

Geothermal Power Plant

**The Tokyo Electric Power Co., Inc., Japan
Hachijo-jima Geothermal Power Plant
3,300kW**



Outline

All equipment and system except for the civil work and geothermal wells were furnished under the turn-key contract from The Tokyo Electric Power Co., Inc. including the design, engineering, procurement, installation and commissioning.

This plant is located in Hachijo-jima island about 300km south from the Tokyo metropolitan and contributing to about 1/3 of the total power demand in the whole island and was put into commercial operation in March 1999.

The plant has the remote monitoring and control capability from the central control room of the diesel power station about 12km away, no-attended operation can be allowed during the night.

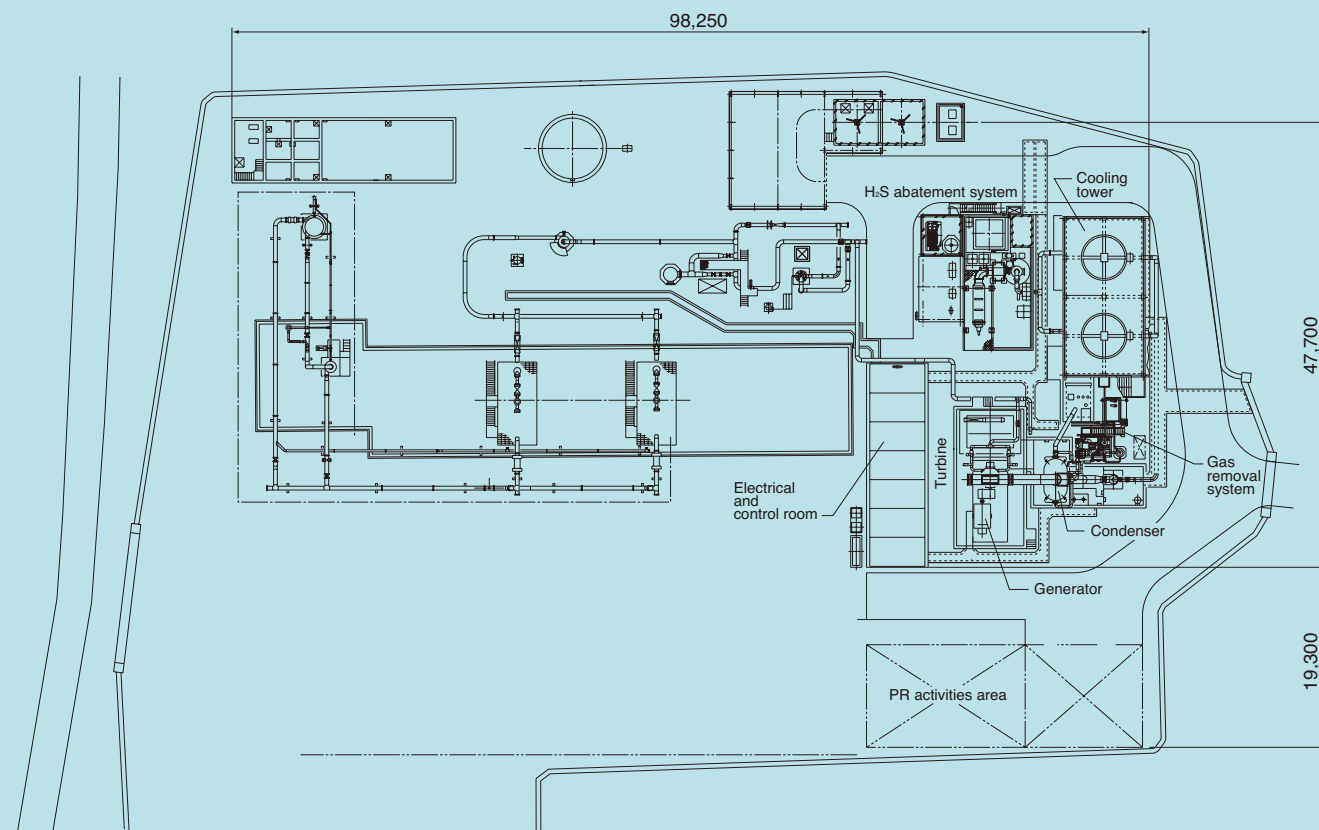
This plant also provides the hot water supplying system to neighbor facilities through plate-fin heat exchangers utilizing the hot water from the condenser.

Location of the plant



Overall layout

[Unit : mm]



Steam Turbine

Fuji standard high-speed reaction turbine is employed to this plant. This turbine is top exhaust single flow skid mounted type and delivered to the site as one package.

The followings are major features of this turbine.

- (1) Reaction blades
- (2) Full arc admission without control stage
- (3) Integral shroud band on moving blades
- (4) Self-standing low pressure blades

Type	: Single cylinder, single flow, top exhaust condensing, high-speed turbine
Rated output	: 3,300kW
Speed	: 7,266r/min
Steam condition	
Pressure	: 0.69MPa g (100psi g)
Temperature	: 170°C
Gas content	: 2.7% (wt.)
Exhaust pressure	: 0.143bar a (4.2inHg a)

Condenser

Low level, spray type, direct contact condenser is adopted. Stainless-clad steel is used to the body of condenser to protect the corrosion from harmful fluid.

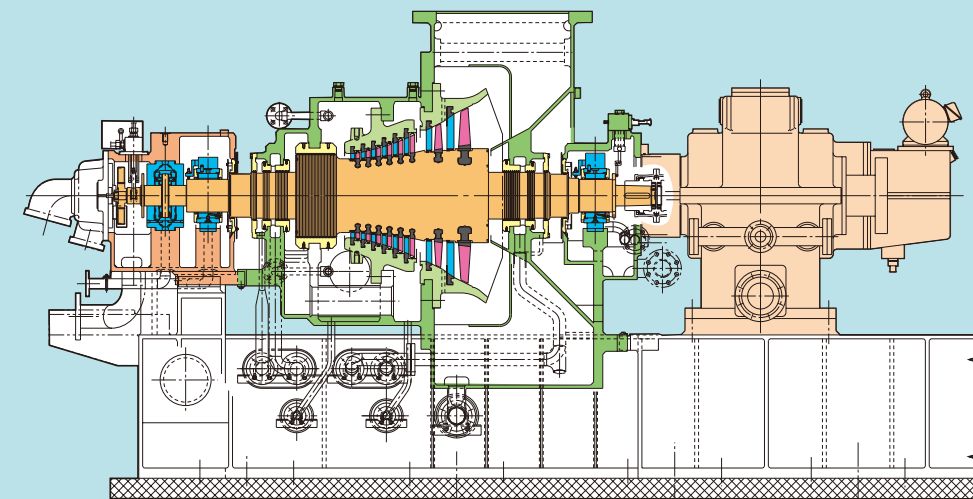
Type	: Low level, spray type direct contact condenser
Pressure	: 0.133bar a (4inHg a)
Cooling water	
Flow	: 1,032m ³ /h (4,540GPM)
Temperature	: 33.2°C

Condenser



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Turbine sectional view



Steam Gathering System

Two-phase geothermal fluids coming from the production wells is transferred to the steam separator and separated to steam and hot water by centrifugal force.

The production wells of this plant are vapor-dominated type, and the impurities, most of them are solids, and tiny rock particles are included.

These particles will cause the sand erosion by high-speed steam velocity. Therefore, the large diameter of steam piping for reducing steam velocity is utilized to protect the sand erosion.

Total pipe length of this steam gathering system is relatively short as shown hereunder.

- From master valve of production well to steam separator : about 30m
- From steam separator to turbine : about 70m

Separator

Type : Vertical, cyclone type, and top outlet

Number : 1

Capacity

Steam : Max. 40t/h (88klb/h)

Hot water : 4t/h (9klb/h)

Design pressure : 0.97MPa g (140psi g)

Design temperature : 200°C (392°F)

Wellhead system



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Separator



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Steam Scrubbing System

The steam scrubbing system is installed upstream of the steam turbine to improve the steam quality.

The system consists of the vane type mist separator and the venturi tube, which can eliminate the impurities.

The main specifications are as follows.

Venturi tube

Steam flow : Max. 40t/h (88klb/h)

Number of nozzles : 4

Injection water flow : 3.7t/h (8klb/h)

Mist separator

Type : Vertical, vane type, and top outlet

Number : 1

Capacity

Steam : Max. 40t/h (88klb/h)

Hot water : 4t/h (9klb/h)

Design pressure : 0.97MPa g (140psi g)

Design temperature : 200°C (392°F)

Venturi tube



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H₂S Abatement System

The fuel gas desulphurization method using magnesium hydroxide in downstream of gas removal system is employed to meet the following requirements.

- (1) H₂S content (700 to 2,000ppm) in geothermal steam of the plant is very high.
- (2) H₂S emission to atmosphere is limited to less than 10ppm by the regulation of the Tokyo metropolitan government.

(3) It is not practical to install a large sized cooling tower to lower the H₂S content in the air blown from the cooling tower.

In the system H₂S gas is burned with LPG and SO_x generated after burning of H₂S gas is desulphurized by the magnesium hydroxide (Mg(OH)₂).

The features of the system are as follows.
(1) The system is simple in construction.

(2) The final waste from the system is a harmless solution of magnesium sulfate and can be easily discharged without the risk of secondary pollution.

(3) It is easy to maintain consistently high desulphurization efficiency by quick responding to any change in load and gas contents.

Firing process for H ₂ S			Desulphurization process		
Firing furnace	Type	Horizontal, cylindrical fixed firing furnace	Absorber	Type	Vertical packing type
	Number	1		Number	1
	Design pressure	0.075bar		Dimension	φ 800×2,000 (length)
	Design temperature	1,200°C	Air blower	Type	Root's type
	Main material	Carbon steel, fire brick		Number	1
Fan for firing	Type	Centrifugal type	Capacity	1,140Nm ³ /h×0.5bar	
	Number	1	Motor rated output	30kW	
	Capacity	3,000Nm ³ /h×0.7bar	Tanks and pits	Oxidizing pit, melting pit for Mg(OH) ₂	
	Motor rated output	11kW	Waste water treatment process		
LPG supply equipment	Type	LPG bomb (50kg)	Filter press	Type	Oil hydraulic auto-press type
	Number	18 (9×2 lines)		Number	1
	Pressure	0.15 to 0.2bar		Capacity	300L
			Tanks and pits	Concrete pit for reaction, flock and precipitation coagulation tank	

H₂S abatement system



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Gas Removal System

The steam jet ejectors are utilized as the gas removal system because of the easy maintenance resulting from a simple structure with no moving parts.

The steam ejector system consists of 2 stages of 100% ×2 trains.

Type	Steam ejector with direct type first and after cooler	
Number	2×100% (1 : back up)	
Capacity	1,181kg/h	
Motive steam	Pressure	0.61MPa g
	Steam consumption	3.9t/h



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Cooling tower



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Cooling Water System

The cooling water flows naturally from the cooling tower cold water basin to the condenser due to the difference in pressure and level. After mixed with the geothermal steam condensate, the hot water flows to the hot water pump suction by gravity and is returned to the cooling tower by the hot water pump.

The cooling tower of the plant is of counter flow type, which are constructed with the concrete body and one sided opened air intake to reduce the noise due to splashing of water droplets.

Cooling tower	Type	Induced draft counter flow type		
	Number	1		
	Water flow	1,262 m ³ /h		
	Cooling water temperature	Inlet	46.6°C	
		Outlet	33.2°C	
	Design wet bulb temperature	21°C		
	Number of cells	2		
Motor rated output	2×55kW			
Pump	Application	Hotwell pump	Cooling water pump	
		Type	Vertical mixed flow type	Horizontal centrifugal type
	Number	1	1	
	Capacity	1,300t/h	260t/h	
	Total head	23m	23m	
	Motor rated output	110kW	30kW	

Hotwell pump



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Electrical and Control System

Plant starting and stopping is performed at the control room of the plant.

After the system is brought up to a steady condition, all necessary monitoring and control of the voltage or load are performed by the ITV at the remote central control room of the diesel power station about 12km far from this plant.

In parallel operation, turbine is usually operated under power control as base load using turbine bypass system, which controls constantly turbine inlet steam pressure by releasing the surplus steams to the condenser.

Electronic governor named "TGR", which has necessary functions such as turbine automatic start up, power control, inlet steam pressure control, load limiting, and AVR, operates this plant.

TGR consists of the digital voltage source, I/O and has redundancy.

Generator protection relays also have redundancy.

Electrical and control panels are installed in the packaged type electrical and control room consists of seven module houses.

As the countermeasures against H₂S gas corrosion to the electrical and instrumentation equipment in the packaged type electrical and control room, H₂S gas absorption filter is installed at air intake of air conditioner.

In addition, the corrosion protection measures such as tin plating, epoxy coating, and special greases are taken to the electrical and instrumentation apparatus.

Packaged type electrical and control room



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Generator

Type	: Horizontal, cylindrical, air cooled
Capacity	: 3,660kVA
Voltage	: 6,900V
Power factor	: 0.93 (leading)
Speed	: 1,500r/min
Frequency	: 50Hz
Excitation	: Brushless

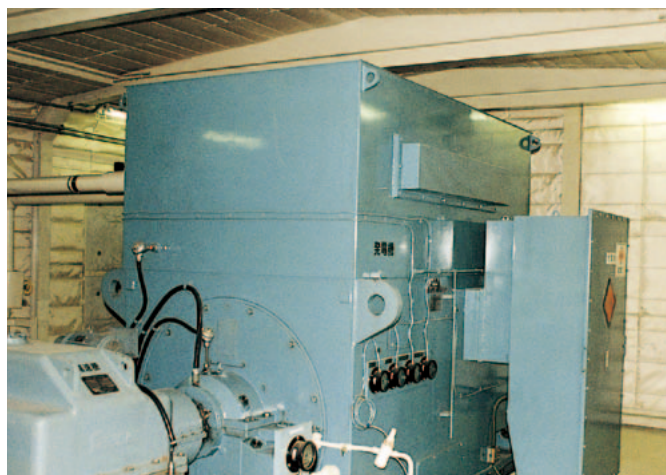
Auxiliary transformer

Type	: Mold type
Capacity	: 600kVA
Voltage	: R6.9-F6.6-F6.3kV/460V

Packaged type electrical and control room

Type	: Aluminum container type composed of 7 module-houses
Number	: 1 house
Dimension	: 21.7m × 5.9m × 3.3m (length × width × height)

Generator



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