Facilities	
	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:

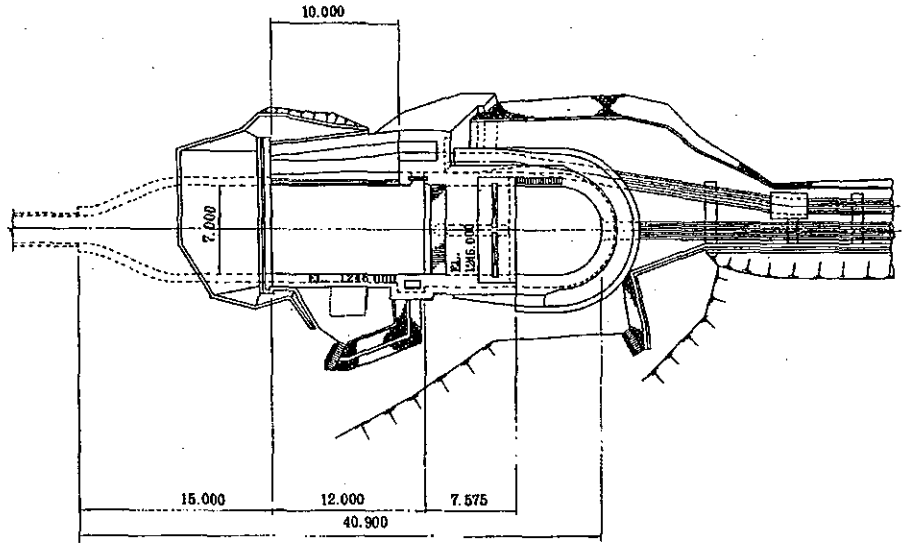
1. Forebays (Settling Basins) shall be stable for anticipated loads such as self-weight, hydrostatic pressure, hydrodynamic pressure, seismic force, external water pressure, and earth pressure. Every material for the Forebays (Settling Basins) shall have required strength and durability for the said 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.

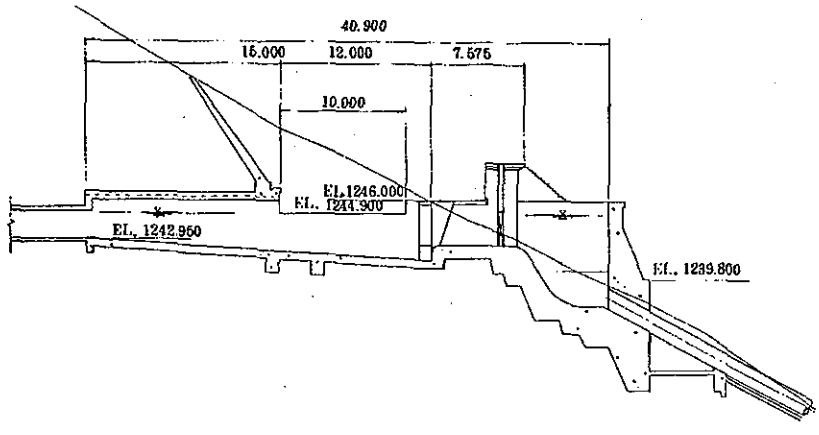


O Chum 2 forebay

Remarks	Revisions	
	2003/Nov.	Original

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





Example of forebay and head tank

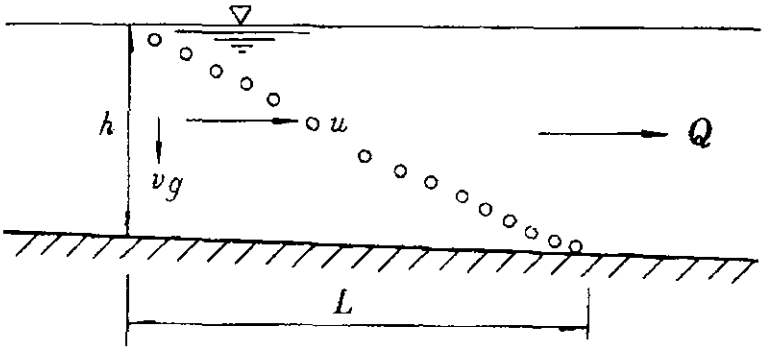
Remarks	Revisions	
	2003/Nov.	Original

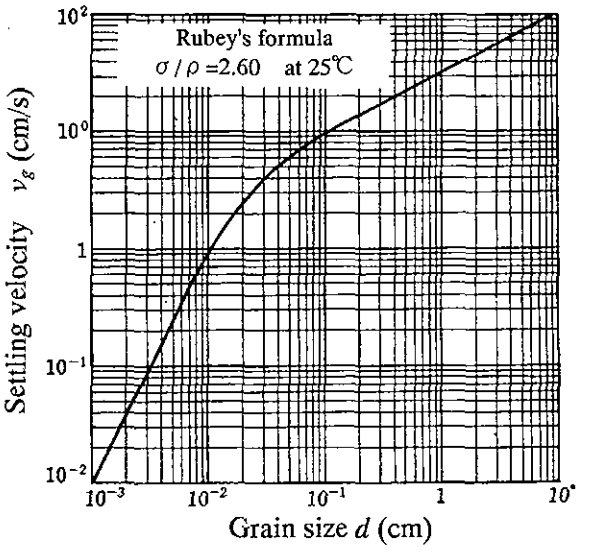
Category				Document No.HW6
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Capability to Settle Sediment**			

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

Headraces shall meet the following:

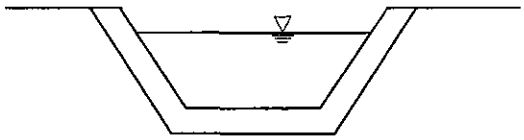
1. Headraces shall be stable for anticipated loads such as self-weight, water weight, hydrostatic pressure, internal water pressure, external water pressure, seismic force, earth pressure, surcharge, and temperature load. Every material for the headraces shall have required strength and durability for 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

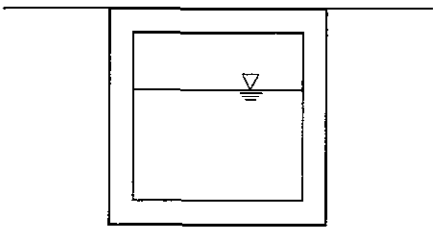
Category				Document No.HW8
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Types of Headraces**			

Headraces ─┬─ pressure waterways
└─ non- pressure waterways

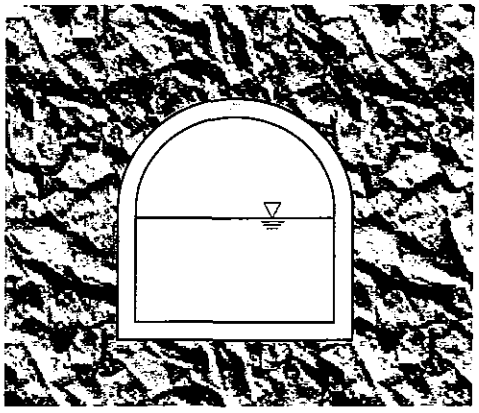
Headraces structures: open canal, covered canal, culvert, aqueduct, inverted siphon, tunnel, etc.



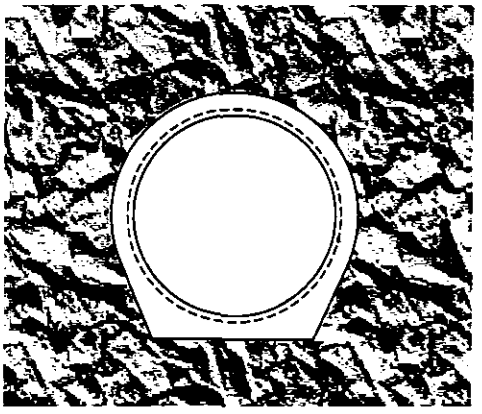
Non-pressure waterway (open canal)



Non-pressure waterway (culvert)



Non-pressure waterway (tunnel)



Pressure waterway (tunnel)

Remarks	Revisions	
	2003/Nov.	Original

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

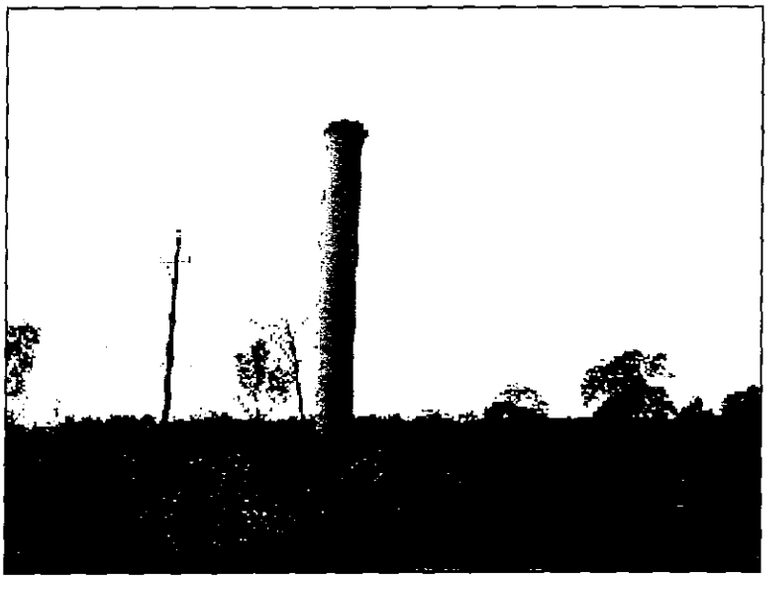
1. Surge tanks shall meet the following:
   (1) Surge tanks shall be stable for anticipated loads such as self-weight, water weight, internal water pressure, seismic force, external water pressure, earth pressure, force caused by wind, and temperature load. Every material for the surge tanks shall have 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
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Surge Tanks			

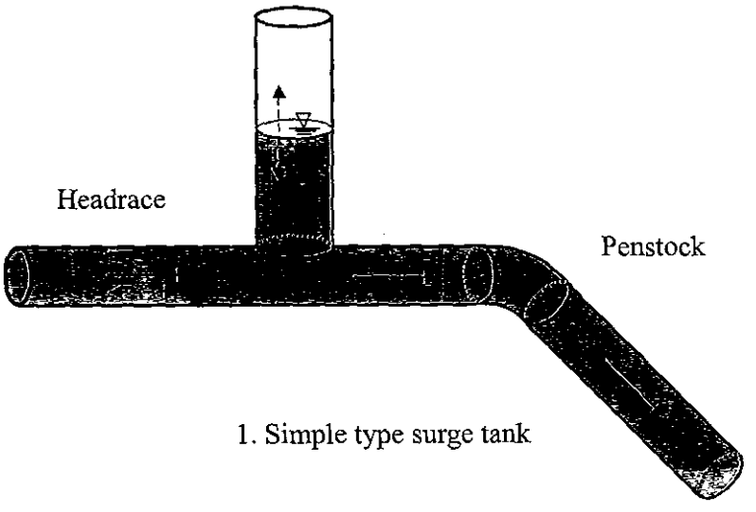
O Chum 2 surge tank



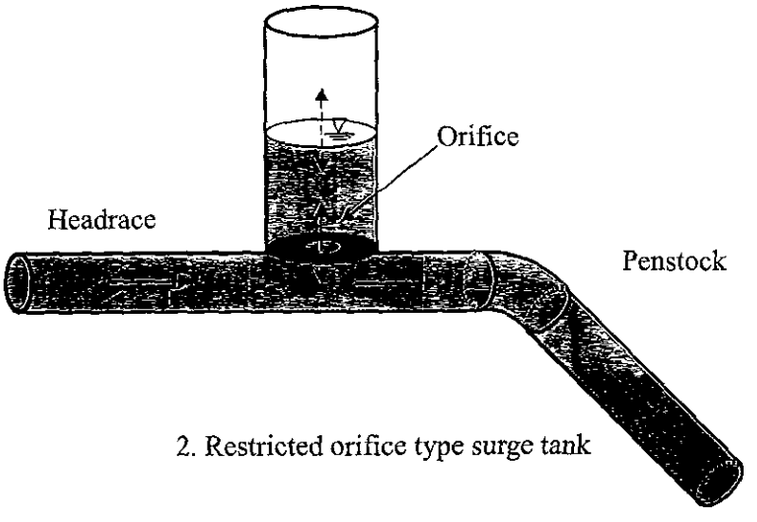
Kirirom 1 surge tank

Remarks	Revisions	
	2003/Nov.	Original

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



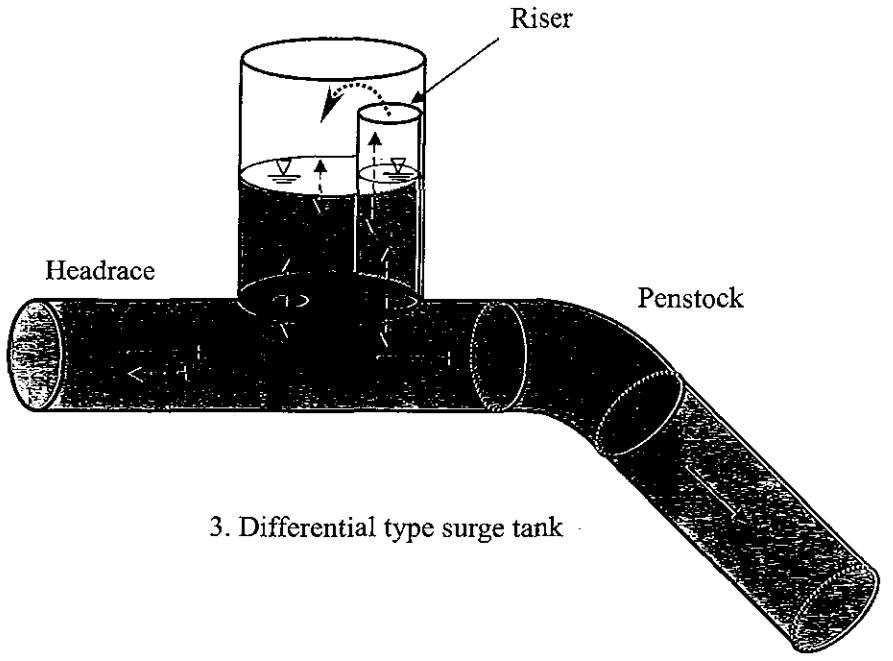
1. Simple type surge tank



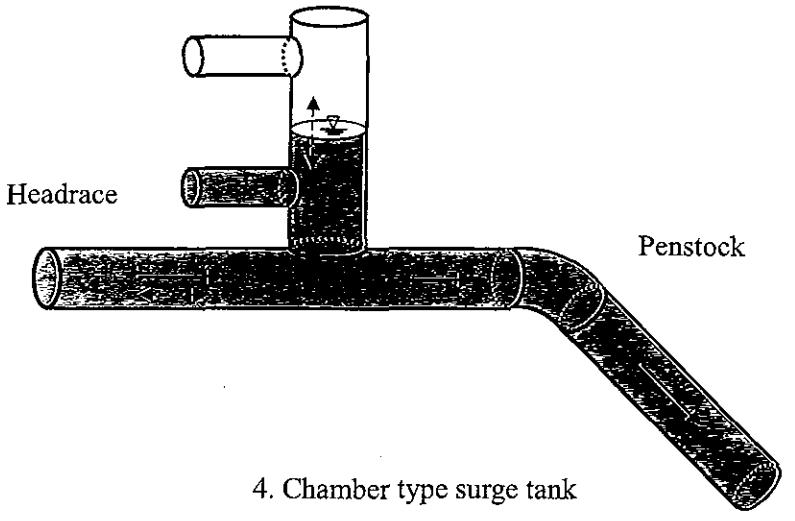
2. Restricted orifice type surge tank

Remarks	Revisions	
	2003/Nov.	Original

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



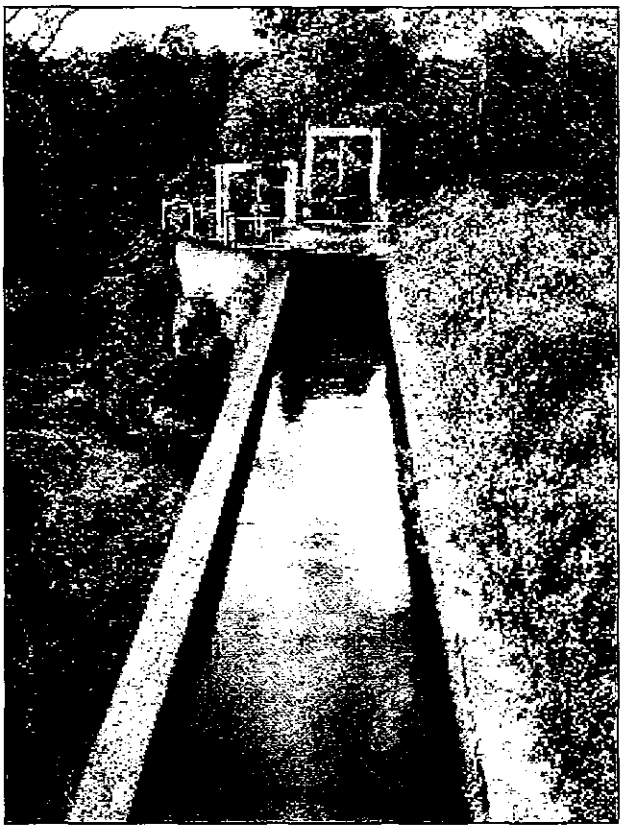
3. Differential type surge tank



4. Chamber type surge tank

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HW12
	Chapter	2	Technical Standards of Electric Power Facilities	
	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

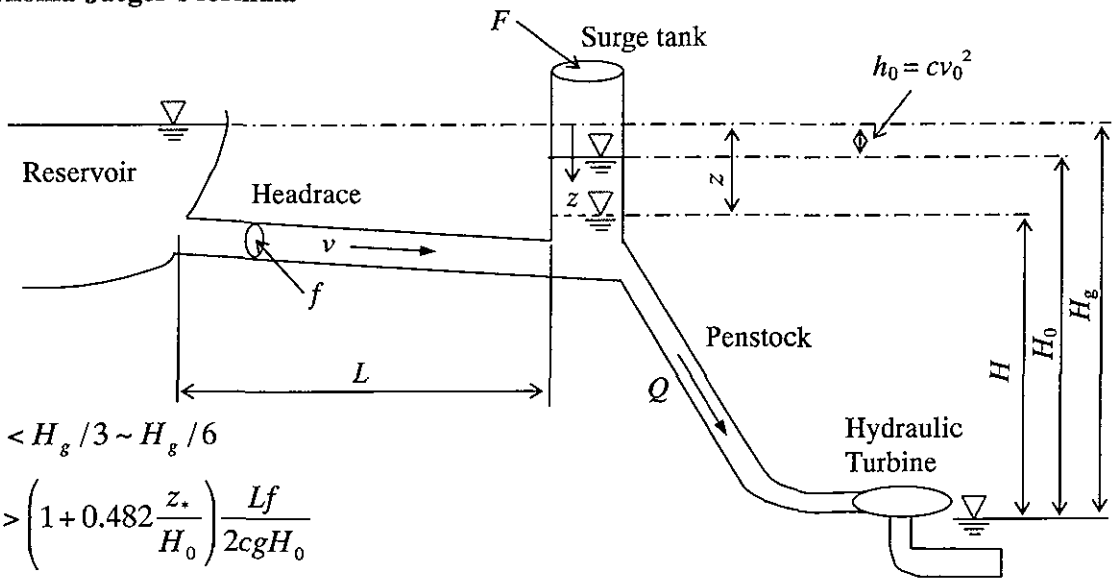
Category				Document No.HW13-1
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	

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

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

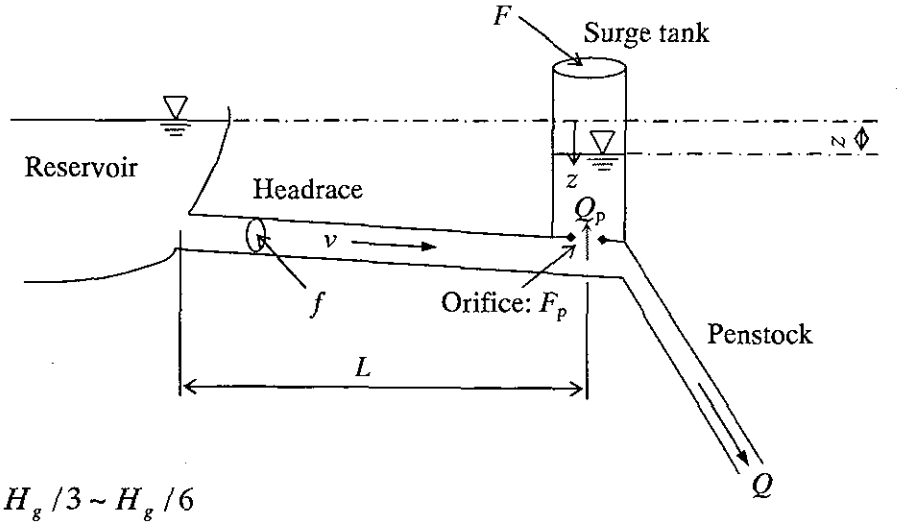
$$H_0 = H_g - h_0$$

Remarks
Formulas for Hydraulics 1999, Japan Society of Civil Engineers

Revisions	
2003/Nov.	Original

Category				Document No.HW13-2
	Chapter	2	Technical Standards of Electric Power Facilities	
	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				Document No.HW14
	Chapter	2	Technical Standards of Electric Power Facilities	
	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				Document No.HW15
	Chapter	2	Technical Standards of Electric Power Facilities	
	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 No.HW16-1
	Chapter	2	Technical Standards of Electric Power Facilities	
	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;

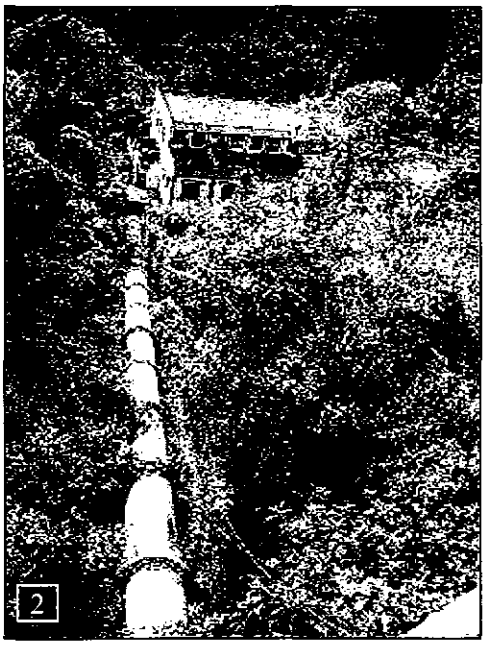
Loads Acting on Penstocks

	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

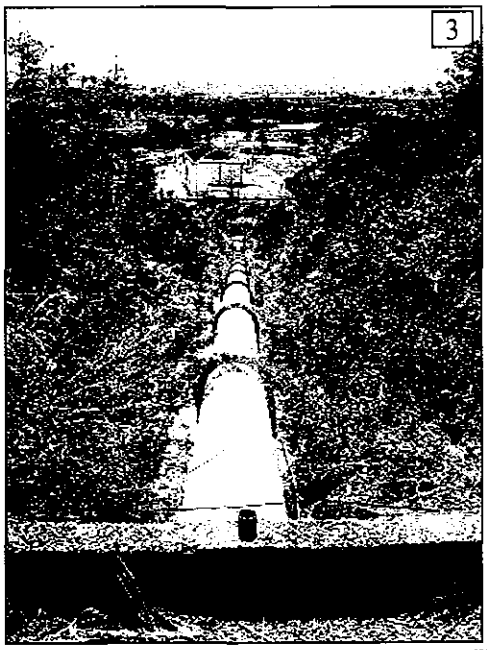
Category				Document No.HW16-2
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Penstocks (2)			

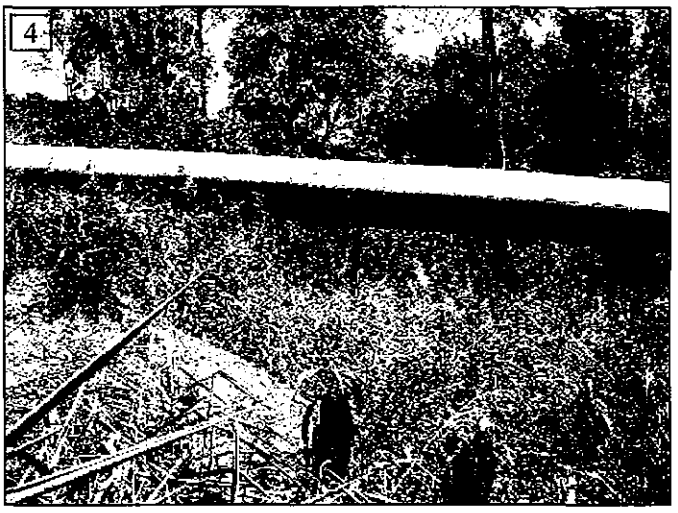


O Chum 2 Penstock

1	2
3	4

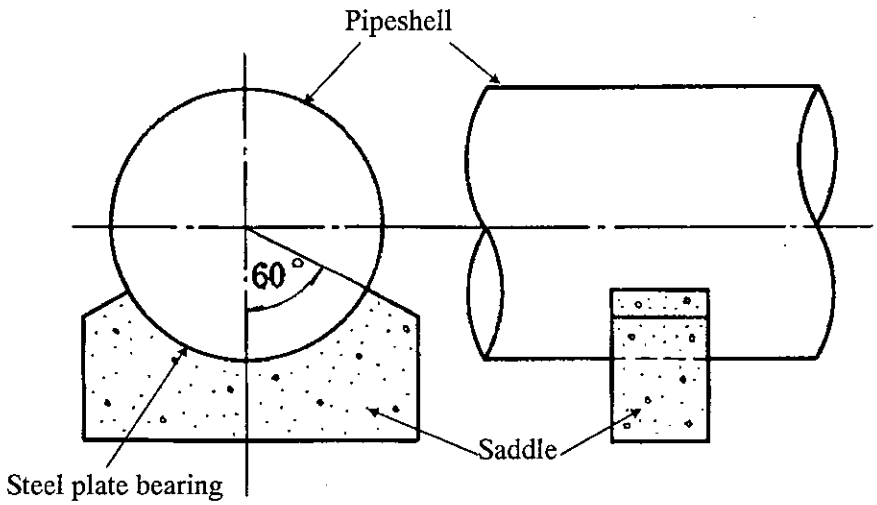
Kirirom 1 Penstock



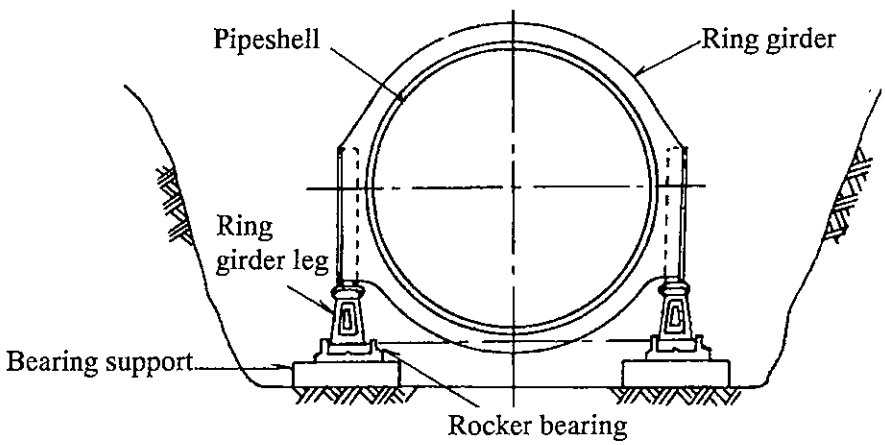


Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HW16-3
	Chapter	2	Technical Standards of Electric Power Facilities	
	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				Document No.HW17
	Chapter	2	Technical Standards of Electric Power Facilities	
	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.

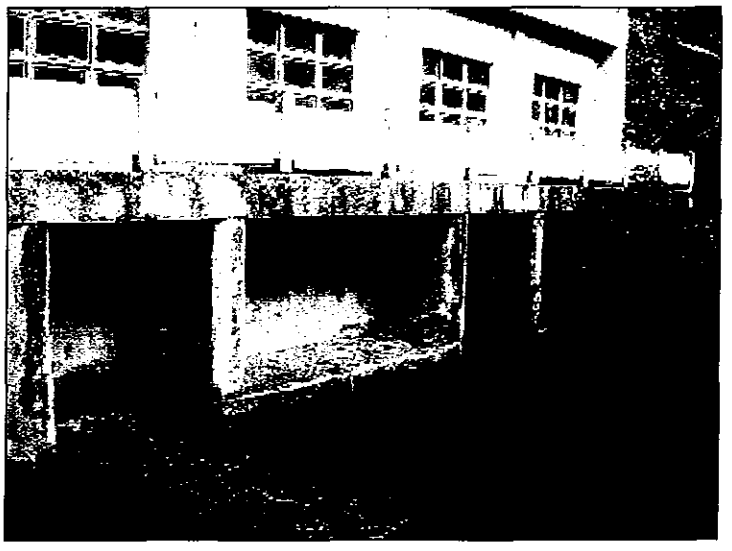
Stipulated safety is as follows:

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				Document No.HW18
	Chapter	2	Technical Standards of Electric Power Facilities	
	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				Document No.HW20
	Chapter	2	Technical Standards of Electric Power Facilities	
	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				Document No.HP1-1
	Chapter	2	Technical Standards of Electric Power Facilities	
	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)**			

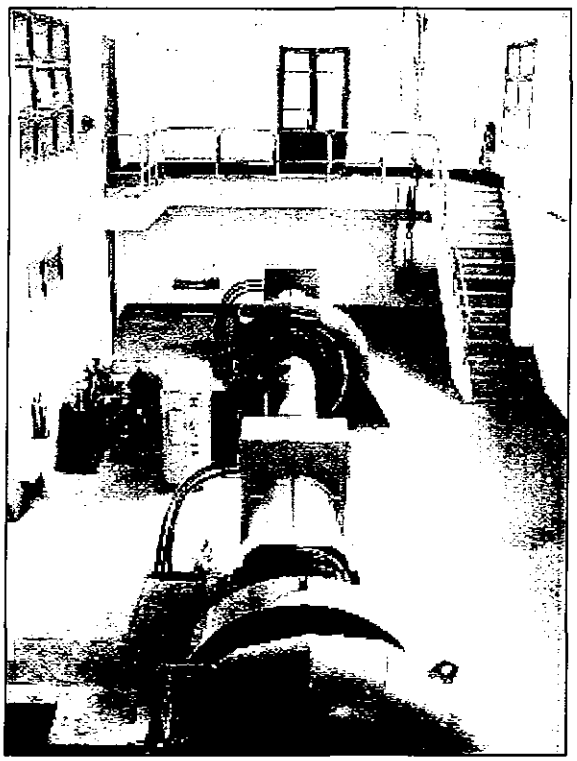
Powerhouse buildings and structures around hydraulic turbines and generators shall meet the following:

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.

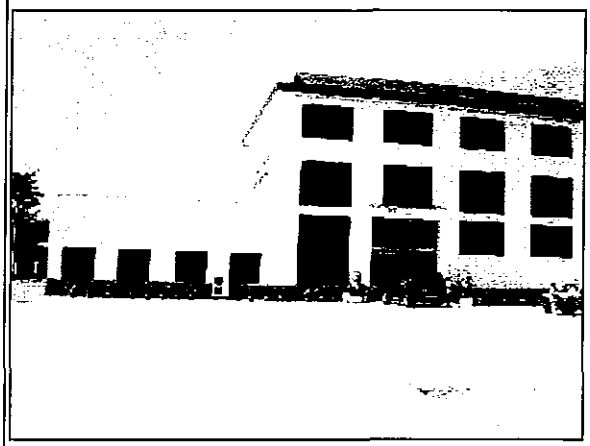
Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HP1-2
	Chapter	2	Technical Standards of Electric Power Facilities	
	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

J-POWER & CEPCO

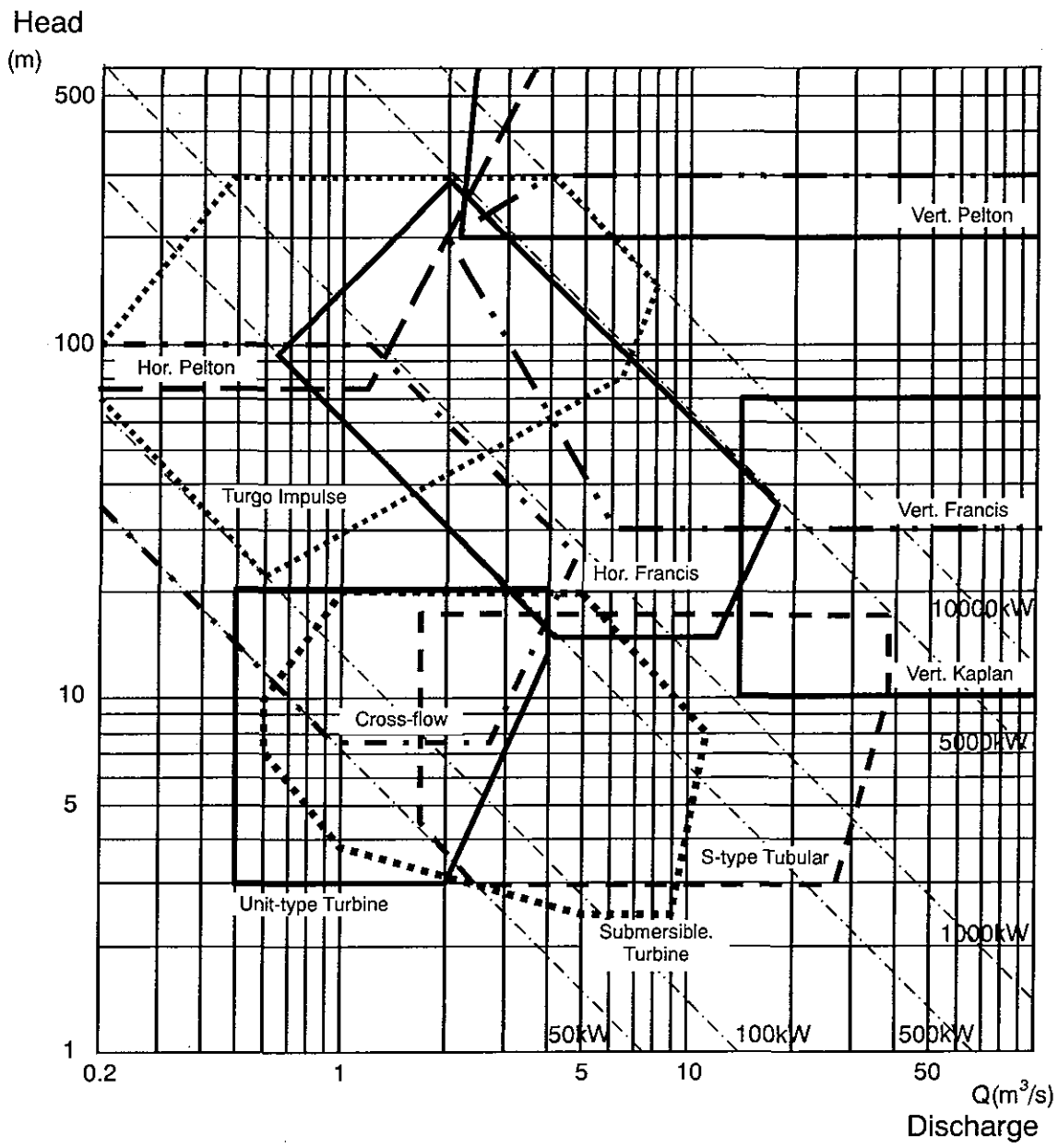
Category				Document No.HP2
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**The Other Hydroelectric Power Civil Engineering Facilities**			

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

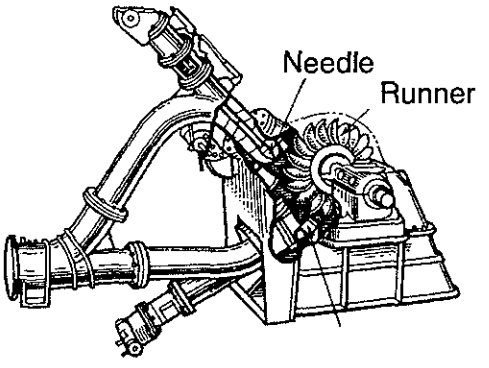
Category				Document No.HE1
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	28	Hydraulic Turbines and Generators	
Title	**Hydraulic Turbine Selection Diagram**			



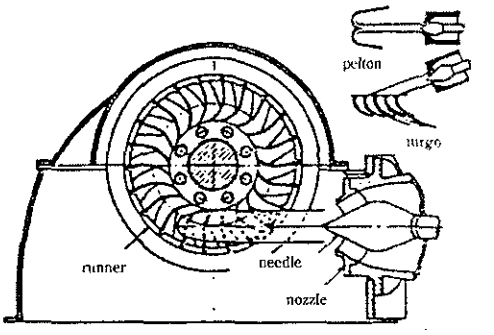
Source: Middle-Small Hydro-power Generation Guidebook (Japanese), New Energy Foundation

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

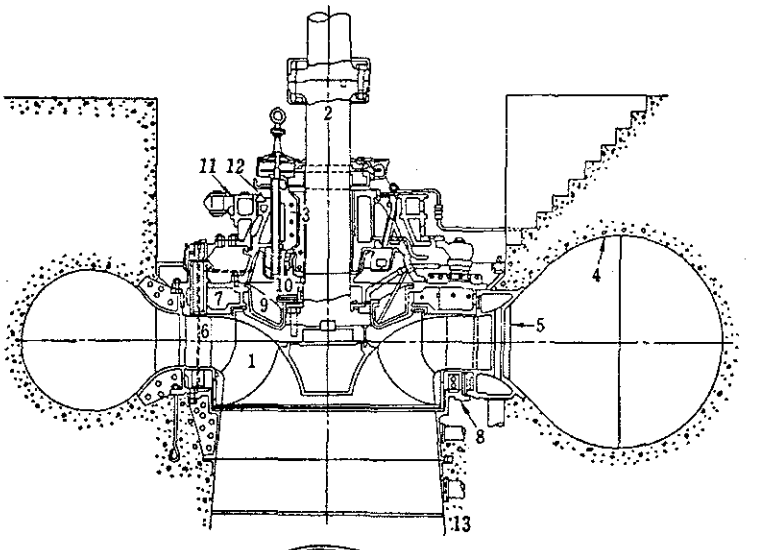
Category				Document No.HE2-1
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	28	Hydraulic Turbines and Generators	
Title	Hydraulic Turbine Types (1)			

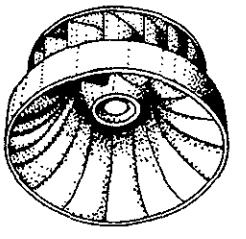


Pelton Turbine



Turgo Impulse Turbine



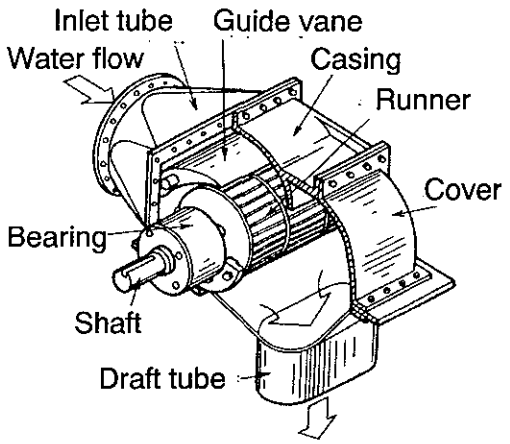


Francis Turbine

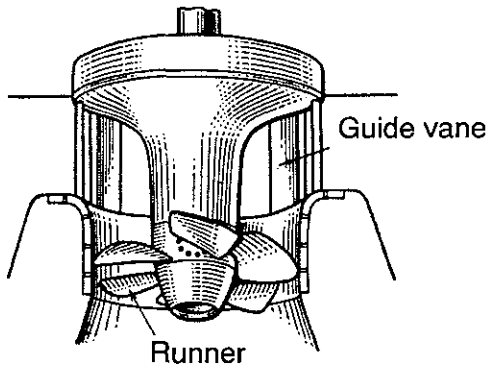
Source: Middle-Small Hydro-power Generation Guidebook (Japanese), New Energy Foundation

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

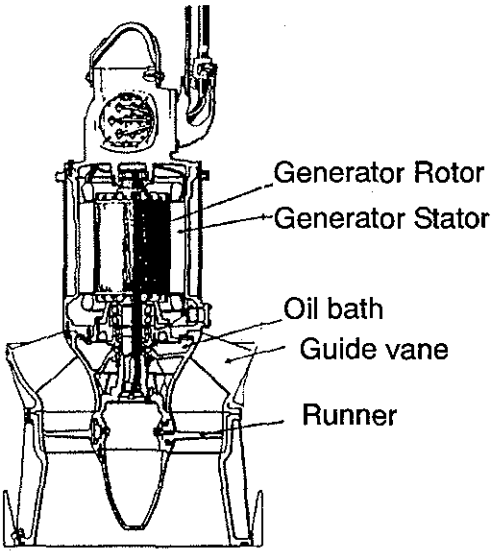


Propeller (Kaplan) Turbine

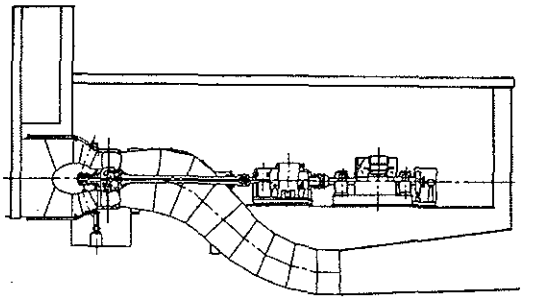
Source: Middle-Small Hydro-power Generation Guidebook (Japanese), New Energy Foundation

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

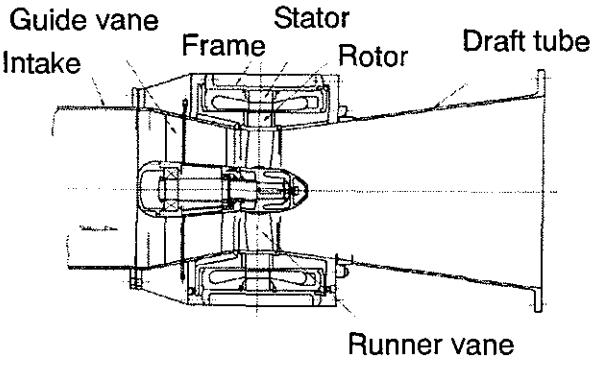
Category				Document No.HE2-3
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	28	Hydraulic Turbines and Generators	
Title	Hydraulic Turbine Types (3)			



Submersible Turbine



S-type Tubular Turbine



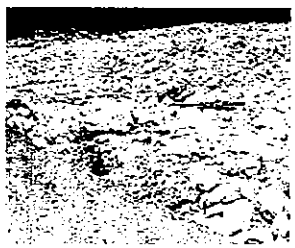
Unit-type Turbine

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

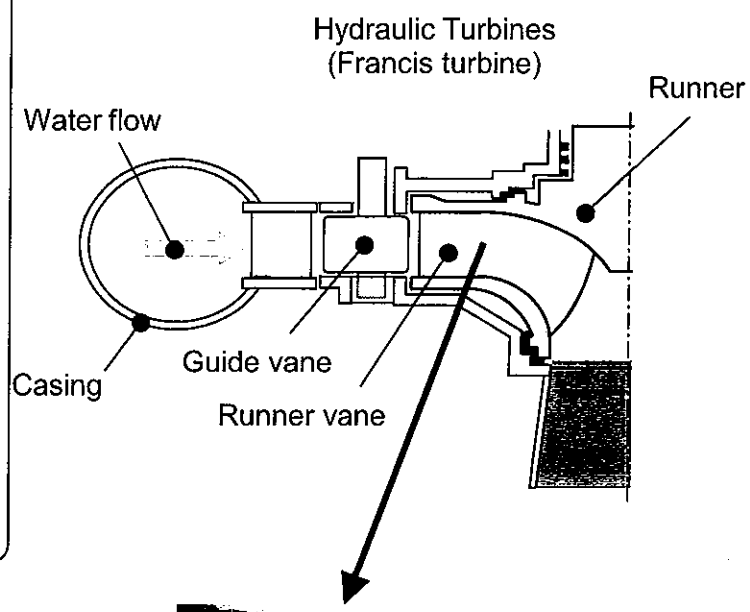
Remarks	Revisions	
Middle-Small Hydro-power Generation Guidebook (Japanese), New Energy Foundation		
	2003/Nov.	Original

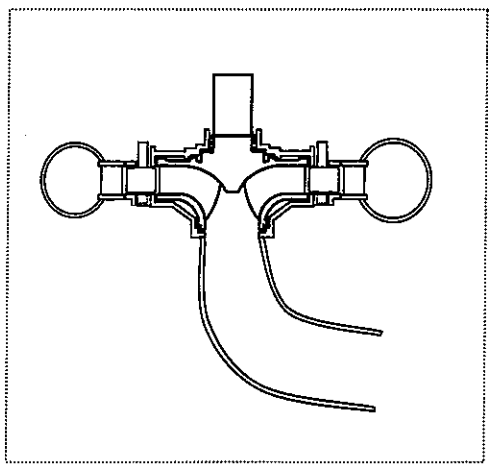
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HE3
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	28	Hydraulic Turbines and Generators	
Title	**Damage to Hydraulic Turbines - Driftwood, Floating Debris, or Sediment**			

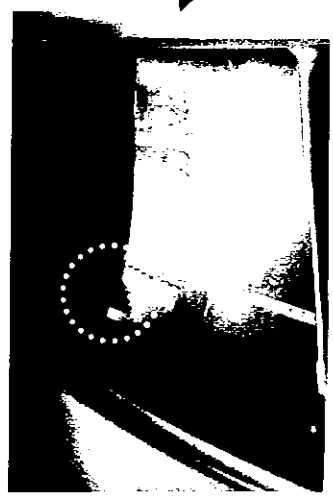
Driftwood



Sediment



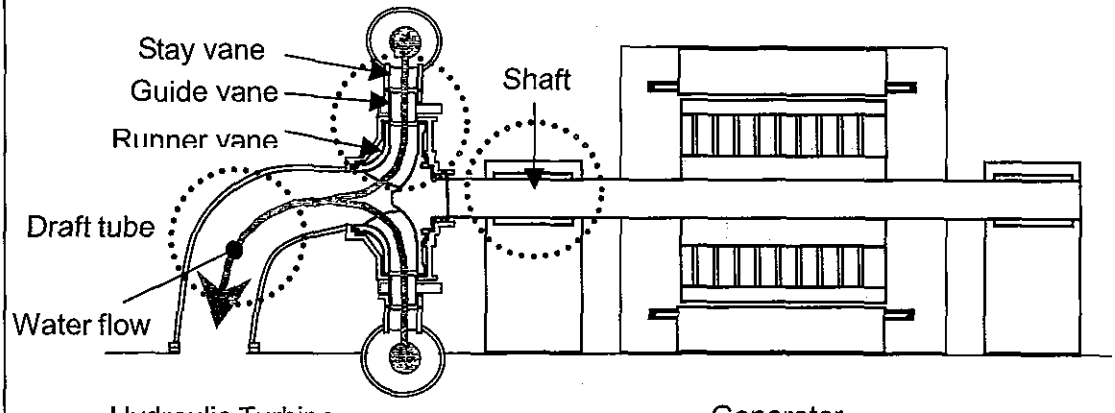




Remarks	Revisions	
	2003/Nov.	Original

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 】

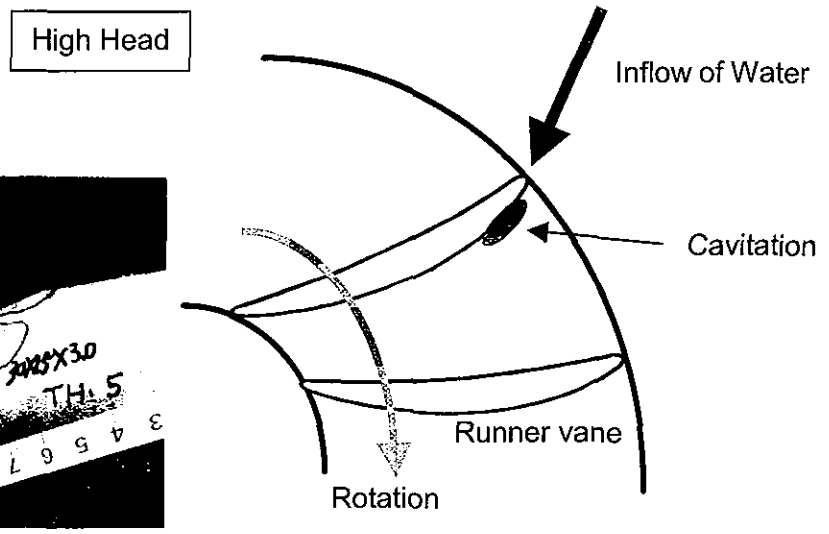


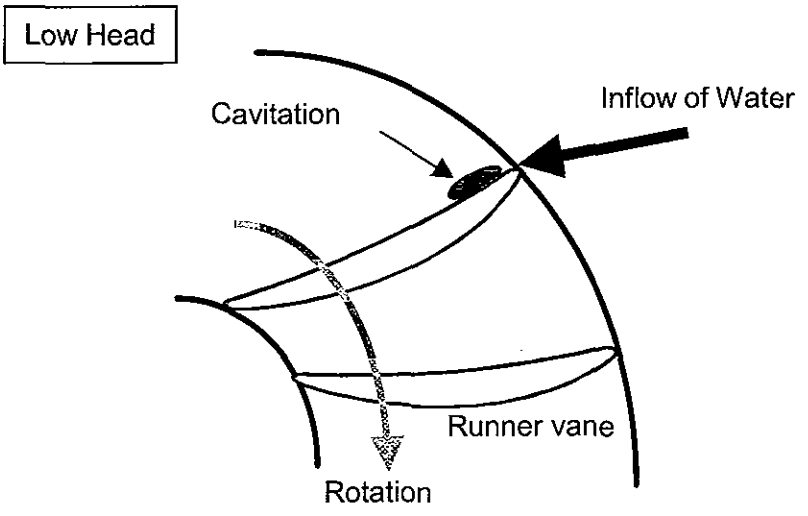
Remarks	Revisions	
	2003/Nov.	Original

J-POWER & CEPCO

Category				Document No.HE5-1
	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 - Cavitation Erosion (1)**			

Cavitation

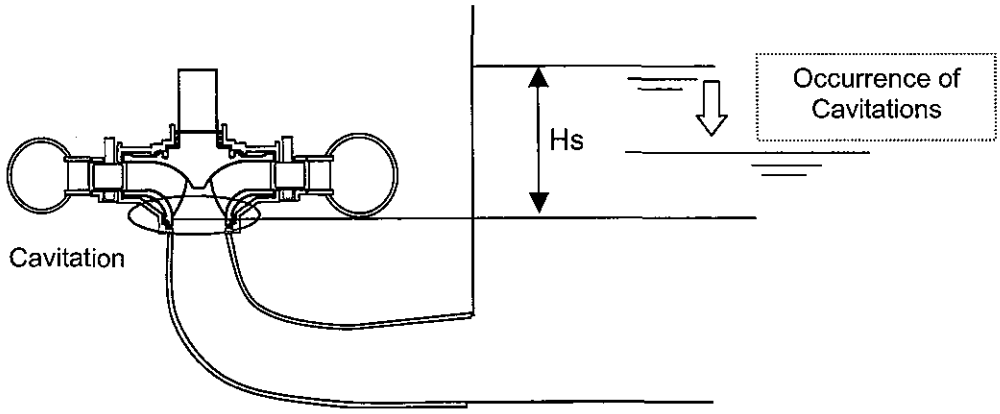




For Francis Turbine, Propeller Turbine

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HE5-2
	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 - Cavitation Erosion (2)**			



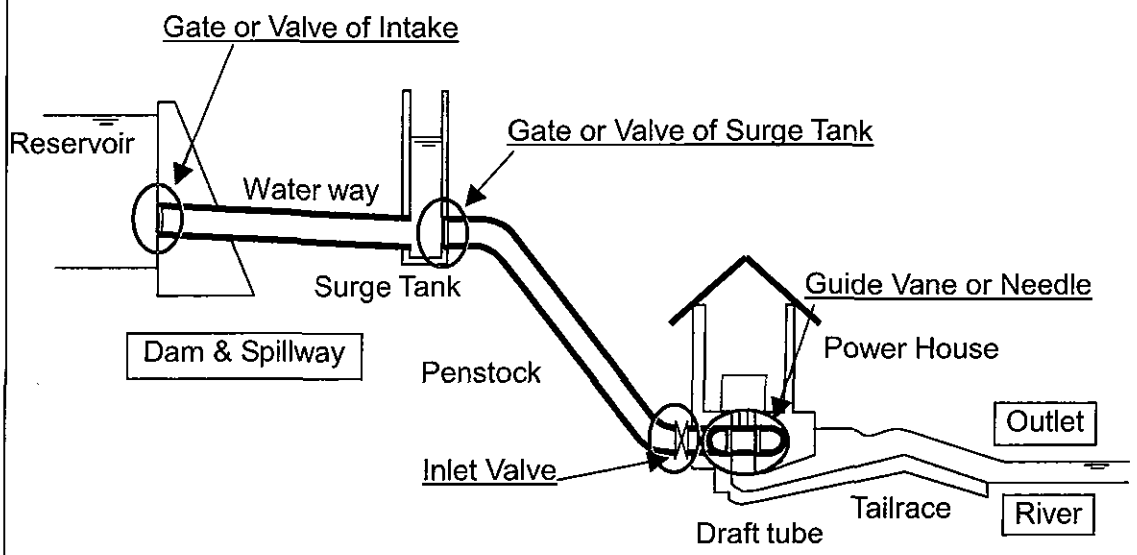
Hs: Draft head

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**			

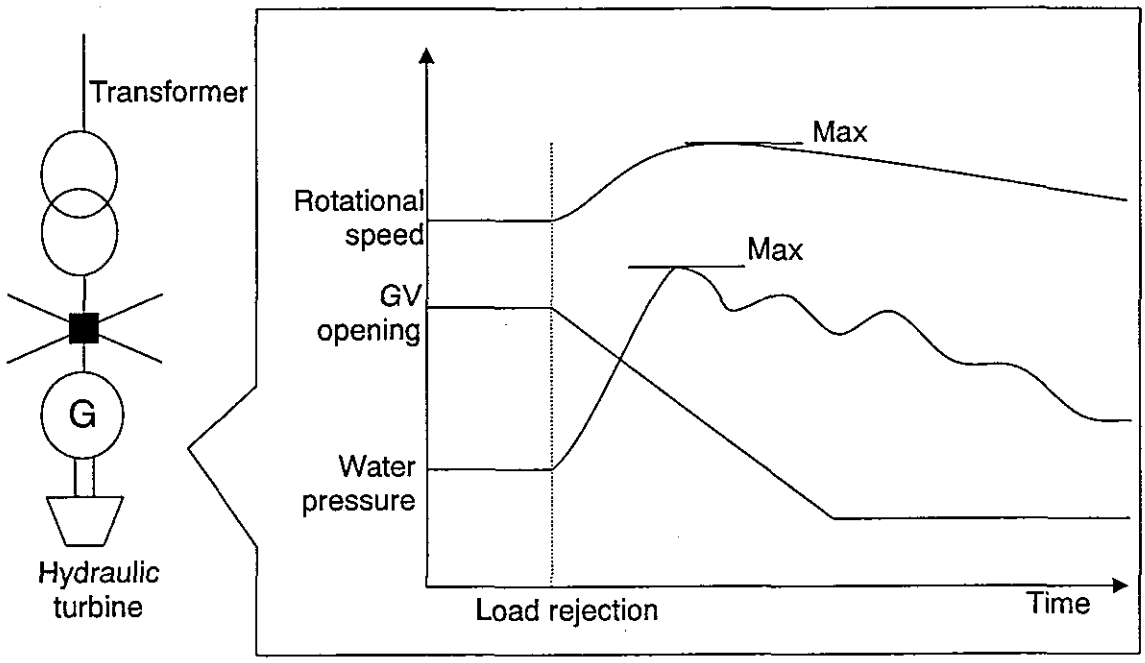
1. Facilities that can quickly shut off the inflow of water shall be one of the following:
   (1) If they are installed at hydraulic turbines, they shall be such guide vanes or needles with a function to shut off in an emergency or such inlet valves capable of shutting off the water flow; and
   (2)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

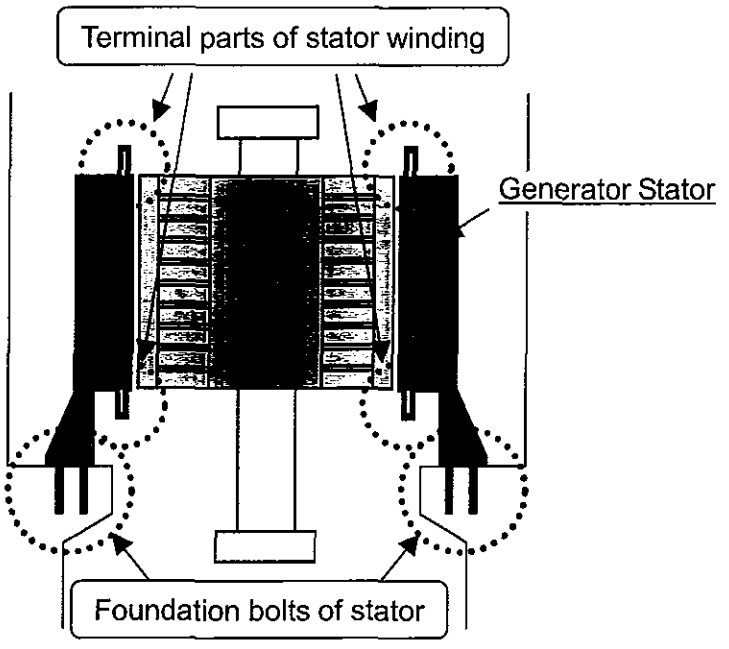
Remarks	Revisions	
Interpretation of Technical Standards for Hydropower Stations, 1998, Japan		
	2003/Nov.	Original

Category				Document No.HE7
	Chapter	2	Technical Standards of Electric Power Facilities	
	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

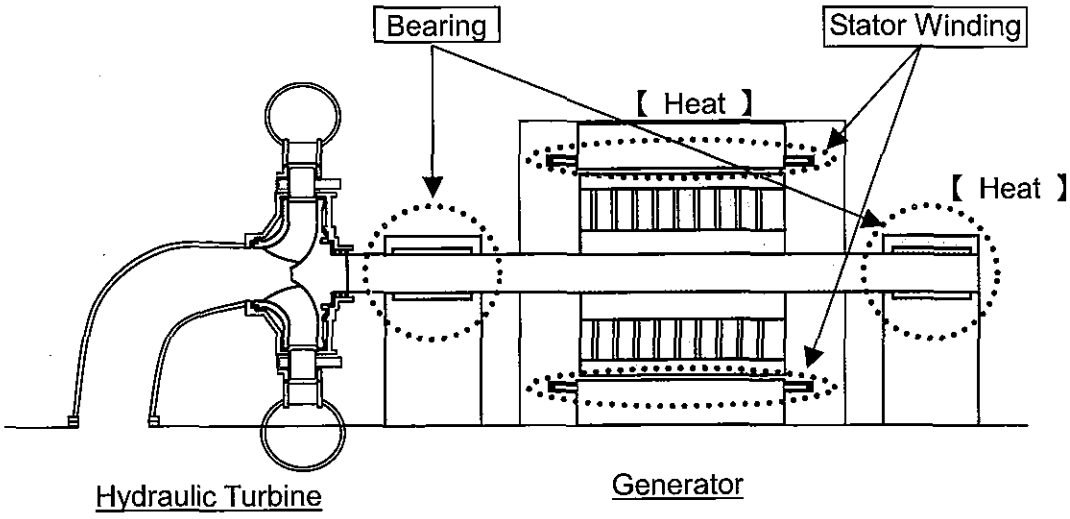
Category				Document No.HE9
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	28	Hydraulic Turbines and Generators	
Title	**Heat Generated by Hydraulic Turbines and Generators under Normal Operations**			

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

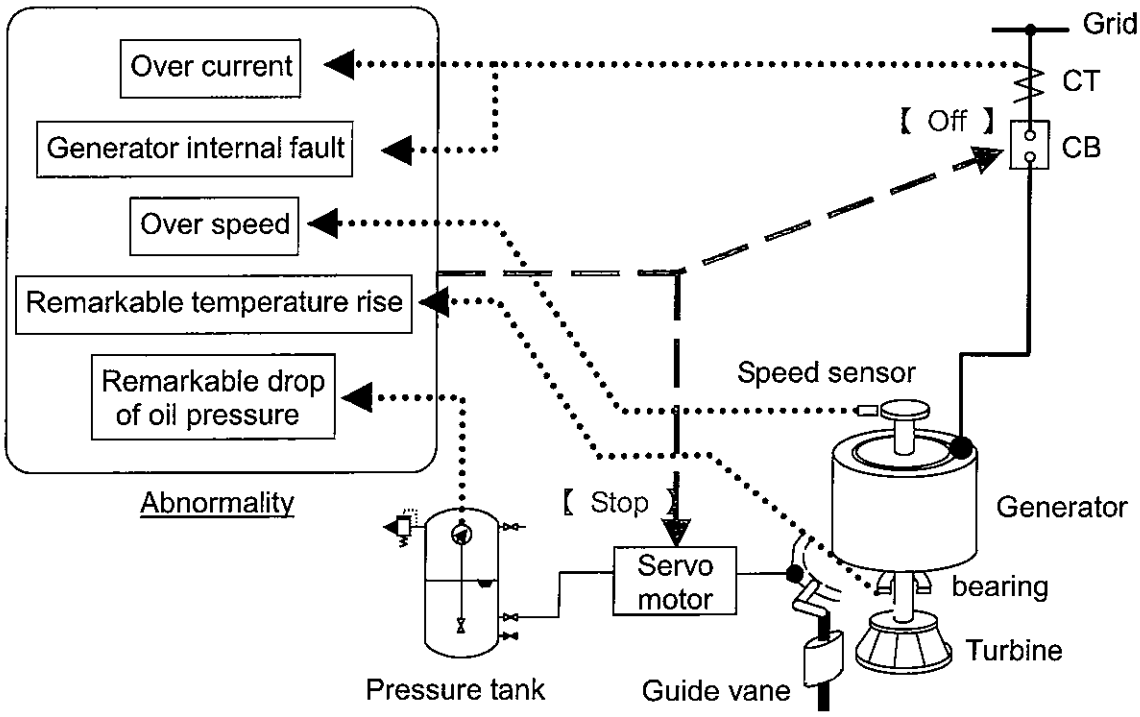
The draft law on water resources management is going to be submitted to the National Assembly after approval of the Council of Ministers in the Kingdom of Cambodia.
The draft law prescribes licenses issued by the Ministry of Water Resources and Meteorology (MOWRM). The diversion, abstraction and use 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

Category				Document No.HE10
	Chapter	2	Technical Standards of Electric Power Facilities	
	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

J-POWER & CEPCO

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

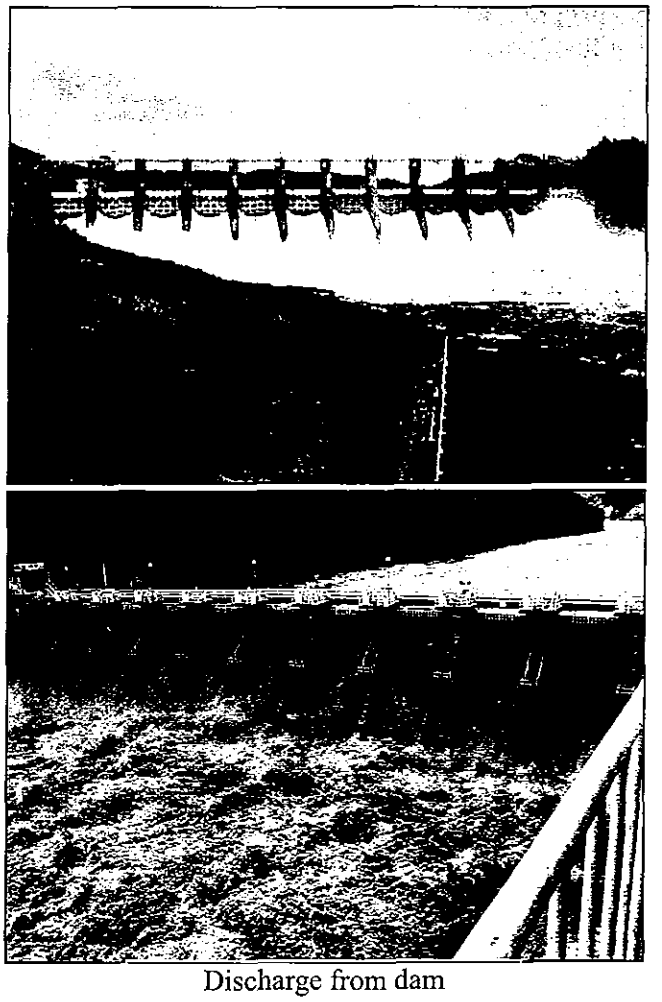
1. Proper remedial measures such as sedimentation dredging, sedimentation flushing, and check dam installation shall be taken as necessary so that the excessive sedimentation due to the existence of reservoirs does not cause losses of reservoir functions such as serious rises in water level at upstream 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				Document No.HO2
	Chapter	2	Technical Standards of Electric Power Facilities	
	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.



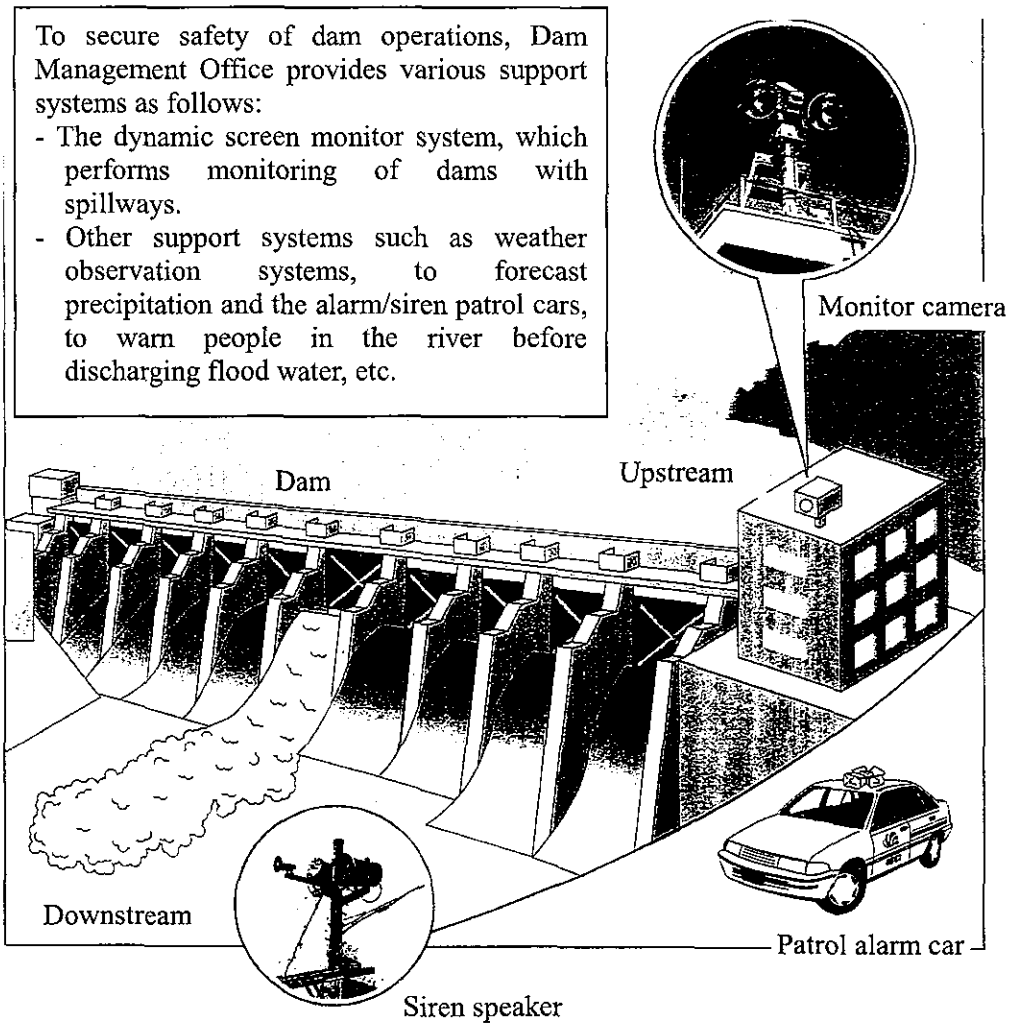
Discharge from dam

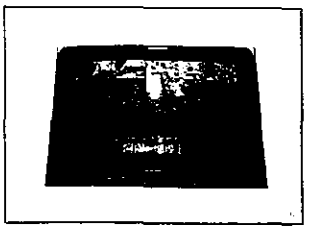
Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HO3
	Chapter	2	Technical Standards of Electric Power Facilities	
	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**			

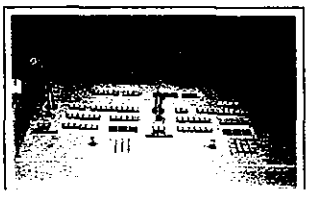
- Alarm devices

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.

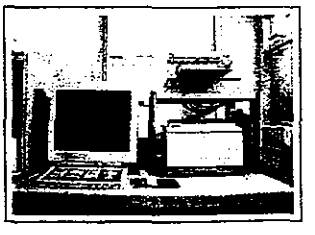




Dynamic screen monitor



Dynamic screen monitor operation table



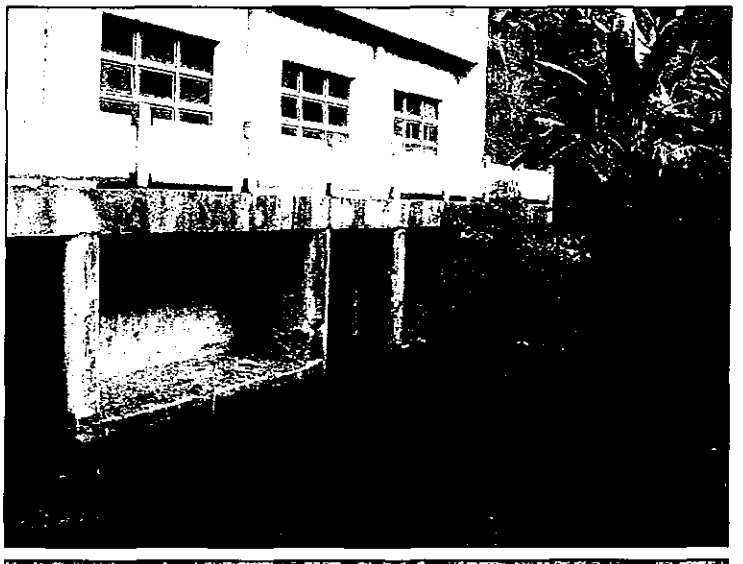
Weather observation system

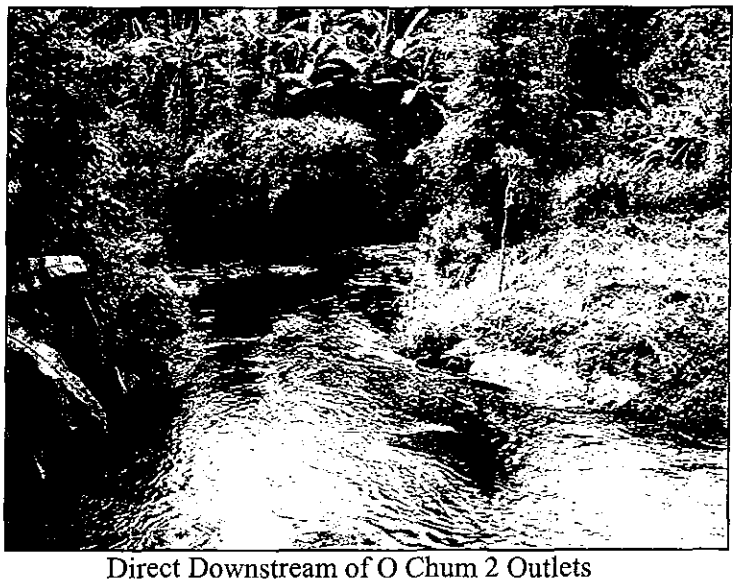
Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HO4
	Chapter	2	Technical Standards of Electric Power Facilities	
	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				Document No.HO5
	Chapter	2	Technical Standards of Electric Power Facilities	
	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**			

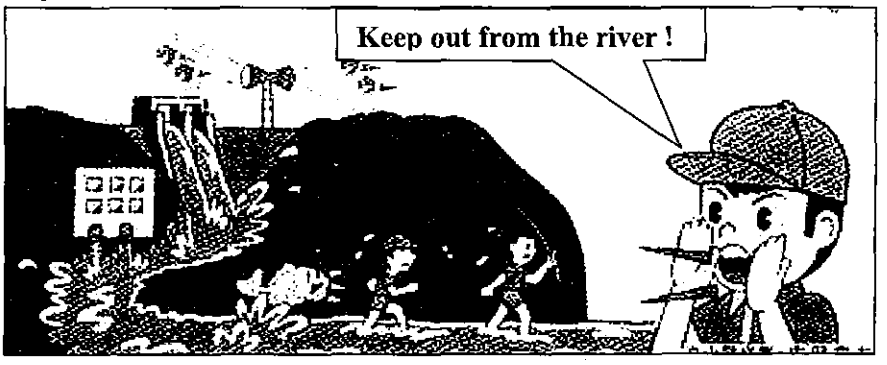
Re-regulating pond

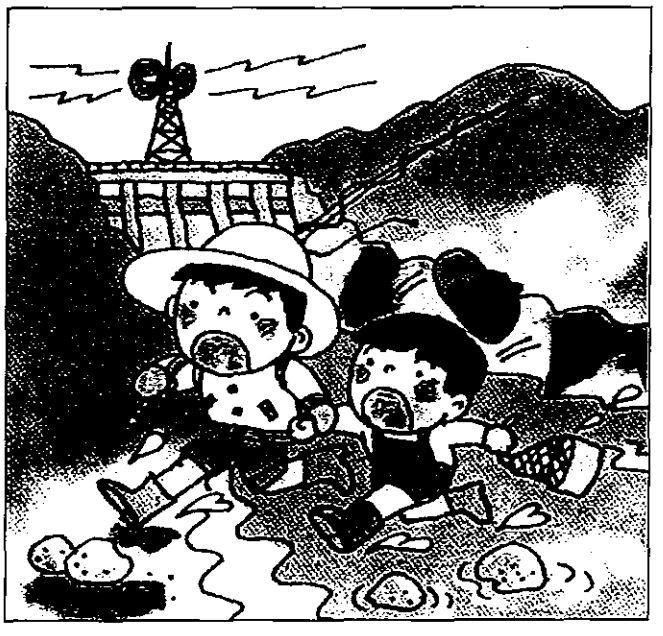
As a power plant of reservoir type or regulating pond type hydroelectric power plant is operated during peak load time in accordance with a peak load, a plant discharge is released into the river for a short period. Consequently, the difference in river flow between peak load time and off-peak load time 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				Document No.HO6-1
	Chapter	2	Technical Standards of Electric Power Facilities	
	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

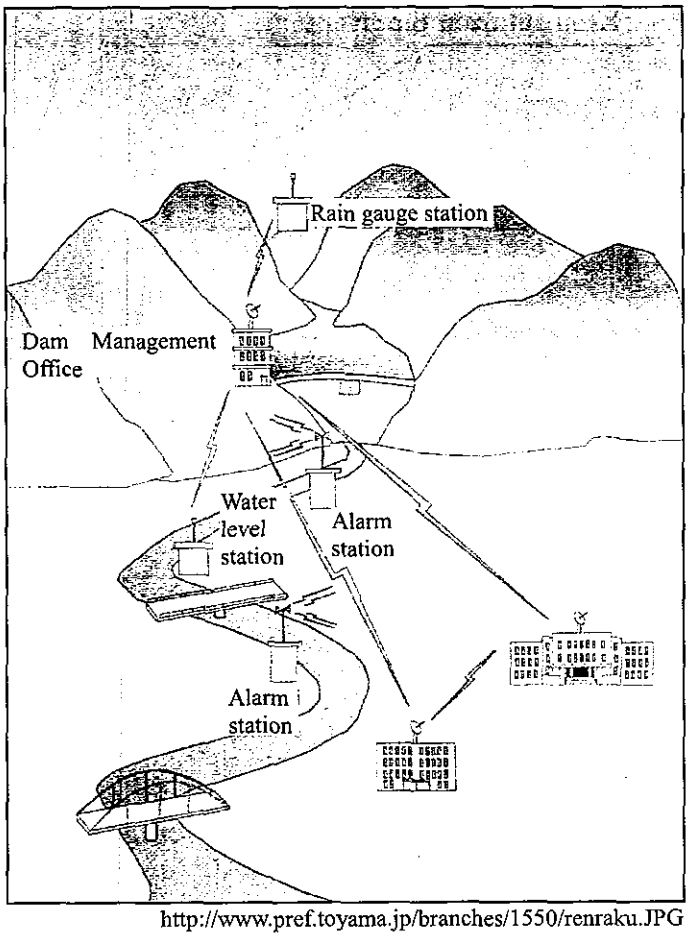




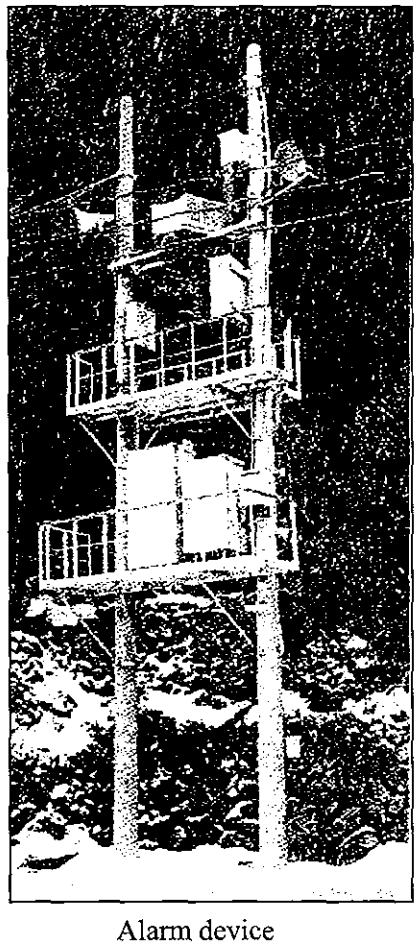
Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HO6-2
	Chapter	2	Technical Standards of Electric Power Facilities	
	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
http://www.pref.toyama.jp/branches/1550/renraku.JPG

Revisions	
2003/Nov.	Original

Category				Document No.HO7
	Chapter	2	Technical Standards of Electric Power Facilities	
	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				Document No.HO8
	Chapter	2	Technical Standards of Electric Power Facilities	
	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/		

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

Document No.	Title
Renewable Energy	
RE1	Renewable Energy
RE2	Renewable Energy (Photovoltaic Power Generation)
RE3	Renewable Energy (Wind Power Generation)
RE4	Renewable Energy (Biomass Power Generation)
RE5	Renewable Energy (Biomass Power Generation)
RE6	Renewable Energy (Waste Power Generation)
Condition of Connection with Power System for Dispersed Generator	
C1	Classification of Power System for Dispersed Generator
C2	Isolated operation
C3	Main Protection Relay
C4	Measures
C5	Establishment of communication system
C6	Method
C7	Harmonic component
C8	Low Frequency Mains Harmonics
C9	The Problem of Flicker
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BT1	Electricity from Biomass
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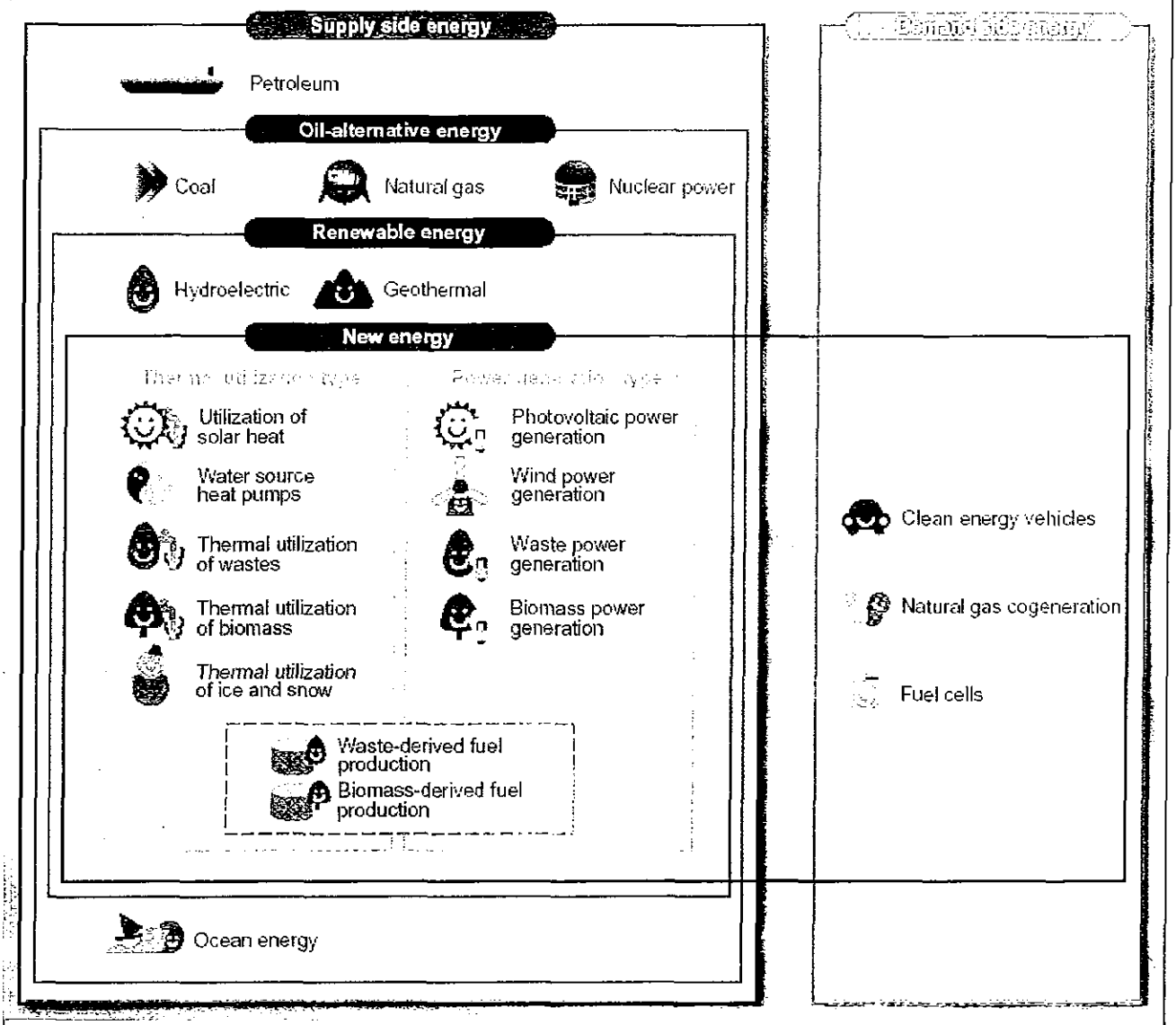
Photovoltaic (SOLAR ENERGY)	
PV1	Photovoltaic (PV) power generating systems
PV2	Photovoltaic (PV) power generating systems
PV3	Photovoltaic (PV) power generating systems

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

Revisions	
2003/Nov.	Original

Category				Document No. RE-02
	Chapter	2	Technical Standards of Electric Power Facilities	
	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				Document No. RE-03
	Chapter	2	Technical Standards of Electric Power Facilities	
	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 energy 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				Document No. RE-04
	Chapter	2	Technical Standards of Electric Power Facilities	
	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:
http://www.enecho.meti.go.jp/english/energy/new_energy/biomass.html
http://solstice.crest.org/articles/static/1/1004994679_6.html

Revisions	
2003/Nov.	Original

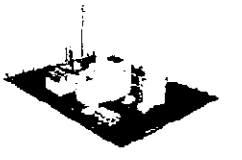
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. RE-05
	Paragraph	5	Generating Facilities (Others)	
	Clause			
Title	Renewable Energy (Biomass Power Generation)			

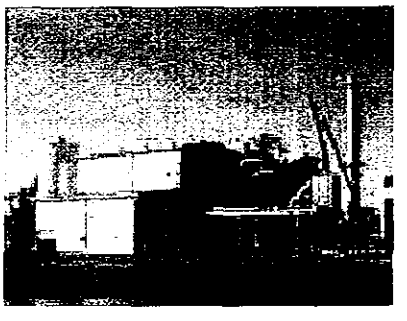
Biomass:
-What is bioenergy?
-Why is bioenergy considered renewable?
-How is biomass used to create energy?
-What are the main forms of biomass?
-What percentage of the world energy mix does bioenergy represents?
-How much does bioenergy cost?
-What are the environmental impacts of bioenergy?
-What are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

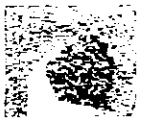
http://solstice.crest.org/articles/static/1/1004994679_6.html

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

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

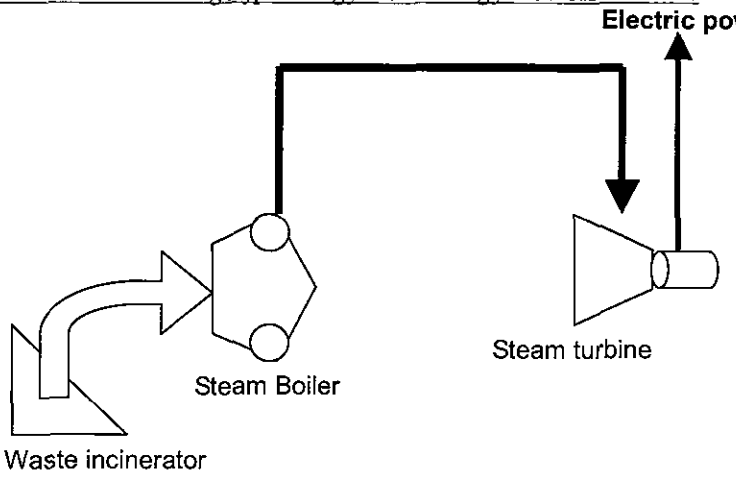
Revisions	
2003/Nov.	Original

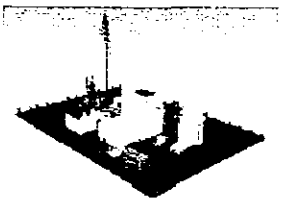
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. RE-06
	Paragraph	5	Generating Facilities (Others)	
	Clause			
Title	Renewable Energy (Waste Power Generation)			

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