Operating Data of Kashiwazaki-Kariwa Nuclear Power Station at the Time of the Occurrence of Niigata-Chuetsu-Oki Earthquake

August 10, 2007

The Tokyo Electric Power Company, Inc.

0. Introduction

The most important functions for nuclear safety.

★ "Shutdown"

⇒ Scram ⇒ Full insertion of all control rods.

★ "Cooling"

⇒ Maintaining sufficient reactor water level.

⇒ Cooling the reactor water below 100°C.

⇒ Cold shutdown.

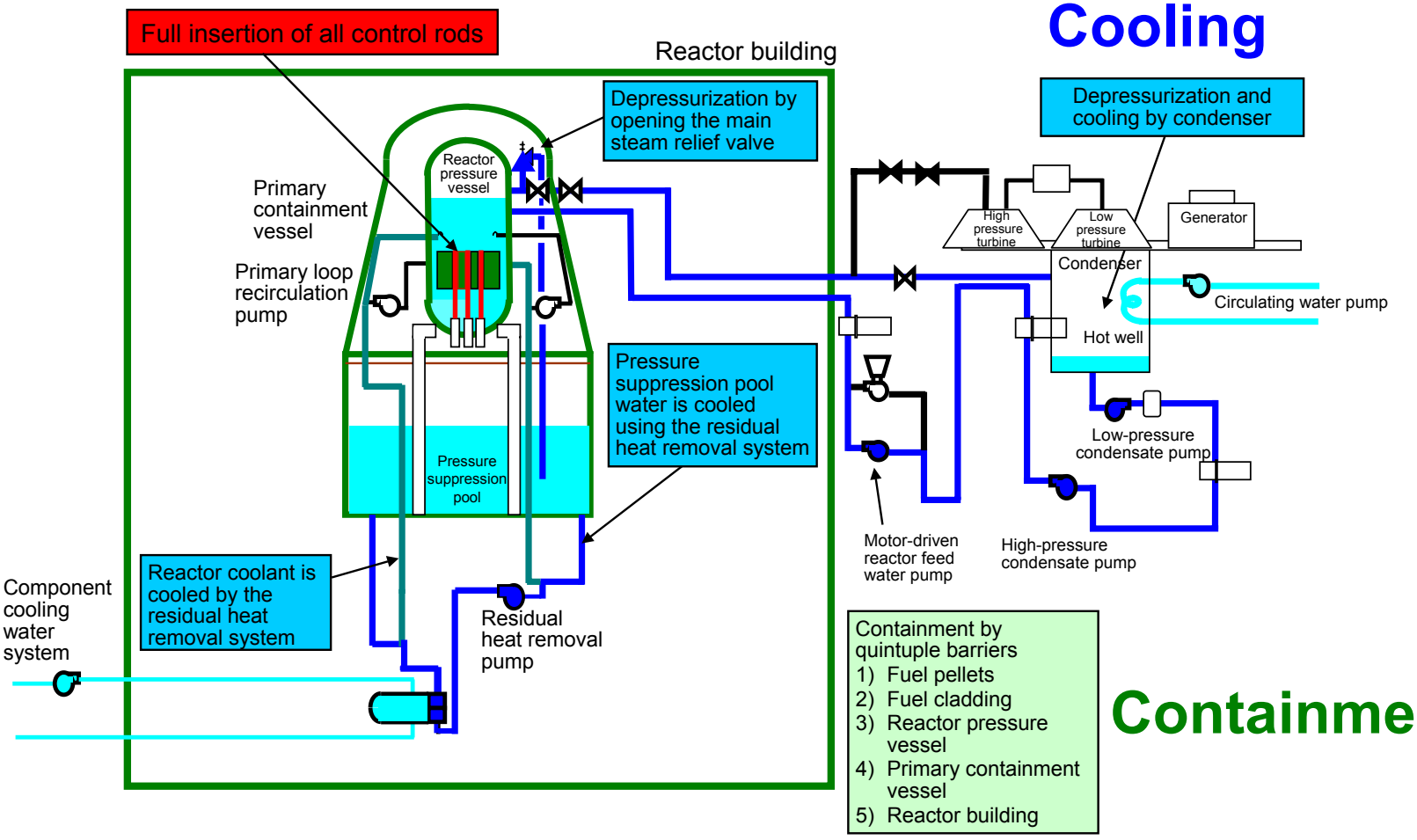
★ "Containment"

⇒ Quintuple barriers ⇒ No release affecting the environment.

These safety functions were secured during and after the earthquake.

“Shutdown”, “Cooling” and “Containment”

Shutdown



1. “Shutdown”

Niigata-Chuetsu-Oki Earthquake occurred at 10:30 on July 16, 2007.
[Status of the units before and after the earthquake]

	Before the earthquake	After the earthquake
Unit 1	Off-line for periodical inspection	←
Unit 2	Start-up operation (subcritical state)	Automatic scram
Unit 3	Constant operation at the rated thermal output	Automatic scram
Unit 4	Constant operation at the rated thermal output	Automatic scram
Unit 5	Off-line for periodical inspection	←
Unit 6	Off-line for periodical inspection	←
Unit 7	Constant operation at the rated thermal output	Automatic scram

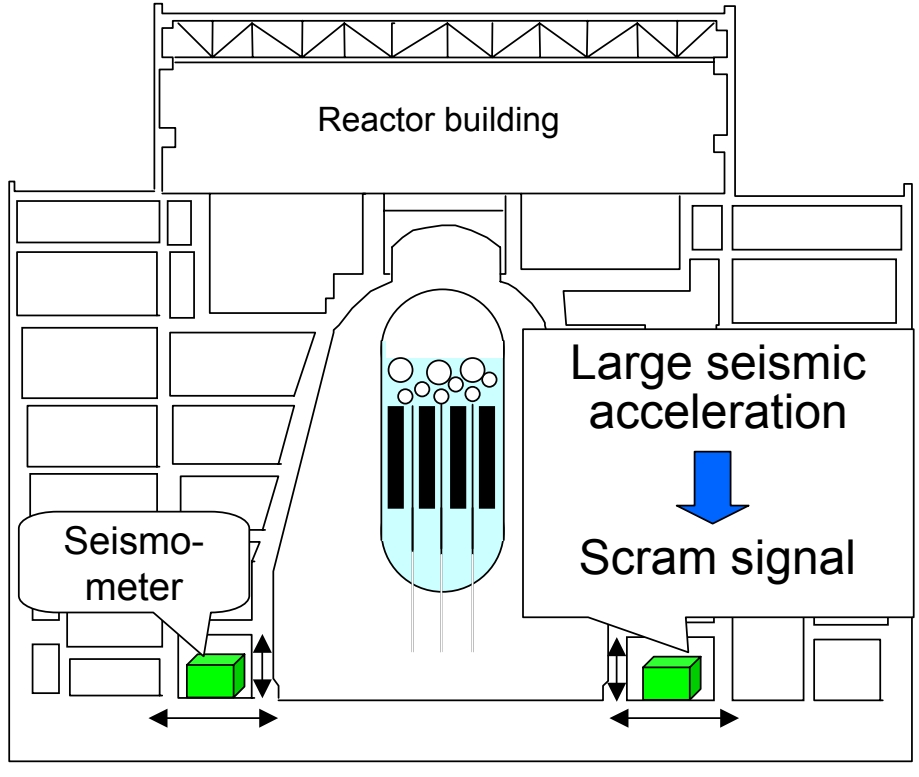
1. “Shutdown”

Occurrence of the earthquake

Large seismic acceleration

Automatic scram of the reactor

- Full insertion of all control rods



Earthquake

1. “Shutdown”

The shift supervisor confirmed automatic scram of the reactor and the full insertion of all control rods on the control panel.

(Reference) [Records of signals relating to scram]

Generated signal	Unit 2	Unit 3	Unit 4	Unit 7
At 10:13, Large seismic acceleration	Printout of the computer *1	←	←	←
At 10:13, Automatic scram of the reactor	Printout of the computer *1	←	←	←
At 10:13, Full insertion of all control rods	Chart *2	Printout of the computer *1	←	←

Printout of the computer immediately after the occurrence of the earthquake (an example of K4)

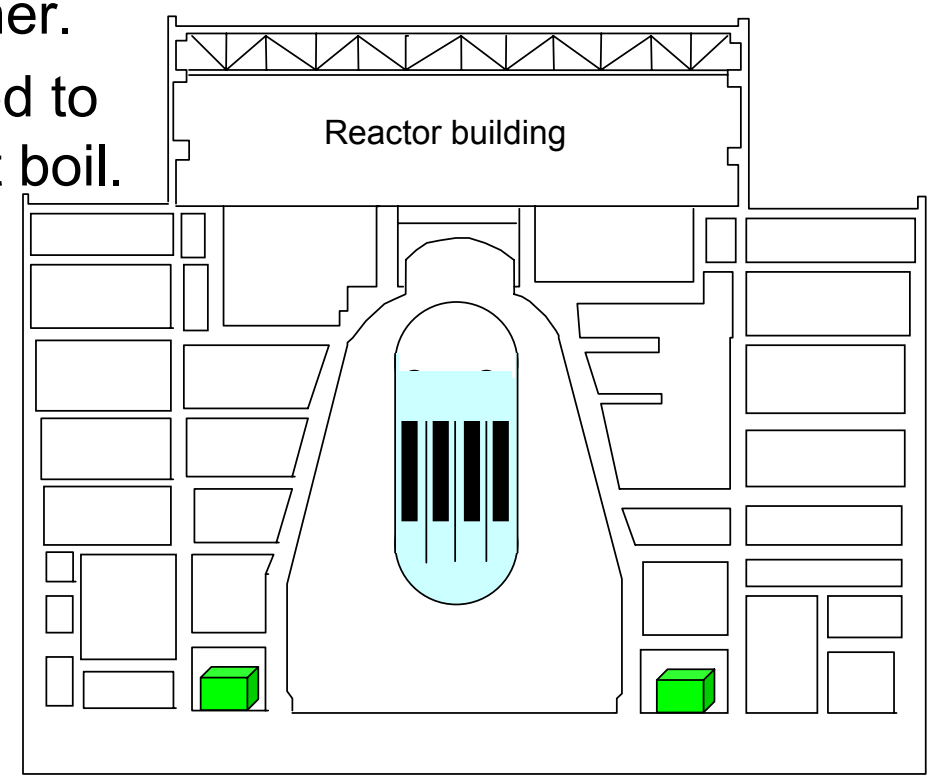
*1: Computer printouts record the generated scram signal or operations of the main devices.

*2: Since the computer printout of Unit 2 did not take place for several minutes after the occurrence of the earthquake and/or the printed time was not correct, data were taken from the neutron flux chart.

Reactors were shutdown

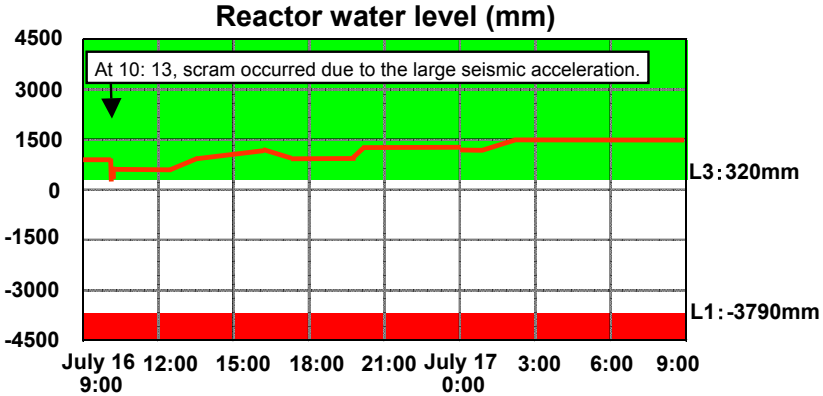
2. “Cooling”

1) Reactor water level is maintained at L3 or higher.
2) Reactor coolant is cooled to the point that it does not boil.
   a) Reactor coolant temperature: below 100°C. (Cold shutdown)
   b) Reactor pressure: atmospheric pressure (0 MPa-gauge).

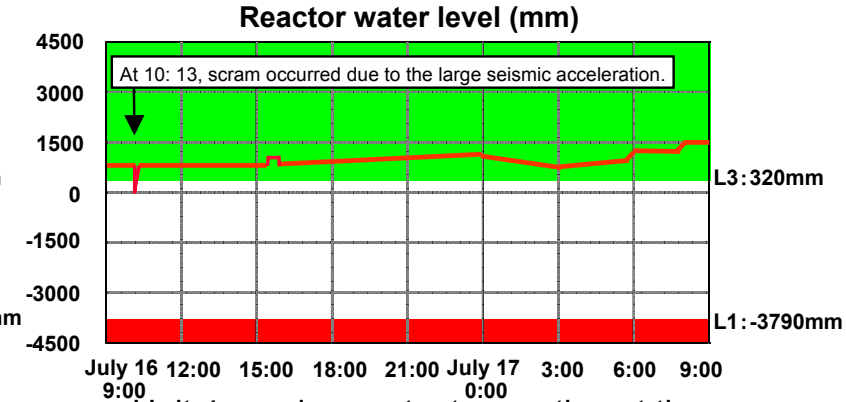


2. “Cooling”

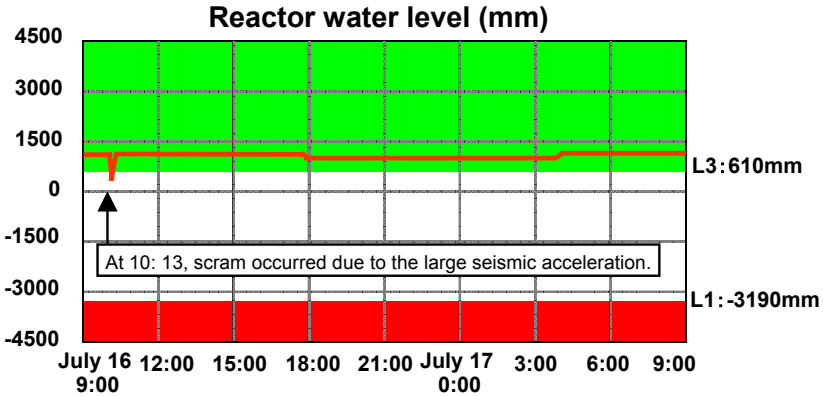
Reactor water level of each unit was maintained properly after the earthquake.



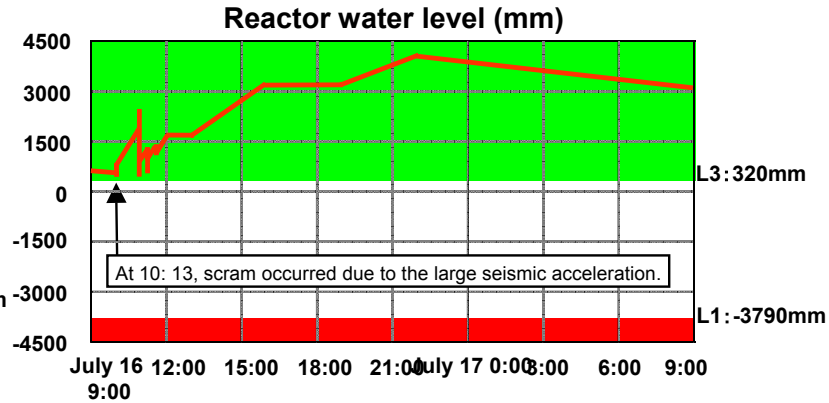
Unit 3 was in constant operation at the rated thermal output.



Unit 4 was in constant operation at the rated thermal output.



Unit 7 was in constant operation at the rated thermal output.



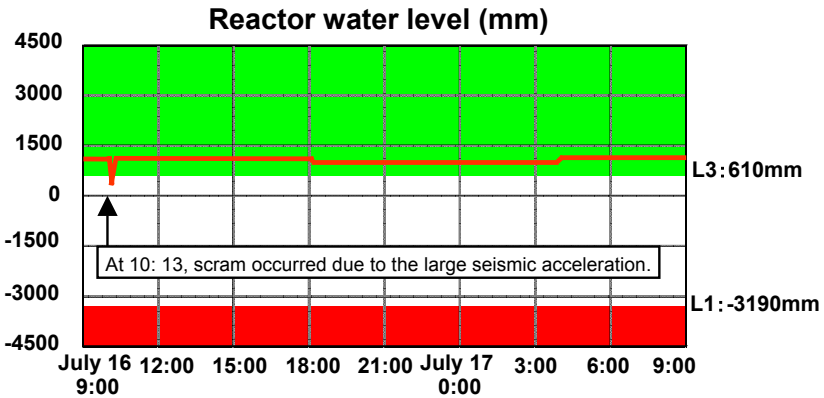
Unit 2 was in start-up operation (subcritical state).

2. “Cooling”

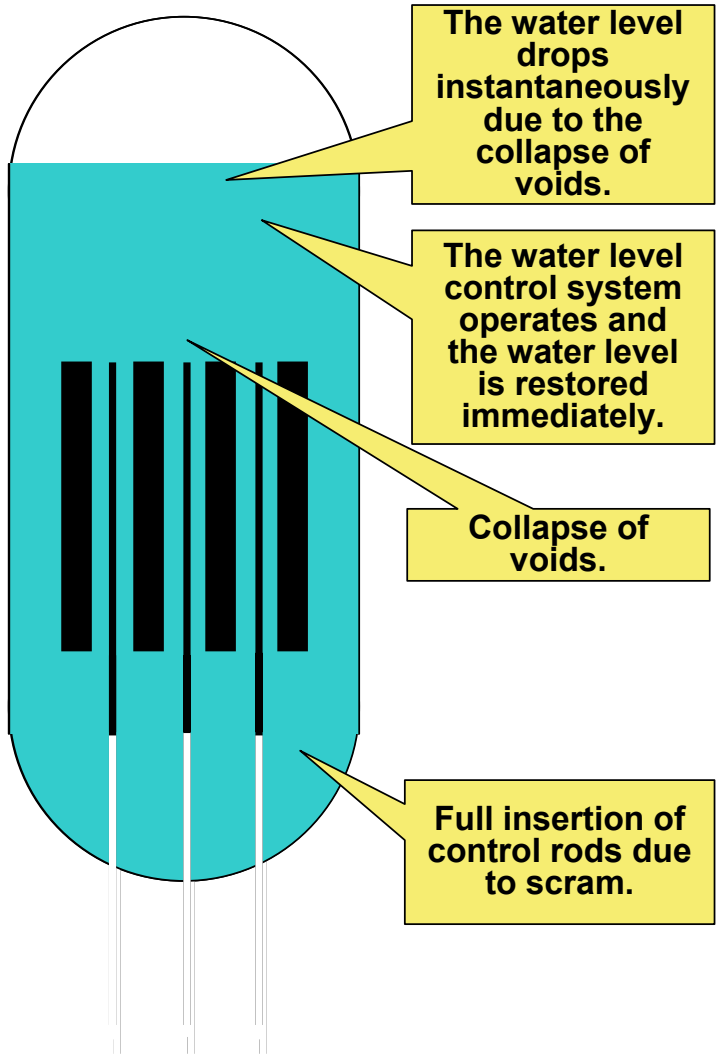
[Fluctuation of the reactor water level immediately after the scram]

When automatic scram of a reactor occurs during operation, full insertion of all control rods reduces the output and collapses the voids (steam bubbles), leading to an instantaneous drop of the reactor water level.

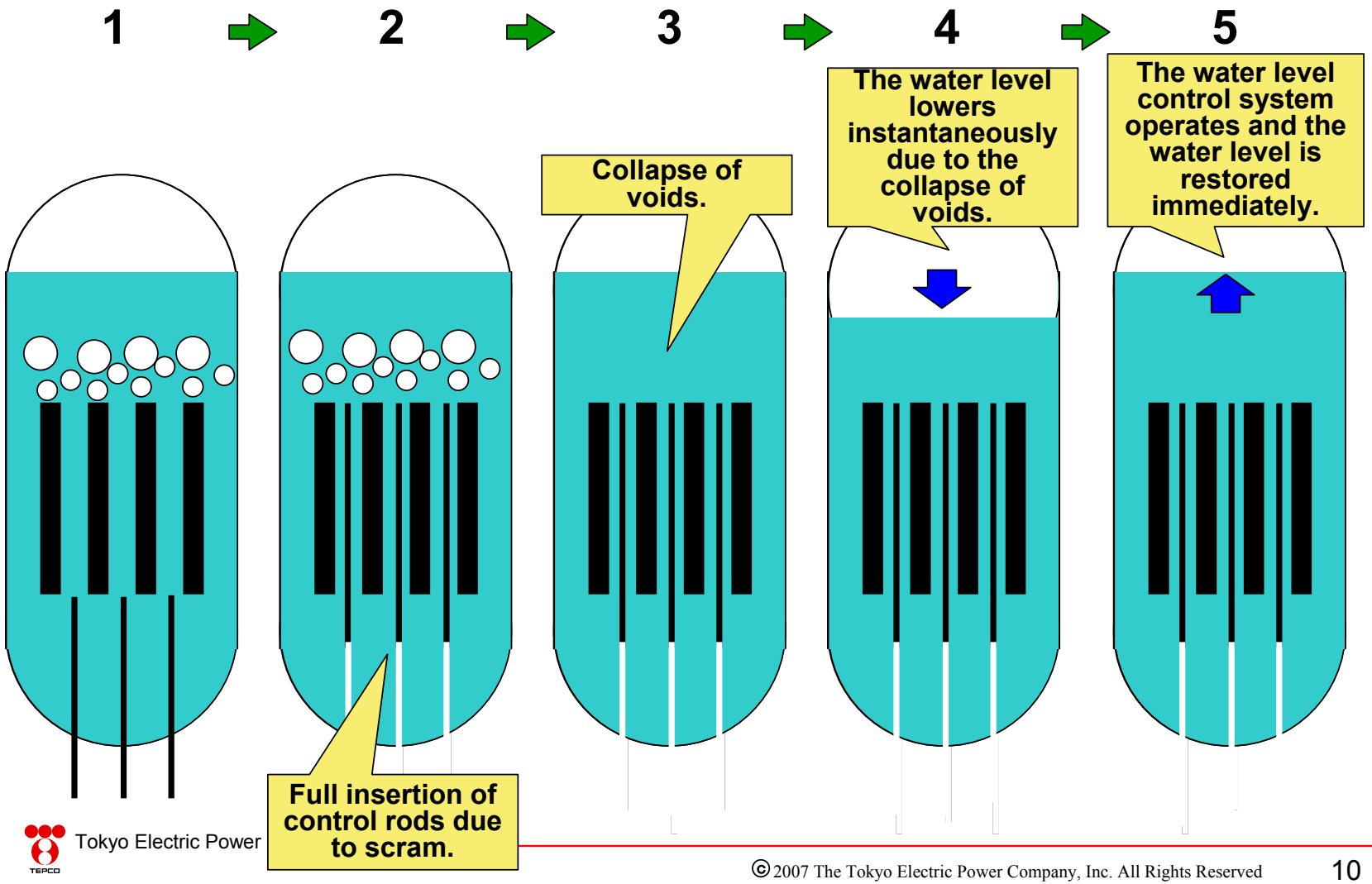
This phenomenon occurred at the time of the earthquake.



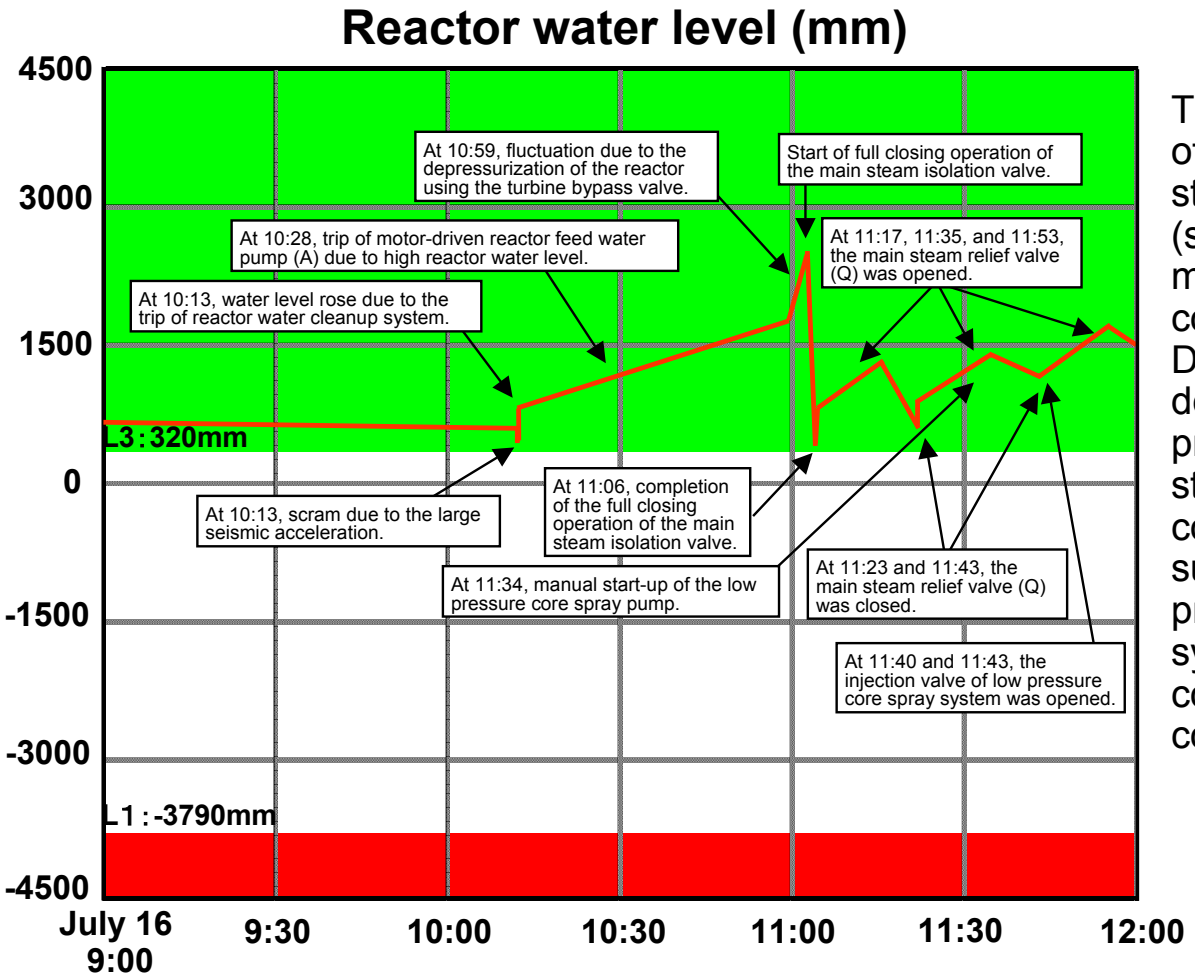
Unit 7 was in constant operation at the rated thermal output.



Fluctuation of reactor water level immediately after the scram



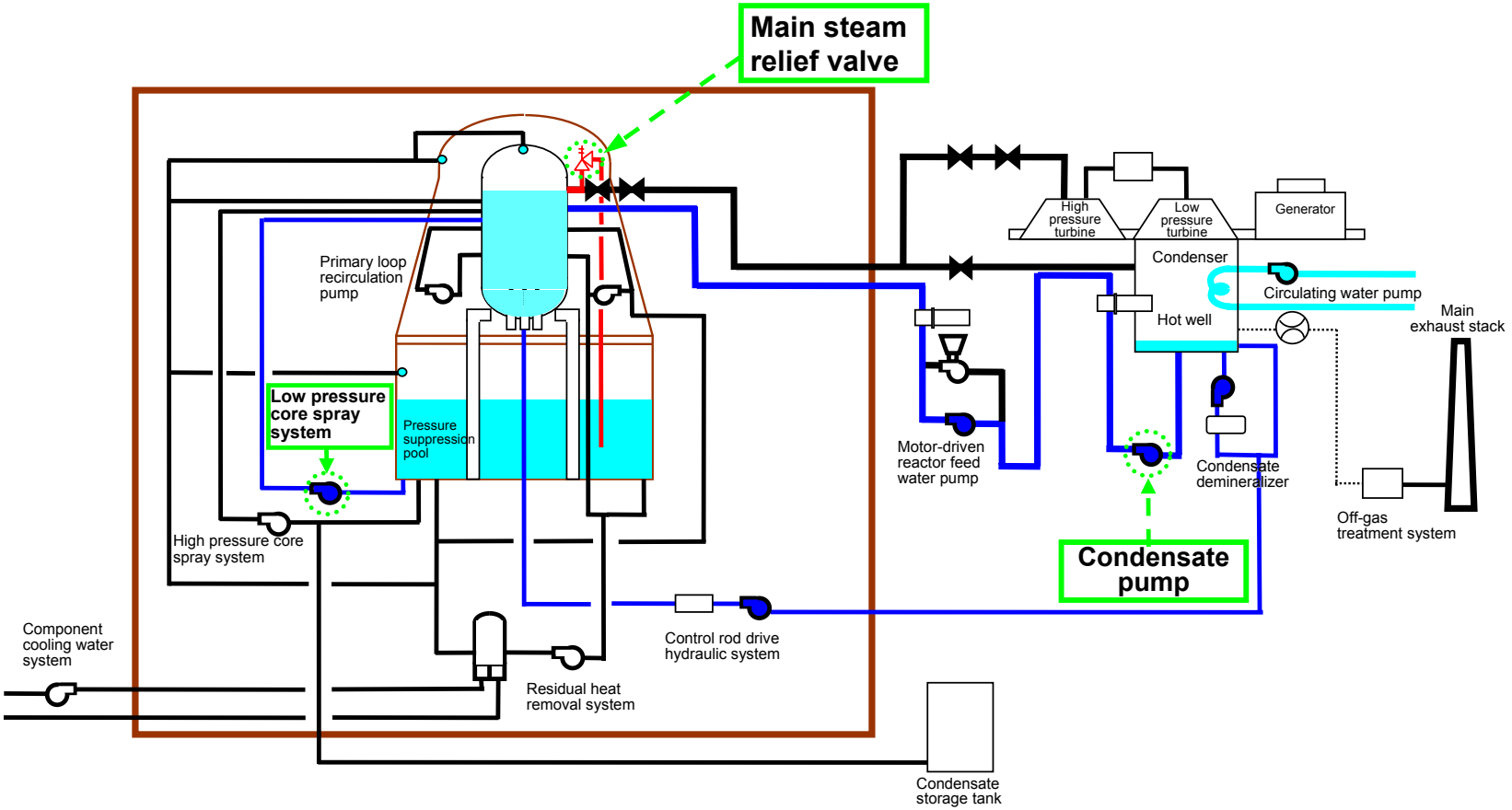
2. “Cooling”



The reactor water level of Unit 2, which was in start-up operation (subcritical status), was maintained by the condensate pump. During the depressurization process using the main steam relief valve, cooling water was supplied using the low pressure core spray system in addition to the condensate pump and control rod drive pump.

2. “Cooling”

[Actual measures taken for water injection at Unit 2]

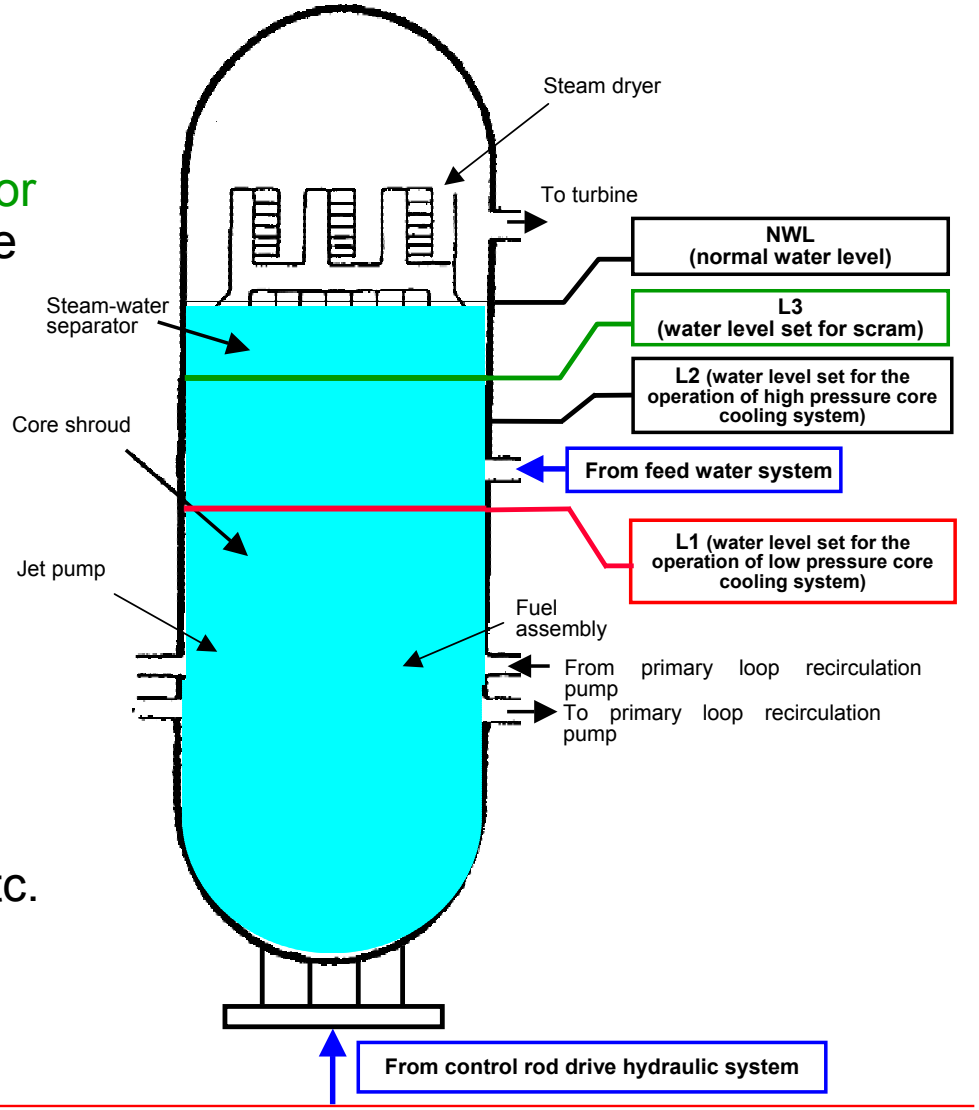


2. “Cooling”

Measures to maintain the reactor water level at L3 or higher in the process after the shutdown of the reactor include:

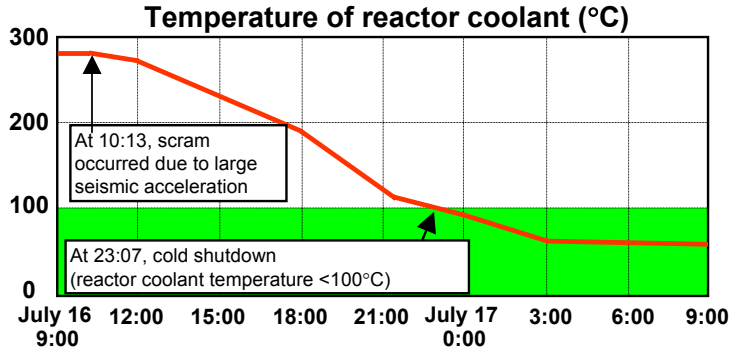
- “Feed water system and condensate system”
- “Control rod drive hydraulic system”
- “Low pressure core spray system”
- “High pressure core spray system”

etc.

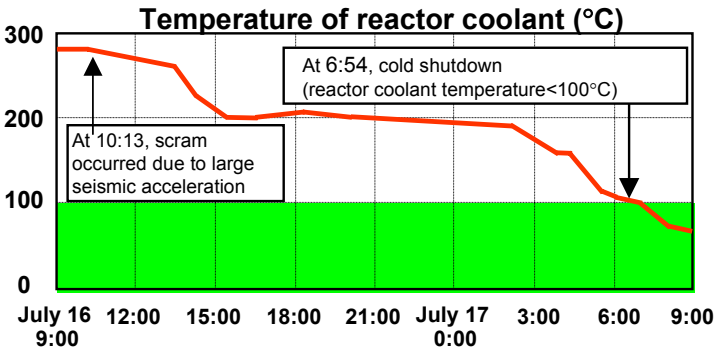


2. “Cooling”

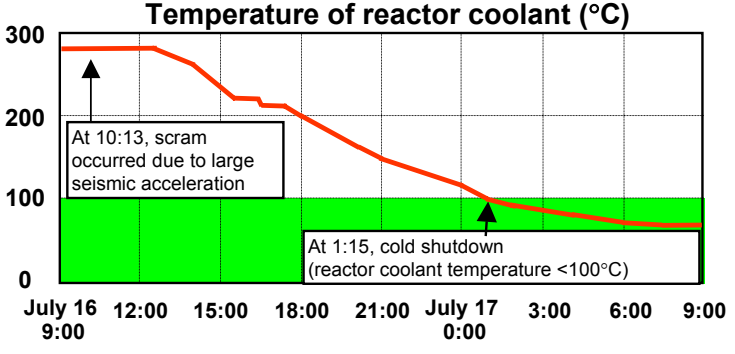
Reactor coolant of each unit was cooled below 100°C.



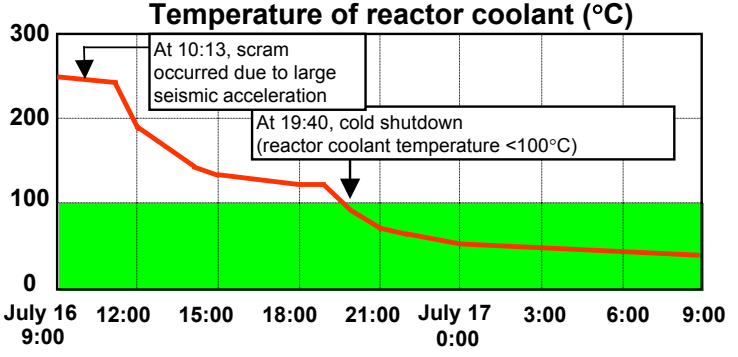
Unit 3 was in constant operation at the rated thermal output (cold shutdown at 23:07, July 16, 2007)



Unit 4 was in constant operation at the rated thermal output (cold shutdown at 6:54, July 17, 2007)



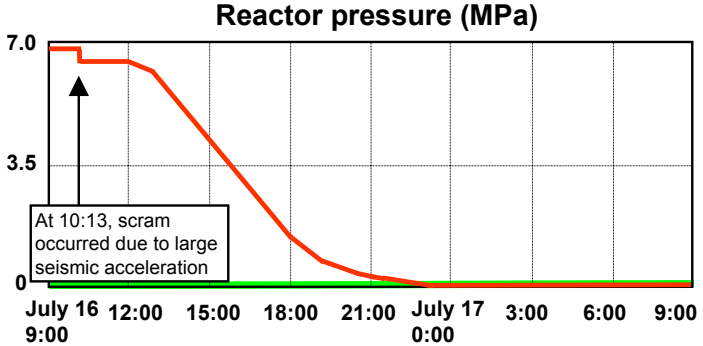
Unit 7 was in constant operation at the rated thermal output (cold shutdown at 1:15, July 17, 2007)



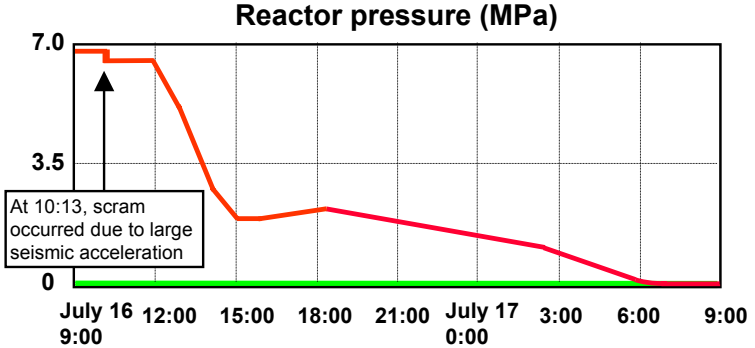
Unit 2 was in start-up operation (subcritical state) (cold shutdown at 19:40, July 16, 2007)

2. “Cooling”

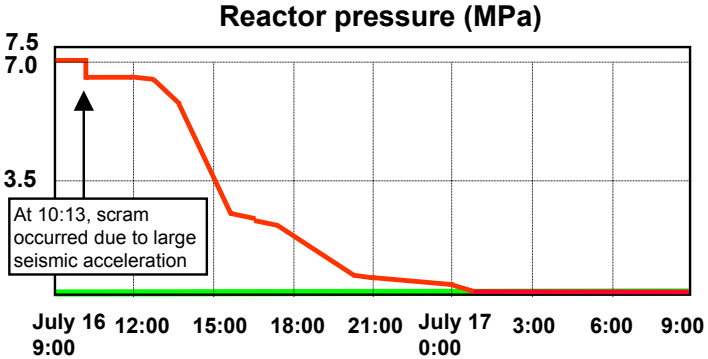
Reactor pressure of each unit was depressurized to atmospheric pressure (0MPa-gauge).



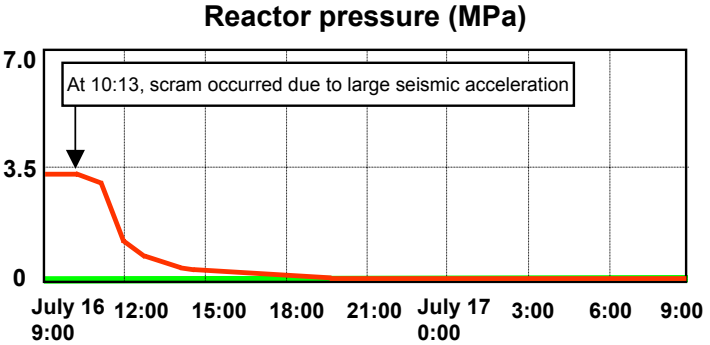
Unit 3 was in constant operation at the rated thermal output (depressurization completed at 23:07, July 16, 2007)



Unit 4 was in constant operation at the rated thermal output (depressurization completed at 6:54, July 17, 2007)



Unit 7 was in constant operation at the rated thermal output (depressurization completed at 1:15, July 17, 2007)



Unit 2 was in start-up operation (subcritical state) (depressurization completed at 19:40, July 16, 2007)

2. “Cooling”

Measures to remove the decay heat after reactor scram are the following:

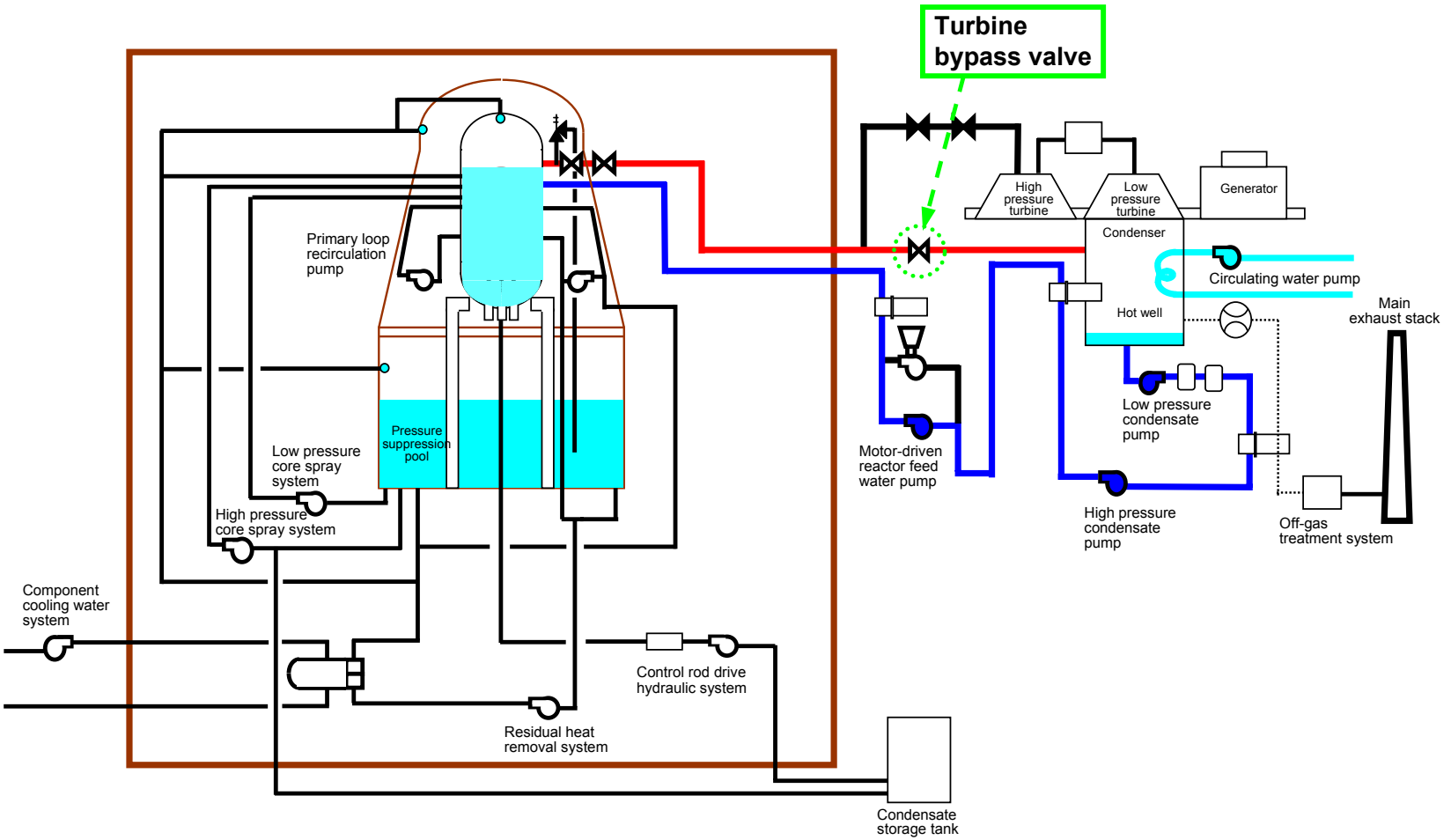
1. Cooling using the turbine bypass valve.
   Steam generated in the reactor is cooled in the condenser*1 via the turbine bypass valve.
2. Cooling using the main steam relief valve.
   Steam generated in the reactor is cooled in the pressure suppression pool*2 via the main steam relief valve.

*1: Direct cooling by seawater.

*2: Indirect cooling by seawater through the residual heat removal system and component cooling water system.

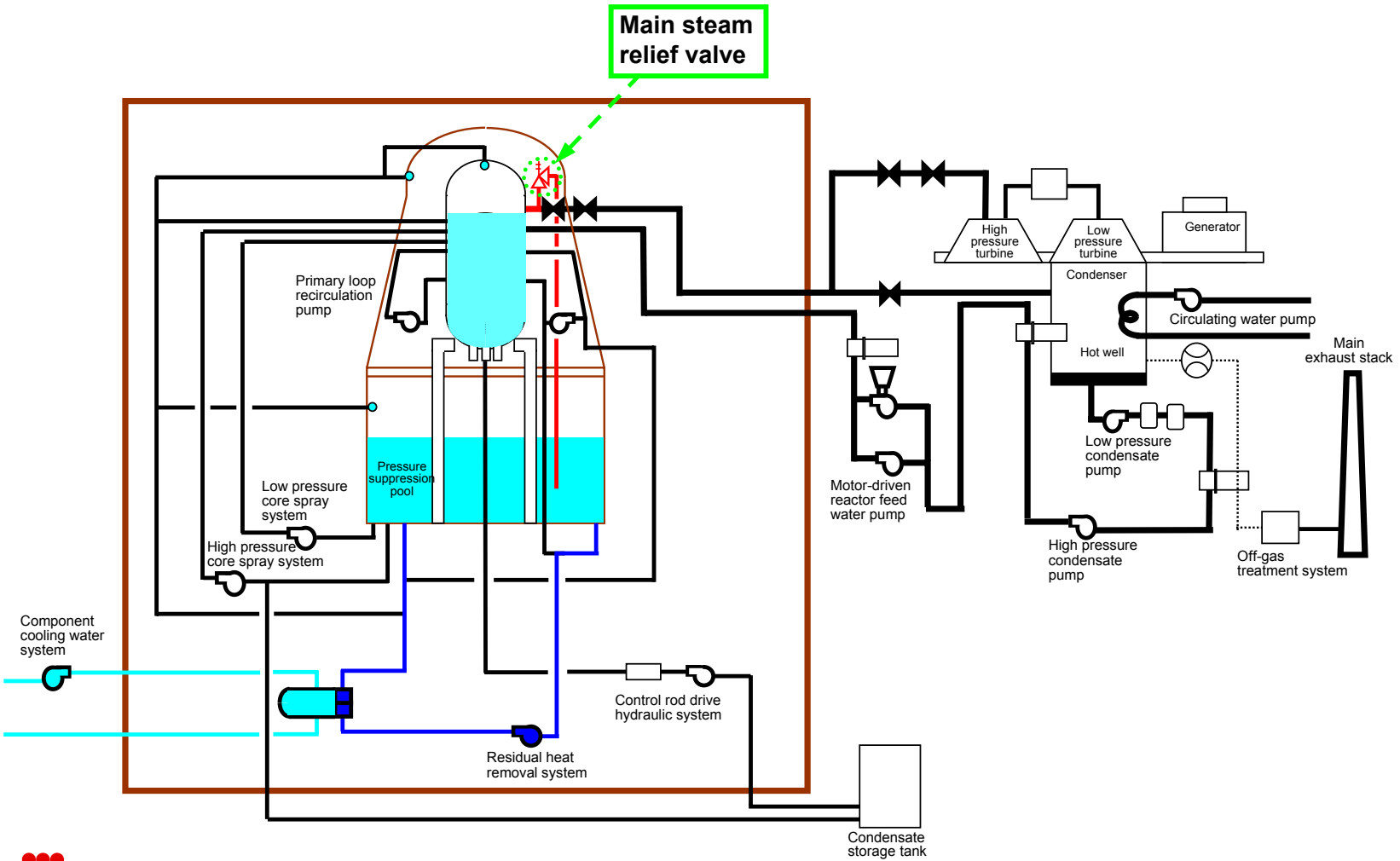
2. “Cooling”

[Cooling by the turbine bypass valve.]



2. “Cooling”

[Cooling by the main steam relief valve.]



(actual operation)

2. “Cooling”

[Units 3 and 4 were in constant operation at the rated thermal output] Operation carried out as specified in the procedure.

- Cooled by the condenser via the turbine bypass valve. Water was fed to the reactor from the condenser hot well by the condensate pump.

- When the temperature of reactor coolant decreased to around 100°C, the water was further cooled using the residual heat removal system shutdown cooling mode.

(Since the common in-house boiler is used for Units 3 and 4 when maintaining the vacuum of the condenser, the operation of decay heat removal was carried out in the order of Unit 3 and Unit 4.)

(actual operation)

2. “Cooling”

[Unit 7 was in constant operation at the rated thermal output]
Operation carried out as specified in the procedure.

- Cooled by the condenser via the turbine bypass valve. Water fed to the reactor from the condenser hot well by the condensate pump.

- Since the in-house boiler stopped due to the earthquake, the main steam isolation valve was fully closed and the cooling was changed to that using the main steam relief valve. Water was fed to the reactor from the condenser hot well by the condensate pump.

- When the temperature of reactor coolant decreased to around 100°C, the water was further cooled using the residual heat removal system shutdown cooling mode.

(actual operation)

2. “Cooling”

[Unit 2 was in start-up operation (subcritical state)]
Operation carried out as specified in the procedure.

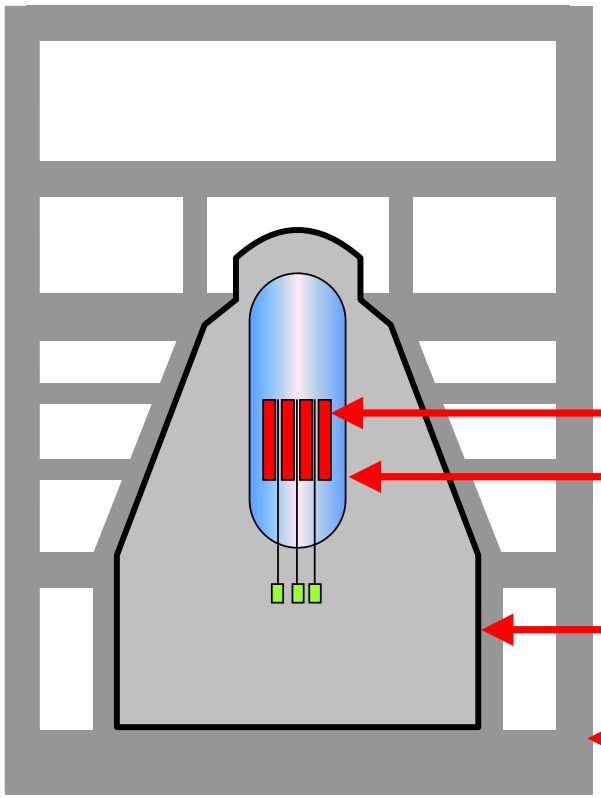
- Since the unit was in start-up operation, the flow of the main steam was low and the turbine bypass valve was fully closed.

- The main steam isolation valve was fully closed and the cooling was changed to that using the main steam relief valve. The condensate pump and control rod drive pump as well as the low pressure core spray pump were started to inject water to the reactor from the pressure suppression pool.

- Since decay heat was small, the reactor coolant temperature decreased as the reactor was depressurized. Water was fed to the reactor from the condensate demineralizer outlet by the control rod drive pump.

- When the temperature of reactor coolant decreased to around 100°C, the water was further cooled using the residual heat removal system shutdown cooling mode.

3. “Containment”



The first barrier — **Pellet**

Sintered uranium fuel, in which most of the radioactive materials are confined.

The second barrier — **Fuel cladding tube**

About 350 pellets are encapsulated within a rigid metallic tube and radioactive noble gas emitted from the pellet is confined in the tube.

The third barrier — **Reactor pressure vessel**

A vessel made of low-alloy steel with a thickness of about 16 cm. The vessel prevents radioactive materials from escaping from the reactor in case radioactive materials leak due to pinholes in the cladding tube.

The fourth barrier — **Primary containment vessel**

A containment vessel with a wall thickness of about 3 cm, in which main components of the reactor are enclosed. This is a barrier in case radioactive materials escape from the reactor.

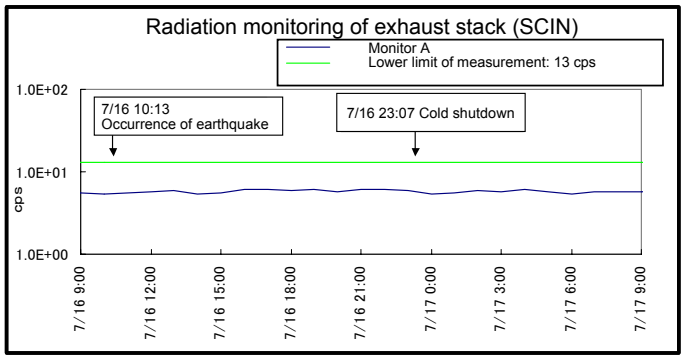
The fifth barrier — **Reactor building**

The outermost barrier is the reactor building made of concrete with a thickness of over 1 m. The reactor building is provided to fully assure the containment of radioactive materials.

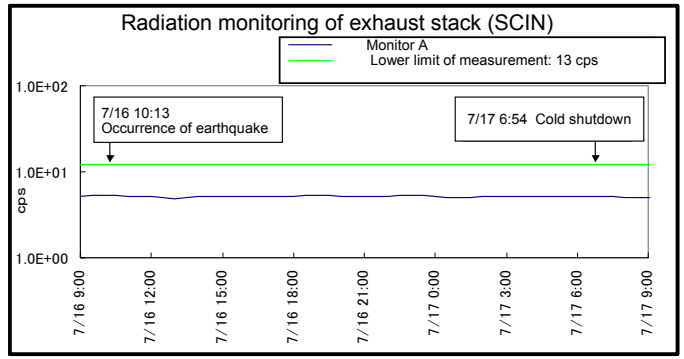
3. “Containment"

No changes in iodine concentration in the reactor coolant and spent fuel pool water was detected, indicating that the fuels of all units were sound.

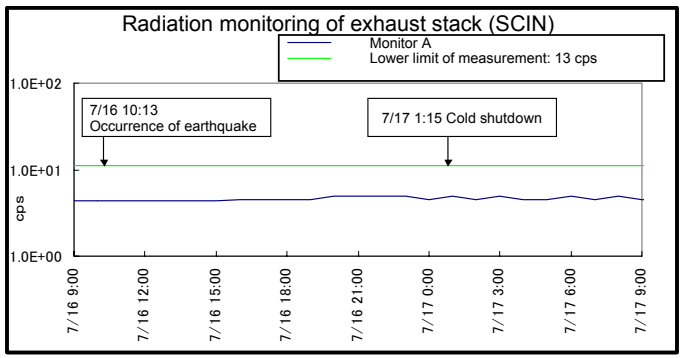
(Reference) Radiation monitoring of the main exhaust stack



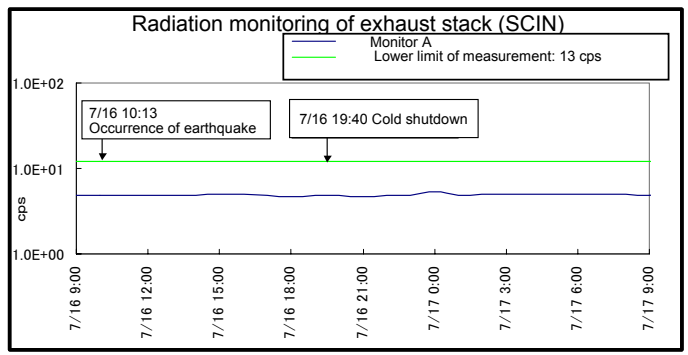
Unit 3 was in constant operation at the rated thermal output.



Unit 4 was in constant operation at the rated thermal output.



Unit 7 was in constant operation at the rated thermal output.



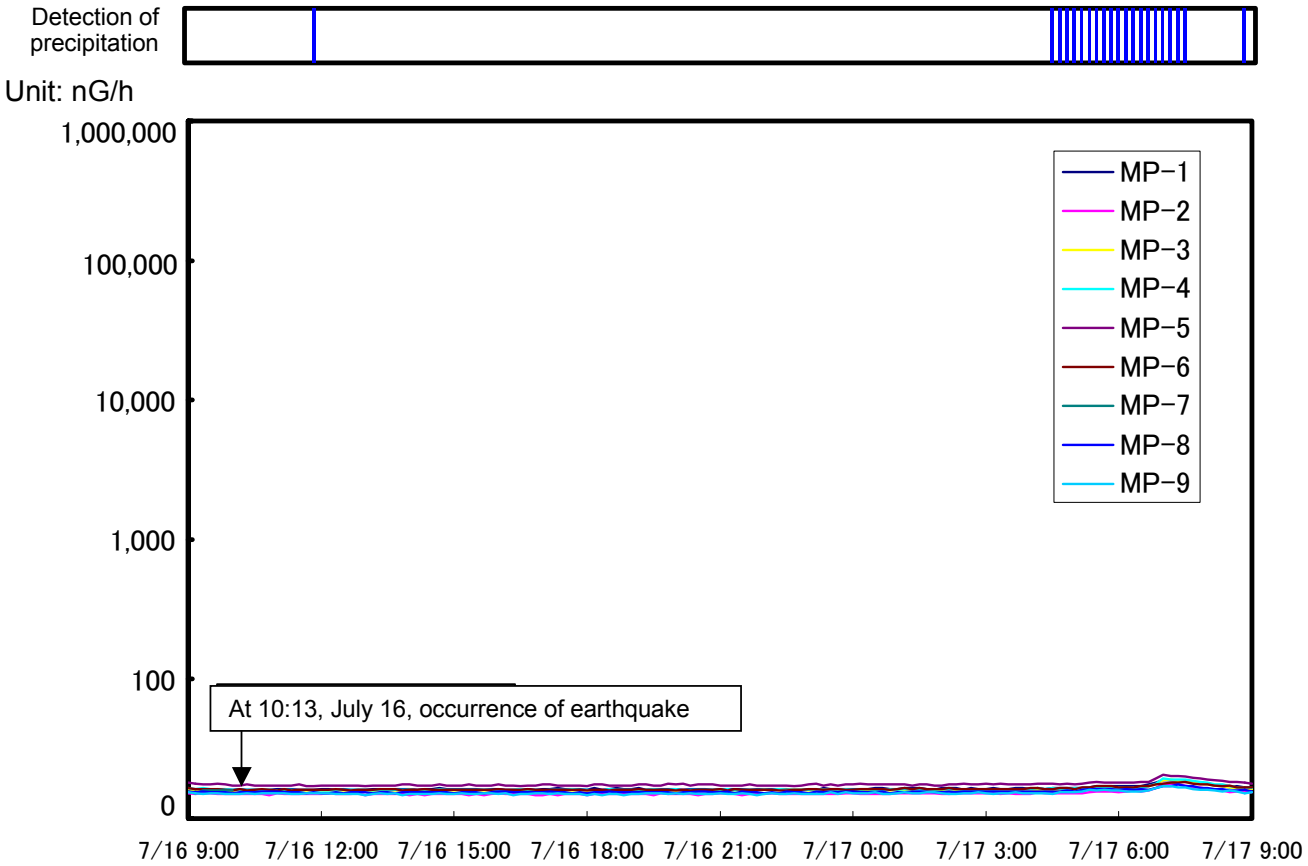
Unit 2 was in start-up operation (subcritical status)

Note: The fluctuation of measured values is within the range of normal fluctuation

3. “Containment”

[Monitoring post]

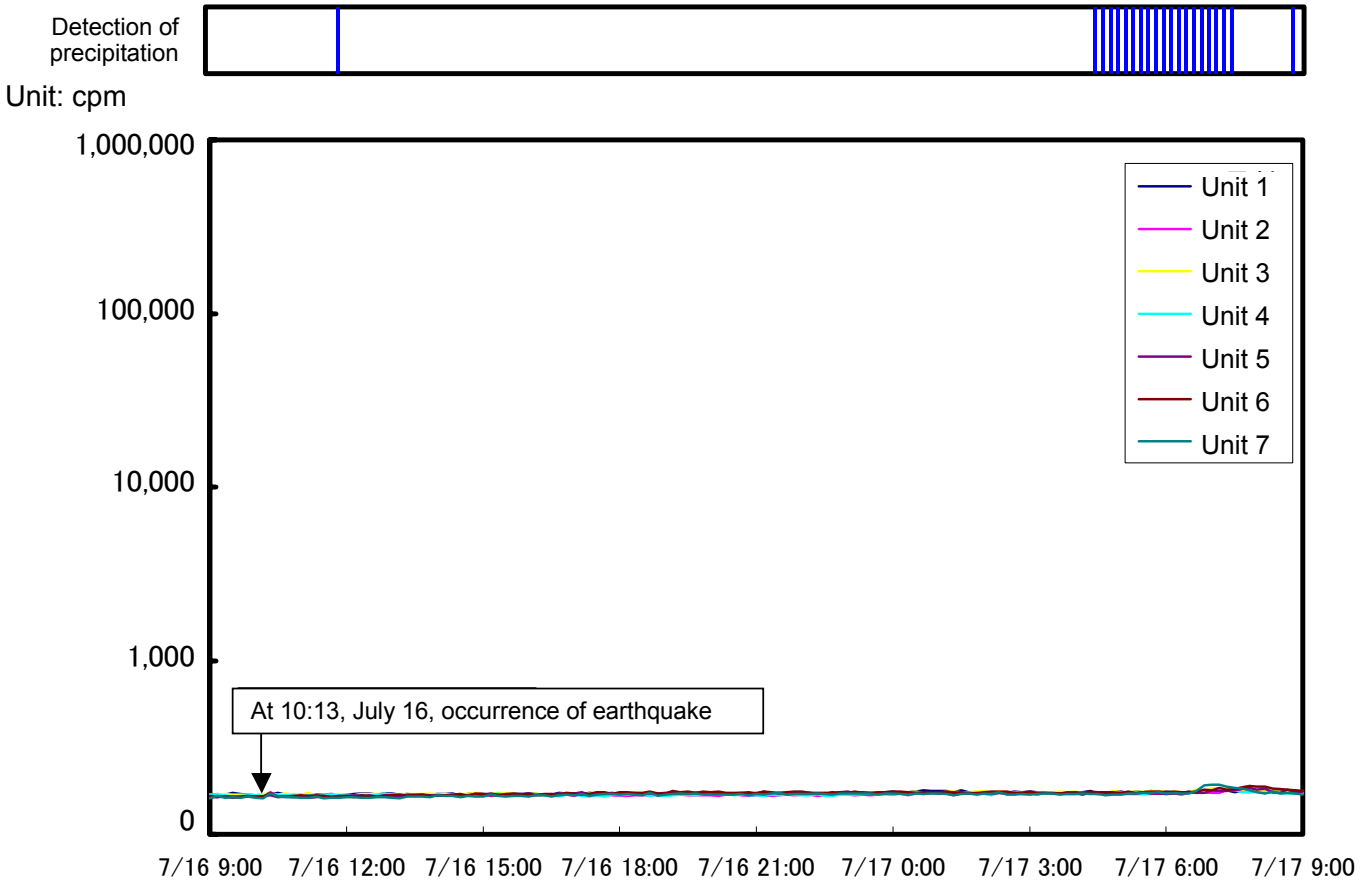
Monitoring post real time data (from 9: 00, July 16 to 9:00, July 17)



3. “Containment”

[Seawater monitoring]

Seawater monitoring real-time data (from 9: 00, July 16 to 9:00, July 17)



(Reference)

Detection of radioactive materials in the main exhaust stack of Unit 7

<Time series >

- At around 13:00, July 17, iodine and radioactive particulates (chromium 51 and cobalt 60) were detected in a periodical measurement (implemented once a week) of the main exhaust stack.
- Press release at 16:00 of the same day.

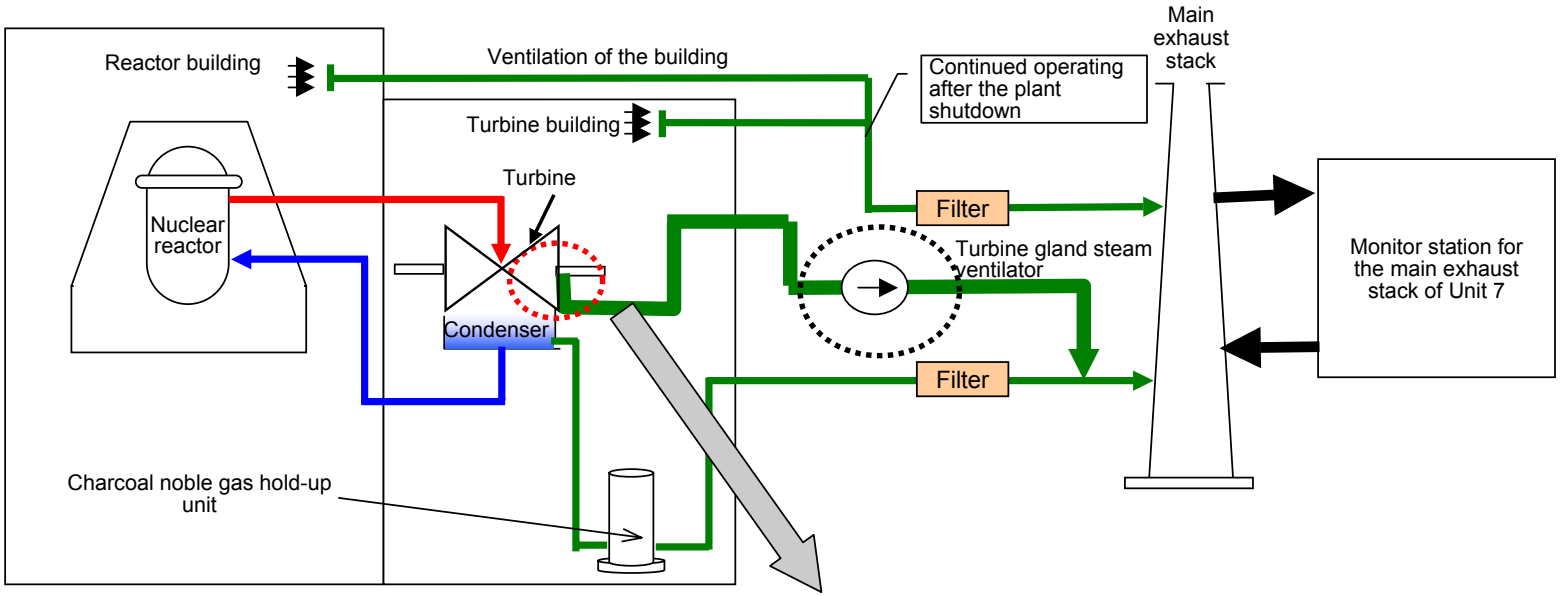
Total radioactivity: about 4×10^{8} Bq
Radiation dose from the above radioactivity : about 2×10^{-7} mSv
(About one ten-millionth of the radiation that an average person is exposed to from natural sources annually.)
(About one millionth of the radiation received by a person in a round-trip flight between Tokyo and New York.)

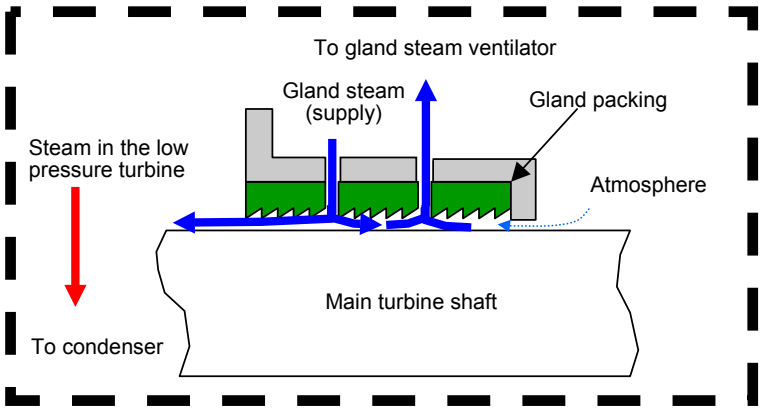
<Cause of occurrence>

- It is presumed that radioactive materials were sucked out from the condenser and subsequently released from the main stack due to the delay in shutting down the gland steam ventilator after automatic shutdown of the reactor.
- No radioactive material has been detected in measurements after July 19.

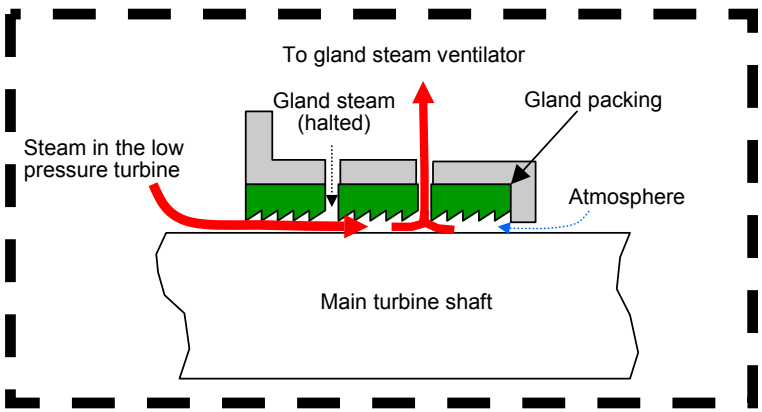
(Reference)

Situation of the release of iodine from the exhaust stack of Unit 7





Normal situation



Situation after the quake

4. Conclusion

The most important functions for nuclear safety:

★"Shutdown" ⇒ Full insertion of all control rods.

★"Cooling" ⇒ Cold shutdown.

★"Containment" ⇒ No release affecting the environment.

All functions were satisfactory.

Stable cold shutdown conditions for all reactors have been maintained after the earthquake.