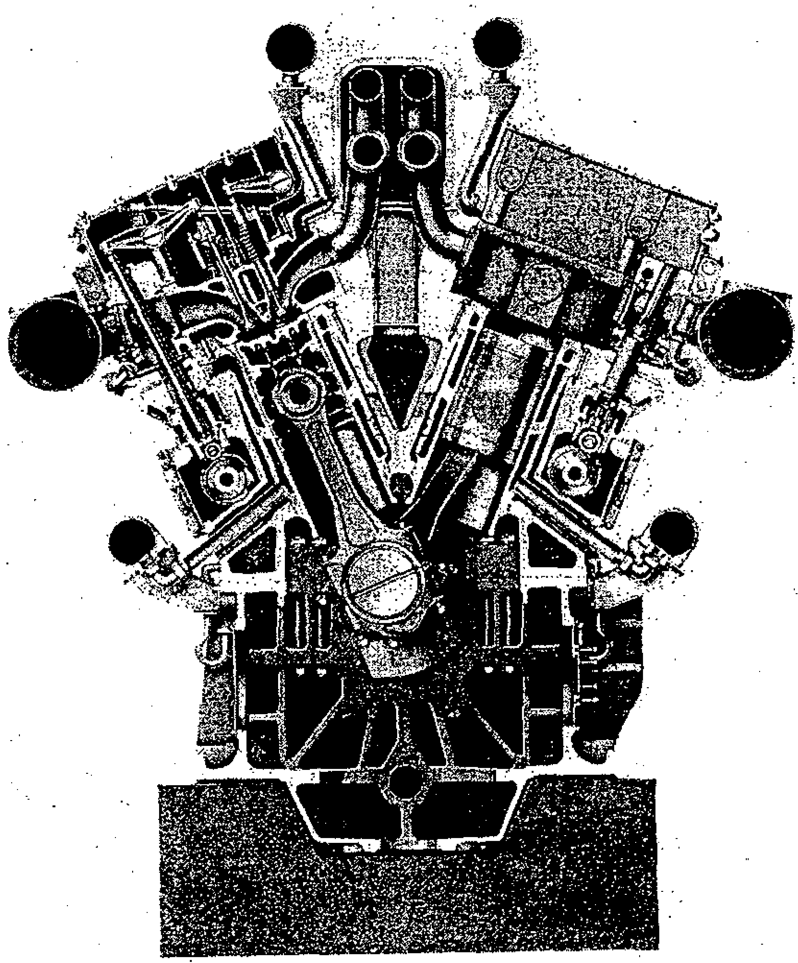
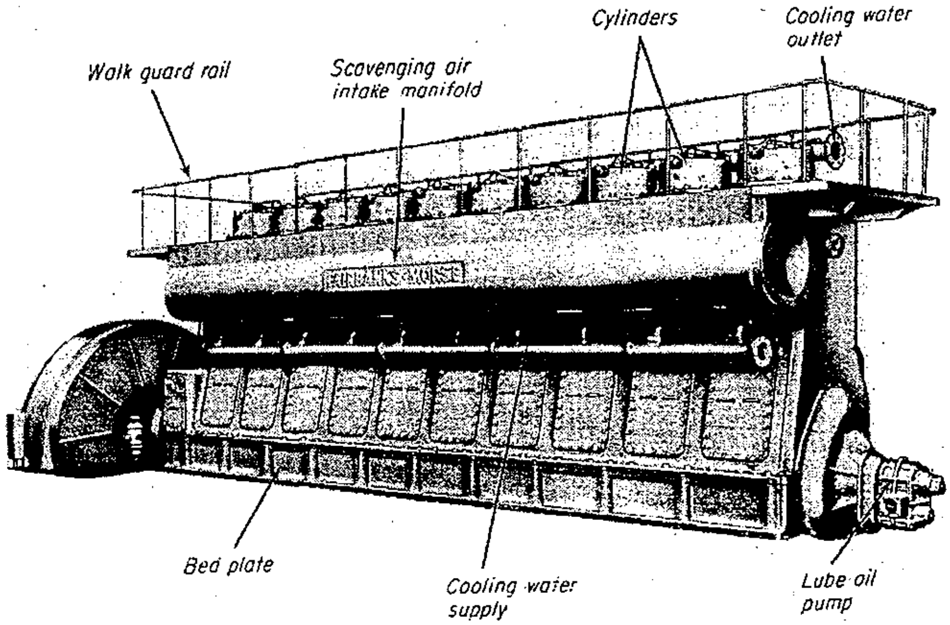
Category				Document
	Chapter	2	Technical Standards of Electric Power Facilities	No.DG5-1
	Paragraph	2	Generating Facilities (Thermal)	
	Clause	24	Internal Combustion Engine	
Title	Four –Stroke Diesel Engine (1)			

Figure shows Four- Stroke diesel engine. These are cross sections through the cylinders of a typical two- and four- strokes diesel engine.



Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DG5-2
	Paragraph	2	Generating Facilities (Thermal)	
	Clause	24	Internal Combustion Engine	
Title	Four –Stroke Diesel Engine (2)			



Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DG6
	Paragraph	2	Generating Facilities (Thermal)	
	Clause	24	Internal Combustion Engine	
Title	Two–Stroke Diesel Engine			

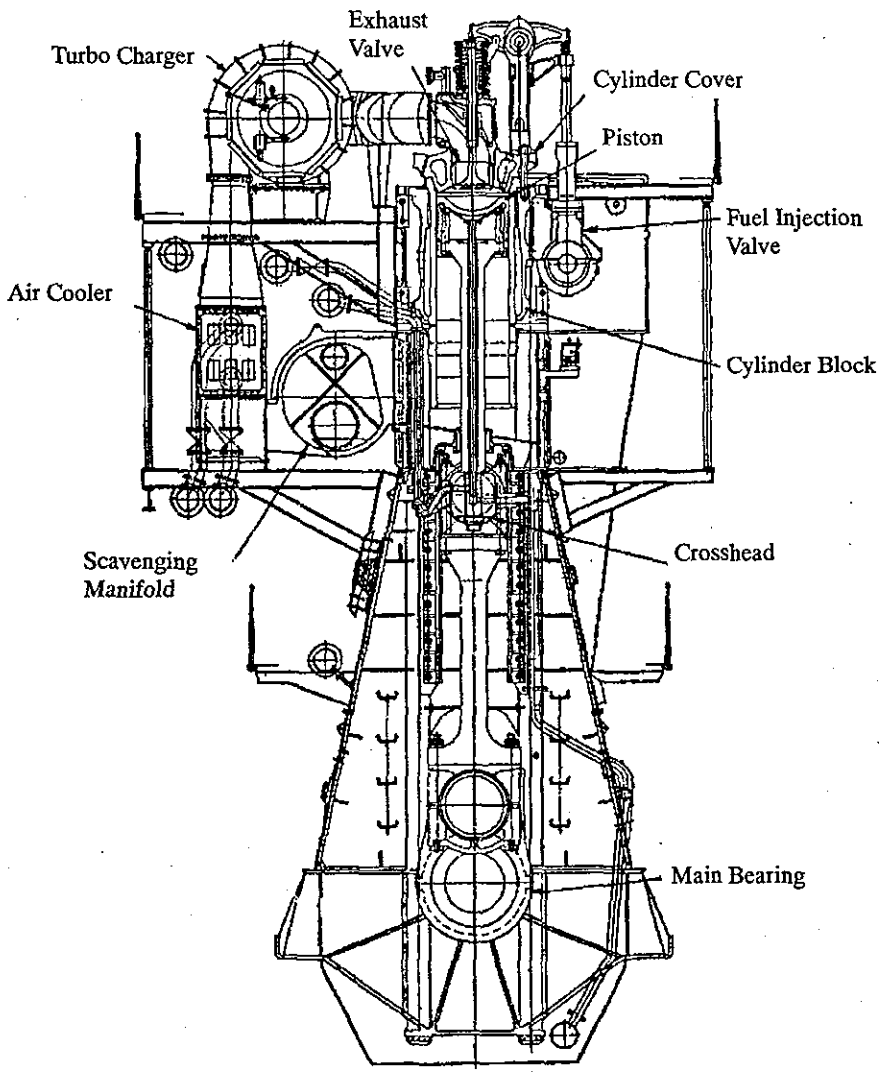


Figure shows Two- Stroke diesel engine.

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DG7**
	Paragraph	2	Generating Facilities (Thermal)	
	Clause	24	Internal Combustion Engine (reciprocating engine) and its Accessories	
Title	**Relief valve**			

1. The cylinder of an internal combustion engine which cylinder diameter is not smaller than 230mm and which maximum working pressure is not lower than 35kg/cm^2 and the enclose type crank case of an internal combustion engine which cylinder is larger than 250mm must be equipped with a proper relief valve respectively.

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DG8**
	Paragraph	2	Generating Facilities (Thermal)	
	Clause	24	Internal Combustion Engine (reciprocating engine) and its Accessories	
Title	**Emergency stop device**			

1. All internal combustion engines except those with a rated output not more than 500kV must be equipped with an emergency governor which is actuated at a speed not higher than 1.16 times their rated speed.
2. All internal combustion engines except those with a rated output not more than 500kV must be equipped with a device which interrupts the inflow of fuel automatically in case cooling water temperature made an abnormal rise or the supply of cooling water stopped.

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DG9**
	Paragraph	2	Generating Facilities (Thermal)	
	Clause	24	Internal Combustion Engine (reciprocating engine) and its Accessories	
Title	**Measuring device**			

1. An internal combustion engine must be equipped with the devices for measuring the points specified in the following Items:
   a. Speed of the internal combustion engine
   b. Temperature of cooling water at the outlet of the internal combustion engine
   c. Pressure of lubricating oil at the inlet of the internal combustion engine
   d. Temperature of lubricating oil at the outlet of the internal combustion engine

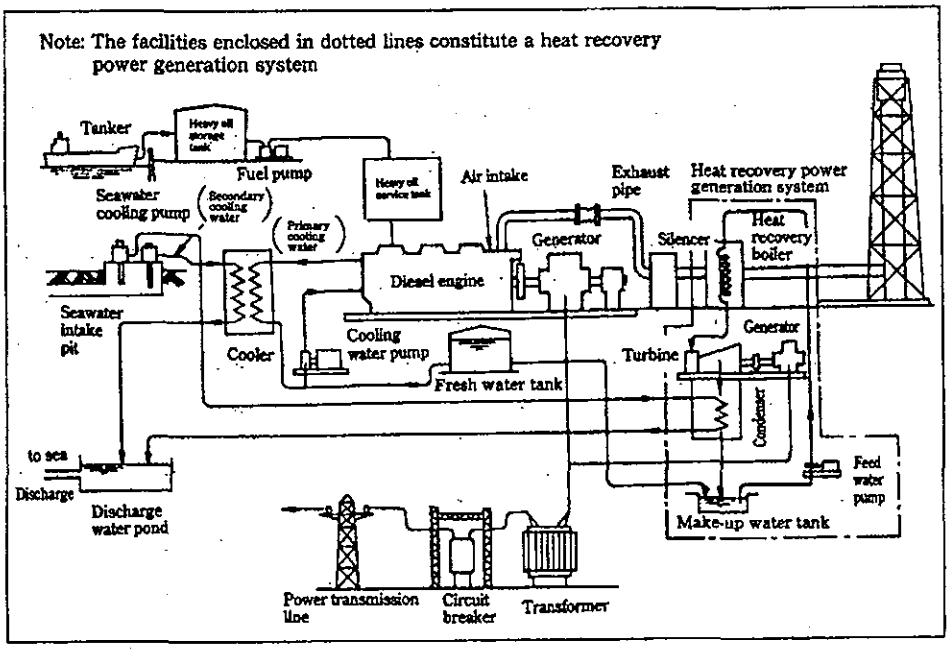
Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DG10**
	Paragraph	2	Generating Facilities (Thermal)	
	Clause	24	Internal Combustion Engine (reciprocating engine) and its Accessories	
Title	***Hydrostatic test***			

1. The pressure parts of internal combustion engine and its accessories must be able to withstand a hydrostatic test using a water pressure 1.5 times their respective maximum allowable working pressures without leakage.

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DG11**
	Paragraph	2	Generating Facilities (Thermal)	
	Clause	24	Internal Combustion Engine (reciprocating engine) and its Accessories	
Title	**System Diagram of Diesel Engine (Example)**			



Remarks	Revisions	
	2003/Nov.	Original

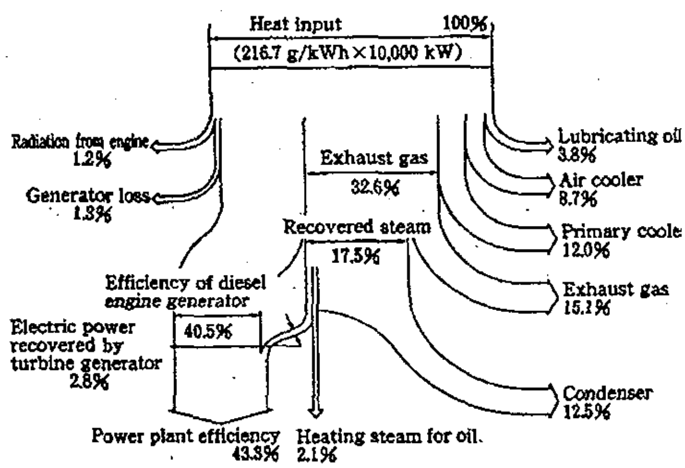
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DG12
	Paragraph	2	Generating Facilities (Thermal)	
	Clause	24	Internal Combustion Engine (reciprocating engine) and its Accessories	
Title	Heat Balance of 4 Cycle Diesel Engine and Related Data			

Heat Balances of 4 Cycle Diesel Engines and Related Data

(1) Heat balance (example)

No	Item	High speed small engine		Low speed large engine[1]	
		Heat load kJ/kWh	Heat input ratio (%)	Heat load kJ/kWh	Heat input ratio (%)
1	Cooling water loss	1,590	16.7	2,010	12.0
2	Lubricant loss	340	3.6	637	3.8
3	Exhaust gas loss	3,190	33.5	2,530	15.1
4	Radiant heat loss	340	3.6	200	1.2
5	Air cooler loss	455	4.8	1,460	8.7
6	Condenser loss	—	—	2,090	12.5
	Remarks	Example of 1,200 rpm engine		Example of 400 rpm engine	

Note: 1) Diesel engine generator with heat recovery steam turbine generator; Exhaust gas loss 32.6% is converted and recovered in steam energy.



Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DG13
	Paragraph	2	Generating Facilities (Thermal)	
	Clause	24	Internal Combustion Engine (reciprocating engine) and its Accessories	
Title	Specifications and performance of 4 Cycle Diesel Engines Generator			

Specifications and Performances of 4 Cycle Diesel Engines for Power Plant

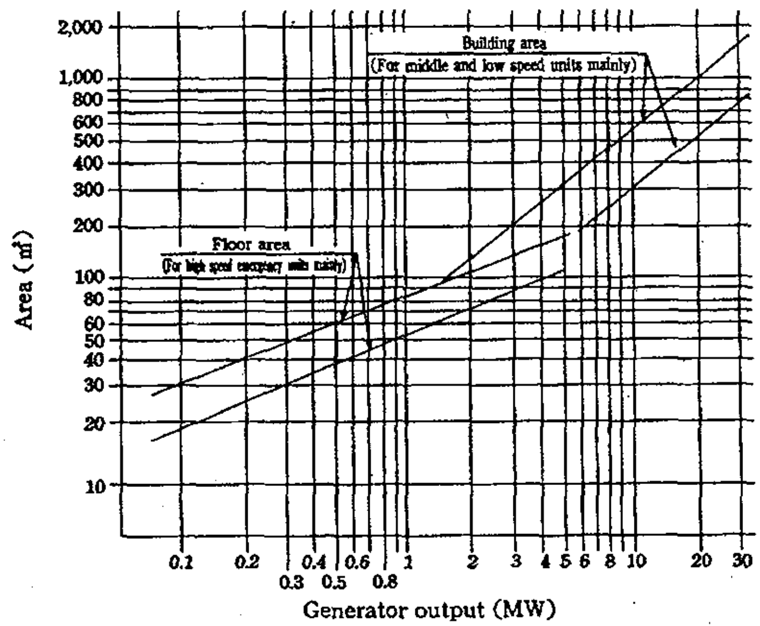
Item	Unit \ Speed (rpm)	300~500 (Low speed engine)	500~1,000 (Middle speed engine)	1,000~1,800 (High speed engine)
Piston speed	m/s	4~10	4.5~10.6	5.3~10.8
Compression ratio	-	11~15	8~16.5	12~23
Maximum pressure	Kgf/cm^2	50~150	50~147	60~147
Net mean Effective pressure	Kgf/cm^2	8~25	5.1~25	5.2~21.8
Fuel consumption	g/PS·h	124~171	132~211	151~218
Thermal efficiency	%	37~51	30~48	29~42
Machine efficiency	%	75~95	75~95	75~92
Fuel oil type	-	Heavy oil A,B or C	Light oil, or heavy oil A,B or C	Light oil or heavy oil A
Startup time of normal facilities	min	Approx.10	Approx.7	Approx.5
Output range	kW	600~21,000	100~11,000	100~4,600
Major application	-	Normal use	Normal use	For emergency

Note: The fuel consumptions are converted on the assumption that the low calorific value of fuel oil is 10,000 kca/kg.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DG14
	Paragraph	2	Generating Facilities (Thermal)	
	Clause	24	Internal Combustion Engine (reciprocating engine) and its Accessories	
Title	Space Requirement for Diesel Power Plants			

Space Requirement for Diesel Power Plants



Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DG15-1
	Paragraph	2	Generating Facilities (Thermal)	
	Clause	24	Internal Combustion Engine	
Title	Starter of Diesel Engine (1)			

Type of Starter of Diesel Engine

There is two-(2) kind of type for Diesel Engine starter. Air starter and Electric self-starter.

Air starter uses compressed air, through the start valve to cylinder.

Electric self- starter uses cell motor connecting Battery and start the fly-wheel engage with pinion.

(1) Air Starter

1) It is necessary to equip air receiver and air compressor.

2) Air compressor is drove by Electric motor.

3) Air pressure keeps constantly.

4) Air receiver usually equips two(2) receivers (including reserved)

5) Air receiver equipped alarm system.

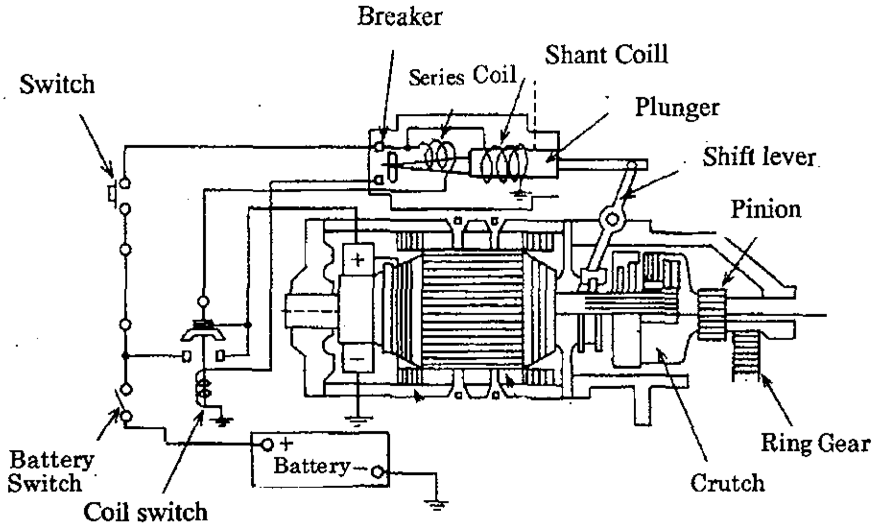
(2) Self- Starter

1) Consisted of battery, motor and start-switch

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.DG15-2**
	Paragraph	2	Generating Facilities (Thermal)	
	Clause	24	Internal Combustion Engine	
Title	**Starter of Diesel Engine (2)**			

Example of starter



Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.DG16-1
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DG16-1
	Paragraph	2	Generating Facilities (Thermal)	
	Clause	24	Internal Combustion Engine	
Title	Injection Systems (1)			

There are two classes of injection systems:

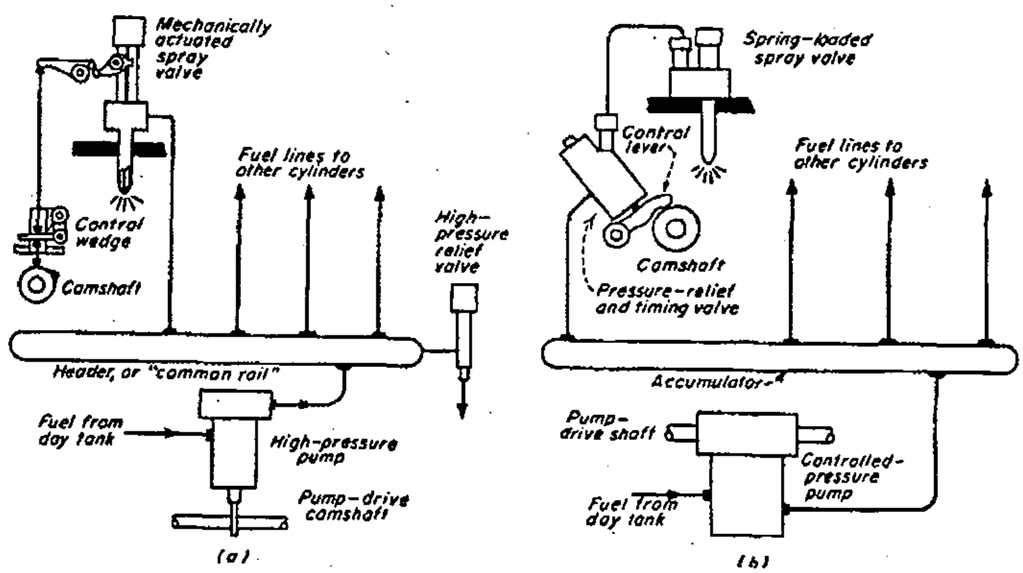
(1) Mechanical – injection systems using a high-pressure pump and (2) air – injection systems using high – pressure air to carry in the fuel. Mechanical- injection systems have superseded the earlier air – injection systems.

In the air – injection system a low – pressure metering pump delivers a measured amount of fuel into the cylinder fuel nozzle when the nozzle valve is closed.

As the nozzle valve opens, a multistage compressor delivers air to the nozzle to inject and spray the fuel into the engine cylinder.

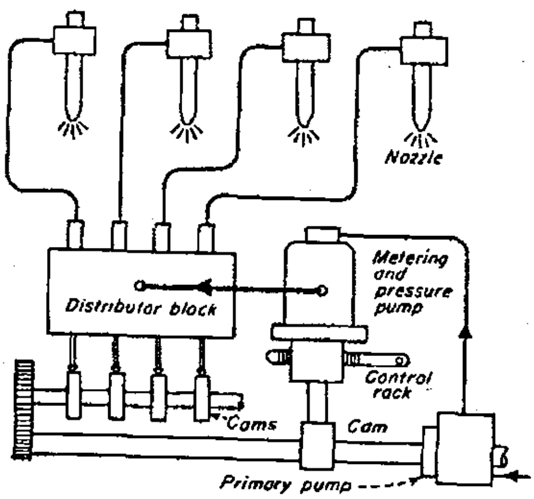
Mechanical – injection systems are available in three types: (1) the common rail system,

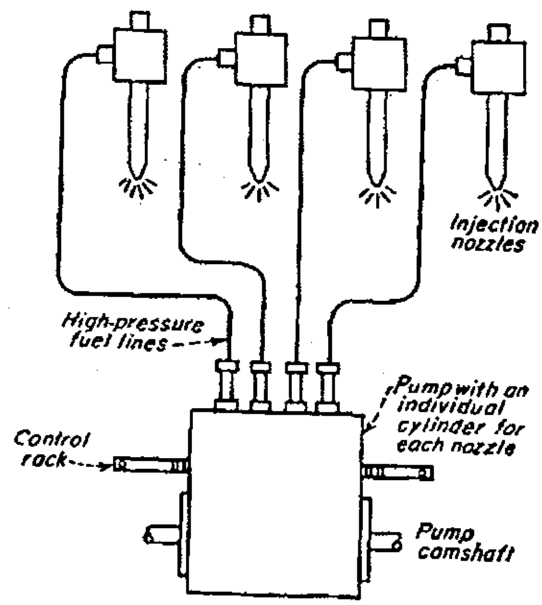
(2) the distributor – injection system, and (3) pump – and pressure – operated nozzle systems. The last is the most often used.



Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.DG16-2
	Paragraph	2	Generating Facilities (Thermal)	
	Clause	24	Internal Combustion Engine	
Title	Injection systems (2)			





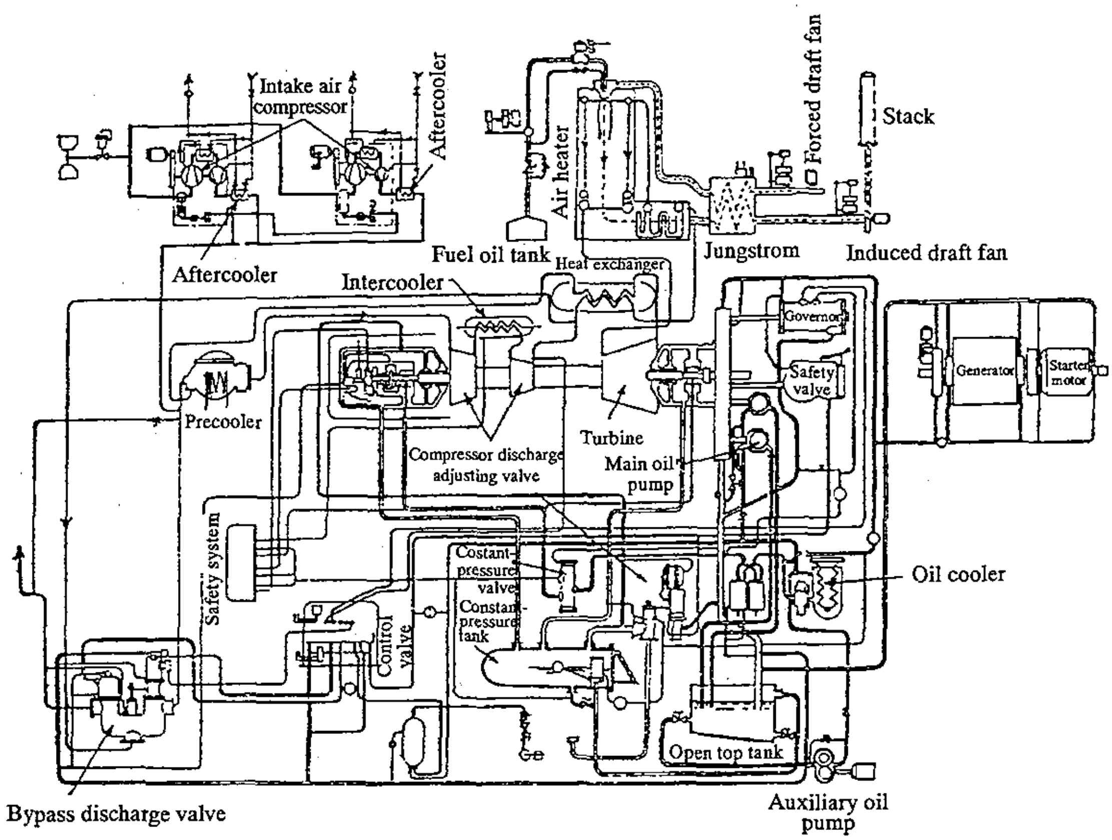
Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.GT1-1
	Paragraph	3	Generating Facilities (Thermal)	
	Clause			
Title	Gas Turbine Power Station (1)			

Electric power is generated by the gas turbine, which turns with a high-temperature, high-pressure gas. This type of power generation is essentially based on four processes: compression, heating, expansion and heat radiation. To these basic processes, other processes are added: regeneration, intermediate cooling, reheating, etc.

1. Components

A gas turbine system mainly consists of a compressors, heaters, gas turbine, silencers, regenerators, and intermediate coolers.



Configuration of a gas turbine power station

Remarks	Revisions	
	2003/Nov.	Original

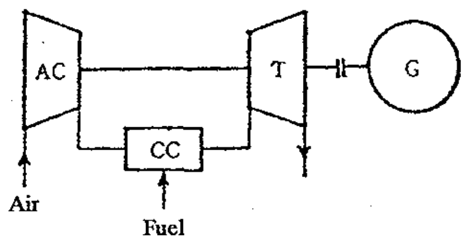
Category				Document No.GT1-2
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Thermal)	
	Clause			
Title	Gas Turbine Power Station (2)			

(1) Compressors

The compressors apply high pressures to the air. Axial-flow compressors are generally used in thermal power stations. These compressors are multiple-stage compressors which are capable of efficiently compressing a large amount of air under high pressures.

(2) Heaters

The heaters are used to heat high-pressure air. Internal combustion heaters (combustors) are applied to the open cycle system.



AC : air compressor
CC : combustor
T : turbine

Open cycle

(3) Gas turbine

The gas turbine performs adiabatic expansion of a high-temperature, high-pressure gas to generate torque.

(4) Regenerators (heat exchangers: HE)

The regenerators recover the heat retained in the turbine exhaust gas for use as combustion air to greatly improve the thermal efficiency.

(5) Intercoolers

The intercoolers lower the temperature of the air during the compression process to enhance the compressor's efficiency.

Remarks	Revisions	
	2003/Nov.	Original

(6) Precoolers

The precoolers lower the temperature of the fluidic air in the closed cycle at the compressor inlet to enhance the compressor's efficiency.

(7) Silencers

A gas turbine power station generates undesired noise because it intakes and discharges large amounts of air at high speeds. For this reason, a noise insulating material is installed to cover the ducts and silencers are provided at the intake side. At the discharge side, the air is discharged upward through a chimney to the atmosphere.

2. Description of gas turbine

(1) General

Axial-flow turbines are widely used in the power generation industry. The turbine blades are so designed that the air flow secures an equilibrium in the radial directions. If based on the axial-flow system, an impulse turbine is not differentiated from a reaction turbine. The rotor and blades are made of a special heat resistant alloy to meet the temperature requirements for the service gas.

Recently, new heat resistant materials have been developed and the cooling structure of the blades has been modified. High-efficiency gas turbines have been commercialized for service temperatures around 1100°C.

(2) Open gas turbine

An open gas turbine is a turbine which integrates a combustor and a compressor.

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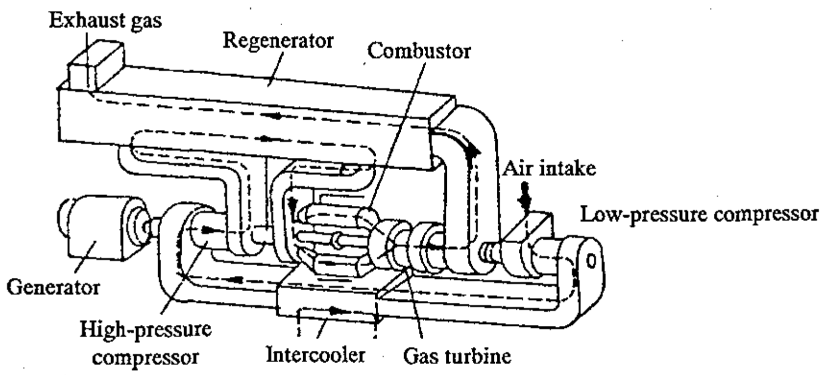
An open gas turbine is a turbine which integrates a combustor and a compressor.



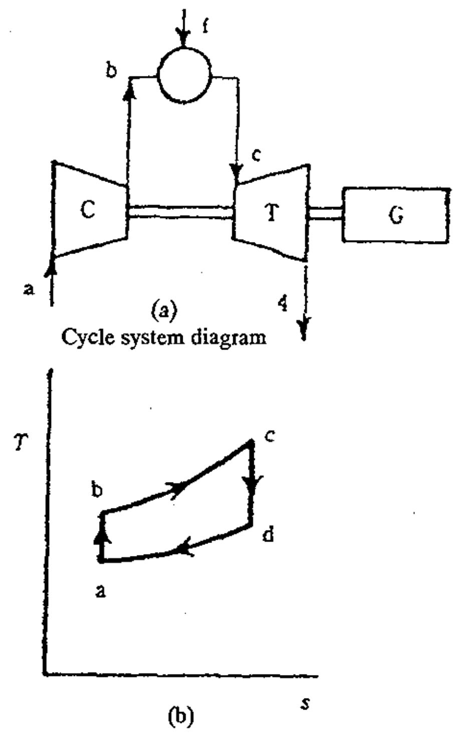
Open gas turbine

The air placed under high pressures in the compressor is transferred to the combustion chamber. A small part of this air is used to burn the fuel in the combustion unit. A large amount of high-temperature, high-pressure gas obtained by mixing the majority of high-pressure gas with the high-pressure, high-temperature combustion gas performs adiabatic expansion in the turbine. This process generates torque to the impeller. The exhaust enters the regenerator and preheats the combustion air before being discharged to the external environment.

(3) Thermal cycle of gas turbine

In the single cycle:

1) The quantity of heat which has changed into work in the gas turbine is represented by the area formed by a, b, c, and d in the *T-s* diagram.



(a)
Cycle system diagram

(b)
T-s diagram

Thermal cycle of gas turbine

2) The theoretical thermal efficiency is $\eta_c = 1 - \left(\frac{P_a}{P_b}\right)^{\frac{k-1}{k}}$

where P_a, P_b: absolute pressures of the gas at a and b [MPa] and k: specific heat ratio (constant-pressure specific heat / constant-volume specific heat).

The actual gas body is not a perfect gas body, and the compression and the expansion are not perfectly isentropic. Therefore, the theoretical values are slightly different from the actual values. Higher turbine intake temperatures correspond to higher thermal efficiencies.

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.GT2
	Paragraph	3	Generating Facilities (Thermal)	
	Clause	22	Gas Turbine and its Accssories	
Title	Hydrostatic test			

1. The pressure parts of a gas turbine and its accessories must be able to withstand a hydrostatic test using a water pressure 1.5 times their respective maximum allowable working pressures without leakage.

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.GT3
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.GT3
	Paragraph	3	Generating Facilities (Thermal)	
	Clause	22	Gas Turbine and its Accssories	
Title	Emergency stop devices			

1. A gas turbine must be equipped with an emergency governor which is actuated at a speed not higher than 1.11 times its rated speed.
2. A gas turbine must be equipped with a device which interrupts the inflow of fuel automatically in the cases specified in the following Items:

(1) In case a trouble occurred with a generator with a capacity of not less than 10,000kVA.

(2) In case gas temperature increase extremely high.

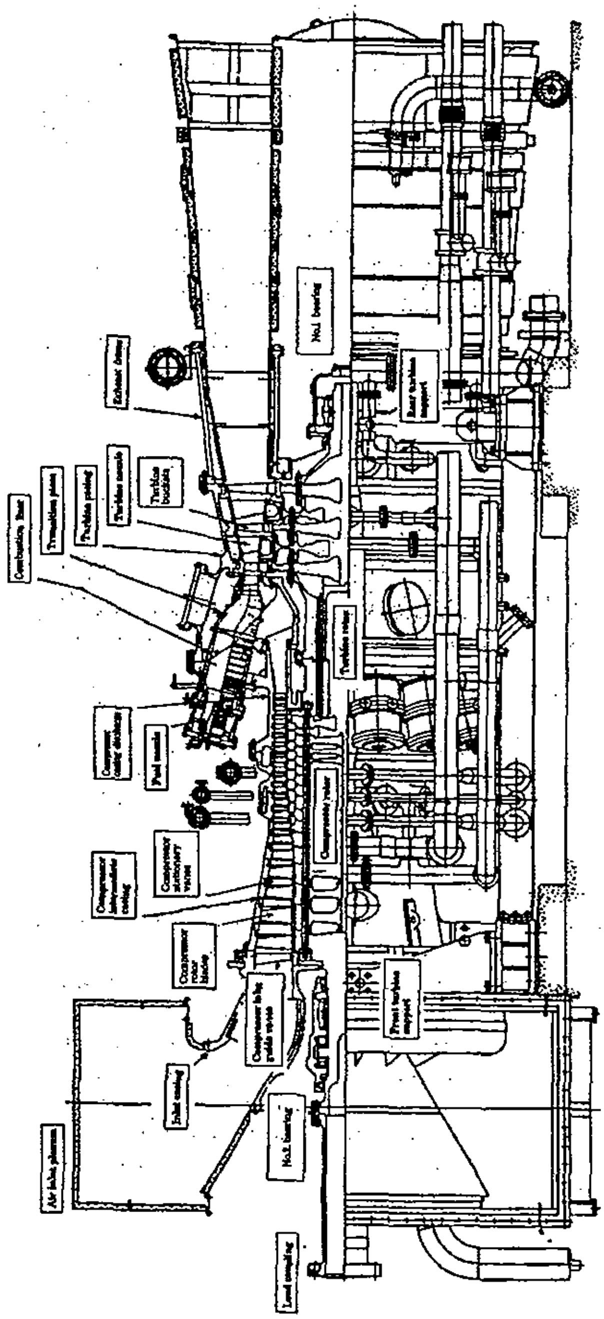
Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.GT4
	Paragraph	3	Generating Facilities (Thermal)	
	Clause	22	Gas Turbine and its Accssories	
Title	**Measuring devices**			

1. A gas turbine must be equipped with devices for measuring the points specified in the following Items:
   a. Speed of a gas turbine
   b. Discharge pressure of the air compressor of a gas turbine
   c. Gas temperature at inlet of a gas turbine
   d. Oil pressure at the bearing inlet of a gas turbine
   e. Oil temperature at the bearing outlet of a gas turbine

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.GT5
	Paragraph	3	Generating Facilities (Thermal)	
	Clause	22	Gas Turbine and its Accssories	
Title	Example of Construction of Large Capacity Gas Turbine			



21-. _xample of Construction of Large Capacity Gas Turbine

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.GT6-1**
	Paragraph	3	Generating Facilities (Thermal)	
	Clause			
Title	**Type of Gas Turbine Combind cycle**			

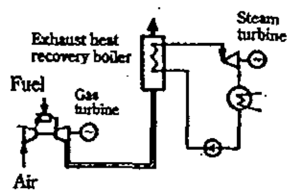
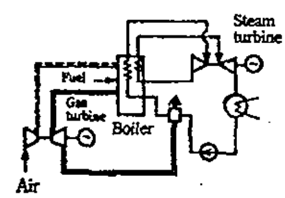
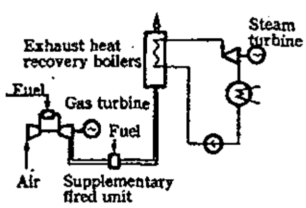
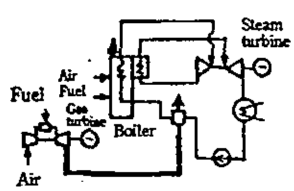
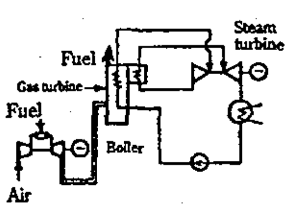
(4) Combined cycle power generation

This is an exhaust heat recovery power generation system in which the exhaust from an open gas turbine is sent for steam generation to the exhaust heat recovery boiler in a steam power station. Another system is based on a supercharged boiler. The air from the compressor in the gas turbine is fed to the boiler in the steam power station to be combusted as combustion air. The resulting combustion gas is sent to the gas turbine.

Use of combined cycle power generation will improve the total thermal efficiency up to 43%.

Remarks	Revisions	
	2003/Nov.	Original

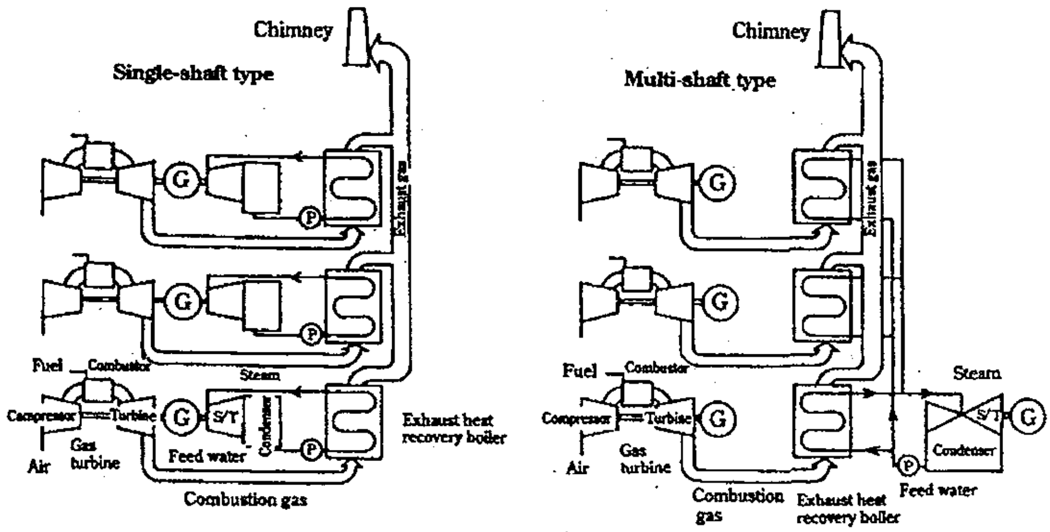
Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.GT6-2**
	Paragraph	3	Generating Facilities (Thermal)	
	Clause	24	Gas-turbine Combined Cycle and its Accessories	
Title	**Types of Gas Turbine Combined Cycle**			

Types	Systems	Types	Systems
Exhaust heat recovery		Supercharged boiler (Pressurized fluidized bed combustion)	
Supplementary fuel to exhaust gas		Feed water heating	
Exhaust gas refiring			

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.GT7**
	Paragraph	3	Generating Facilities (Thermal)	
	Clause	22	Gas Turbine and its Accessories	
Title	**Conception of Exhaust Heat Recovery Combined Cycle**			

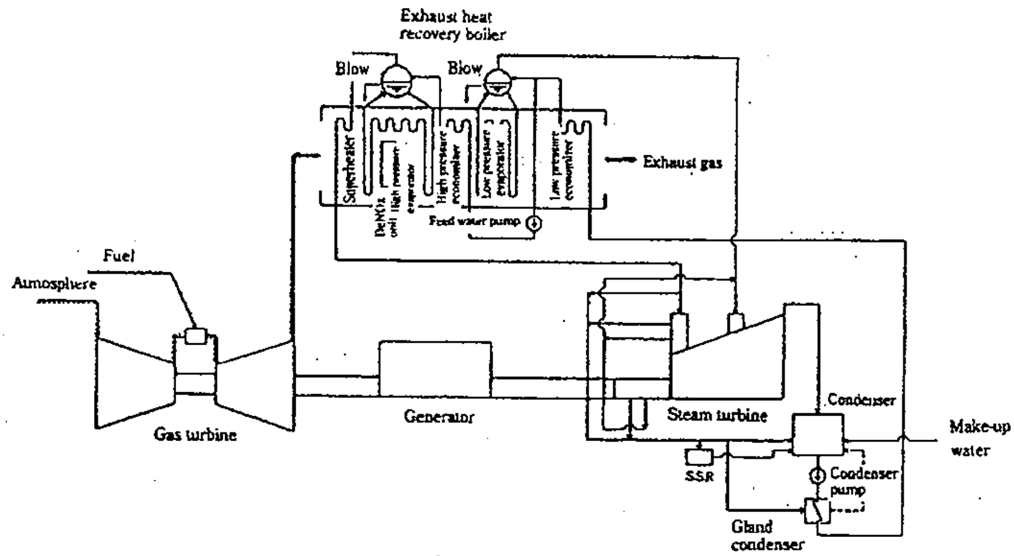
Conception of Exhaust Heat Recovery Combined Cycle
Power Generating Plants



Remarks	Revisions	
	2003/Nov.	Original

Category				Document
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.GT8-1
	Paragraph	3	Generating Facilities (Thermal)	
	Clause	24	Gas-turbine Combined Cycle and its Accessories	
Title	System Diagram of gas Turbine Combined Cycle Plant (Single Shaft Type)			

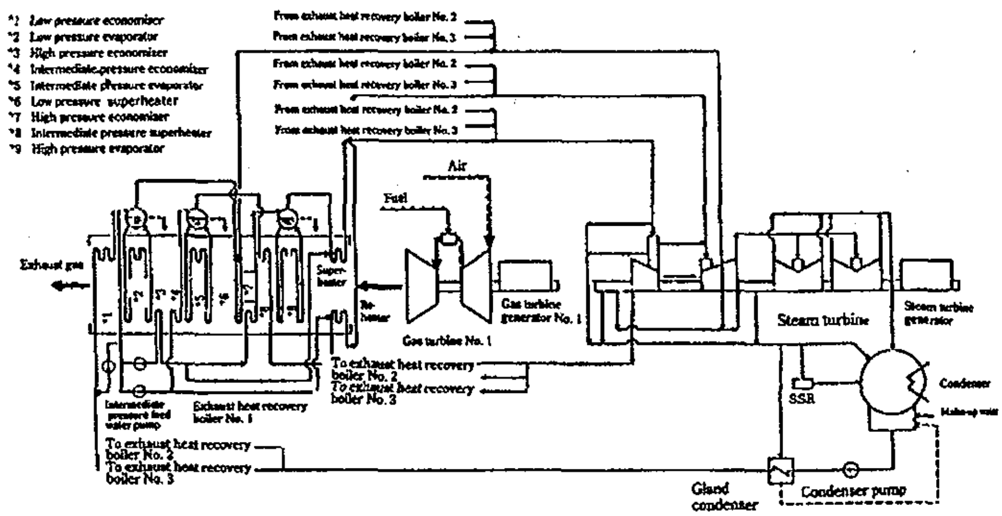
(1) Exhaust heat recovery type compound power generation plant



Single-shaft type

Remarks	Revisions	
	2003/Nov.	Original

Category				Document
	Chapter	2	Technical Standards of Electric Power Facilities	No.GT8-2
	Paragraph	3	Generating Facilities (Thermal)	
	Clause	24	Gas-turbine Combined Cycle and its Accessories	
Title	System Diagram of Gas Turbine Combined Cycle Plant (Multo-shaft Type)			

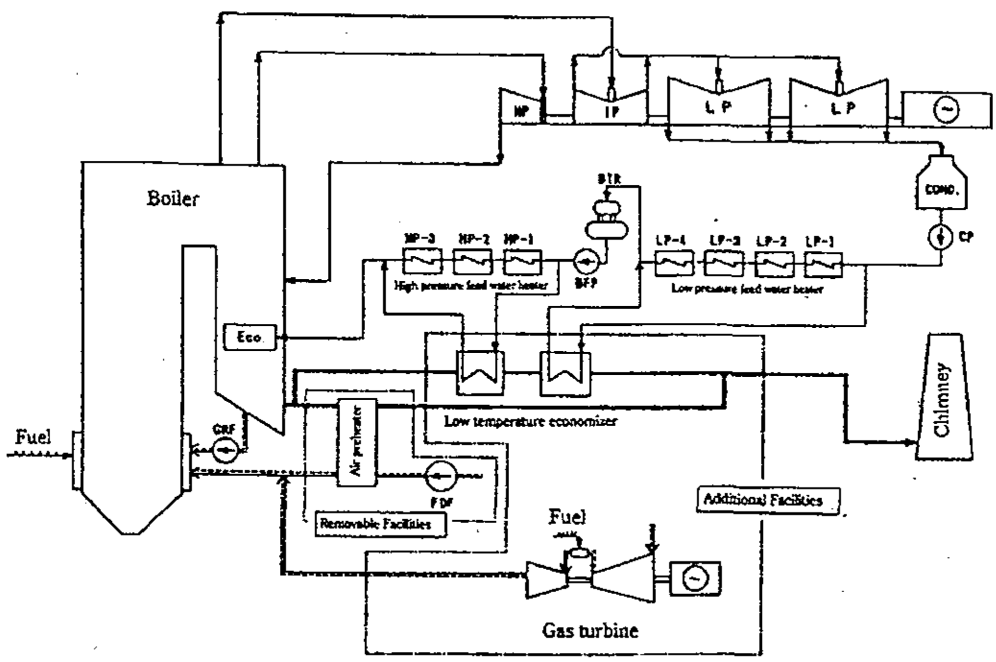


Multi-shaft type

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.GT9
	Paragraph	3	Generating Facilities (Thermal)	
	Clause	24	Gas-turbine Combined Cycle and its Accessories	
Title	System Diagram of Gas Turbine Combined Cycle Plant (Exhaust gas full fired Type)			

(2) Exhaust gas fully-fired combined cycle type power plant



Remarks	Revisions	
	2003/Nov.	Original

Category				Document No. FL1-1
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Thermal Power)	
	Clause		Boiler Accessories	
Title	Fuel Systems (1)			

Fuel-oil Handling

Oil delivered to a storage tank flows through a strainer on the way to the oil-pump suction. The pump discharge oil through heaters and another strainer to the burners. Straining, pumping, and heating equipment in duplicate allow cleaning while maintaining oil flow.

Oil arrives at a plant by ship, barge, tank car, or truck and is usually stored close to the unloading point. Storage tanks usually are fitted with fill pipe, vent pipe, oil gauge, steam smoothing line, sludge pumpout, manhole, low-and high-suction taps, suction heating coil, return line, and electric ground.

The steel tanks may be inside or outside the plant. Cylindrical tanks may be installed above ground or below ground or as semiburied tanks (Fig. 1)

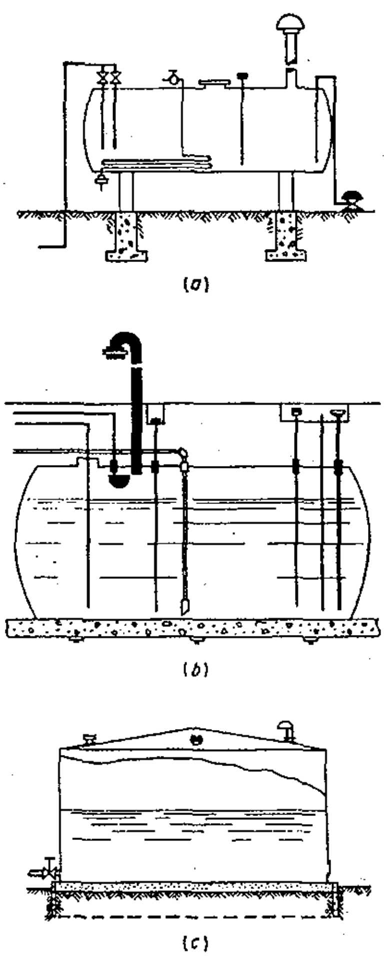


Fig. 1
Fuel-oil storage-tank arrangements:
(*a*) outdoors aboveground;
(*b*) underground;
(*c*) large cone-roofed tank.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.FL1-2
	Paragraph	3	Generating Facilities (Thermal Power)	
	Clause		Boiler Accessories	
Title	Fuel Systems (2)			

Bulk storage tanks and engine day tanks hold the engine fuel oil. The former receive the oil delivered to the plant and stand outdoors for safety. Pumps draw oil from the storage tank to supply the smaller day tanks in the plant at daily or shorter intervals. Large storage capacity allows purchasing fuel when prices are low. Fig.2 shows a typical tank system. Oil may be delivered by truck, or barge and tanker, with very large capacities.

Storage tanks aboveground must be surrounded by a dike to form a moat large enough to hold the tank contents if the tank should leak. Tanks must have manholes for internal access and repair, fill lines to receive oil, vent lines to discharge vapors, sounding connections to measure content, overflow return lines for controlling oil flow, and a suction line to withdraw oil. Coils heated by hot water or steam reduce oil viscosity to lower pumping power needs.

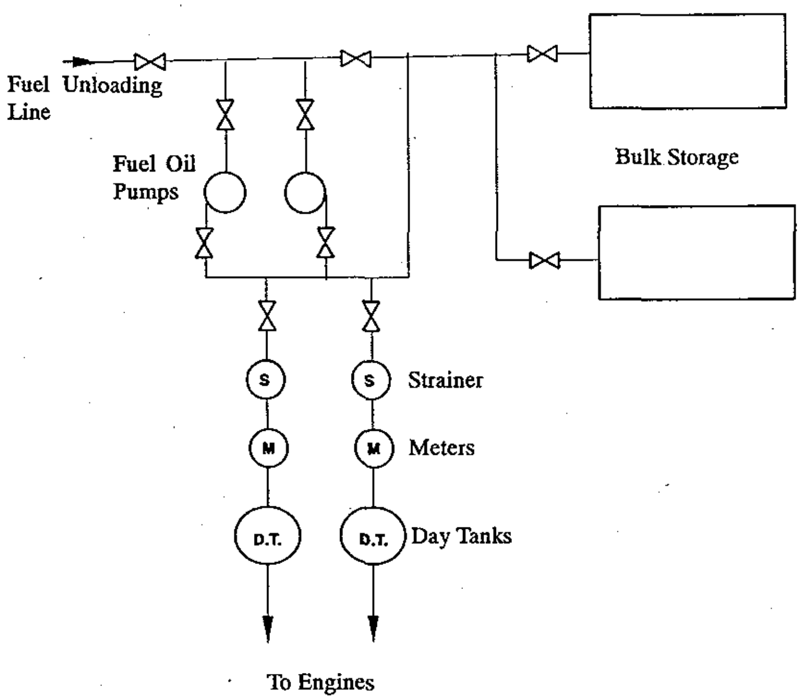
Storage and day tanks, transfer pumps, connecting piping, and injection pumps must be used to burn oil. Storage tanks usually hold at least a 2 weeks' supply.

Delivered oil sometimes holds water, dirt, metallic chips, and other foreign matter that must be removed by filtering or centrifuging. Much of this will settle out in the storage tank, especially with the lighter fuel oils and at higher temperatures. A light degree of contamination may be removed by filters, but heavier fouling requires centrifuging.

Dip-stock measurements give quick spot checks of tank contents, but meters give continuous indications. Fig.2 shows flowmeters between storage and day tanks, but not between the latter and the engines. The return line from the injection systems would make such meters useless since they would measure the gross oil pumped to the injection system, but not the net amount burned by the engine.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No. FL1-3
	Paragraph	3	Generating Facilities (Thermal Power)	
	Clause		Boiler Accessories	
Title	Fuel Systems (3)			



Remarks	Revisions	
	2003/Nov.	Original

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GUIDEBOOK
FOR
POWER ENGINEERS

English Edition

VOL. No.3
HYDROELECTRIC POWER

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GUIDEBOOK FOR POWER ENGINEERS

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Category				Document No.HG1
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HG1
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	-	General	
Title	**Theoretical Water Power, Technical Water Power, Economical Water Power**			

Theoretical water power means the work done by water being dropped with a certain potential height. It is water power described with a unit of watt (W). It is calculated with the following formulas:

$P_e = 9.8 \times Q \times H_e$

$H_e = H_g - H_l$

Where,

P_e: Theoretical water power (kW)

9.8: Gravitational acceleration (m/s^2)

Q: Plant discharge (m^3/s)

H_e: Effective head (net head) (m)

H_g: Gross head (m)

H_l: Head loss (m)

Technical water power means technically feasible water power taking account of turbine efficiency and generator efficiency among theoretical water power.

Economical water power means economically feasible water power among technical water power.

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HG2**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	-	General	
Title	**Gross Head, Head Loss, and Effective Head (Net Head, Rated Head)**			

Gross head is the difference in elevation between a water level at an intake and that of a powerhouse or a tailrace. The former water level is called an intake water level (*IWL*) and the latter is called tail water level (*TWL*)

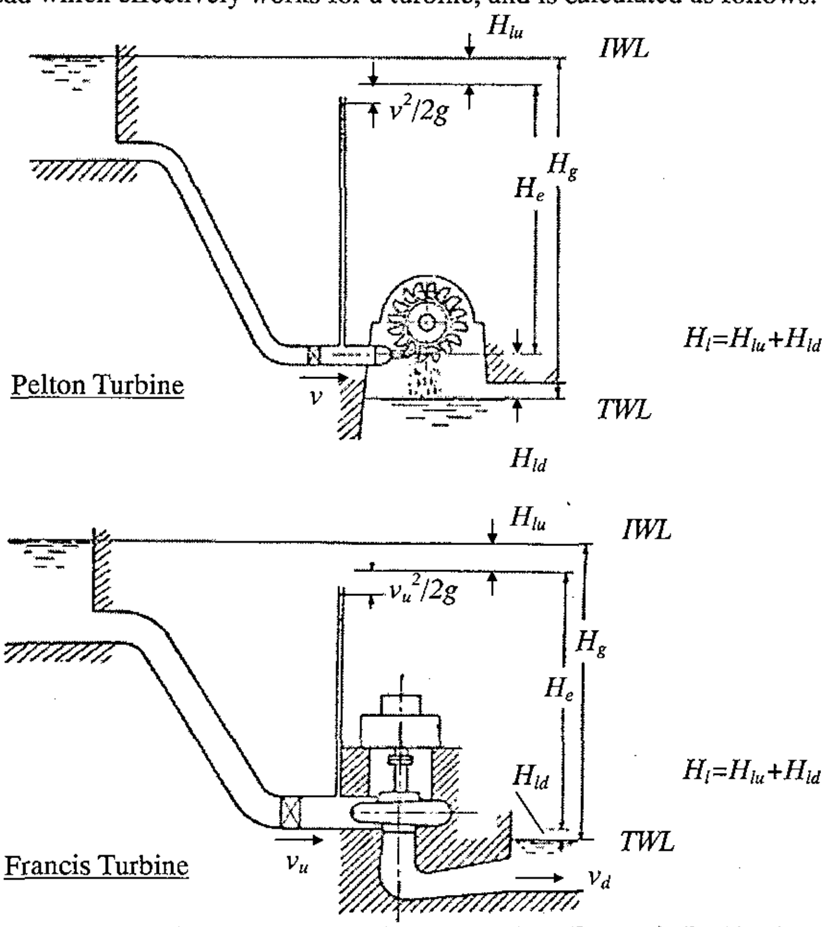
Gross head (H_g) is calculated as follows:

$$H_g = IWL - TWL$$

Head loss (H_l) is a loss when water flows down in a hydroelectric power system. It is the sum of head losses such as a potential head loss, a pressure head loss, and a velocity head loss of water flow.

Effective head (H_e) is a head which effectively works for a turbine, and is calculated as follows:

$$H_e = H_g - H_l$$



Source: Turbines and Pump Turbines (Japanese), Denkisyoin

Remarks	Revisions	
Turbines and Pump Turbines (Japanese), Denkishoin		
	2003/Nov.	Original

Category				
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HG3
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	-	General	
Title	**Maximum Output (Maximum Capacity) and Maximum Plant Discharge**			

Maximum output is a power output which a certain power plant is able to generate. It is often used in the same context as an installed capacity and a rated capacity of the power plant.

Maximum plant discharge is the largest water flow discharged by a power plant. It is a basis for determining an installed capacity and for designing a waterway and turbine of a power plant.

Maximum output corresponding to a maximum plant discharge is calculated with the following formula:

$$P_{max} = 9.8 \times Q_{max} \times H_e \times \eta_t \times \eta_g$$

Where,
P_{max}: Maximum output (kW)
H_e: Effective head at maximum plant discharge (m)
Q_{max}: Maximum plant discharge (m^3/s)
η_t: Turbine efficiency at maximum plant discharge
η_g: Generator efficiency at maximum plant discharge

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HG4
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	-	General	
Title	**Firm Peak Output (Firm Peak Capability, Firm Peak Power) and Firm Peak Plant Discharge**			

Firm peak output is a power output which a certain power plant is able to generate almost everyday in a year, for example 90 to 95 % of the days in a year.

Firm peak plant discharge is a water flow discharged by a power plant almost everyday in a year. It is usually a water flow which is subtracted water flows incapable of using for generation such as discharge for irrigation, fishery, tourism, and river function preservation from the water flow during drought.

Firm peak output corresponding to a firm peak plant discharge is calculated with the following formulas:

$$P_f = 9.8 \times Q_f \times H_{ef} \times \eta_{tf} \times \eta_{gf}$$

Where,
P_f: Firm peak output (kW)
H_{ef}: Effective head at firm peak plant discharge (m)
Q_f: Firm peak plant discharge (m^3/s)
η_{tf}: Turbine efficiency at firm peak plant discharge
η_{gf}: Generator efficiency at firm peak plant discharge

Firm peak output is a numerical basis for evaluating an electric power supply capability and economy of a run-off-river type hydroelectric power project. The power supply service level (non-interruption level) is set, for example, at 90 to 95 % or in some cases 98 %, depending on importance of power supply in a service area. Firm peak plant discharge is, therefore, determined to meet the above level.

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HG5**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	-	General	
Title	**Annually Available Generated Energy (Annually Available Energy Generation, Annually Available Energy Production)**			

Annually available generated energy means generated energy capable of one-year generation at a certain power plant assuming no forced outages and no plant outages due to inspection, maintenance, and repair works.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HG6
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	-	General	
Title	**Annual Generated Energy (Annual Energy Generation, Annual Energy Production)**			

Annual generated energy is less than annually available generated energy by a loss of generated energy caused by forced outages and plant outages due to planned inspection, maintenance and repair works.

Outage energy means energy unable to be generated due to the above plant outages.

Outage rate means the proportion of the outage energy to annually available generated energy.

The annual generated energy is calculated with the following formula.

(Annual generated energy) = (Annually available generated energy) x (1 - Outage rate)

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HG7
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	-	General	
Title	**Plant Factor**			

Hydroelectric power plant wastes a river water flow that is available for a plant discharge when its operation is stopped due to inspection, maintenance, and repair works. In this case, the plant is not able to generate 100 % of the annually available generated energy.

The ratio of annual energy generation to electric energy produced at continuous operation for one year at maximum output is called a plant factor.

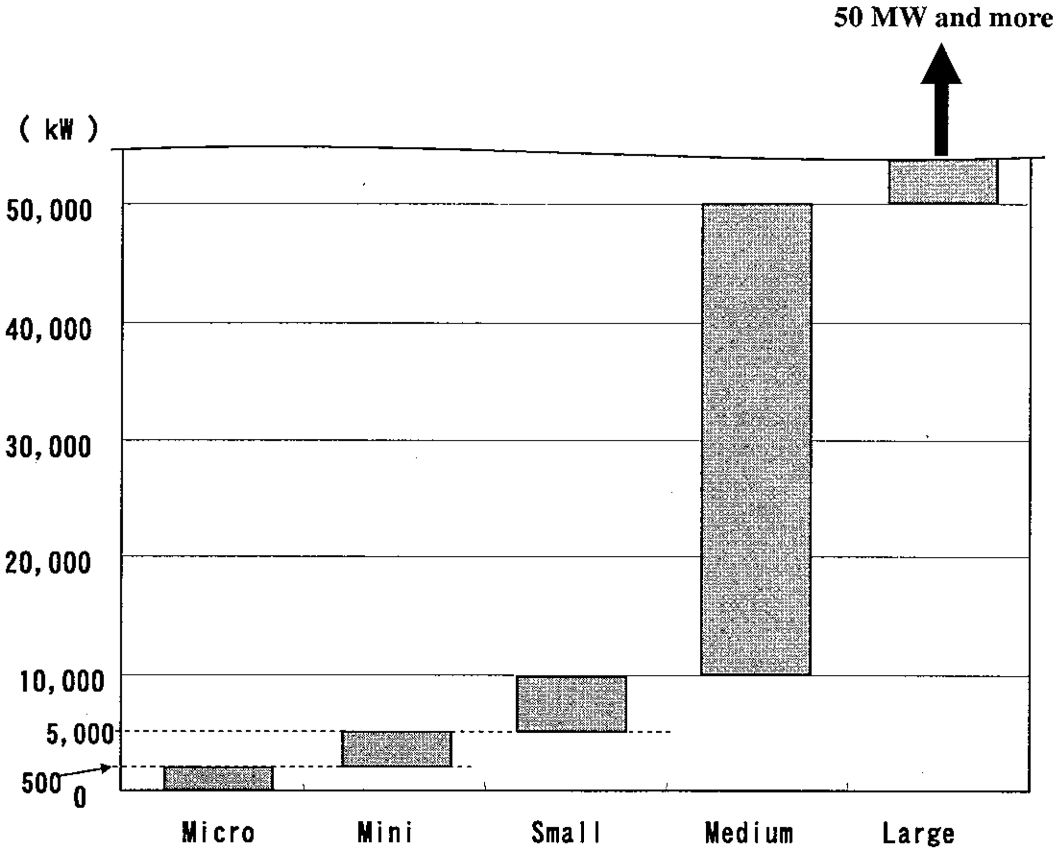
(Plant factor: %) = (Annual energy generation: kWh) / (Maximum output: kW) / 8,760 (hours) x 100

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HG8-1
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	-	General	
Title	Classification of Hydroelectric Power Plant (1)			

1. Classification by capacity in Cambodia

(1) Large: 50MW and more;
(2) Medium: 10MW and more, under 50MW;
(3) Small: 5MW and more, under 10MW;
(4) Mini: 500kW and more, under 5MW; and
(5) Micro: under 500kW.



Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HG8-2
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	-	General	
Title	***Classification of Hydroelectric Power Plant (2)***			

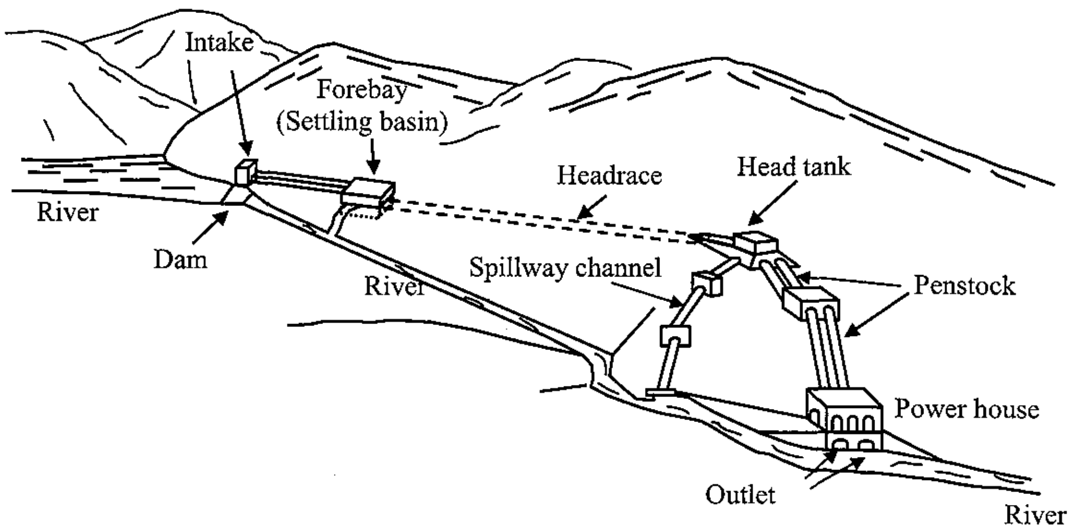
2. Classification by operational role in power system

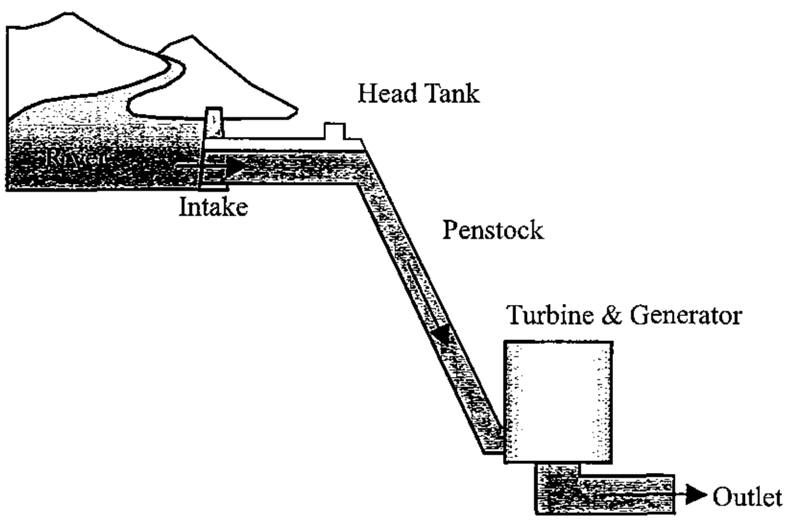
- Hydroelectric Power Plant
  - Conventional HP
    - Run-off-river Type HP
    - Regulating Pond Type HP
    - Reservoir Type HP
  - Pumped Storage HP
    - Recirculating Pumped Storage Type HP (Pure Pumped Storage Type HP)
    - Multiple-use Pumped Storage Type HP (Pumped and Natural Flow Storage Type HP)

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HG8-3
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	-	General	
Title	Classification of Hydroelectric Power Plant (3)			

2-1 Conventional HP
2-1-1 Run-off-river type

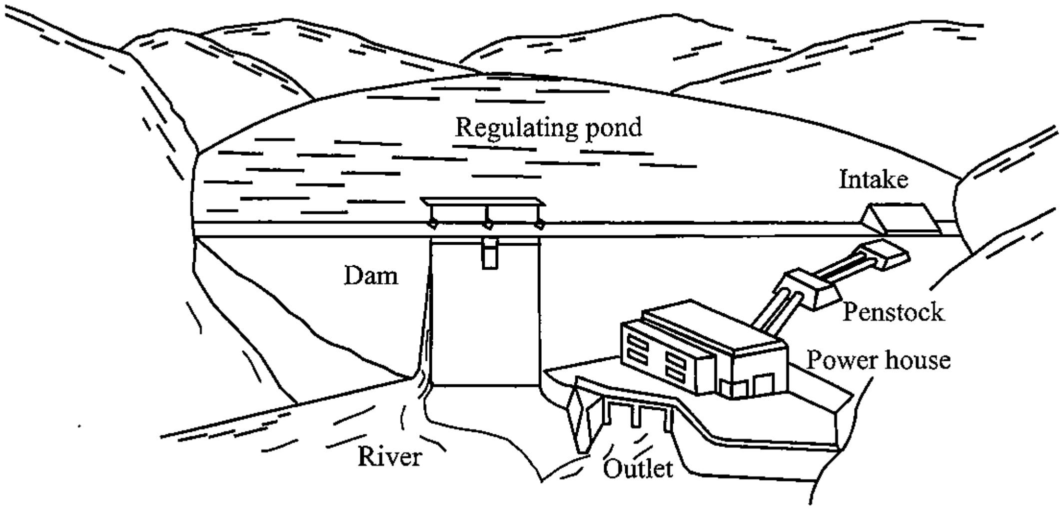


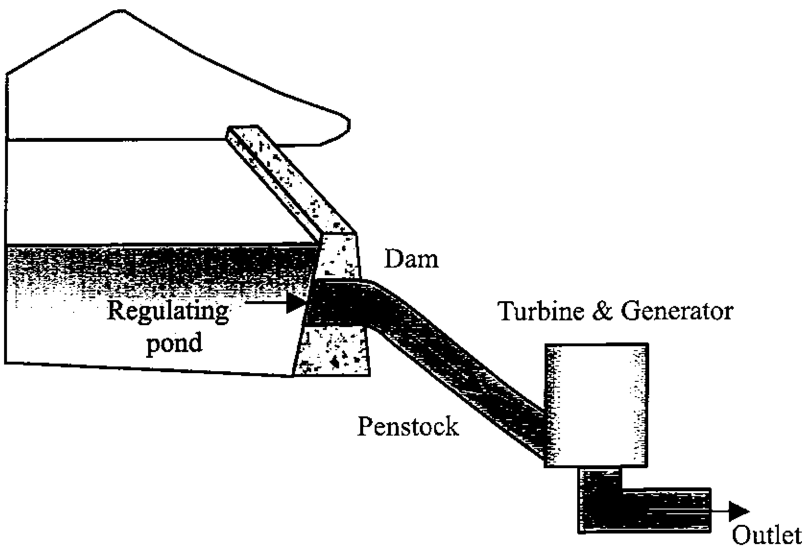


Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HG8-4
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	-	General	
Title	**Classification of Hydroelectric Power Plant (4)**			

2-1-2 Regulating pond type

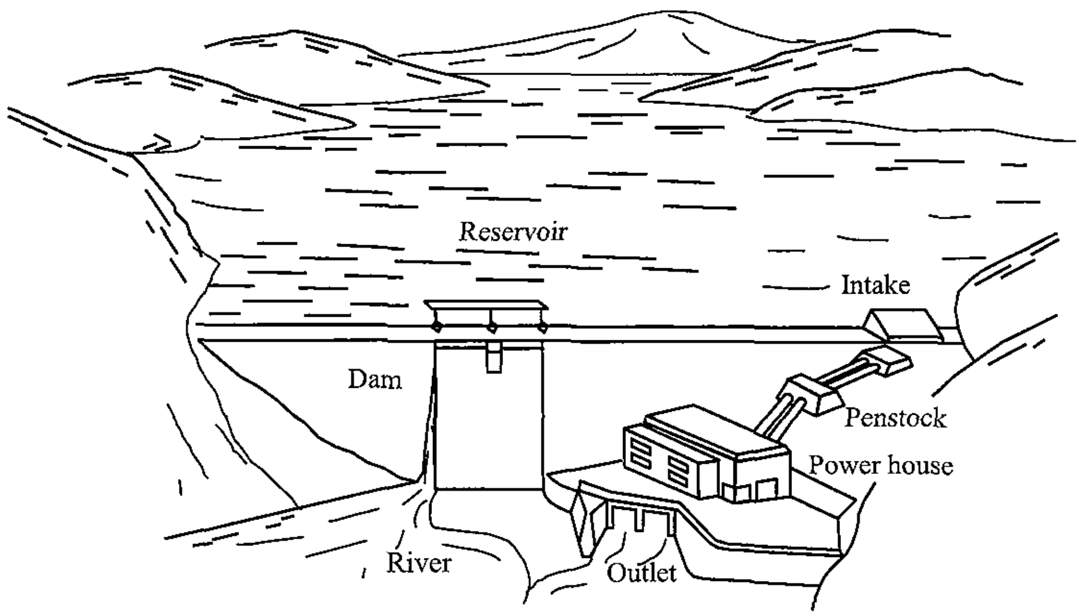


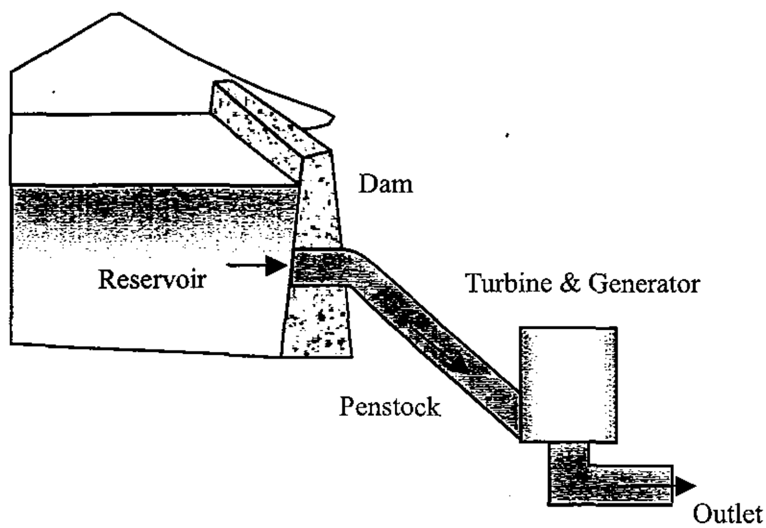


Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HG8-5
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	-	General	
Title	**Classification of Hydroelectric Power Plant (5)**			

2-1-3 Reservoir type



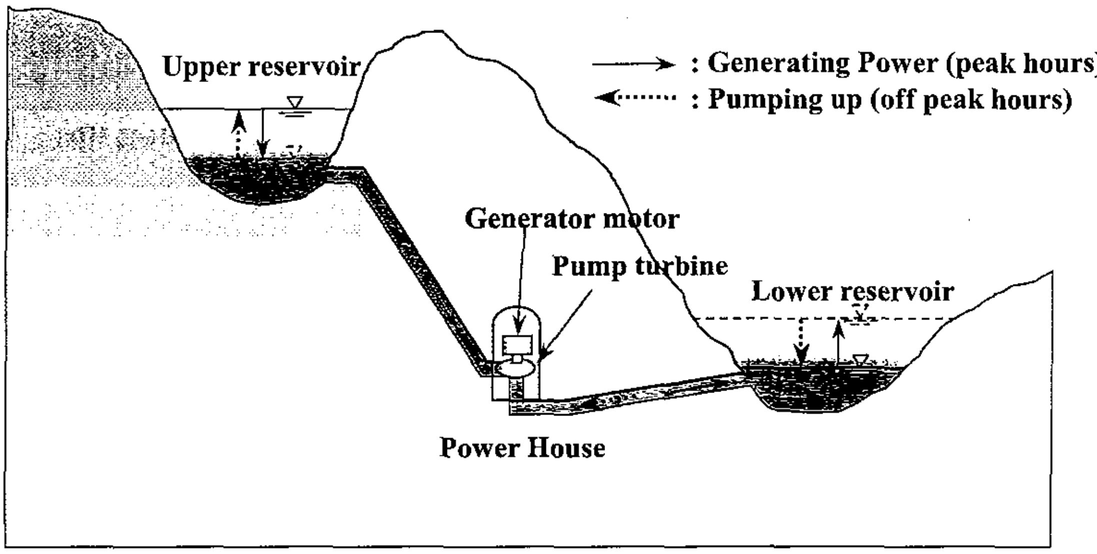


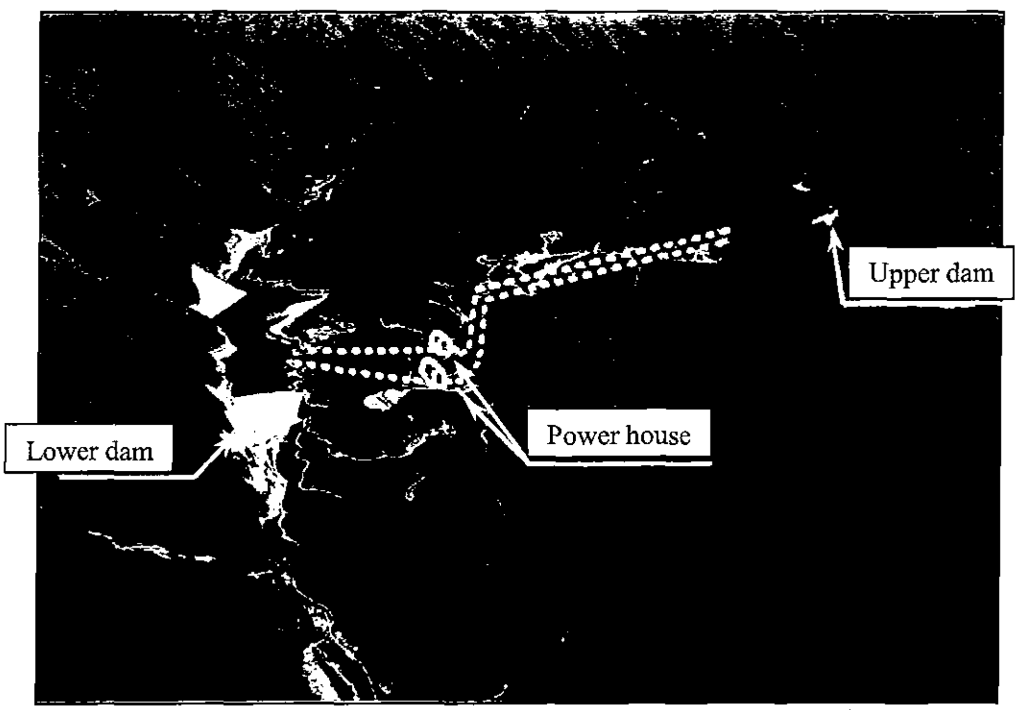
Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HG8-6
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	-	General	
Title	Classification of Hydroelectric Power Plant (6)			

2-2. Pumped Storage Type

2-2-1 Recirculating pumped storage type (pure pumped storage type)





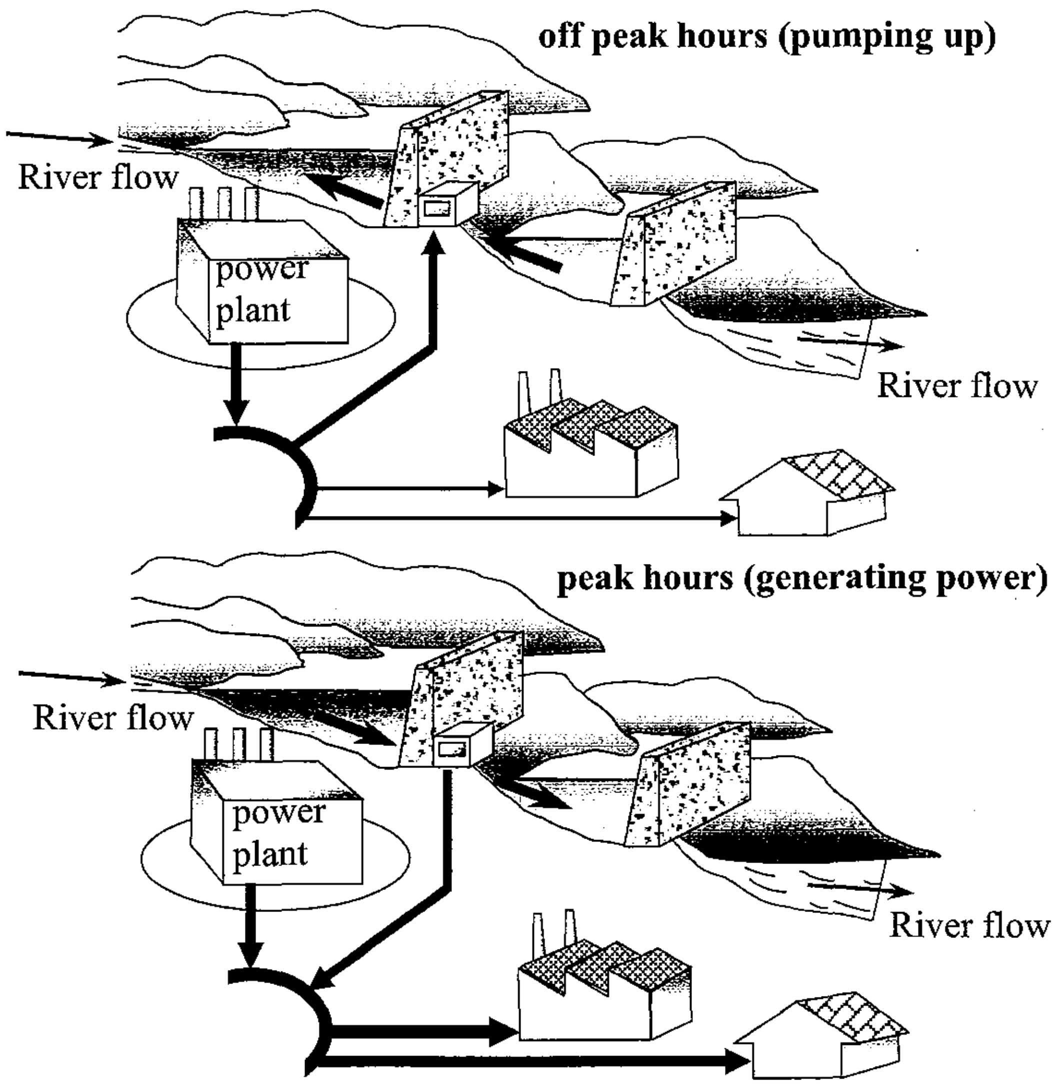
Recirculating Pumped Storage Type Hydroelectric Power Plant

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HG8-7
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	-	General	
Title	Classification of Hydroelectric Power Plant (7)			

2-2-2 Multiple-use Pumped Storage Type (Pumped and natural flow storage type)

Multiple-use Pumped Storage HP is a combination of a Conventional HP and a Recirculating Pumped Storage HP

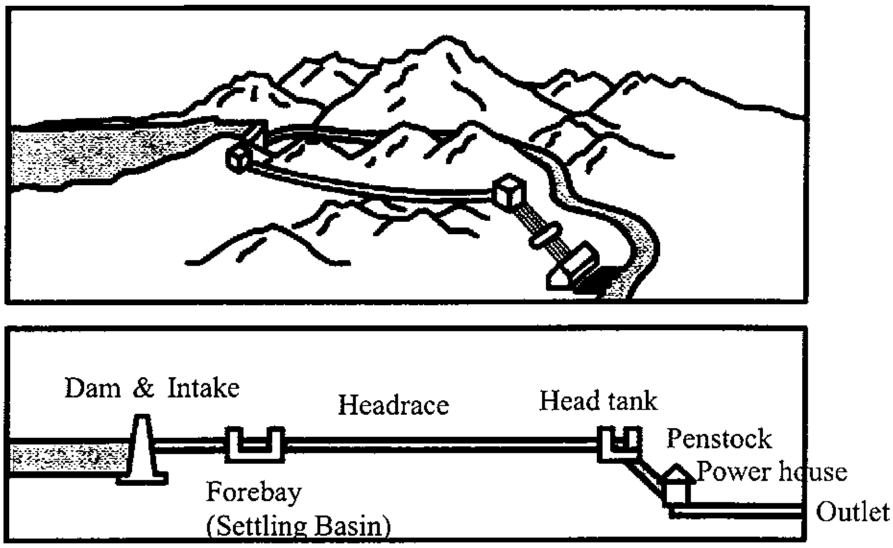


Remarks	Revisions	
	2003/Nov.	Original

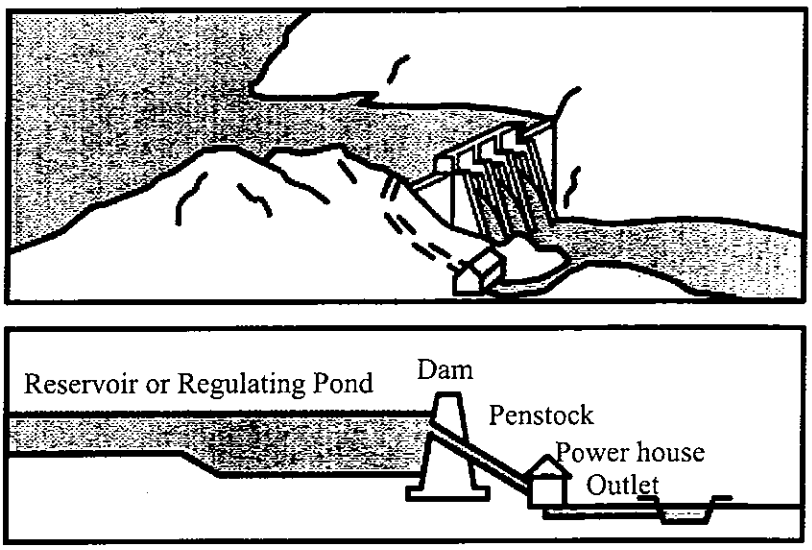
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HG8-8
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	-	General	
Title	Classification of Hydroelectric Power Plant (8)			

3. Classification by method of water head acquisition

3-1 Waterway type



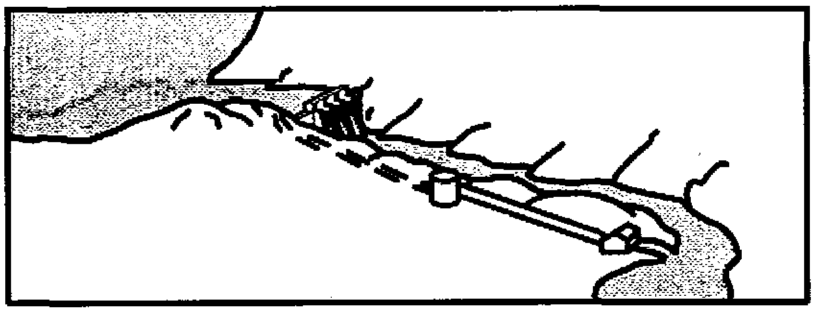
3-2 Dam type

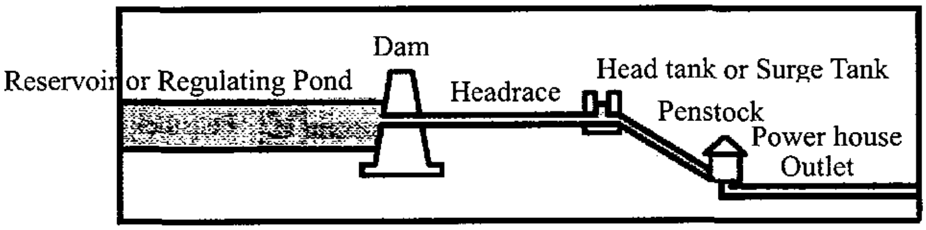


Remarks	Revisions	
	2003/Nov.	Original

Category				
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HG8-9
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	-	General	
Title	Classification of Hydroelectric Power Plant (9)			

3-3 Dam and waterway type





Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HG8-10
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	-	General	
Title	**Classification of Hydroelectric Power Plant (10)**			

4. Classification by regulation procedures

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 the projects are crucial for environment.

Remarks	Revisions	
Sub-decree on Environmental Impact Assessment Process (August 11, 1999)		
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HG9
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	-	General	
Title	**Planning of Hydroelectric Power Development**			

Outline of planning of hydroelectric power development is as follows;

1. Plant configuration

- Selection of dam and power house site

  To select dam site and power house site (or outlet site) in consideration of the river flow, topography, and geology of the planned river area;

- Layout of waterways and roads

  To draw a route and layout of the waterways and roads for construction and maintenance such as intake, forebay, headrace, head tank or surge tank, penstock, tailrace, and outlet in consideration of the topography and geology;

2. Maximum plant discharge

To set the maximum plant discharge on the basis of the river flow at the dam site/sites;

3. Calculation of power output and energy generation

To calculate the power output and energy generation from the product of the discharge multiplied by the head between the intake/intakes and the power house in consideration of head losses;

4. Construction cost estimates

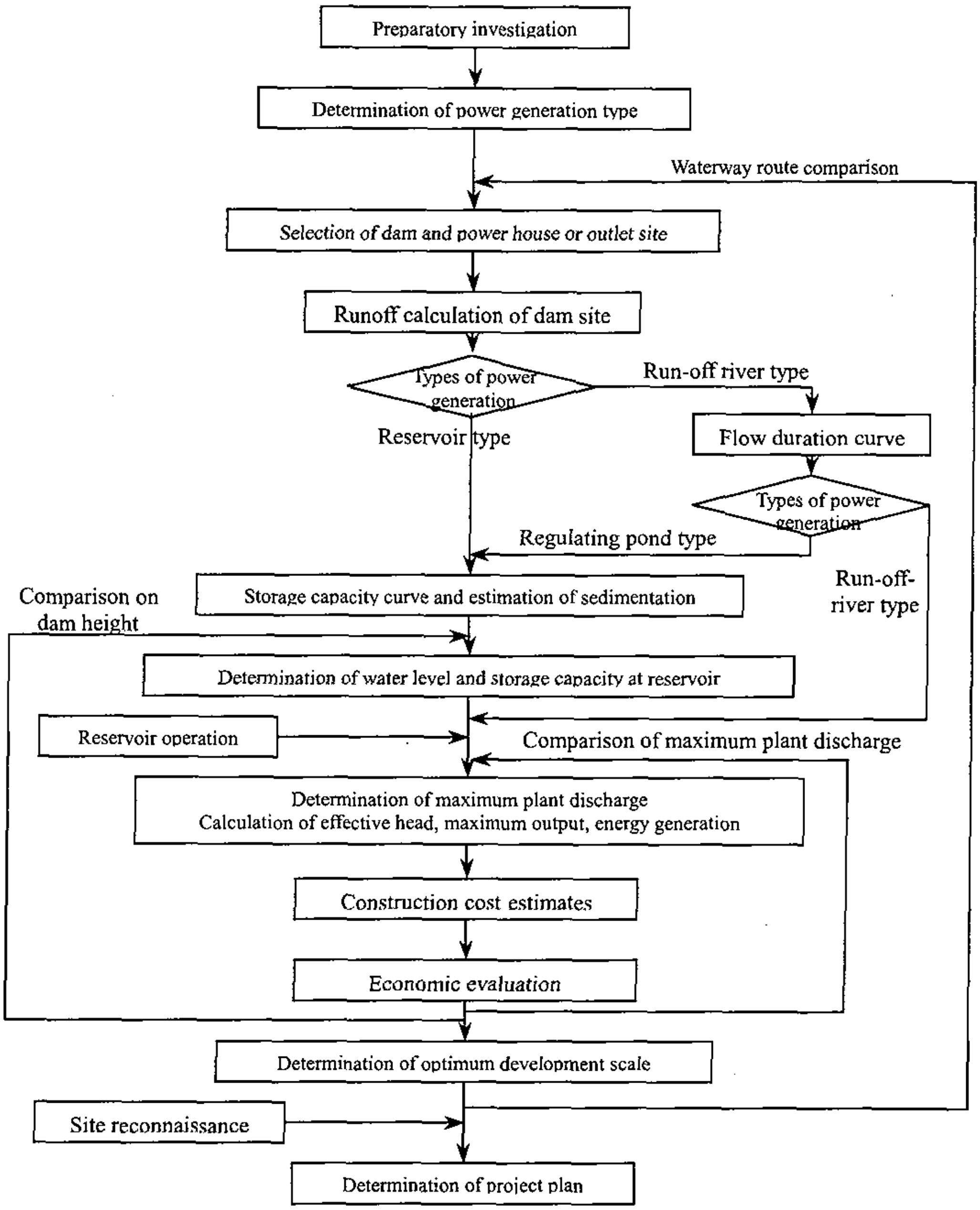
To estimate the construction cost of the dam, waterway, powerhouse, and other civil works and the turbine, generator and other electric facilities, thereby obtaining the construction cost for the entire project.

5. Evaluation of the project

To study and evaluate the project from the aspects of engineering, economy, and environment then to complete the plan.

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HG10**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	-	General	
Title	**Flow Chart for Hydroelectric Power Planning**			



Remarks	Revisions	
Guide Manual for Development Aid Programs and Studies of Hydro Electric Power Projects, 1996, New Energy Foundation		
	2003/Nov.	Original

Category				Document No.HG11
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	-	General	
Title	Important Data for Planning of Hydroelectric Power Plant			

Important and essential data required in planning hydroelectric power plant are topographic maps and runoff data. Other data such as hydrology, meteorology, and geology are also important data for the planning and feasibility study on hydroelectric power plant.

1. Topographic maps
Plant discharge of hydroelectric power plant is determined by the river flow available at the dam site. The watershed (or catchment) area is necessary for calculation of the river flow. The head is determined by the difference in elevation between the water level at intake and that at outlet. The waterway route connecting these sites is determined from topographic maps.

Topographic maps are required to compute the watershed (or catchment) area and the head. If available, the more accurate the maps are, the more reliable study or planning is conducted.

2. Runoff data
The most important and essential data for drawing up a hydroelectric power development is runoff data because it is basis of energy production of a hydroelectric power plant that affects feasibility of the power plant particularly economy. It is necessary that the runoff data be observed at the dam site or adjacent to the dam. If river flow is not recorded in the project site or nearby, it is necessary to prepare runoff data of the project site using data available, including runoff data of adjacent rivers.

The runoff data shall be observed and recorded by installing river flow gaging stations for a long period enough to plan and study the hydroelectric power plant.

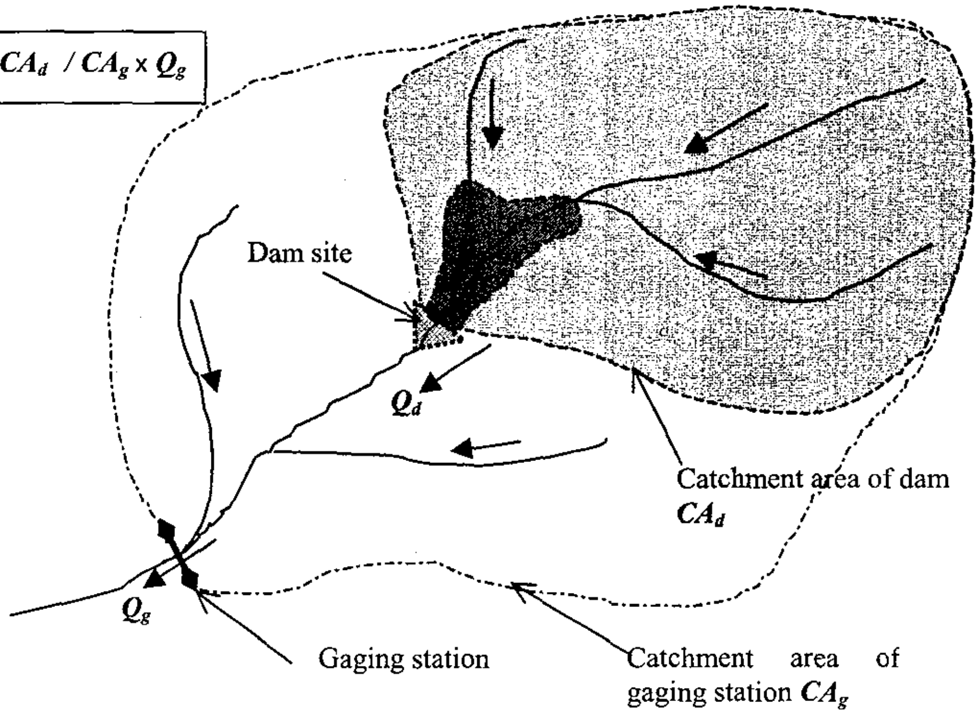
3. Other important data
- Hydrological data
- Meteorological data
- Geological data
- Data concerning power demand, power supply, and transmission line to the power plant
- Master plan of river basin development
- Environmental laws and regulations
- Existing vested water utilization rights and licenses
- Data concerning construction cost

etc.

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HG12
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	-	General	
Title	Relation between Runoff of Dam Site and that of Gaging Station			

$$Q_d = CA_d \ / CA_g \times Q_g$$



Relation between runoff of dam site and that of gaging station

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HD1-1**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Reservoirs (1)**			

This standard do not make any differences in reservoirs, regulating ponds, and ponds. "Reservoir" means a general term for reservoirs, regulating ponds, and ponds that mean stored water impounded by one or more dams, or land on which the water is impounded to the largest water storage in this standard.

1. Reservoir

Reservoir is a large pond in water storage capacity. It is capable of regulating seasonal fluctuation of river flow according to annual schedule of the plant operation.
River flow fluctuates significantly throughout the course of one year. Plant discharge can be increased by storing surplus water in a wet season and then the stored water can be released in a dry season. Thus, a relatively equalized discharge can be obtained and stable electric power supply can be done.

2. Regulating Pond

Regulating pond is also a large pond in water storage but generally smaller than a reservoir. It is capable of regulating water flow for daily or weekly plant operation.
River flow fluctuates greatly by season but does not change largely in the course of one day or week. On the other hand, power demand does change sharply in a day or a week. Regulating pond regulates water flow for a day or a week by storing water when the demand is low in the middle of the night or on Sunday, and then using it at peak load time.

3. Pond

Pond is a very small reservoir in water storage capacity with a small and low dam so called a weir. It is not capable of regulating water flow for power generation even for daily plant operation. Thus, a hydroelectric power plant with only a pond or ponds generates electricity just corresponding to a water flow normally less than the natural river flow. This type of power plant is called a run-off-river type hydroelectric power plant.

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD1-2
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Reservoirs (2)			

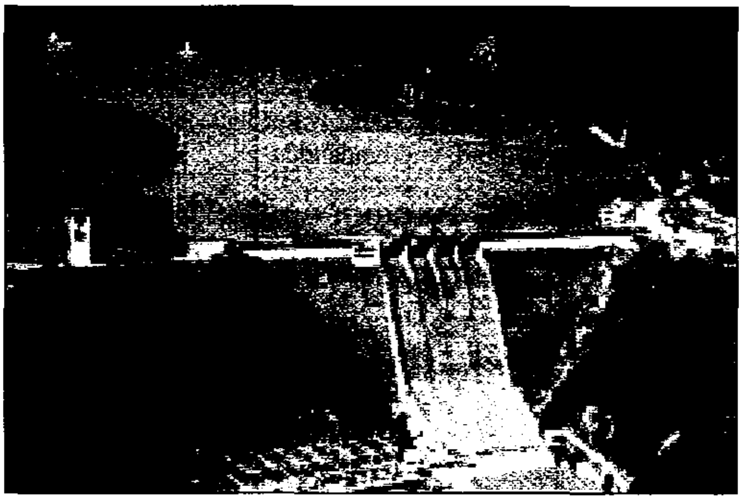
Reservoirs shall meet the following:

1. In case of large reservoirs installation, the permeability of surrounding ground and possibility of landslides shall be investigated. Particularly, narrow ridges and landslide areas shall be sufficiently investigated; and
2. Water sealing measures and countermeasures against landslides shall be taken so that installation of reservoirs may not cause harmful water leakage through the surrounding ground, seepage failure of surrounding ground, and landslides.

Remarks	Revisions	
	2003/Nov.	Original

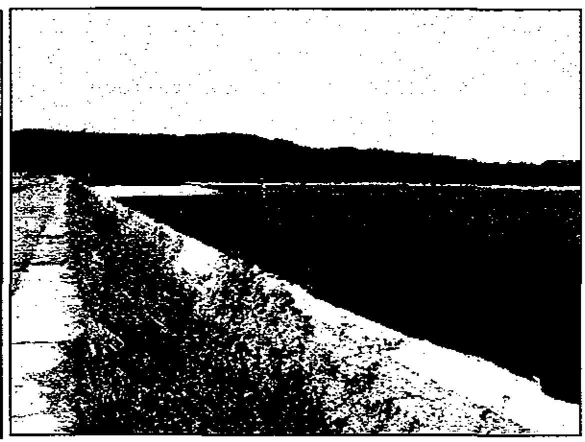
Category				
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD1-3
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Reservoirs (3)			

1. Reservoir



Reservoir

O Chum 1 Reservoir

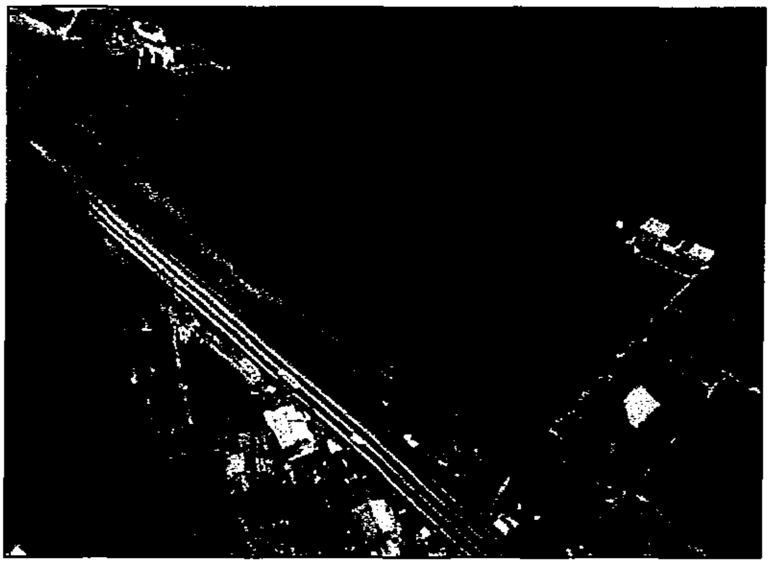


Kirirom 1 Reservoir

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HD1-4
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Reservoirs (4)			

2. Regulating Pond



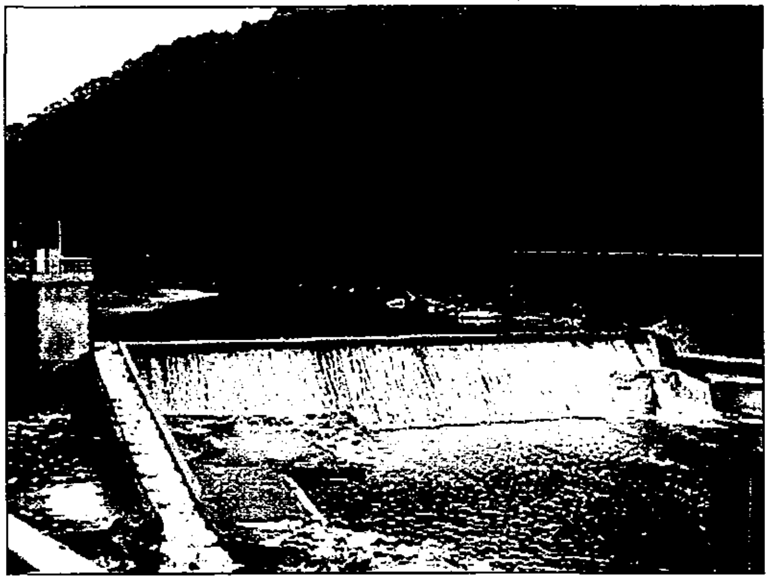
Regulating pond

O Chum 2 Regulating pond

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD1-5
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Reservoirs (5)			

3. Pond



Pond

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HD2-1**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Dam types (1)**			

1. The following dam types shall be adopted for dams in principal in order to meet the Standard:
(1) Concrete dams such as gravity dams and arch dams; and
(2) Fill dams.
2. In case dams are structurally stable and safe, the above Section 1 may not apply.

Classification of Dam Type

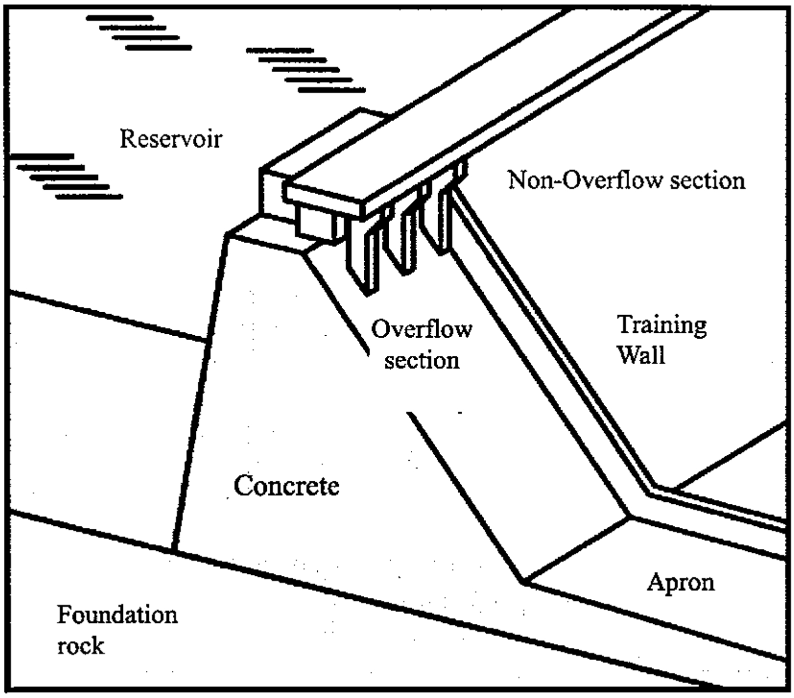
- Dam
  - Concrete dam
    - Gravity dam
      - Gravity dam
      - Hollow gravity dam
      - Buttress dam
    - Arch dam
      - Arch dam
      - Gravity arch dam
  - Fill dam
    - Homogeneous type fill dam
    - Zoned type fill dam
    - Surface diaphragm type fill dam

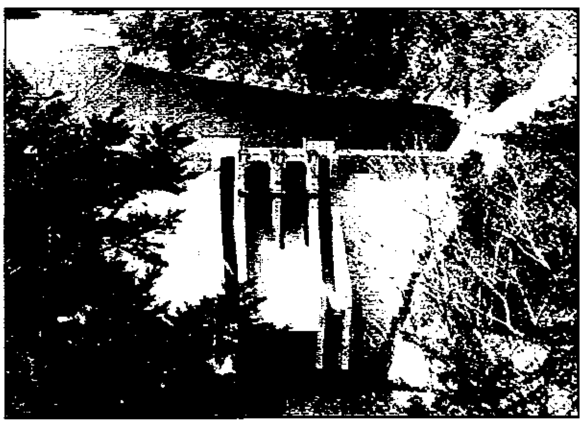
Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD2-2
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Dam types (2)			

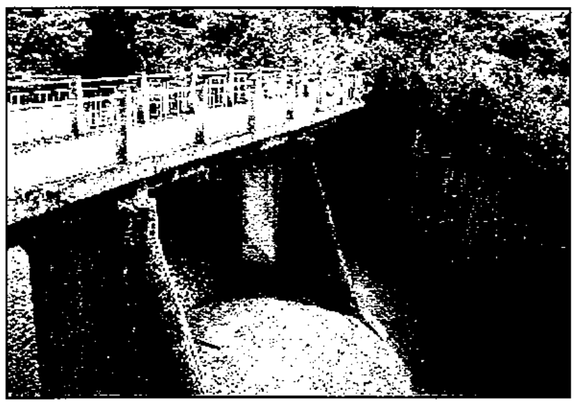
Examples of Concrete Dam

1. Concrete Gravity Dam





Concrete Gravity Dam

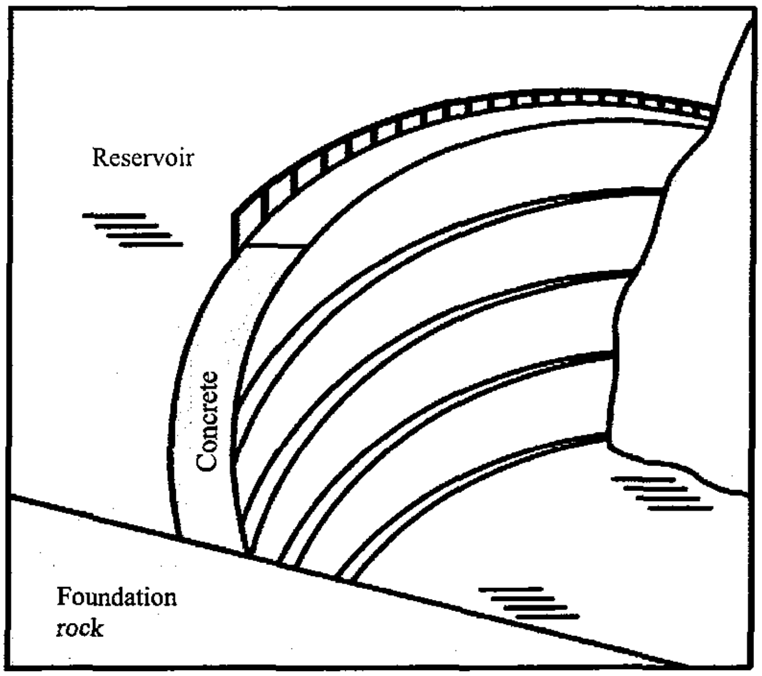


O Chum 2 dam

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HD2-3**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Dam types (3)**			

2. Concrete Arch Dam

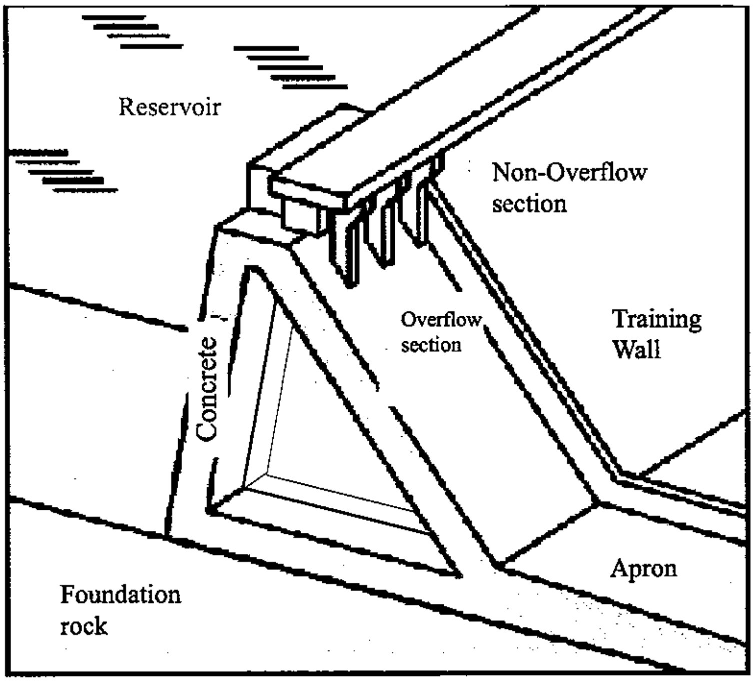


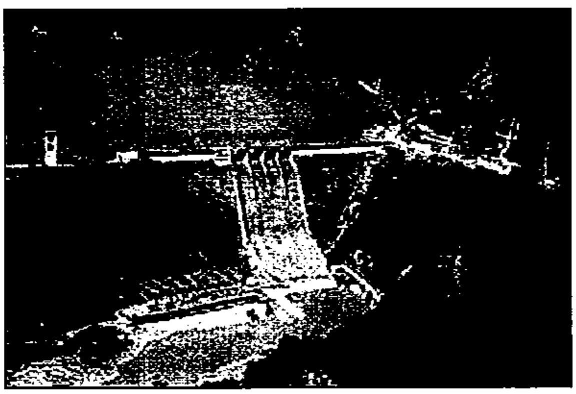
Concrete Arch Dam

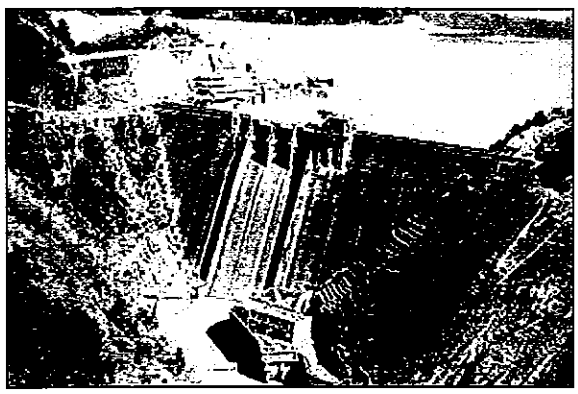
Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HD2-4
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD2-4
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Dam types (4)			

3. Concrete Hollow Gravity Dam







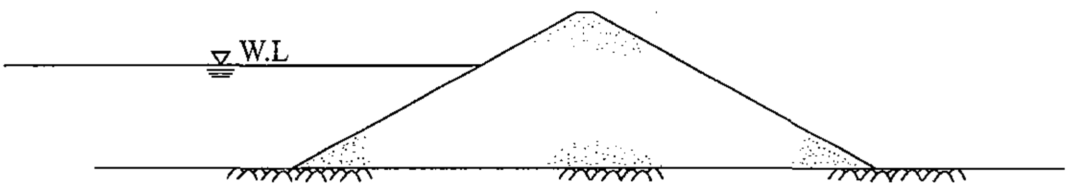
Concrete Hollow Gravity Dam

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD2-5
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Dam types (5)			

Examples of Fill Dam

1. Homogeneous Type Fill Dam



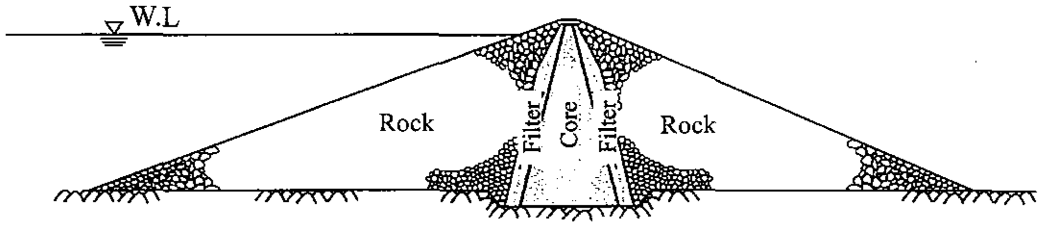
O Chum 1 dam

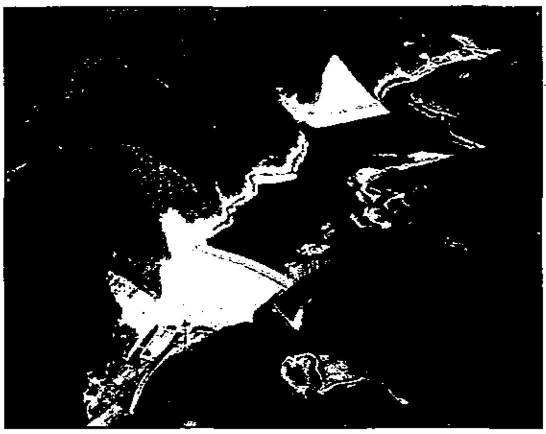
Kirirom 1 dam

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HD2-6
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Dam types (6)			

2. Zoned Type Fill Dam





(Arial view)

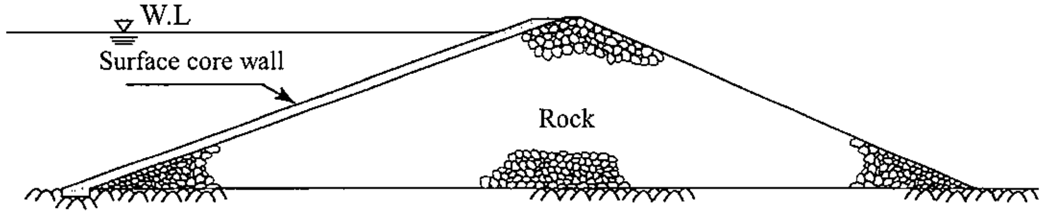
(View from the downstream)

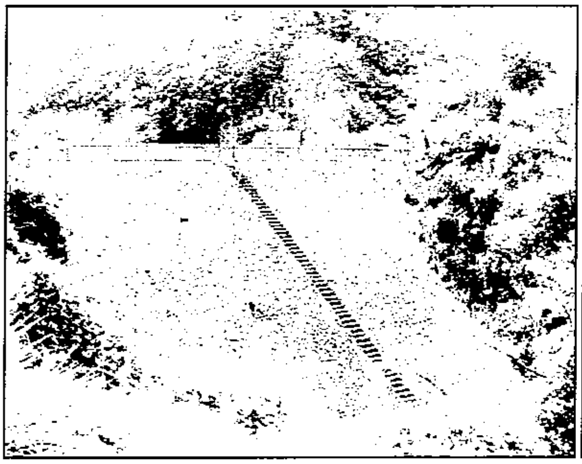
Zoned Type Fill Dam

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HD2-7**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Dam types (7)**			

3. Surface Diaphragm Type Fill Dam





http://www2u.biglobe.ne.jp/~damu/photo/library/kobuchi.jpg

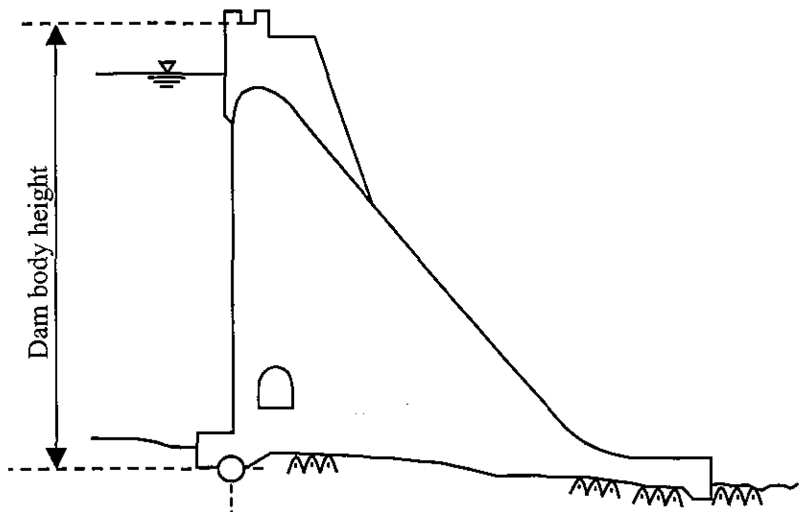
Surface Diaphragm Type Fill Dam

Remarks	Revisions	
http://www2u.biglobe.ne.jp/~damu/photo/library/kobuchi.jpg		
	2003/Nov.	Original

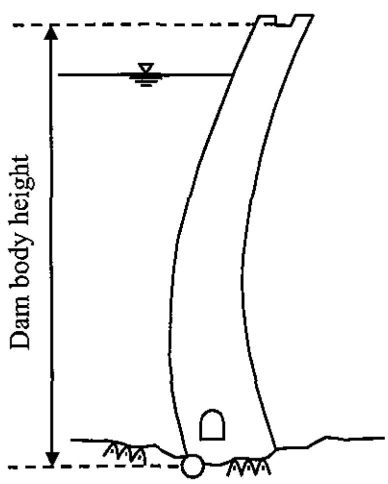
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD3-1
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Dam Body Height (1)			

"Dam body height" means a difference in elevation between the lowest part of dam body foundations and the crest of the non-overflow section of the dam body.

Definition of Dam Body Height by dam type.



1. Concrete Gravity Dam

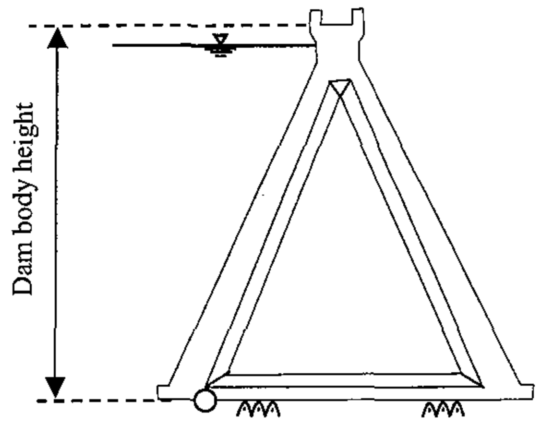


2. Concrete Arch Dam

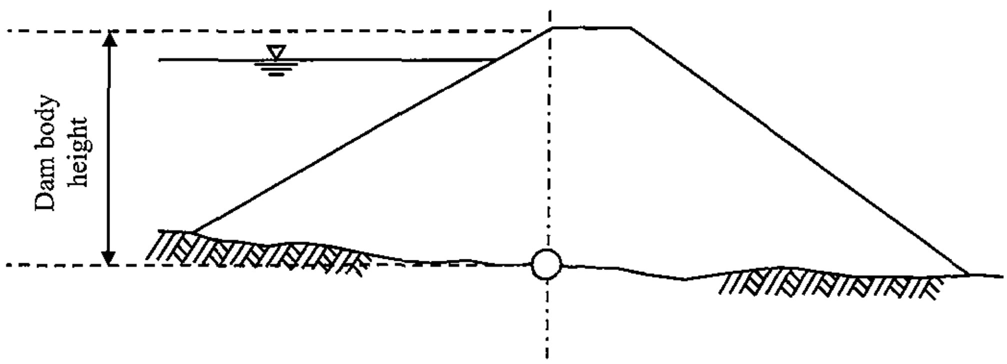
Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD3-2
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Dam Body Height (2)			

Definition of Dam Body Height by dam type (cont.)



3. Concrete Hollow Gravity Dam

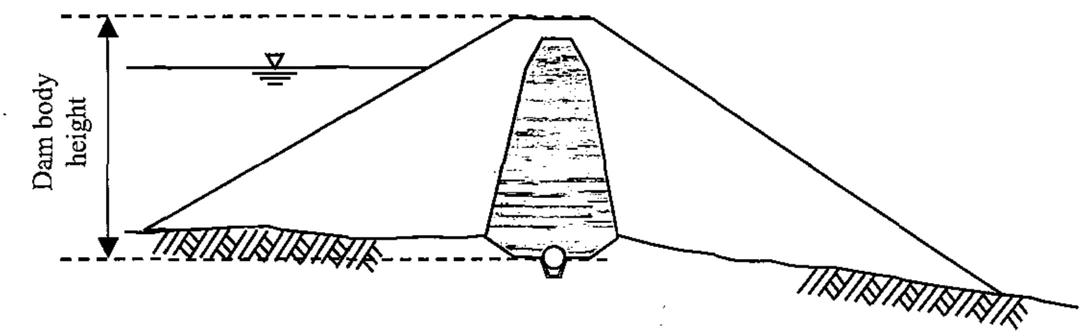


4. Homogeneous Type Fill Dam

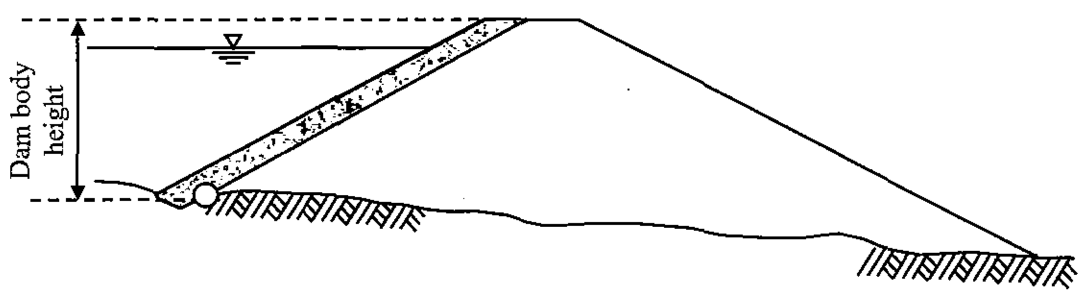
Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HD3-3**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Dam Body Height (3)**			

Definition of Dam Body Height by dam type (cont.)



5. Zoned Type Fill Dam



6. Surface Diaphragm Type Fill Dam

Remarks	Revisions	
	2003/Nov.	Original

Category				Document
	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD4-1
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	*26*	*Dams, Waterways, Powerhouses and Other Facilities*	

Title	**Inflow Design Flood (1)**

Inflow design flood shall be properly set for every dam based on hydrological observation, research, and study, taking account of the impacts caused by dam failure to human safety, properties, economy, environment and so on.

Examples of inflow design flood, in Japan, U.S.A, and China.

1. Japan (Example of "Ministerial Ordinances on Regulating Technical Standards Related to Hydropower Stations, JFY1998")

Inflow design flood for dams with the height 15m or more shall be the maximum flood among the following three methodologies:

(1) The flood expected to occur once every 200 years at the direct upstream of the dam. In case the flow derived from this calculation is inappropriate in terms of the calculation method, 1.2 times of the flood expected to occur once every 100 years should be applied;

(2) The maximum flood ever experienced at the direct upstream of the dam; and

(3) The flood estimated on the basis of hydrological or meteorological data for the largest floods that occurred in the watershed where the dam is to be built and another watershed with similar hydrological or meteorological properties to the watershed.

1.2 times larger flood than the above maximum flood is applied as an inflow design flood of a fill dam.

Inflow design flood which is the flood expected to occur once every 100 years at the direct upstream of the dam, shall be applied to dams lower than 15m in height without purpose of flood control.

2. U.S.A.

Example of "Civil Engineering Guidelines for Planning and Designing Hydroelectric Development" American Society of Civil Engineers

Hazard level	Size of dam	Design flood discharge
Low	Small	50-year to 100-year flood
	Intermediate	100-year flood to 1/2 PMF
	Large	1/2 PMF to PMF
Significant	Small	100-year flood to 1/2 PMF
	Intermediate	1/2 PMF to PMF
	Large	PMF
High	Small	1/2 PMF to PMF
	Intermediate	PMF
	Large	PMF

Remarks

- Ministerial Ordinances on Regulating Technical Standards Related to Hydropower Stations, 1998, Japan
- Civil Engineering Guidelines for Planning and Designing Hydroelectric Development, American Society of Civil Engineers

Revisions	
2003/Nov.	Original

Category				Document No.HD4-2
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Inflow Design Flood (2)**			

U.S.A (cont.)

Hazard level classifications:

Hazard level	Explanation
Low	No loss of life expected because no permanent structures for human habitation exist downstream of the dam. Minimal economic loss is expected because the area is undeveloped, or has only occasional structures for agricultural or other use.
Significant	Few deaths expected, due to lack of concentrated (urban) development and few habitable structures. Economic loss would be appreciable due to significant agricultural or industrial development.
High	Numerous deaths expected. Excessive property damage to communities, industry or agriculture.

Dam size classifications:

Category	Reservoir capacity (acre-feet)	Height of the dam (feet)
Small	between 50 and 1,000 ($0.062 \sim 1.23 \times 10^6 m^3$)	between 25 to 40 (7.62 ~ 12.2 m)
Intermediate	between 1,000 and 50,000 ($1.23 \sim 61.7 \times 10^6 m^3$)	between 40 to 100 (12.2 ~ 30.5 m)
Large	more than 50,000 ($61.7 \times 10^6 m^3$)	more than 100 (30.5m)

3. China

Inflow Design Flood

Annual Exceedance Probability (unit: years)

Structure ranking		1	2	3	4	5
Normal operation	Permanent Structure	500	100	50	30	20
Emergency operation	Earth dam, rock fill dam, masonry dam with fine materials	10,000 or PMF	2,000	1,000	500	200
	Concrete dam, masonry dam with coarse materials, and other river structure	5,000	1,000	500	200	100

In case a dam with a large reservoir whose collapse may result in a relatively large disaster to the downstream area, and a fill dam with an important intermediate scale reservoir or an extremely important small reservoir, PMF shall be applied as an inflow design flood under emergency

Remarks	Revisions	
Civil Engineering Guidelines for Planning and Designing Hydroelectric Development, American Society of Civil Engineers		
	2003/Nov.	Original

Category				Document
	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD4-3
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Inflow Design Flood (3)**			

China (cont.)

Structure ranking

Project ranking	Permanent structure ranking		Temporary structure ranking
	Major structure	General structure	
I	1	3	4
II	2	3	4
III	3	4	5
IV	4	5	5
V	5	5	-

Prescribed in GB50199

Project ranking

Project ranking	Storage capacity ($10^6 m^3$)	Hydro-electric power plant	Flood control		Counter-measure against flooding	Irrigation	Water service
		Installed capacity (MW)	Urban and industrial area	Farmland (10^3ha)	Drainage area (10^3ha)	Irrigation land area (10^3ha)	City water and mine industry
I	>1,000	>750	Very important	>333	>133.3	>100	Very important
II	1,000~100	750~250	Important	333~67	133.3~40	100~33.3	Important
III	100~10	250~25	Intermediate	67~20	40~10	33.3~3.3	Intermediate
IV	10~1.0	25~0.5	Normal	20~3.3	10~2.0	3.3~0.3	Normal
V	<1.0	<0.5	-	<3.3	<2.0	<0.3	-

Prescribed in GB50199

Remarks	Revisions	
GB50199, China		
	2003/Nov.	Original

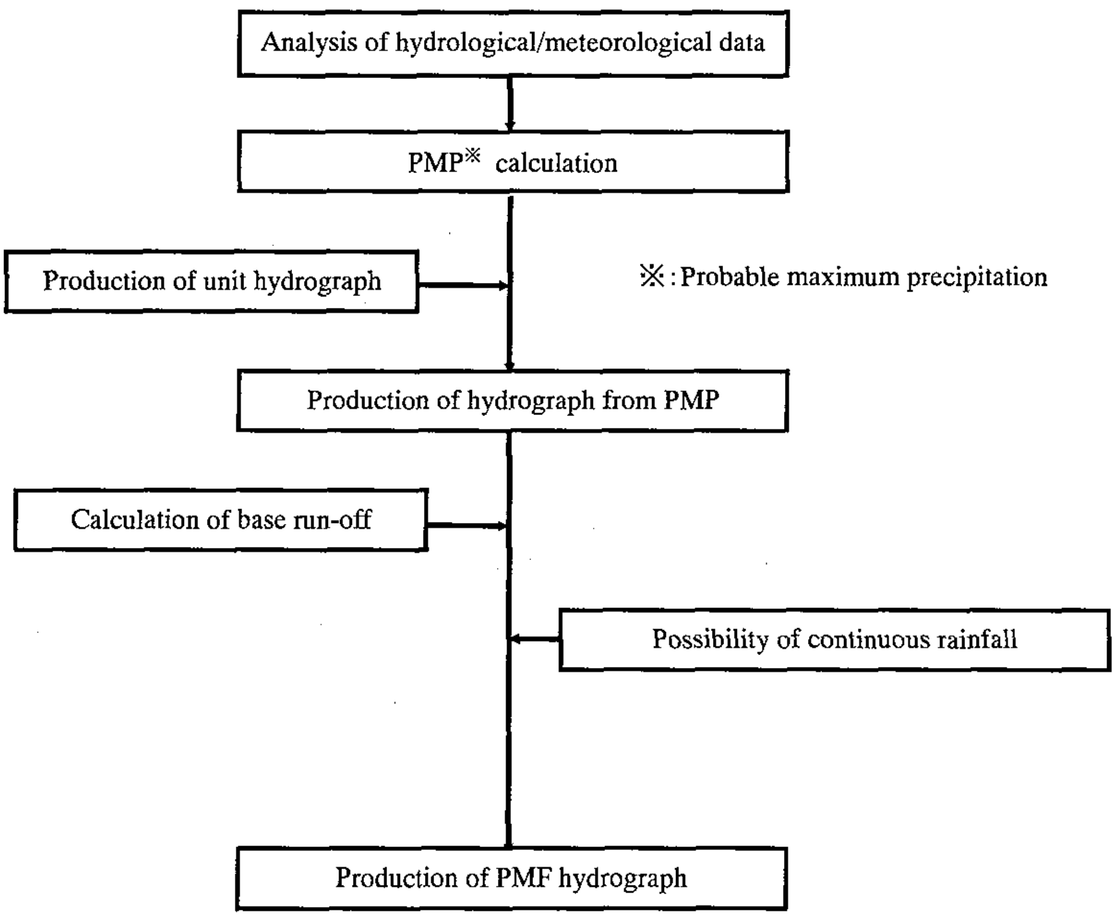
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD5
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	PMF (Probable Maximum Flood)			

PMF (Probable Maximum Flood)

PMF is generally defined as flood expected when the theoretically worst hydrological and meteorological conditions are combined in an area.

It is necessary to consider the two factors of "run-off due to rainfall" and "base run-off" that form PMF. It is also necessary to examine the possibility of rainfall occurring in a few day intervals.

A flow chart of PMF calculation is described as follows.



Flow of PMF calculation

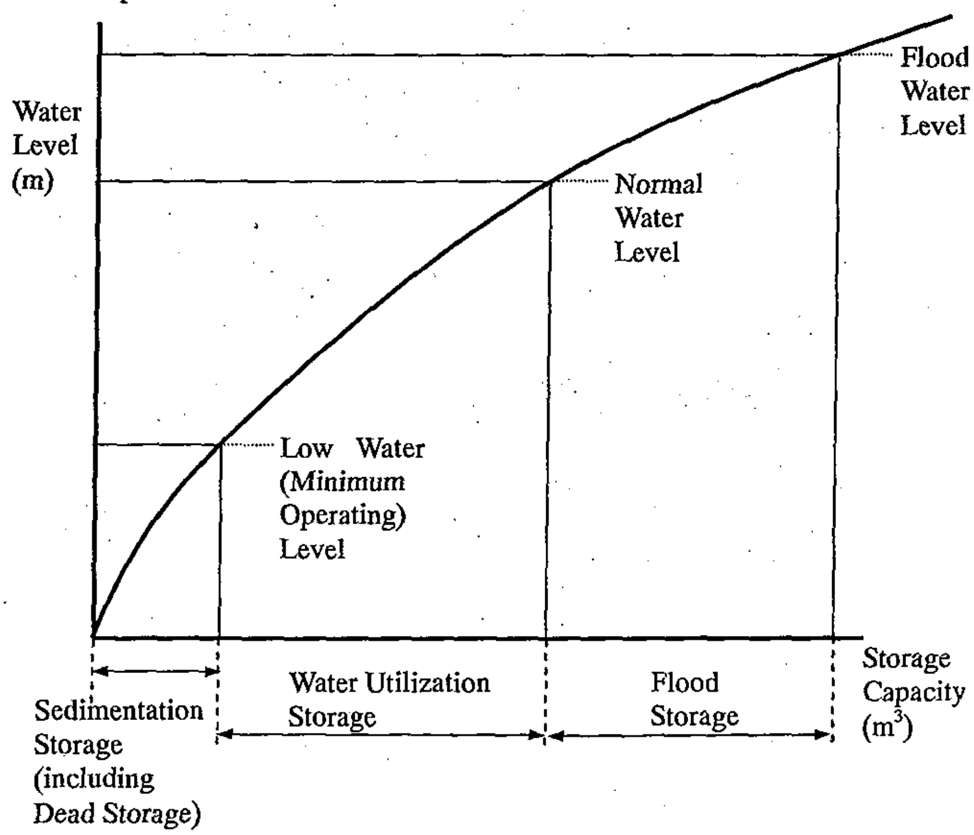
Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HD6**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Basic Water Levels**			

Basic water levels, on which the specifications of dams are to be determined, shall be set as follows:

1. "Normal Water Level" shall be the highest level of water stored in a reservoir of a dam during a non-flood period;
2. "Flood Water Level" shall be the highest water level when an inflow design flood flows over a spillway. In the case that the storage effect of a reservoir is obviously identified, the flood water level may be the water level deducted the height in consideration of the storage effect from the highest water level; and
3. "Low Water Level" shall be the lowest level of water stored in a reservoir of a dam under normal reservoir operation.

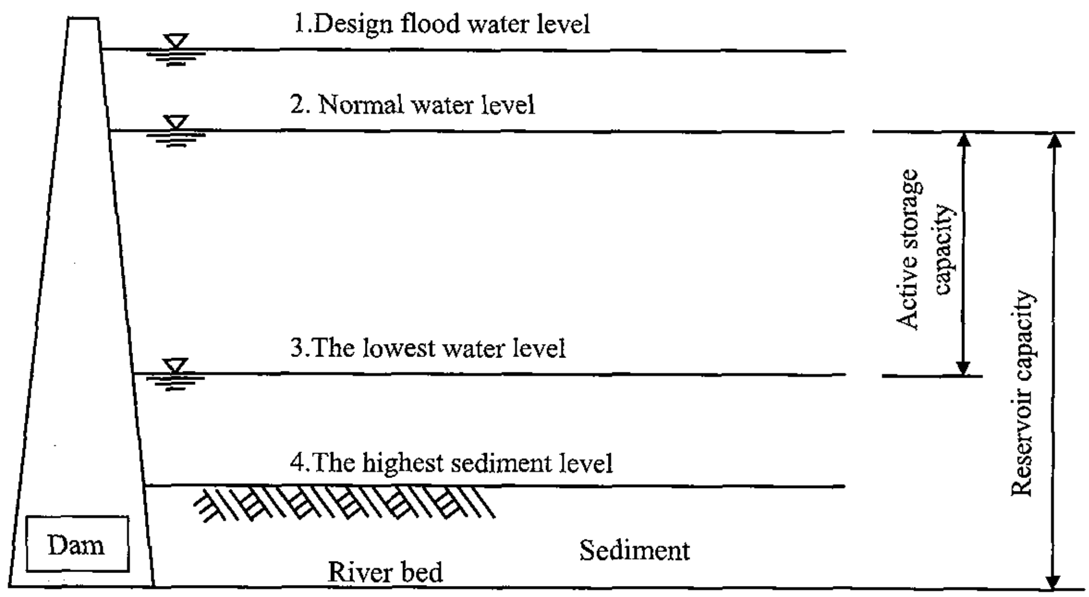
Example of Basic Water Level



Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HD7**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Examples for Reservoir Water Level**			

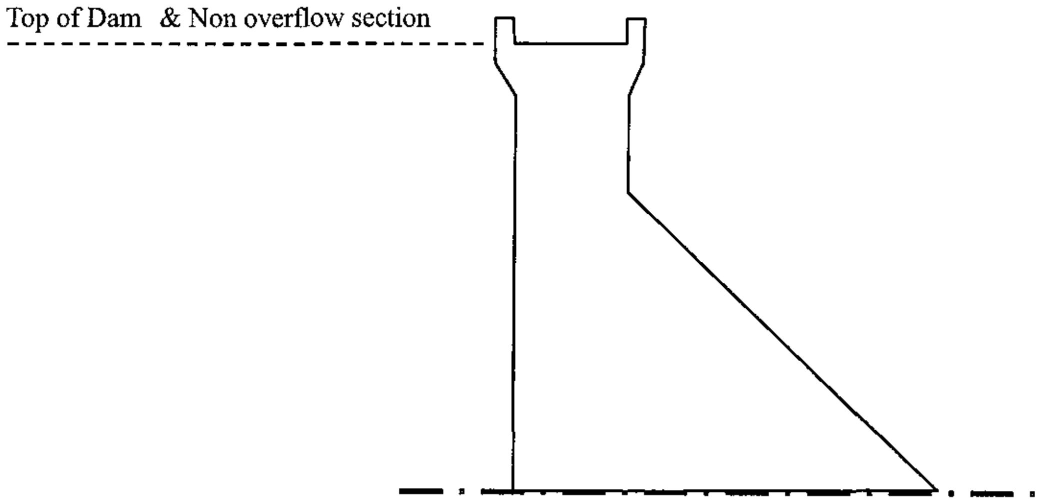
1. Design flood water level
2. Normal water level
3. The lowest water level
4. The highest sediment level



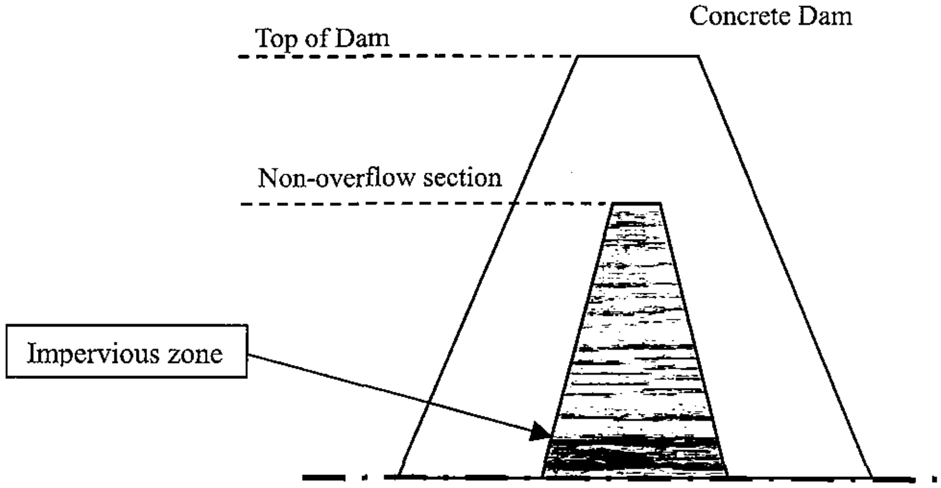
Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HD8-1
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Position of Non-Overflow Portion (1)**			

1. The position of a non-overflow portion of a dam body shall be higher than either the level of the normal water level plus a freeboard or that of the flood water level plus a freeboard.
2. The position of a non-overflow portion of the fill type dam body shall be equal to the crest height of its impervious zone.



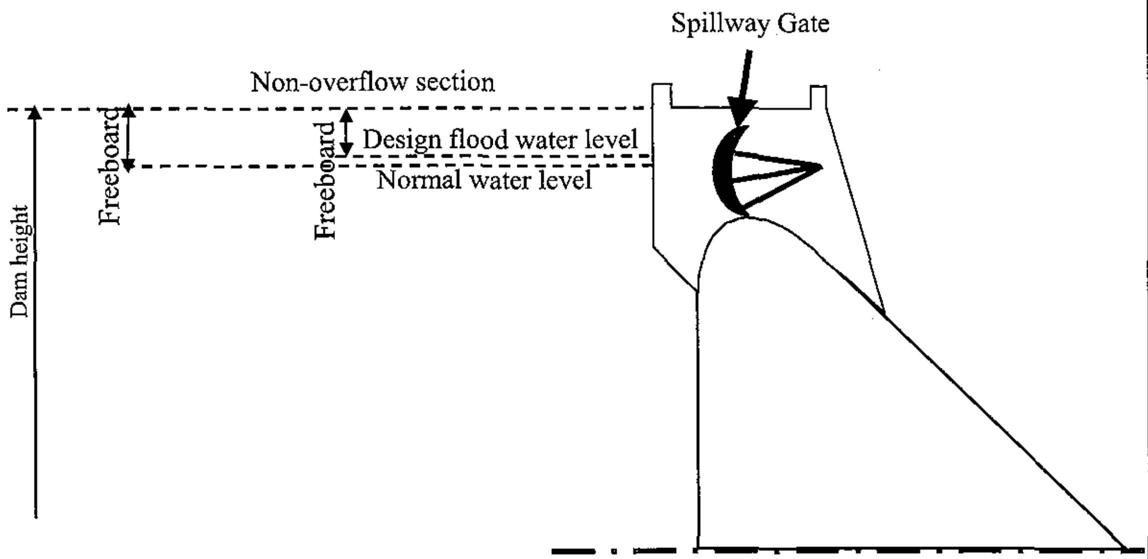
Concrete Dam

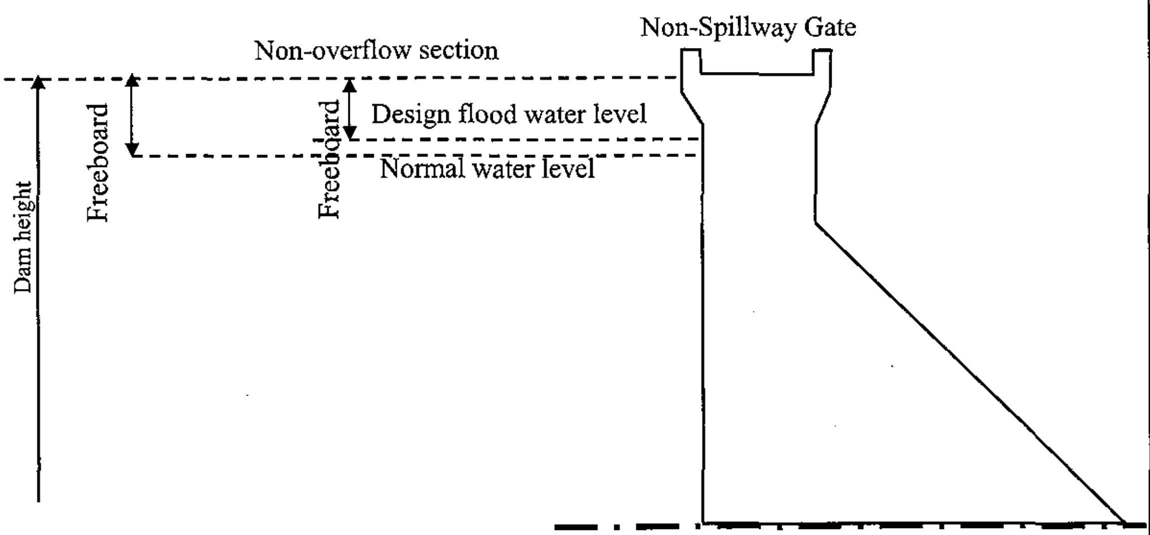


Fill Dam (Zoned Type)

Remarks	Revisions	
	2003/Nov.	Original

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD8-2
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Position of Non-Overflow Portion (2)**			





Concrete Dam

Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HD9**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Freeboard**			

Freeboard shall be set for the flood water level and the normal water level of the dam respectively in consideration of type of the dam, wind-induced waves, earthquake-induced waves, and existence of a spillway gate.

Example of freeboard in Japan

(1) Freeboard for normal water level (normal freeboard)

$h_w + h_e + h_a + h_i$ and 2m or higher

(2) Freeboard for flood water level (minimum freeboard)

$h_w + h_a + h_i$ and 1m or higher

Where,
h_w : the wave height caused by wind
h_e : the wave height caused by earthquake
h_a : 0.5 m in case the dam has a spillway gate and 0 m otherwise
h_i : 1 m for a fill dam and 0 m for a concrete dam.

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

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HD10**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Loads Acting on Dam Bodies**			

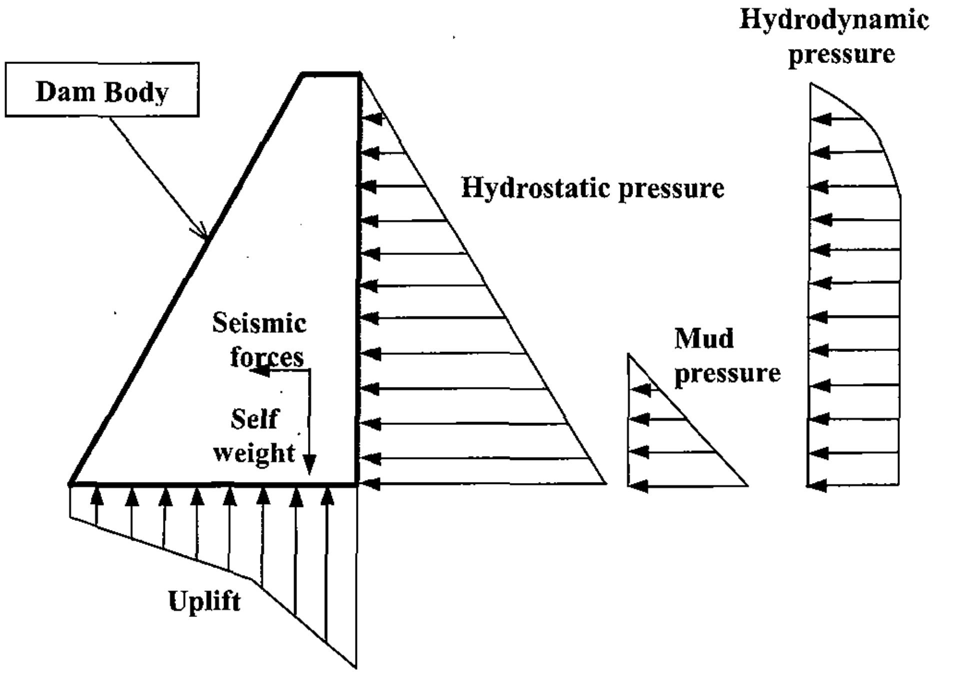
Loads acting on dam bodies, which are considered for design of the bodies, shall be set corresponding to the following table:

Loads Acting on Dam Bodies

Type of dam	Concrete gravity dam	Concrete arch dam	Fill dam
Loads	- Self-weight - Hydrostatic pressure - Hydrodynamic pressure - Mud pressure - Seismic forces - Uplift	- Self-weight - Hydrostatic pressure - Hydrodynamic pressure - Mud pressure - Seismic forces - Uplift - Temperature load	- Self-weight - Hydrostatic pressure - Seismic forces - Pore pressure

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HD11-1
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD11-1
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Calculations of Loads Acting on Dam Bodies (1)			



1. Self weight

Self weight shall be calculated based on the density of the dam material.

For gravity dams in Japan with a height less than 15 m, the unit weight of concrete can be 2.3 t/m^3.

2. Hydrostatic pressure

Hydrostatic pressure shall be imposed perpendicularly on the surface contacting the dam and calculated based on the value derived from the following formula:

$P = gW_oH$

Where,

P: the hydrostatic pressure at a random point on the contacting surface (in units kPa);

g: the gravity per unit mass (9.8 N/kg);

W_o: the unit weight of water (in units t/m^3); and

H: the unit weight of water between the water level in the upstream directly of the dam plus the surge level and a random point on the contacting surface (in units m).

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

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD11-2
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Calculations of Loads Acting on Dam Bodies (2)			

3. Hydrodynamic pressure

Hydrodynamic pressure shall be imposed on a vertical surface, and calculated based on the value derived from the formula given under a). In case the upstream end of the dam is a slope, it can be calculated based on the value derived from the formula given under b):

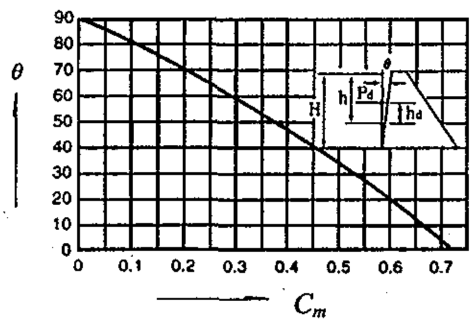
a) $$P_d = \frac{7}{8} g W_0 k_1 \sqrt{Hh}$$: Westergaard's approximate formula

b) $$P_d = gCW_0 k_1 H$$

$$C = \frac{C_m}{2}\left[\frac{h}{H}\left[2-\frac{h}{H}\right]+\sqrt{\frac{h}{H}\left[2-\frac{h}{H}\right]}\right]$$: Zanger's formula

Where,

P_d: the hydrodynamic pressure at a random point on the upstream end (in units kPa);
g: the gravity per unit mass (9.8 N/kg);
W_o: the unit weight of water (in units t/m^3);
k_1: the design seismic coefficient;
H: the depth of water between the water level in the direct upstream of a dam and the foundation at the direct upstream of a dam (in units m);
h: the depth of water between the water level in the direct upstream of a dam and a random point on the cross section surface (in units m); and
C_m: the value obtained from the below diagram.



θ : Angle of the slope at the upstream end of the dam to the vertical line

4. Seismic forces

Seismic force acting on the dam body shall be deemed as acting horizontally on the dam body as static design seismic coefficient. Design seismic coefficient shall be determined by considering various parameters, including the level of seismic activity at the dam site, geological conditions of the foundation, type of dam, and reservoir operational conditions.

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

Category				Document No.HD11-3
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Calculations of Loads Acting on Dam Bodies (3)**			

Example of the design seismic coefficient in Japan

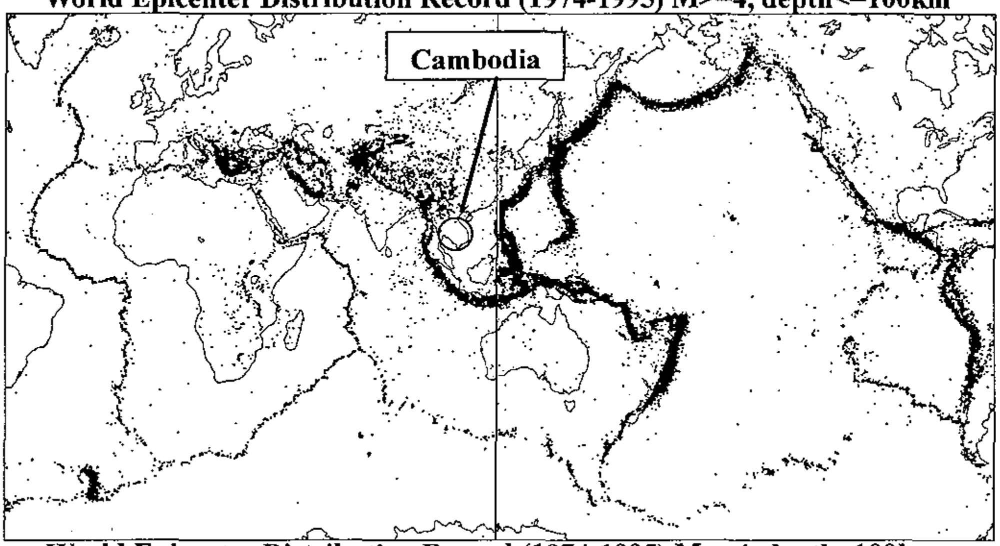
Type of dam		Gravity dam and hollow gravity dam	Arch dam	Fill dam	
				Material used for the dam is roughly *homogeneous*	The others
Minimum design seismic coefficient	Severe earthquake zones	0.12	0.24	0.15	0.15
	Moderate earthquake zones	0.12	0.24	0.15	0.12
	Minor earthquake zones	0.10	0.20	0.12	0.10

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

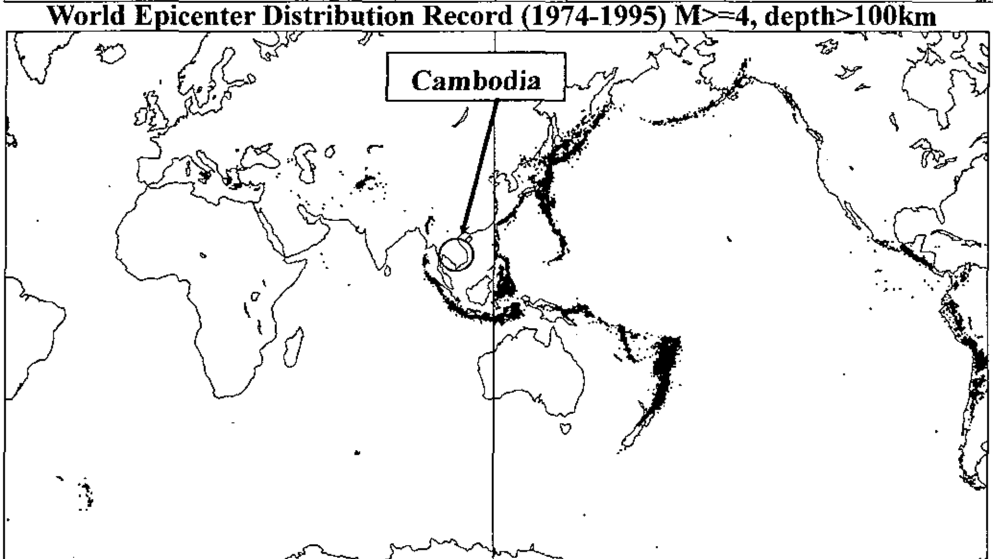
Category				
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD11-4
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Calculations of Loads Acting on Dam Bodies (4)			

Although no earthquake more than M=4 has been recorded for a long period in and around Cambodia land area and lack of sufficient data for determining the design seismic coefficient in Cambodia, the design seismic coefficient shall be applied for a dam taking account of the conditions such as geology of foundations, its location, and importance from the view point of safety, economy and environment at the downstream.

World Epicenter Distribution Record (1974-1995) M>=4, depth<=100km



World Epicenter Distribution Record (1974-1995) M>=4, depth>100km



Source: Chronological Scientific Tables 2003, National Astronomical Observatory, Japan

Remarks	Revisions	
Chronological Scientific Tables 2003, National Astronomical Observatory, Japan		
	2003/Nov.	Original

Category				Document
	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD11-5
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Calculations of Loads Acting on Dam Bodies (5)**			

5. Mud pressure

Mud pressure shall be calculated based on the value derived from the following formula:

$P_{ev} = g\ W_1\ d$

$P_{eh} = g\ C_e\ W_1\ d$

Where,

P_{ev}: the vertical component of mud pressure at a random point on the contacting surface with the dam (in units kPa);

P_{eh}: the horizontal component of mud pressure at a random point on the contacting surface with the dam (in units kPa);

g : the gravity per unit mass (9.8 N/kg);

C_e : the mud pressure coefficient;

W_1: the value derived from the following formula (in units t/m^3); and

d: the depth of water between the sedimentation surface and a random point on the contacting surface with the dam

$W_1 = W - (1 - v)\ W_0$

Where,

W: the unit weight of sediment (in units t/m^3);

v: void ratio of sediment; and

W_o: the unit weight of water (in units t/m^3)

For the mud pressure coefficient and so on, the following ranges of values are adopted in Japan.

$C_e = 0.4 \sim 0.6$ $W = 1.6 \sim 1.8$ $v = 0.30 \sim 0.45$

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

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HD11-6**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Calculations of Loads Acting on Dam Bodies (6)**			

6. Uplift

Uplift for a concrete dam shall be determined by considering the permeability of the foundation after treatments, and drainage.

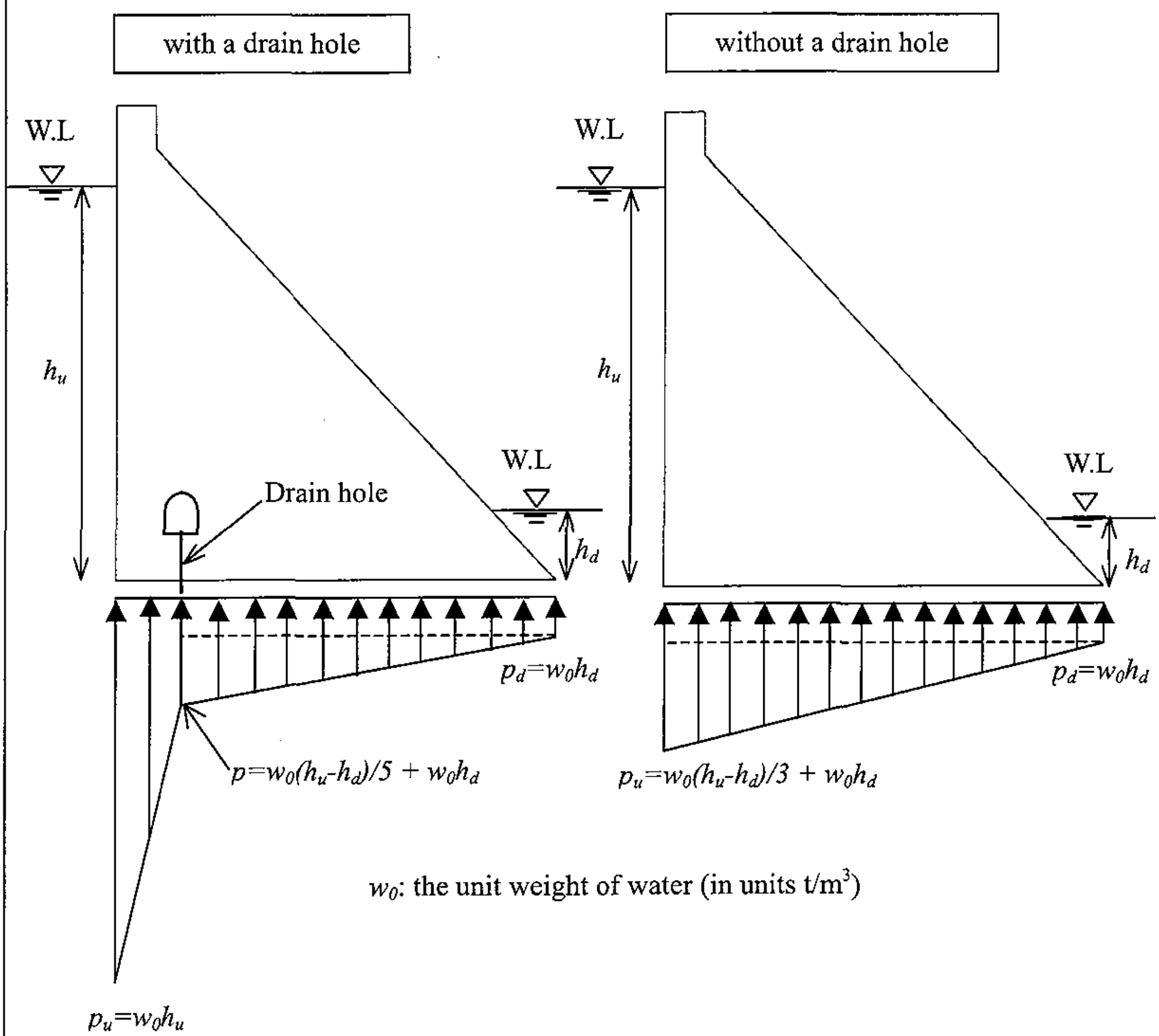
Example of uplift calculation in Japan

<table>
<tr><th colspan="2" rowspan="2">Type of dam</th><th colspan="3">Uplift</th></tr>
<tr><th>At upstream end</th><th>At a drainage hole or at joint between the head and web</th><th>At downstream end</th></tr>
<tr><td rowspan="2">Concrete gravity dam and arch dam</td><td>At horizontal cross section with a drain hole</td><td>Water pressure caused by depth of water between the water level at the upstream end of the dam and the horizontal cross section</td><td>1/5th of the difference in water pressure between at the upstream end and at the downstream end, plus the water pressure at the downstream end</td><td rowspan="3">Water pressure caused by depth of water between the water level at the downstream end of the dam and the horizontal cross section</td></tr>
<tr><td>At horizontal cross section without a drain hole</td><td>1/3rd of the difference in water pressure between at the upstream end, that is caused by depth of water between the water level at the upstream end the dam and the horizontal cross section, and at the downstream end, plus the water pressure at the downstream end</td><td></td></tr>
<tr><td colspan="2">Concrete hollow gravity dam</td><td>Water pressure caused by depth of water between the water level at the upstream end of the dam and the horizontal cross section</td><td>1/10th of the difference in water pressure between at the upstream end and the downstream end, plus the water pressure at the downstream end</td></tr>
</table>

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

Category				
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD11-7
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Calculations of Loads Acting on Dam Bodies (7)**			

Uplift distribution for cross section of concrete gravity dam and arch dam



Remarks	Revisions	
	2003/Nov.	Original

Category				
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD11-8
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Calculations of Loads Acting on Dam Bodies (8)**			

7. Temperature loads

Temperature loads shall be calculated according to the difference between the temperature inside the dam at contraction joint grouting and the highest and the lowest temperatures inside the dam after grouting.

8. Pore pressure

(1) Pore pressure shall be calculated based on the penetration flow.

(2) Pore pressure for a fill dam shall be determined by considering the permeability of the materials used for the dam body, and drainage, and based on calculations, tests and experience through actual measurements of seepage flow.

Remarks	Revisions	
	2003/Nov.	Original

Category				Document
	Chapter	2	Technical Standards of Electric Power Facilities	**Document No.HD12**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Combination of Loads Acting on Dam Bodies**			

Example in Japan

Type of dam		Gravity dam and hollow gravity dam	Arch dam	Fill dam
Loads	When the water level at the upstream end of a dam is at normal water level or at surcharge water level.	- Self weight - Hydrostatic pressure - Hydrodynamic pressure - Mud pressure - Seismic forces - Uplift	- Self weight - Hydrostatic pressure - Hydrodynamic pressure - Mud pressure - Seismic forces - Uplift - Temperature loads	- Self weight - Hydrostatic pressure - Seismic forces - Pore pressure
	When the water level at the upstream end of a dam is at design flood water level.	- Self weight - Hydrostatic pressure - Mud pressure - Uplift	- Self weight - Hydrostatic pressure - Mud pressure - Uplift - Temperature loads	- Self weight - Hydrostatic pressure - Pore pressure
	When the water is empty at the upstream end of a dam	- Self weight - Seismic forces		
	When the water level at the upstream of a dam decreases quickly from the normal water level to the low water level.			- Self weight - Hydrostatic pressure - Seismic forces - Pore pressure

Remarks

Interpretation of Technical Standards for Hydropower Stations, 1998, Japan

Revisions	
2003/Nov.	Original

Category				Document
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD13
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Dam Foundations**			

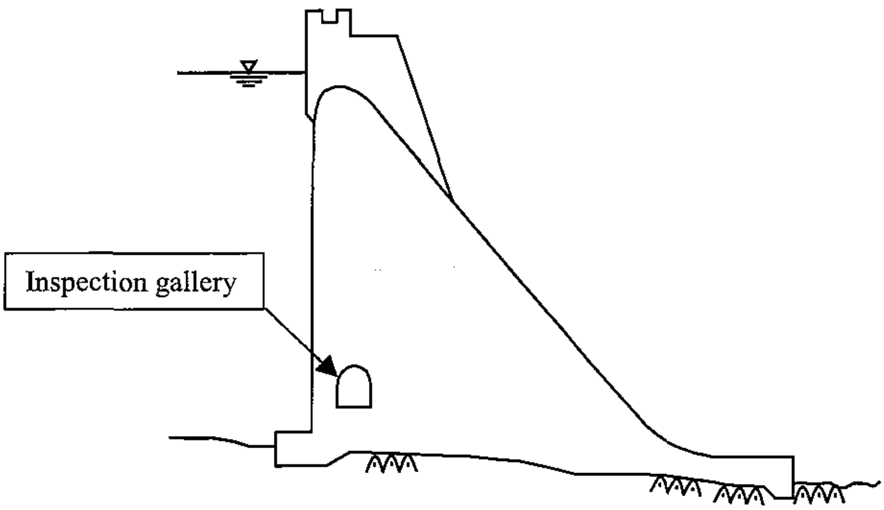
Dam foundations shall meet the following:

1. Dam foundations shall be properly investigated about their geology, permeability, and physical and mechanical properties, taking into account whether the dam is crucial for human safety, properties, economy, and environment, in order to properly evaluate dam stability and seepage properties;
2. Dam foundations shall have a required bearing capacity and a shear strength, and not result in serious settlements, deformations, cracks, sliding failure, or serious erosion;
3. Proper treatments such as grouting or drainage shall be taken at dam foundations in order to protect the dams from excessive uplift, serious water leakage, or seepage failure;
4. Proper treatments shall be taken to any faults or other weak strata in dam foundations, which may harm dam stability and seepage failure, so that the foundations have required strength and water-tightness; and
5. Proper treatments shall be taken to any faults or other weak strata, which may cause harmful settlements, in the dam foundations

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HD14
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Monitoring and Inspections**			

1. Monitoring equipment shall be equipped and periodical monitoring shall be done corresponding to soundness of a dam body and progress of sedimentation in a reservoir, in order to confirm the safety and proper functions of the dam body, and the proper functions of the reservoir, in such cases that:
   - The dam is crucial for human safety, properties, economy, and environment;
   - The type of the dam is unique;
   - High permeability in the dam foundations before taking foundation treatments; and
   - Existence of a large weak stratum with insufficient strength in the foundations before taking foundation treatments.
2. In case of unusual loads such as earthquake and flood, an inspection shall be immediately done in order to confirm the safety and proper functions of the dam.
3. It is desirable that a dam such as mentioned in Section 1 shall have inspection galleries according to needs for inspections and repairs.



Remarks	Revisions	
	2003/Nov.	Original

Category	**Chapter**	2	Technical Standards of Electric Power Facilities	**Document No.HD15**
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Equipment for Inspection of Dam Soundness**			

1. Concrete dam
Volume of water leakage, Uplift, Deformation and Sedimentation

2. Fill dam
Volume of water leakage, Deformation, Permeation line (for homogeneous type) and Sedimentation

Dam Monitoring Items (Example in Japan)

Type of dam and its height	Concrete gravity dam and hollow gravity dam		Arch dam		Fill dam	
	under 50m	50m and more	under 30m	30m and more	Material used for the dam is almost homogeneous	Others
Monitoring items	Volume of the water leakage and Uplift	Volume of the water leakage, Uplift, and Deformation	Volume of the water leakage and Deformation	Volume of the water leakage, Uplift, and Deformation	Volume of the water leakage, Deformation, and Permeation line	Volume of the water leakage and Deformation

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

Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD16
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Emergency Inspection Items in Case the Abnormal Loads are Acted**			

1. Volume of water leakage through a dam body
2. Volume of water leakage through surrounding grounds of a dam
3. Uplift of a concrete dam body
4. Deformation and permeation line of a fill dam body
5. Proper function of a spillway gate

etc.

Remarks	Revisions	
	2003/Nov.	Original

Category				Document No.HD17
	Chapter	2	Technical Standards of Electric Power Facilities	
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Concrete Materials**			

Concrete materials for dams shall be confirmed whether they meet the following requirements through the tests that are specified in a standard such as ISO (the International Organization for Standardization), or be such materials that are specified in a standard for example ISO, which meets the following requirements:

1. Cement shall be capable of adequately cementing and solidifying corresponding to its quality;
2. Aggregates shall be adequately strong and durable;
3. Aggregates, water, and admixtures shall be free of acid, salt, organic substances, and mud, which prevent concrete from cementing, seriously rusts reinforcements, or prevent adhesion between concrete and reinforcements; and
4. Properties of concrete such as unit weight, strength, deformation modulus and the Poisson's ratio shall be determined by testing the materials to be used.

References

(Cements)
- ISO679: 1989/ Method of testing cements- Determination of strength
- ISO9597: 1989/ Cements- Test methods- Determination of setting times and soundness
- ISO680: 1990/ Cements- Test methods- Chemical analysis
- ISO863: 1990/ Cements-Test methods- Pozzolanicity test for pozzolanic cements
- ISO3048: 1974/ Gypsum plasters- General test conditions
- ISO3049: 1974/ Gypsum plasters- Determination of physical properties of powder

(Concrete)
- ISO4012/ Concrete- Determination of compressive strength of test specimens
- ISO4108/ Concrete- Determination of tensile splitting strength of test specimens
- ISO4013: 1978/ Concrete- Determination of flexural strength of test specimens
- ISO6784: 1982/ Concrete- Determination of static modulus of elasticity in compression
- ISO6275: 1982/ Concrete, hardened- Determination of density

(Aggregate)
- ISO6274: 1982/ Concrete- Sieve analysis of aggregates
- ISO6783: 1982/ Coarse aggregates for concrete- Determination of particle density and water adsorption- Hydrostatic balance method
- ISO6782: 1982/ Aggregates for concrete- Determination of bulk density

Remarks	Revisions	
	2003/Nov.	Original

Category				
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD18
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	**Foundations of Concrete Dams**			

Foundations of concrete dams shall meet the following:

1. In case the dam safety and stability is crucial for human safety, properties, economy, and environment, properties of dam foundations such as strength and deformation shall be determined in consideration of the geology of the foundations based on the results of in-situ tests. In case that, in principle, the dam is not crucial for human safety, properties, economy, and environment, and the geology of the dam site to be built is similar to that of existing neighbor dams, the foundation properties may be determined in consideration of both the actual results of the existing dams and the geology of the dam to be built; and
2. When an in situ test is conducted, test points that are typical and proper for determining properties of the dam foundations shall be deliberately selected in consideration of the geology of the foundations.

Remarks	Revisions	
	2003/Nov.	Original

Category				
Category	Chapter	2	Technical Standards of Electric Power Facilities	Document No.HD19
	Paragraph	3	Generating Facilities (Hydroelectric Power)	
	Clause	26	Dams, Waterways, Powerhouses and Other Facilities	
Title	Examples of In Situ Test for Dam Foundations			

Method of test and evaluation for dam foundations

	Method of test	Evaluation parameter
Strength	- In situ block (rock) shear test - Triaxial test - Box shear test	- Shear strength τ - Coefficient of internal friction f
Deformability	- In situ load test - Triaxial test	- Elastic modulus E - Modulus of deformation D
Permeability	- Lugeon test - Permeability test	- Lugeon value Lu - Coefficient of permeability k

Remarks	Revisions	
	2003/Nov.	Original